

STS-101 SPACE SHUTTLE MISSION REPORT

July 2000



**National Aeronautics and
Space Administration**

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

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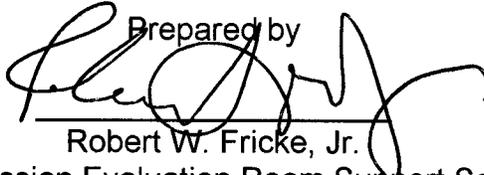
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STS-101

SPACE SHUTTLE

MISSION REPORT

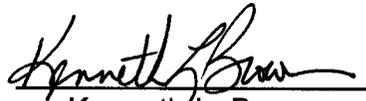
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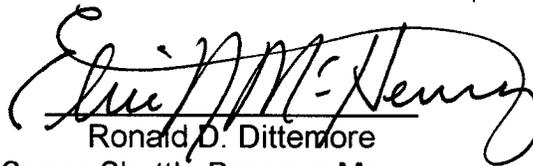
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INTRODUCTION

The Space Transportation System (STS)-101 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-101 flight was the third mission to the International Space Station (ISS) to perform maintenance and logistics tasks.

This Space Shuttle Program Mission Report presents a discussion of the Orbiter subsystem operation and the in-flight anomalies that were identified. The report also summarizes the activities of the STS-101 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 ninety-eighth mission of the Space Shuttle Program. STS-101 was the seventy-third flight since the return to flight, and the twenty-first flight of the OV-104 (Atlantis) vehicle.

The flight vehicle consisted of the OV-104 Orbiter; an ET, which was the sixth Super Lightweight Tank (SLWT), and it was designated ET-102; three Block IIA SSMEs that were designated as S/Ns 2043, 2054, and 2049, in positions 1, 2, and 3, respectively; and two SRBs that were designated B1100. The two RSRMs were designated RSRM-74 with one installed in each SRB. The individual RSRMs were designated as 360L074A for the left SRB and 360L074B for the right SRB.

The primary objectives of the STS-101 flight were to provide the ISS Program with logistics capability for transfer and internal/external installation and checkout of ISS hardware, specifically the Orbiting ISS Stage 2A.1, utilizing a double Spacehab module, Integrated Cargo Carrier (ICC) and Orbiter crew compartment. Prior to undocking, one scheduled extravehicular activity (EVA) was performed for external equipment transfer. In addition, the secondary objectives of this flight were to perform the requirements for Space Experiment Module (SEM-06), Mission to America's Remarkable Schools (MARS), Commercial Protein Crystal Growth (CPCG), Protein Crystal Growth-Biotechnology Ambient Generic (PCG-BAG), BioTube Precursor Experiment (BioTube), Astroculture (AST) and Spacehab Commercial's.

The STS-101 flight was planned as a 10-day plus 1 day if a flight day 4 rendezvous was required instead of the planned flight day 3 rendezvous, plus 2-contingency-day flight. The two contingency days were available for bad weather avoidance for landing or other Orbiter contingency operations. The sequence of 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-101 flight consisted of James D. Halsell, Col., U. S. Air Force, Commander; Scott Horowitz, Lt. Col., U. S. Air Force, Pilot; Mary Ellen Weber, Ph. D., Civilian, Mission Specialist 1; Jeffrey N Williams, Lt. Col., U. S Army, Mission Specialist 2; James S. Voss, Col., U. S. Army, retired, Mission Specialist 3; Susan J. Helms, Lt. Col., U. S. Air Force, Mission Specialist 4; and Yuri V. Usachev, Civilian, Russian Cosmonaut, Mission Specialist 5. STS-101 was the fifth space flight for the Commander, the fourth space flight for Mission Specialist 3 and Mission Specialist 4, the third space flight for Pilot and Mission Specialist 5, the second space flight for Mission Specialist 1; and the first space flight for Mission Specialist 2. The first two space flights for Mission Specialist 5 were long-duration missions to the Russian Mir Space Station, and STS-101 was the first flight on the Space Shuttle.

MISSION SUMMARY

The planned launch of the STS-101 mission on April 24, 2000, was scrubbed because of excessive crosswinds at Kennedy Space Center (KSC) as well as excessive winds at Edwards Air Force Base, CA. The decision was made at the External Tank tanking meeting following the first launch attempt to launch on April 25, 2000; however, the second launch attempt was scrubbed prior to the T-20 minute hold because the crosswinds again exceeded the vehicle limits. The launch was rescheduled for April 26, 2000, at 3:29 p.m. e.d.t. The weather conditions were acceptable at KSC; however, the third launch attempt was scrubbed because of excessive crosswinds at the transAtlantic abort (TAL) site, Ben Guerir. Also, unacceptable weather conditions existed at the other two TAL sites. The launch was rescheduled for May 19, 2000.

During the countdown for the April 26th launch attempt, the External Tank (ET) liquid oxygen (LO₂) 100-percent wet sensor no. 1 failed off-scale high. The failure had no impact on the prelaunch or launch operations. The sensor was not repaired prior to the May 19th launch.

The STS-101 mission began with the launch of the vehicle at 140:10:11:09.994 G.m.t. (6:11:09 a.m. e.d.t.) on May 19, 2000. The ascent phase was nominal with main engine cutoff (MECO) occurring at 140:10:19:35 G.m.t. [00:00:08:25 mission elapsed time (MET)]. An orbital maneuvering subsystem (OMS) dual-engine assist maneuver was performed during ascent with ignition occurring at 140:10:13:24.1 G.m.t. (00:00:02:14.1 MET). The firing was 59.4 seconds in duration and the OMS performed satisfactorily during the maneuver.

A bright streak was seen in the launch video 34 seconds after liftoff. The streak appeared to originate from the underside of the right wing. During STS-26, a similar streak was observed at 52 seconds MET. Upon return on STS-26, thermal protection system (TPS) tile damage was present on the underside of the right wing. There was no structural damage in the STS-26 case. A small change to the end-of-mission thermal-conditioning attitude that resulted in a cold bias of the right wing/elevons structure was employed. This attitude enhancement was made to reduce the potential for local damage and impact to turnaround processing. This possible TPS damage was not considered a safety-of-flight issue. Postlanding video of the underside of the right wing did not reveal any significant TPS damage.

A determination of vehicle propulsive performance during ascent, using vehicle acceleration and preflight propulsion prediction data, showed that the flight-derived engine I_{sp} was 453 seconds. The Space Shuttle main engine (SSME) tag value for this flight was 452.1 seconds at the 104.5-percent power level. No

in-flight anomalies were identified in the vehicle propulsive systems during ascent.

The OMS 2 maneuver was performed satisfactorily at 140:10:54:14.3 G.m.t. (00:00:43:04.3 MET). The maneuver was 53 seconds in duration, and the differential velocity (ΔV) was 81.1 ft/sec. The resultant orbit was 85.4 by 178.6 nmi., and subsystem performance was nominal.

During the OMS assist and OMS 2 post-maneuver purges, the left orbital maneuvering engine (OME) gaseous nitrogen (GN_2) regulator pressure indicated approximately 297 psia, which is below the fault detection and annunciation (FDA) limit of 299 psia (Flight Problem STS-101-V-02). As a result, FDA alarms were generated during the purges. Upon completion of the purges, the regulated pressure returned to a nominal value of 311 psia. This condition did not impact the successful completion of the planned mission.

The opening of the payload bay doors was completed satisfactorily at 140:12:20:28 G.m.t. (00:02:09:18 MET).

The crew reported that the panel F9 meter that indicates dc amperes and signal strength was fluctuating during ascent. The meter was in the signal-strength position during ascent. The readings appeared to be accurate but fluctuated for about one minute before stabilizing when the selector switch was moved.

Operations (OPS) recorder 1 experienced two problems. The first was the failure to receive playback data that was recorded on tracks 3 through 9 in the forward direction. The second problem was erratic tape-counter indications while operating in high-speed (120 inches/second) in the reverse direction and in the 80 to 100-percent tape region. The workaround was to record data only in the reverse direction during acquisition of signal (AOS) periods, and avoid using the tape past the 70-percent region. The OPS recorder 1 problem worsened as the mission progressed, and the decision was made to discontinue its use. OPS recorder 2 was used exclusively and no plans were made to use the OPS recorder 1 for a source of data for the remainder of the mission.

At 140:16:09 G.m.t. (00:05:58 MET), the crew was downlinking ascent video from the video tape recorder (VTR) with a color signal reaching the ground. After a 1-minute loss of signal (LOS), the video appeared black and white. The crew performed a test and reported that good quality color video was being observed onboard. Troubleshooting will be performed postflight.

During the flight day 2 post-sleep cryogenic reconfiguration, the oxygen (O_2) tank 4 A and B heaters were placed into the automatic mode. Following the first heater cycle at 141:00:02 G.m.t. (00:13:51 MET) that was nominal, the A heater did not operate during subsequent cycles (Flight Problem STS-101-V-04). The

heater switch was cycled to the off position and then back to automatic mode at 141:16:12 G.m.t. (01:06:01 MET), and the operation of the heater was regained. During the depletion of O₂ tank 4, several planned heater reconfigurations were performed, and the A heater operated nominally.

After the NC2 OMS rendezvous maneuver cutoff at 141:01:49:24 G.m.t. (00:15:38:14 MET), the left OME bipropellant valve 2 indicated failed open, with the valve position fluctuating around the 98.4-percent level (Flight Problem STS-101-V-01). As a result, the remaining OMS firings for the rendezvous were made with the right OME. However, both engines were used for the deorbit maneuver. There was no change in the indicated position of the left OME bipropellant valve 2 during the deorbit maneuver.

All of the rendezvous maneuvers were completed successfully, resulting in a docking with the International Space Station (ISS) at 142:04:44:09 G.m.t. (01:18:32:59 MET)

At 142:07:28 G.m.t. (01:21:17 MET), Assembly Power Converter Unit (APCU) 1 and 2 were activated. Initially, both the A and B converters in APCU 1 performed nominally when the ISS cabin fan was powered on. After 1 hour and 15 minutes of nominal operation when the intermodule ventilation (IMV) fan was powered on, converter B showed erratic behavior and was no longer equally sharing the load with APCU 1 converter A and APCU 2 converters A and B. The unit continued to display erratic operation and approximately 3 hours after the initial activation, APCU 1 was deactivated in accordance with the nominal timeline. Prior to undocking from the ISS on flight day 9, a test of APCU 1 was performed with APCU 2 off. APCU 1 operated properly with equal load sharing.

During extravehicular activity (EVA) preparation, the crew reported finding two small pieces of debris. The pieces were identified as part of the spindle and a ball from a double-acting pip pin. The parts were identified as coming from the pip pin located at the unoccupied hatch position of the external airlock.

The EVA, which began at 143:01:52:51 G.m.t. (02:15:41:41 MET), was successfully completed in 6 hours and 44 minutes. The Extravehicular Mobility Unit (EMU) and supporting subsystems performed satisfactorily.

A minor problem was noted while stowing the remote manipulator system (RMS) manipulator positioning mechanisms (MPMs). Although stowing was completed successfully, one of the two stow microswitches that indicates proper positioning of the aft MPM was not received. The MPMs were rolled back out for Space Vision System (SVS) operations and stayed rolled out until after undocking from the ISS.

The Orbiter Space Vision System (OSVS) was processing an automatic software script without crew interaction. The script generated a large number of status messages that were written into the internal buffer. The buffer overflowed and created an unrecoverable software error condition that can be only observed by the ground controllers. As a result, data were lost until a workaround was instituted to have the crew power-cycle the payload and general support computer (PGSC) each day during the post-sleep and pre-sleep periods.

During the EVA when the cabin was being repressurized to 14.7 psia at 143:07:49 G.m.t. (02:21:38 MET), the pressure control system (PCS) nitrogen (N₂) system 2 flow sensor failed to indicate flow while in auto mode. Nitrogen flow was confirmed through alternate instrumentation. This was the first use of system 2. System 1 was performing the cabin pressurization while system 2 was controlling oxygen (O₂) concentration. The flow sensor was functional during prelaunch checkout. The hardware has a 3/3 criticality and will not be replaced until the new flow sensor design is delivered.

The crew ingress the ISS and began the electrical system hardware replacements and transfer operations.

The first ISS reboost maneuver was initiated at 145:00:02:11 G.m.t. (04:13:51:01 MET) and consisted of 27 +X primary-RCS-thruster reboost pulses with vernier-RCS-thruster attitude adjustments between each pulse. The reboost maneuver was terminated at 145:01:02:42 G.m.t. (04:14:51:32 MET). The aft down firing vernier-reaction control subsystem (RCS) thrusters were pulsed every 130 seconds for about 85 seconds. The +X primary-RCS thrusters were pulsed every 130 seconds for 5.52 seconds. There were no thermal violations during the reboost maneuver and the propellant usage was as expected. The ΔV delivered was 29.1 ft/sec and the final orbit was 190 by 184 nmi., an altitude increase of approximately 9 nmi.

The second ISS reboost maneuver was initiated at 146:01:15:51 G.m.t. (05:15:04:41 MET) with a minus-pitch pulse of the aft-vernier-RCS thrusters. Once again the maneuver consisted of 27 +X primary-RCS-thruster reboost pulses with vernier-RCS-thruster attitude adjustments between each pulse. The reboost maneuver was terminated at 146:02:14:01 G.m.t. (05:16:02:51 MET). There were no thermal violations during the reboost maneuver and the propellant usage was as expected. The ΔV delivered was 29.0 ft/sec and the final orbit was 196 x 195 nmi.

The third ISS reboost maneuver was initiated at 146:23:32:38 G.m.t. (06:13:21:28 MET) with a minus-pitch pulse of the aft-vernier-RCS thrusters. This maneuver consisted of 26 +X primary-RCS-thruster reboost pulses with vernier-RCS-thruster attitude adjustments between each pulse. The reboost maneuver was terminated at 147:00:28:53 G.m.t. (06:14:17:43 MET). There

were no thermal violations during the reboost maneuver, and the propellant usage was as expected. The ΔV delivered was 28.2 ft/sec and the final orbit was 206.7 x 199.5 nmi.

The crew reported periodic shutter lockup of the digital camera system (DCS) that was used to support the ISS internal operations. Cycling the power momentarily cleared the alarm, but the lockup condition returned in a few minutes. The camera was stowed and an alternate camera was used for the photography. Postflight troubleshooting of the camera will be performed.

On two occasions while the Orbiter was docked with the ISS, the Ku-band traveling wave tube (TWT) transmitter radiated into the radio frequency (RF) protect box (Flight Problem STS-101-V-03). The first occurrence was at 146:09:32 G.m.t. (05:23:21 MET) and the second was at 147:08:26 G.m.t. (06:22:15 MET). On each occasion, the duration was approximately 1 to 2 seconds. The radiation took place when the antenna was driving from the Tracking and Data Relay (TDRS) East satellite to the TDRS West satellite. To prevent future occurrences, the ground controllers turned the transmitter off when the TDRS was predicted to radiate within the protect box at TDRS AOS. The cause of these occurrences is being investigated.

The RMS MPMs were stowed for the final time at 148:01:50 G.m.t. (07:15:39 MET). As had occurred earlier in the mission, no indication was received from one of the two stow microswitches that indicate proper positioning of the aft MPM. The stow-microswitch was received during entry.

There is a known condition that the Multifunction Electronic Display System (MEDS) multifunction display unit (MDU) cathode ray tubes (CRTs) can announce an operational self-test (OST) power supply/lamp fail error message if the brightness control knob is adjusted too rapidly. This condition is documented in a user note that states that the error condition is transient and should clear in less than 10 seconds. On two occasions within a 12-hour period, MDU CRTs 1 and 2 announced error messages that were 34 and 71 seconds in duration, respectively. As a result, the crew performed comprehensive self-tests on both MDU CRTs. The results of these tests were nominal. Based on the reported cockpit conditions at the time of the occurrences, the luminance control bit failure was due to direct or indirect sunlight. This explanation will be confirmed postflight when the mass storage unit (MSU) logs are retrieved and analyzed.

The crew completed the ISS maintenance tasks and transfer operations and prepared the ISS for undocking. The Orbiter was successfully undocked from the ISS at 147:23:02:38 G.m.t. (07:12:51:28 MET). Separation from the ISS was initiated at 147:23:02:47 G.m.t. (07:12:51:37 MET) with a low Z-axis pulse of the Orbiter primary RCS. Undocking and separation from the ISS, the partial

flyaround of the ISS, and the final separation from the ISS were all performed nominally.

The flight control system (FCS) checkout was performed using auxiliary power unit (APU) 1, which was started at 149:00:17:05.946 G.m.t. (08:14:05:56 MET). The data showed that APU performance was nominal. The APU run time was 5 minutes 33 seconds, and 13 lb of fuel were consumed. Because of the short run-time of the APU, water spray boiler (WSB) 1 cooling was not required.

During the secondary actuator check portion of FCS checkout at 149:00:20:02 G.m.t (08:14:08:52 MET), the speedbrake channel 3 secondary differential pressure (ΔP) exhibited an approximate 1.95-second delay when the positive stimulus was applied. The pressure rose to approximately 1100 psid and remained at that level before reaching the 2800 to 2900 psid expected pressure. When the expected pressure was reached, the failure detection operated properly. The channel bypassed nominally during the negative stimulus portion of the test.

The RCS hot fire was performed. All thrusters were fired at least twice for at least 0.320 second and demonstrated nominal performance.

Late in the mission, a blurred or fuzzy image was noted whenever video is downlinked from camera A. The degraded image did not impact the mission.

An orbit-adjust maneuver was performed using the right OME at 149:09:22:10.3 G.m.t. (08:23:11:00.3 MET). The maneuver was 20.4 seconds in duration and imparted a ΔV of 16.9 ft/sec. The performance of the right OME was nominal.

During preparations for the landing minus 1-day communications checkout, the ground controllers could not command the frequency modulation (FM) system 1 into the payload analog mode. FM system 2 could, however, be commanded into the desired mode and will be used for entry. Postflight troubleshooting is required to determine the cause of this condition.

The payload bay doors were closed and latched for landing at 150:02:37:26 G.m.t. (09:16:26:17 MET). The deorbit maneuver for the first KSC landing opportunity was performed on orbit 155 150:05:12:10.2 G.m.t. (09:19:01:00.2 MET). The maneuver was 185 seconds in duration with a ΔV of 314 ft/sec.

Entry interface occurred at 150:05:48:27 G.m.t. (09:19:37:17 MET), and entry was completed satisfactorily. Main landing gear touchdown occurred on Shuttle Landing Facility (SLF) concrete runway 15 at 150:06:20:19 G.m.t. (09:20:09:09 MET) on May 29, 2000. The Orbiter drag chute was deployed at

150:06:20:22.1 G.m.t. (09:20:09:12.1 MET). Nose landing gear touchdown occurred at 150:06:20:30 G.m.t. (09:20:09:20 MET). The drag chute was jettisoned at 150:06:20:57.1 G.m.t. (09:20:09:47.1 MET). Wheels stop occurred at 150:06:21:17 G.m.t. The rollout was normal in all respects. The flight duration was 09 days 20 hours 09 minutes 09 seconds. The APUs were shut off 16 minutes 52 seconds after landing.

The Collins Tactical Air Navigation (TACAN) equipment in position 3 experienced two built-in test equipment (BITE) faults during landing with the first occurring at 150:05:51:10 G.m.t.(09:19:40:00 MET) (Flight Problem STS-101-V-05). The two BITE faults lasted for 3 seconds and 10 seconds, respectively. This BITE signature is the first occurrence for a Collins TACAN. Once the TACAN locked onto the ground station, the TACAN performance was nominal. Data retrieval has determined that the event occurred during the plasma period and what role this might have played in the event is being investigated. A decision was made to remove and replace that TACAN unit.

During the postflight thermal protection subsystem (TPS) inspection, a tile was discovered slumped with a 0.262-inch gap to the radial carbon-carbon (RCC) T-seal. The indications were found that flow did exist (Flight Problem STS-101-V-06). The lower leading edge structure system (LESS) panel 6 and upper LESS panels 6 and 7 were removed to gain access. The "butterfly" gap filler at the lower LESS panel 6/7 interface was not installed correctly. The aft portion that interfaces the LESS 7 panel, the T-Seal and RCC panel 7 was folded up and pushed away from the intended cavity it was made to fill. The misconfiguration created a substantial flow path. The only seal came from the horse-collar gap filler to the edge of the T-Seal. Inspections of the RCC, insulators and attaching hardware exhibit various signs of overheating. The insulator between RCC panel 7 and the T-Seal appeared to have had the outer Inconel cover breached on the lower corner (approximately 1/4-inch diameter). The RCC did not display any obvious signs of overheating (e.g. flaking or burnt areas), but further inspections are being conducted. The fittings revealed a large amount of outgassing deposits and evidence of some elevated temperatures and heating. The fittings did not exhibit any signs of melting or distortion. The RCC panels have been removed and more detailed inspections of this area of hardware are being performed. The Program Requirements Control Board (PRCB) made the resolution of this anomaly a constraint to the STS-106 mission.

PAYLOADS AND EXPERIMENTS

After the completion of a successful rendezvous, the Space Shuttle Atlantis (OV-104) docked with the International Space Station (ISS) at 142:04:44:09 G.m.t. (01:18:32:59 MET) at the pressurized mating adapter (PMA) 2 station. Following the successful docking and before entering the ISS, a 6-hour 44-minute extravehicular activity (EVA) was performed. During the EVA, the U. S. Orbital Replacement Unit (ORU) Transfer Device (OTD) was repositioned, the Russian Strela crane was transferred and assembled, and the Early Communications (ECOMM) antenna was removed and replaced. This mission was the second flight of the Spacehab Integrated Cargo Carrier (ICC), which consisted of an Unpressurized Cargo Pallet (UCP) mounted on a keel assembly that was used for mounting external transfer items and Development Test Objective (DTO) 700-21 hardware.

During the five days of docked operations, all preflight planned on-orbit task priorities were completed as well as 3,371 lb of hardware and supplies being transferred during EVA and intravehicular activity (IVA) operations. Also, seven additional on-orbit inspection tasks were requested and completed. In addition, three reboost maneuvers were successfully performed that raised the ISS orbit 26 nautical miles from 180 by 176 to 206.7 by 199.5 nmi.

ISS OPERATIONS

All of the mission objectives were successfully completed and the ISS portion of the mission is considered a total success. Significant improvements were made to the air quality system during this flight. All of the ISS maintenance activities were successfully accomplished. The Functional Cargo Block (FCB) module electrical power system was restored to full operation and all of the FCB limited-life items were replaced and that will now provide extended functionality of the systems.

All of the planned supplies and equipment were delivered to the ISS. The EVA tasks, which were successfully performed, included resealing hardware and delivering and installing additional hardware. The ISS DTO 700-21, Space Integrated Global Positioning System/Inertial Navigation System (SIGI) Operational Attitude Readiness (SOAR), was completed and provided valuable data for the future ISS attitude-determination system. In addition to all of the planned mission objectives, several additional objectives were completed for future flights and this will allow those flights to dedicate more time to completion of other IVA and EVA mission objectives.

A summary of the total weight of the transferred items shows 2657 lb of dry cargo during IVA operations plus 387 lb of water in four contingency water

containers (CWCs). Weight transferred during the EVA was 372 lb. The total weight of the ISS was increased by 1980 lb during the transfer operations.

SPACEHAB

Spacehab subsystems operated nominally during the entire mission. The versatility of the Spacehab stowage system proved to be invaluable for transition of cargo between the Orbiter and ISS.

The Self-Standing Drawer – Morphological Transition and Model Substances (SSD-MOMO) experiment was a Spacehab commercial experiment that investigated the solidification behavior of metals by using organic model systems which are transparent and solidify like metals. The experiment sent no telemetry to the ground. Science and housekeeping data were recorded in the facility for postflight processing. A total of eight samples and 27 of the 28 runs were completed successfully. The last run was terminated before completion because of the start of Spacehab entry preparation.

INTEGRATED CARGO CARRIER

The ICC was located in the payload bay and provided space for the exterior cargo to the ISS could be carried. The ICC is an unpressurized flatbed pallet and keel yoke assembly, which carried three cargoes on this flight. These were parts of the Russian Strela crane, the SOAR payload and the SPACEHAB-Oceanering Space System (SHOSS) box, which carried EVA tools and flight equipment. No anomalies were noted with the ICC.

SIGI OPERATIONAL ATTITUDE READINESS PAYLOAD

Performance of the SOAR payload was evaluated throughout this mission and the test objectives were completed successfully. A more complete discussion of this Development Test Objective is found in that section of this report.

CARGO BAY PAYLOADS

Mission to America's Remarkable Schools

The Mission to America's Remarkable Schools (MARS) contained 20 experiments from schools across the United States. The MARS experiments required no power or crew intervention during the mission. These 20 experiments were returned to the respective schools for assessment. The results were not known at the time this report was published.

Space Experiment Module 6

The Space Experiment Module 6 (SEM 6) contained 10 passive experiments sponsored by students in various levels of education in the United States and Argentina. The experiments were mounted in a standard Get Away Special (GAS) canister in the payload bay. The experiments were returned to the sponsoring schools for assessment. The results were not known at the time this report was published.

MIDDECK PAYLOADS

Astroculture

The Astroculture (AST) successfully completed all required flight objectives. AST initialization occurred at 140:07:01 G.m.t. (01:20:50 MET). Prior to initialization, the soybeans had developed 1-inch roots, and this condition was expected and indicated good plant health. AST fluid transfer began at 143:04:56 G.m.t. (02:18:45 MET). The soybeans had generated an excess of gas and not all of it could be extracted back into bag 2. This condition presented only an inconvenience and the remaining tasks for this procedure were completed as planned. AST closeout was started at 143:05:26 G.m.t. (02:19:15 MET) and was completed with no problems. Approximately 90 percent of the water was purged from the soybean bag and this was comparable to the amount removed during ground tests. The AST met all preflight expectations and between 90 and 100 percent of the science return was received.

BioTube Precursor Experiment

The crew reported that the seeds had germinated on flight day 8. The seeds were watered again on flight day 9, and this completed all of the planned operations for this payload.

Commercial Protein Crystal Growth Experiment

The Commercial Protein Crystal Growth (CPCG) experiment was successfully activated at 140:14:28 G.m.t. (00:04:17 MET) with nominal mission operations. The thermal carrier maintained experiment temperature control to 0.1 °C during the duration of the flight and throughout the temperature ramp from 4 °C to 22 °C. All mission objectives were accomplished and all planned activities were performed.

Results from this experiment are expected to provide important scientific information into Human alpha interferon-2b, a protein pharmaceutical that is currently used against several indications including human viral hepatitis B and C, melanoma, hairy cell leukemia, multiple myeloma and AIDS-related Kaposi's

sarcoma. The mission objective was to crystallize alpha interferon samples of sufficient size and in sufficient quantity under a range of conditions to assess impurity concentrations and distribution as compared to ground-based experiments. These assessments will be made by mass spectral and high-performance liquid-chromatography methods.

**Protein Crystal Growth Biotechnology Ambient
Generic Payload**

The 504 individual experiments, which were stored in eight containers, were activated at 141:29:35 G.m.t. (01:19:25 MET). This payload required no crew support for the remainder of the mission, except to deactivate the experiments. This deactivation took place at 149:07:28 G.m.t. (08:21:17 MET). All planned activities were completed and no anomalies were noted.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) subsystems performed satisfactorily during the prelaunch testing and countdown as well as during the first stage of ascent. Analysis of the flight data confirmed this nominal performance. No SRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specification Document (OMRSD) violations or in-flight anomalies occurred. One problem was noted during recovery operations when 1 of the 48 sea water activated release (SWAR) links failed to release its parachute riser upon contact with the sea water. The postflight inspection showed that the SWAR had activated but not released the risers. The investigation is continuing to determine the cause of this problem.

The heated, ground-supplied, aft skirt purges maintained the case/nozzle joint and flexible bearing temperatures within the required LCC ranges.

Evaluation of the thrust vector controller (TVC) data showed that the TVC responded as expected to the Space Shuttle main engine (SSME) trim modifications made as a part of the Shuttle Performance Enhancements. This was the eleventh flight for these SSME trim changes that decrease the angle between the SSME and the SRB thrust vectors during first stage. The SRB thrust vectors were then trimmed to maintain moment balance. This trimming of the SRB thrust vectors resulted in the TVC actuator positions being outside of their experience base during certain specific time frames. The overall actuator position experience base was not exceeded; however, certain areas of the time specific (second by second) experience base were expanded.

Both SRBs were successfully separated from the vehicle at 123.756 seconds after liftoff. The SRBs floated as planned and were recovered and towed to Port Canaveral. The SRBs were taken to Kennedy Space Center (KSC) for inspection, disassembly and refurbishment. The overall condition of the SRBs, as observed during the postflight inspection, was excellent. No significant damage or anomalous conditions were noted during the SRB open inspection.

REUSABLE SOLID ROCKET MOTORS

The Reusable Solid Rocket Motors (RSRMs) performed satisfactorily with no in-flight anomalies noted in the data. Also, no LCC or OMRSD violations occurred during the countdown.

The power-up and operation of all igniter and field-joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown.

Data indicate that the flight performance of both RSRMs was within the contract end item limits and was typical of the performance observed on previous flights. The propellant-mean bulk temperature (PMBT) was 73 °F. The maximum trace shape variation of pressure versus time during the 62 to 80 second time frame was calculated to be -0.848 percent at 95.5 seconds for the left motor and 0.985 percent at 96.5 seconds for the right motor. Both of these values were well within the 3.2 percent allowable limits. The delivered RSRM burn rates were 0.3724 and 0.3723 inch/second for the left and right motors, respectively. The propulsion system performance is shown in the following table.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 73 °F		Right motor, 73 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	64.87	65.49	64.96	65.49
I-60, 10 ⁶ lbf-sec	173.96	174.71	174.16	175.23
I-AT, 10 ⁶ lbf-sec	297.25	296.63	297.19	297.49
Vacuum Isp, lbf-sec/lbm	268.6	268.0	268.6	268.8
Burn rate, in/sec @ 60 °F at 625 psia	0.3662	0.3682	0.3666	0.3679
Event times, seconds ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	110.1	109.4	109.9	109.2
50 psia cue time	120.2	119.0	120.0	119.2
Action time ^b	122.5	121.2	122.3	121.2
Separation command	124.7	124.0	124.7	124.0
PMBT, °F	73	73	73	73
Maximum ignition rise rate, psia/10 ms	90.8	N/A	90.8	N/A
Decay time, seconds (59.4 psia to 85 K)	3.1	3.1	3.1	2.8
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		241.3	

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

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

^bReferenced to liftoff time (ignition interval).

The field-joint heaters operated for 13 hours 12 minutes during the final launch countdown and exhibited nominal operation. Power was applied to the heating elements an average of 34 percent of the time during the LCC time frame. The field-joint heaters operated for a total of 56 hours 47 minutes during all countdowns.

The igniter-joint heaters operated for 13 hours 3 minutes during the final launch countdown. Power was applied to the heating elements 49 percent of the time to maintain the igniter joints within the normal operating range. The igniter heaters operated 56 hours 13 minutes during all of the countdowns.

The aft skirt purge was operated for 5 hours 27 minutes prior to launch. The aft skirt purge was activated nine times prior to and during the four countdowns for a total of 43 hours 6 minutes. The operation was necessary to maintain the nozzle/case joint temperatures above the minimum LCC temperature.

The postflight evaluation of the RSRM hardware indicated that the hardware was in good condition and that no erosion was noted in either nozzle.

EXTERNAL TANK

All External Tank (ET) objectives and requirements associated with propellant loading and flight operations were satisfactorily met and no in-flight anomalies were noted. No significant oxygen or hydrogen leakage concentrations were detected in the intertank.

All ET electrical equipment and instrumentation operated satisfactorily except the liquid oxygen 100-percent-level 1 sensor and that is discussed in a later paragraph. Replenish level control was transferred to the no. 2 sensor without incident. Purge and heater operations were monitored and their performance was nominal. No LCC or OMRSD violations were detected during the countdown.

During stable replenish operations for the April 26th launch attempt, the ET LO₂ 100-percent liquid-level sensor 1 failed wet and control was switched to 100-percent liquid-level sensor 2. Loss of the single liquid-level sensor had no effect on loading operations. The 100-percent sensor has no criticality during ascent. Failure of the second 100-percent sensor would have necessitated the use of the 100-plus-percent liquid level sensor for control. No corrective action was performed between the launch attempts, and no further failures occurred.

All ice conditions were acceptable. Likewise, the thermal protection subsystem (TPS) cracks were acceptable. The crack growth and additions for the three propellant loadings as well as the final launch loading were acceptable.

The pressurization systems functioned properly throughout engine start and the flight. The minimum LO₂ ullage pressure experienced during the ullage pressure slump was 13.6 psid.

ET separation was confirmed at the expected time followed by entry and breakup, which occurred within the predicted footprint. The postflight predicted impact point was approximately 46 miles from the STS-101 preflight prediction.

SHUTTLE RANGE SAFETY SYSTEM

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

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle main engine (SSME) parameters were normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time; all LCC were met; and the engine start and thrust buildup parameters were normal. No in-flight anomalies were identified during the data analysis.

Data indicate that the flight derived specific impulse (I_{sp}) was 0.9 second higher than predicted. The Block IIA engines have delivered approximately 0.8 second higher flight I_{sp} than predicted during ground testing.

Main engine cutoff (MECO) occurred 504.8 seconds after SRB ignition, and this was 1.3 seconds later than predicted. The commanded maximum dynamic pressure throttle-down was in two steps (96 and 72 percent), and a single throttle step to 72 percent was predicted.

ORBITER SUBSYSTEMS PERFORMANCE

Main Propulsion Subsystem

No main propulsion subsystem (MPS) LCC or OMRSD violations were detected during the countdown.

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 back-pressure used for fastfill, was 160 ppm. This compares favorably with previous data for this vehicle.

During the loading for the second launch scrub, the Orbiter liquid oxygen inlet temperature transducer failed off-scale high at the start of the Orbiter chill-down. A decision was made to only recommend a scrub if the other inlet pressure transducer was also lost, however, this would only be done in the event of a subsequent stop flow. Flow initiation without knowing the liquid oxygen temperature at the Orbiter inlet would be a hazardous operation. This same measurement also failed during the third launch scrub and the sensor was replaced prior to the final loading for launch.

During the stable replenish operations for third launch scrub, the no. 1 liquid oxygen 100-percent level sensor measurement went full-scale, diverging from the no. 2 sensor. The sensor was bypassed and control was transferred to the no. 2 sensor. Loss of the single liquid-level sensor had no effect on the loading, drain or ascent operations. A decision was made that this condition would not impact the launch as a workaround procedure was established. The 100-percent sensor is used for loading control only and has no criticality during ascent.

All events and sequences were performed satisfactorily, and the overall prelaunch performance was nominal. Data indicate that the LO₂ and liquid hydrogen (LH₂) pressurization systems performed as planned, and that engine-inlet net-positive-suction pressure requirements were met throughout the flight. The liquid oxygen residuals were approximately 6400 lbm. The gaseous oxygen (GO₂) fixed-orifice pressurization system performed as predicted. Reconstructed data from the engine and MPS parameters closely matched the actual ET ullage pressure measurements. All flow control valves operated nominally.

The helium system performance for the SSME and pneumatic Helium systems was slightly above nominal. Entry Helium usage was 60.5 lbm, which failed the File IX requirements. The data will be evaluated in light of the OMRSD requirement and the File IX will be updated based on the latest data.

Reaction Control Subsystem

The reaction control subsystem (RCS) performed satisfactorily throughout the mission. No LCC or OMRSD violations were noted prior to launch, and no failures or problems were noted during the countdown. No in-flight anomalies were noted during the data review and analysis. The following table lists pertinent data concerning all RCS maneuvers.

A total of 5264.8 lbm propellants (3226.6 - oxidizer, 2038.2 - fuel) were used from the RCS during the rendezvous mission with the International Space

Station. In addition, 5323 lbm of the orbital maneuvering subsystem (OMS) propellants were used by the RCS during interconnect operations..

RENDEZVOUS, SEPARATION, AND ORBIT ADJUST MANEUVERS

Maneuver ^a	Time, G.m.t./MET	System	ΔV , ft/sec	Duration, sec
NC-1	140:13:11:11.06 00:03:00:01.06	RCS +X Primary	5.0	19.8
NC-4	142:00:08:51 01:13:57:41	RCS +X Primary	3.9	4.0
NCC	142:00:41:49 01:14:30:39	RCS Primary	1.9	10.0
MC-1	142:01:59:32 01:15:48:21	RCS Primary	1.9	3.0
MC-2	142:02:36:25 01:16:25:15	RCS Primary	1.6	7.0
MC-3	142:02:53:25 01:16:42:15	RCS Primary	1.6	3.0
MC-4	142:03:03:40 01:16:52:30	RCS Vernier	1.6	5.0
Reboost 1	145:00:02:11 04:13:51:01	RCS Primary	29.06	3631
Reboost 2	146:01:15:51 05:15:04:41	RCS Primary	29.0	3490
Reboost 3	146:23:32:38 06:13:21:28	RCS Primary	28.2	3375
ISS Separation	147:23:02:47 07:12:51:37	RCS Primary	N/A	N/A

The three reboost maneuvers were performed satisfactorily. The first reboost maneuver, which used propellants from the left OMS, consisted of 27 +X pulses of 5.52 seconds each and the aft-firing vernier thrusters pulsed with an average duty cycle of 85 seconds on and 45 seconds off. The second reboost maneuver was performed using the same thrusters and firing times, but propellants were from the right OMS. The third reboost maneuver, which used propellants from the left OMS, consisted of 26 +X pulses of 5.52 seconds each and the aft-firing vernier thrusters pulsed with an average duty cycle of 88 seconds on and 42 seconds off. The orbital altitude following the third maneuver was 206.7 by 199.5 nmi.

Orbital Maneuvering Subsystem

The OMS performed satisfactorily throughout the mission. STS-101 was the first flight of the left OMS engine since being rebuilt at White Sands Test Facility

(WSTF). The engine was not fired as a complete assembly prior to installation in the left OMS pod. Two in-flight anomalies occurred with this engine and these are discussed in the following paragraphs. Pertinent data concerning the OMS maneuvers is shown in the following table.

OMS MANEUVERS

Maneuver	Time, G.m.t./MET	Engine	ΔV , ft/sec	Duration, sec
OMS Assist	140:10:13:23.9 00:00:02:13.9	Both	N/A	59.0
OMS 1	Not required	-	-	-
OMS 2	140:10:54:14.2 00:00:43:04.2	Both	81.1	53.0
OMS 3	141:01:48:22.4 00:15:37:12.4	Both	95.2	62.4
OMS 4	141:10:51:38.7 01:00:40:28.7	Right	65.4	83.6
OMS 5	142:01:39:32.1 01:15:28:22.1	Right	8.8	10.4
OMS-6 (orbit adjust)	149:09:22:10.3 08:23:11:00.3	Right	16.9	20.4
Deorbit	150:05:12:10.2 09:19:01:00.2	Both	314.0	185.0

During the OMS assist maneuver start transient and post-firing purge as well as the OMS 2 post-firing purge, the left OMS engine gaseous nitrogen (GN₂) regulator pressure indicated 296, 295 and 297 psia, respectively. All of these values are below the fault detection annunciator (FDA) limit of 299 psia (Flight Problem STS-101-V-02). As a result, FDA alarms were generated. Upon completion of the start transients and purges, the regulated pressure quickly returned to a nominal value of 312 psia. This condition did not impact the mission operations.

During postflight safing operations at KSC, the OMS engine GN₂ vent was performed, and regulator performance was nominal with the pressure indicating 316 psia with a bit toggle to 315 psia. However, because of in-flight concerns, the decision was made to remove and replace the regulator prior to the next flight. The regulator was replaced without removing the engine.

Following the NC2 rendezvous maneuver at 141:01:49:24 G.m.t. (00:15:38:14 MET), the left OMS engine bipropellant valve 2 continued to indicate open (Flight Problem STS-101-V-01). The valve position remained at 98.4 percent and should have been 0 ± 5 percent. The first two firings were

nominal with 98.7-percent open, 0.6-second opening period, and 0.4-second closing period for the OMS assist maneuver, and 98.9-percent open, 0.4-second opening period and 0.4-second closing period for the OMS 2 maneuver. STS-101 was the first flight of this engine since it was rebuilt at WSTF in 1997. In accordance with the flight rules, the engine was not used until the deorbit maneuver, where it performed nominally. The bipropellant-valve 2 open indication remained open throughout the firing and continued to indicate open after engine shutdown. Chamber pressure, injector temperatures and inlet pressures indicated nominal engine performance throughout the firing and bipropellant valve 1 closed nominally.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was nominal during the STS-101 mission. The oxygen/hydrogen (O₂ and H₂) manifold isolation valves were cycled for the crew sleep periods, and this satisfied the OMRSD File IX in-flight checkout requirements.

A total of 2583 lbm of oxygen and 325 lbm of hydrogen was furnished to the fuel cells for power generation and potable water production. In addition, the PRSD supplied 150 lbm of oxygen to the environmental control and life support system (ECLSS) for pressurization and crew breathing. A 79-hour mission extension was possible at the average power level of 15.9 kW with the reactants remaining at landing. At extension-day power levels of 12.9 kW, a 97-hour mission extension was available.

During the flight day 2 post-sleep cryogenic systems reconfiguration, the oxygen tank 4 A and B heaters were placed in automatic operation. Following the first heater cycle at 141:00:02 G.m.t. (00:13:51 MET), which was nominal, the A heater did not come on during subsequent cycles (Flight Problem STS-101-V-04). The heater switch was cycled to the off position and then back to automatic about 3 hours later and both heaters cycled. The heaters performed nominally for the remainder of the mission with several switch operations and the heaters were used to deplete two tanks (4 and 5) later in the mission. Postflight troubleshooting has been performed and the data are being evaluated.

The PRSD tanks were loaded twice because of the three initial launch attempts and the 24-day delay in the launch. The total mass of hydrogen and oxygen in the PRSD subsystem at launch was 458.3 lbm and 3921 lbm, respectively.

The hydrogen manifold 1 valve panel was replaced during the Orbiter Maintenance Down Period (OMDP) because of false-closed indications from the fuel cell 1 hydrogen reactant valve. The panel performed nominally during its first flight since the Orbiter Maintenance Down Period (OMDP).

Fuel Cell Powerplant Subsystem

The overall performance of the fuel cell powerplant (FCP) subsystem was nominal during the STS-101 mission, and there were no in-flight anomalies noted in the data. The average electrical power level and load was 15.9 kW and 519 amperes. The fuel cells produced 2908 lbm of potable water and 3765 kWh of electrical energy while using 2583 lbm of oxygen and 325 lbm of hydrogen. Four purges of the fuel cells were performed during the mission. The actual fuel cell voltages at the end of the mission were 0.15 V above predicted for fuel cell 1, as predicted for fuel cell 2, and 0.30 V above predicted for fuel cell 3. The voltage margin above the minimum performance curve at the end of the mission was 1.2 V for fuel cell 1, and 1.1 V for fuel cells 2 and 3.

The overall thermal performance of the fuel cell water relief, water line, and reactant purge heater systems was nominal. The heaters were reconfigured to the B system during the flight. All of the water system heaters cycled to satisfy the in-flight checkout requirements, except for fuel cell 1 water relief valve B heater. The fuel cell reactant purge system operated nominally in both the automatic and manual modes.

The fuel cell monitoring system (FCMS) monitored individual cell voltages during prelaunch, on-orbit, and postlanding operations. The fuel cell cell-performance-monitor (CPM) did not stabilize until on-orbit operations began. Once stabilization was achieved, all of the CPM values remained steady.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performance was nominal throughout the mission. No in-flight anomalies were identified from the data review and analysis. The run-times and fuel-consumption for the APUs are shown in the following table.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 310)		APU 2 (S/N 204)		APU 3 (S/N 404)	
	(a) (b) Time, min:sec	Fuel consumption, lb	(a) Time, min:sec	Fuel consumption, lb	(a) Time, min:sec	Fuel consumption, lb
Ascent	18:59	44	19:16	51	19:35	51
FCS checkout	5:35	13				
Entry ^a	61:14	105	89:52	167	61:39	120
Total	85:48	162	109:08	218	81:14	171

^a APUs were shut down 16 minutes 45 seconds after landing.

The flight control system (FCS) checkout was performed using APU 1, which was started at 149:00:17:05.941 G.m.t. (08:14:05:56 MET). The data showed that APU performance was nominal. The APU run time was 5 minutes 33 seconds, and 13 lb of fuel were consumed. Because of the short run-time of the APU, water spray boiler (WSB) 1 cooling was not required.

Hydraulics/Water Spray Boiler Subsystem

The overall hydraulics and WSB system performance was nominal during the mission. STS-101 was the first of eight flights in which Propylene Glycol Monomethyl Ether (PGME) will be used along with water as the core preload for the system 3 water spray boiler (WSB). Cooling was achieved 2.5 and 3 minutes sooner than WSB 1 and 2, respectively. This permitted the APU lubrication oil temperature to reach the active cooling limit of 250 °F sooner and thereby preventing water-spray-bar freeze-ups. This new additive performed as designed and no problems or anomalies of WSB 3 were noted.

All three WSB systems displayed nominal steam-vent heater cycling during the prelaunch activities. The gaseous nitrogen (GN₂) isolation valves were opened for the launch 90-minutes before liftoff. A "WSB Ready" indication was present from that time through liftoff. Circulation pump performance was nominal during the prelaunch time period.

During ascent, no over-cooling or under-cooling operations of the WSBs were noted, and the priority valve openings at APU activation were all within the one-second-specification limit. However, the system 2 valve did not reseal at APU shutdown within the pressure limit. The post-shutdown lockup pressure was 26 psia below the specification limit of 2675 psia. This was the first flight of the bellows accumulators and all three system lockup pressures were 40 to 70 psia lower than observed on previous flights where the piston accumulator was being flown. Additional flights are required on the bellows accumulator before any conclusions can be drawn regarding the priority valve operations. This condition did not impact operations of system 2 or the APUs during the mission.

A total of 75 circulation-pump runs were noted during the mission. A majority of these runs were for thermal conditioning of the rudder speed brake (RSB) power drive unit (PDU) and to a lesser extent, the elevon actuators. The system B heaters have lower set points for the rudder speedbrake. The system B heaters caused circulation pump runs of two to three minutes, whereas, the system A heaters with higher set points caused significantly longer runs. Using the system B heaters, the power savings during the docked phase was approximately 172 watts compared to 40 watts for STS-96.

During the FCS secondary actuator check portion of the checkout, speedbrake channel 3 secondary ΔP exhibited a 1.95-second delay when the positive stimulus was applied. The pressure rose to approximately 1100 psid and remained at that level before reaching the 2800 to 2900 psid expected pressure. The channel typically bypasses in less than 0.2 second. The channel bypassed nominally during the negative stimulus portion of the test. This condition did not impact the mission.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed nominally during all phases of the mission. The data review and analysis of all available EPDC parameters showed no abnormal conditions.

At 142:07:28 G.m.t. (01:21:17 MET), Assembly Power Converter Unit (APCU) 1 and 2 were activated. Initially, the A and B converters in APCU 1 performed nominally when the ISS cabin fan was powered on. After 1 hour and 15 minutes of nominal operation when the intermodule ventilation (IMV) fan was powered on, converter B showed erratic behavior and was no longer equally sharing the load with APCU 1 converter A and APCU 2 converters A and B. The unit continued to display erratic operation and approximately 3 hours after the initial activation, APCU 1 was deactivated in accordance with the nominal timeline. Prior to undocking from the ISS on flight day 9, a test of APCU 1 was performed with APCU 2 off. APCU 1 operated properly with equal load sharing.

Ground laboratory tests duplicated the on-orbit load sharing condition (unbalanced load sharing between converters when APCUs were operated at low loads in a load sharing mode). The results of these tests indicate that the phenomenon is caused by the design of the hardware as opposed to a failure in the Orbiter unit. Tests of modifications to the APCUs were successful and no changeout of the APCUs is required.

Orbiter Docking System

The Orbiter Docking System (ODS) performed satisfactorily throughout the mission, with no in-flight anomalies noted.

The ODS valves were used during the docked operation and the extravehicular activity (EVA). After docking, the vestibule/pressurized mating adapter (PMA) 2 pressurization and leak check was satisfactorily performed. One equalization valve was configured to normal to pressurize the vestibule/PMA 2. The crew cycled the valve 10 times, 8 seconds on and 30 seconds off to prevent the vestibule-to-PMA 2 hatch from burping. The valve was left open after the tenth cycle to let the Orbiter, vestibule and PMA 2 pressure equalize.

The vestibule depressurization valves were used to depressurize the vestibule and PMA 2 to a vacuum prior to undocking.

The external airlock water lines heaters were configured to the system B heaters before the EVA and system C was turned on in addition to the system B heaters to prevent hot and cold conditions in the water lines.

The active system monitor parameters indicated normal outputs throughout the duration of the flight.

Atmospheric Revitalization Pressure Control Subsystem

The atmospheric revitalization pressure control subsystem (ARPCS) performed nominally throughout the mission. The crew compartment was depressurized to 13.7 psia before PMA 2 and vestibule pressurization. This was done to prevent the equalized pressure from exceeding the Node 1 pressure and possibly damaging the PMA 2 and Node 1 hatch. After the PMA 2 and vestibule were pressurized, the top airlock hatch was closed and the cabin was depressurized to 10.2 psia in preparation for the planned EVA, and the airlock and tunnel adapter were depressurized the next day for the EVA.

The cabin was repressurized to 14.7 psia during the EVA; however, during the repressurization, the system 2 N₂/O₂ flow controller switched from O₂ to N₂ flow, but the nitrogen flow sensor failed to indicate flow while in the automatic mode. NC₂ flow was confirmed through alternate instrumentation. This was the first use of system 2 during this mission. System 1 was performing the cabin repressurization while system 2 was controlling the oxygen concentration. The overhead-flow-meter was checked and it indicated no flow, which confirmed that the flow sensor had failed. KSC performed minimal testing that verified power to the sensor.

Before undocking, the ISS stack and Orbiter were pressurized to 14.9 psia using the Orbiter's oxygen. The final pressures at undocking were 14.9 psia for the Functional Cargo Block (FGB), 12.7 psia for the structure between the FGB and Node 1 as well as PMA 1, Node 1 at 14.2 psia and PMA 2 at vacuum.

Atmospheric Revitalization Subsystem

The atmospheric revitalization subsystem (ARS) performed satisfactorily throughout the mission. One LCC violation was noted during the prelaunch operations, and it is discussed in the following paragraph.

The avionics-bay cooling-fan ΔP exceeded the upper limit, and the upper limit for the fan ΔP was removed. This resulted from prior missions experiencing fan ΔP s exceeding 3.2 inches of water. In addition, this vehicle (OV-104) also received

new avionics fans and preflight data indicated that the ΔP s would exceed the upper limit. As a result, the decision was made to fly with only a lower limit in place, thereby verifying fan operation. However, the bay 3A fan ΔP held steady near the upper limit throughout the mission.

The Orbiter ARS was modified to improve the ISS air for breathing. Previous crews had noted that the air in the ISS appeared to be stagnant. The environmental control engineering personnel believed a contributing factor may have been the location of the air supply venturi. As a result, the modification was the 106-inch air duct that enabled the repositioning of the Orbiter air provided to the ISS. This change improved the ventilation and circulation within the ISS.

Active Thermal Control Subsystem

The active thermal control subsystem (ATCS) operation was nominal throughout the mission.

Ascent performance was nominal. The pre-evaporative cooling was observed about 2 minutes into the ascent phase with the flash evaporator system (FES) outlet temperature dropping by approximately 20 °F from 83 °F to 63 °F. The FES was configured to the primary B controller so that the feed-water sources was supply tanks C and D. Tanks A and B were then ganged together to support the filling of contingency water containers (CWCs) for transfer to the ISS. The radiators were not deployed during the flight. Both Freon coolant loop (FCL) flow proportioning valves (FPVs) remained in the interchanger position for the entire on-orbit phase of the mission. The Spacehab did not require the FPV to be placed in the payload position.

Seven water dumps were performed through the FES to dump excess fuel cell water. The sixth water dump was ended early to prevent further drops in radiator panel outlet temperatures. The cold radiator temperatures occurred because the top of the Orbiter was pointing to space at that time. The coldest temperature was observed at the Freon coolant loop radiator panel outlet when it bottomed at -89 °F.

The radiator coldsoak provided satisfactory cooling during entry. Four minutes after landing, the radiators were configured to the high set point and the ammonia boiler system (ABS) was activated. The ABS provided satisfactory cooling until ground cooling was activated.

Supply and Waste Water Subsystem

The supply and waste water subsystem performed nominally throughout the mission. By the completion of the mission, all of the scheduled in-flight checkout requirements were satisfied.

Supply water tanks A and B were ganged together to provide potable water for transfer to the ISS in CWCs. The total water transferred was in four CWCs and the weight was 387 lbm.

Two simultaneous supply and waste water dumps were performed during the mission. The first occurred on flight day 4 and the second on flight day 8. Two additional waste water dumps were made during the mission. All supply and waste water dump rates were nominal.

Waste Collection Subsystem

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

Airlock Support System

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

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 Subsystem/Multifunction Electronic Display System

The flight data subsystem performed satisfactorily throughout the mission. STS-101 was the first flight of the Multifunction Electronic Display System (MEDS). The MEDS performed satisfactorily.

Early in the flight when the MEDS cathode ray tube (CRT) 2 was powered on, the crew reported that the multifunction display unit (MDU) CRT came up blank. The MDU was power cycled several times, using both switches that are available. The crew stated that there was a wait of at least 10 seconds between each power cycle, and the display finally came up on the third time. A User Note explains this type of response.

The modification of the MDU described in the User Note has been approved and incorporated in other units in the fleet; however, the OV-104 units were delivered early and have not had the modification. On MDU's already delivered, the modification will be implemented on an attrition basis, wherein the MDU will be upgraded when it is sent back to the vendor for another reason that requires the unit be removed from the vehicle. The MDU will not be removed for the blank screen anomaly.

Three operational self-test (OST) power supply/lamp failure error messages were observed on the ground. A known condition that the MEDS MDU CRTs can annunciate an OST power-supply/lamp-fail error message exists if the brightness control knob is adjusted too rapidly. The first message occurred on CRT 2 and the indication cleared in 71 seconds. The vehicle was entering a night pass and the crew reported that a manual brightness control adjustment had been made. The second message occurred on CRT 1 and the indication lasted for 34 seconds. The vehicle was entering a day pass and no manual brightness control adjustment was reported. Both event 1 and 2 exceeded the transient time limit documented in the User Note. The third message also occurred on CRT 1 and the indication cleared after 4 seconds. The crew reported a manual brightness control adjustment was associated with the third event. The duration of the MEDS error in this case was within the 10-second limit documented in the User Note. This condition will be corrected in the next version of the software (4.0).

As a result, the crew performed comprehensive self-tests on both MDU CRTs. The results of these tests were nominal with no repeats of the manual brightness-control adjustment problem. Based on the reported cockpit conditions at the time of the occurrences, the luminance control bit failure was due to direct or indirect sunlight. This explanation will be confirmed postflight when the mass storage unit (MSU) logs are retrieved and analyzed.

The descent navigation hardware performed satisfactorily. All external sensor data were incorporated into the onboard navigation state vector at their expected regions of operations. All external sensor measurement residuals and residual ratio values were nominal with no navigation editing observed.

Overall, the miniature air-to-ground receiver (MAGR) global positioning system (GPS) performed well throughout the mission. The receiver did have some minor problems acquiring GPS satellites during the high-altitude portion of the entry where it had a period of greater than 5 minutes with only two or less satellites tracked. Because of the design of the receiver, the solution under these conditions converged to the aiding state vector approximately 3 minutes into the period. Once the receiver regained four-satellite tracking at 235,000 ft, the MAGR performance returned to normal.

The inertial measurement units (IMUs) performed satisfactorily throughout the mission. Drift performance was nominal. All three units were less than the specification limit of 0.0009 deg/hour/day. Compensation of the IMU values was required only once during the mission.

STS-101 was the first flight of the -Y solid-state star tracker. The postflight analysis showed that the performance of the -Y as well as the -Z star tracker was nominal.

Flight Software

The flight software performed satisfactorily throughout the mission. No problems or in-flight anomalies were noted. The navigation and control software performed as planned during the rendezvous and docking portion of the mission. The undocking and separation software also performed satisfactorily. Entry was also performed satisfactorily by the software.

Flight Control Subsystem

The FCS performed satisfactorily throughout the mission. The FCS checkout was performed using auxiliary power unit (APU) 1, which was started at 149:00:17:06 G.m.t. (08:14:05:56 MET).

During the secondary actuator check portion of FCS checkout at 149:00:20:02 G.m.t (08:14:08:52 MET), the speedbrake channel 3 secondary differential pressure (ΔP) exhibited a delay of approximately 1.95 seconds when the positive stimulus was applied. The pressure rose to approximately 1300 psid and then maintained a pressure between 1100 and 1200 psid before reaching the 2800 to 2900 psid expected pressure after the delay. When the expected pressure was reached, the failure detection operated properly and the channel was bypassed. A channel typically bypasses in less than 0.2 second. The channel bypassed nominally during the negative stimulus portion of the test. There was no impact to the mission as a result of this condition.

This condition was seen on a previous flight of this rudder speedbrake power drive unit (PDU) when it was installed on OV-102. That occurrence was on STS-87, and the delay was approximately 1.43 seconds. KSC did extensive speedbrake individual channel checks as well as a desilting procedure and was unable to repeat the signature. The condition did not repeat on the following two flights (STS-90 and STS-93). This PDU was installed on the OV-104 vehicle prior to this flight. KSC performed a desilting procedure on this valve during the postflight operations, and the initial review of the data indicates nominal operation.

Displays and Controls Subsystem

The overall performance of the displays and controls subsystem was satisfactory. One minor problem was noted and it did not impact the mission. The problem is discussed in the following paragraph.

The crew reported that during ascent, the panel F9 meter that is used to indicate dc amperes and signal strength was fluctuating. The meter was in the signal strength position during ascent. The readings appeared accurate on-orbit but fluctuated for about one minute before stabilizing when the selector switch was moved. The crew was requested to perform troubleshooting of the problem just prior to performing the communications string 1 checkout. The crew was asked to check the status of the F9 meter and A12U meter for S-band signal strength while in string 1 and string 2. Video was taken of the meter to document the problem. KSC will perform troubleshooting to isolate the cause of this problem.

Communications and Tracking Subsystem

The communications and tracking subsystem performed nominally throughout the mission. One significant problem, which is discussed in the following paragraphs, was identified and resolved during the mission.

While the Orbiter was docked to the ISS, on two occasions the Ku-band traveling wave tube (TWT) radiated into the radio frequency (RF) protect box (Flight Problem STS-101-V-03). On each occasion, the duration of the radiation was approximately 1 to 2 seconds. The radiation occurred when the antenna was moving from the Tracking and Data Relay Satellite (TDRS) East to the TDRS West satellite. To prevent future occurrences, the ground turned off the transmitter if the pointing angle to the TDRS at acquisition of signal (AOS) was within the protect box.

The Ku-band system cannot physically point the boresight of the antenna at any of the pyrotechnic devices inside the ODS docking ring nor the shielded cabling running up the side of the ODS. The energy that is radiated at the ODS will normally be lower than the energy radiated on axis.

The antenna management software program was modified from its original design in that when the TDRS East satellite went out of view, the Ku-band system would then point to the point where the other satellite, TDRS West would be when it came into view. The software change now keeps the antenna pointing at the TDRS East satellite until the TDRS West satellite comes into view. The Ku-band system then drives to the TDRS West angles and the software must see in the telemetry that the antenna is pointing into the RF protect box and then send a command to inhibit the TWT from radiating. In the original software, the antenna would be pointing at TDRS West and as soon as

the antenna pointed into the protect box, the software would issue an inhibit command to the TWT to prevent the system from radiating. Consequently, there was no chance of radiating in the protect-box for 1 or 2 seconds.

During preparations for the landing minus one-day communications checkout, the ground controllers could not command the frequency modulation (FM) system 1 into the payload analog mode. FM system 2 could be commanded into that mode and it was used for entry operations. KSC has performed troubleshooting and have not been able to reproduce that problem. Additional troubleshooting is planned in an attempt to isolate the cause of this problem.

The Collins Tactical Air Navigation (TACAN) equipment in position 3 experienced two built-in test equipment (BITE) faults during landing with the first occurring at 150:05:51:10 G.m.t.(09:19:40:00 MET). The two BITE faults lasted for 3 seconds and 10 seconds, respectively. This BITE signature is the first occurrence for a Collins TACAN. Once the TACAN locked onto the ground station, the TACAN performance was nominal. Data retrieval has determined that the event occurred during the plasma period and what role this might have played in the event is being investigated. A decision was made to remove and replace that TACAN unit. The hardware was removed and returned to the vendor where troubleshooting will be performed. One Collins TACAN spare is available. OV-104 must fly all Collins TACANs because of the cooling modification made during the OMDP.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation and modular auxiliary data system (MADS) performance supported the mission satisfactorily. However, the following paragraphs discuss a significant recorder problem that occurred, but did not impact the mission to any great degree.

The Operations (OPS) 1 recorder experienced two problems during the mission. The first was the failure to receive playback data that was recorded on tracks 3 through 9 in the forward direction. The second problem was with erratic tape counter indications while running at high speed (120 in/sec) in the reverse direction in the 80 to 100 percent region of the tape. Initially, the workaround had been to use this recorder only during acquisition-of-signal (AOS) periods, to record data only in the reverse direction, and avoid using the tape past the 70-percent region of the tape. However, further degradation of OPS recorder 1 made alternate procedures impractical and the decision was made to stop using the recorder. Two small periods of data were actually lost during a period of radio frequency interference (RFI) that occurred when OPS recorder 1 was in use. The OPS recorder was removed and replaced during postflight turnaround operations at KSC.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily.

During preparations for the extravehicular activity (EVA), the crew reported finding two small pieces of debris. The pieces were identified as part of a spindle and a ball from a double-acting pip pin. The crew reported that the pieces originated from one of the hinge brackets at the external airlock aft hatch location, where a hatch is not installed. The body of the pip pin was still in place. The parts were bagged and stowed by the crew. The remaining internal parts of the pip pin, which were the second ball and a T-handle, were not found during the flight. The parts that were bagged will be sent to the contractor for failure analysis. The results will be reported in other publications.

LANDING AND BRAKING PARAMETERS

Parameter	From Threshold, ft	Speed, Keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	3359.3	199.0	-2.22	N/A
Nose gear touchdown	6782.7	151.0	N/A	-4.24
Brake initiation speed		101.4 knots		
Brake-on time		34.13 seconds		
Rollout distance		8917.1 feet		
Rollout time		58.31 seconds		
Runway		15 (Concrete) KSC		
Orbiter weight at landing		226,130 lb		
Brake sensor Location	Peak Pressure, Psia	Brake assembly	Gross energy, million ft-lb	
Left-hand inboard 1	1166.88	Left-hand inboard	20.80	
Left-hand inboard 3	1166.88			
Left-hand outboard 2	997.44	Left-hand outboard	17.61	
Left-hand outboard 4	997.44			
Right-hand inboard 1	962.28	Right-hand inboard	15.43	
Right-hand inboard 3	962.28			
Right-hand outboard 2	939.90	Right-hand outboard	15.01	
Right-hand outboard 4	939.90			

The main landing gear tires were reported to be in good condition for a landing on the KSC concrete runway. No ply under-cutting was identified on any of the main landing gear tires.

The ET/Orbiter (EO) separation devices (EO-1, EO-2 and EO-3) functioned normally. No ordnance fragments were found on the runway below the ET/Orbiter umbilicals. The EO-2 and EO-3 fitting retainer springs appeared to be in the nominal configuration, however, two of the EO-2 "salad bowl" clips were missing. No umbilical closeout foam or room temperature vulcanizing (RTV) dam material adhered to the umbilical plate near the liquid hydrogen (LH₂) recirculation line disconnect.

The postlanding activities recovered all components of the drag chute, which appeared to have functioned properly.

During the postflight inspections, the aft bulb seal was torn loose on the port payload bay door between panel 1 and 2. The length of the torn seal is approximately 2 feet. The repairs were in progress as this report was being written.

Integrated Vehicle Heating and Thermal Interfaces

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

The entry aerodynamic heating to the SSME nozzles was nominal.

Higher than normal heating characterized the entry of the STS-101 vehicle. This resulted from the heavy vehicle entering from a high-inclination orbit. Also, the signs of early transition all lend to the higher entry-heating conclusion. While some fuselage skin (structural) temperature indicators attained hotter than normal temperatures, all appeared to have not exceeded the thermal certification database temperatures.

The tile damage sites just forward of the left-hand center elevon were slumped with the coating peeling back. A tile damage site immediately aft and outboard of the right-hand main landing gear door (MLGD) was also slumped with the coating peeling back. The lower left-hand leading edge structure subsystem (LESS) no. 7 closeout tile adjacent to the no. 7 radial carbon-carbon (RCC) T-seal was slumped with signs of subsurface flow. Both the left and right MLGD thermal barriers were breached in multiple places.

Thermal Control Subsystem

The Orbiter thermal control subsystem (TCS) performance was nominal during the prelaunch operations as well as the flight. The beta angle for this mission was low and benign from a thermal standpoint. All subsystem temperatures were maintained within acceptable limits.

During the mission, right-wing tile damage was detected in the ascent video review. As a result, the end-of-mission (EOM) attitudes were modified to top earth, port wing on the velocity vector, and nose pitched down 20 degrees. The right wing was cold-soaked by this attitude, thus providing additional thermal margin for the wing structure.

The hydraulic circulation pump upper and lower temperature control limits were reduced to reduce cryogenic consumption. This was the first flight in which all three systems control limits were reduced. As a result, circulation pump power usage was reduced approximately in half because of the increased PDU heater operation.

Aerothermodynamics

Data indicate that an early asymmetrical boundary layer transition occurred. The aileron recorded position deviated from the command position starting at Mach 16.8 which indicates asymmetric boundary layer transition. Skin temperature rise indicates early transition along the outboard fuselage and aft centerline. Wing skin temperature rise is in line with the mission parameters, indicating no early transition in that area.

Thermal Protection Subsystem and Windows

The TPS performed satisfactorily. Entry heating was significantly higher than expected based on lower-surface structural temperature response data. Boundary layer transition from laminar flow to turbulent flow cannot be determined as the MADS data from entry, which could be used to confirm the transition, has at this writing not been released for evaluation. The bondline temperature data indicate a higher-than-usual temperature rise, which may indicate the occurrence of early transition.

The postlanding inspection of the Orbiter TPS identified a total of 113 impacts of which 27 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.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	19	70
Upper Surface	0	0
Window Area	3	16
Right Side	2	7
Left Side	2	7
Right OMS Pod	0	4
Left OMS Pod	1	9
Total	27	113

A comparison of the number of damage sites with statistics from previous missions indicates that both the total number of hits as well as the number of hits 1-inch or larger were more in line with the fleet averages, which were 124 hits with 20 larger than 1-inch.

A bright streak was seen in the launch video 34 seconds after liftoff. The streak appeared to originate from the underside of the right wing. During STS-26, a similar streak was observed at 52 seconds MET. Upon return on STS-26, thermal protection system (TPS) tile damage was present on the underside of the right wing. There was no structural damage in the STS-26 case. A small change to the STS-101 end-of-mission thermal-conditioning attitude that resulted in a cold bias of the right wing/elevons structure was employed. This attitude enhancement was made to reduce the potential for local damage and impact to turnaround processing. This possible TPS damage was not considered a safety-of-flight issue. The damage site was 5.25 inches in length, 1.5 inches wide and 0.5 inch deep. Erosion during entry had also enlarged this damage site. The gouge-like appearance, as well as its depth, indicates that this damage may have been caused by ice from the ET LO₂ feedline bellows. Several tile hits aft of this location may have been the result of secondary impacts.

The total number of lower surface damage sites was 70, of which 19 were greater than 1-inch in diameter. Some of the damage sites (23 hits with 5 larger than 1-inch) were located in the area from the nose gear to the main landing gear wheel wells on both the left and right chines. This damage is consistent with the loss of foam from the ET thrust panels, but the quantity and average size of the damage sites compared with previous flights were reduced because of the prelaunch TPS venting modification. In general, the lower surface tile damage is considered to be improving from previous flights and returning to fleet averages. The following table presents a comparison of lower surface damage for the last 10 flights.

**COMPARISON OF LOWER SURFACE DAMAGE SITE DATA FROM LAST
TEN FLIGHTS**

Parameter	STS -87	STS -89	STS -90	STS -91	STS -95	STS -88	STS -96	STS -93	STS -103	STS -101
Lower surface total hits	244	95	76	145	139	80	160	161	84	70
Lower surface hits > 1 in.	109	38	11	45	42	21	66	42	13	19
Longest damage site, in.	15	2.8	3.0	3.0	4.0	4.5	4.0	6.0	1.5	8
Deepest damage site, in.	1.5	0.2	0.25	0.5	0.4	0.5	0.5	0.5	0.25	0.75

Numerous tile damage sites around the ET/Orbiter umbilicals have been attributed to impacts from umbilical ice or shredded pieces of umbilical purge barrier material flapping in the air stream.

Less than the usual amounts of tile damage occurred on the base heat shield. All SSME dome-mounted heat shield closeout blankets were in excellent condition. No unusual tile damage occurred on the leading edges of the OMS pods and vertical stabilizer. The drag chute deployment caused a 2-inch long by 1-inch wide by 1/8 inch deep on the stinger tile. On the inside of the upper right split rudder, a 3.5-inch by 1-inch piece of black tile surface coating material was missing.

During the postflight thermal protection subsystem (TPS) inspection, a tile, no. V070-199712-051, was discovered slumped with a 0.262-inch gap to the RCC T-seal. The indications were found that flow did exist. The lower LESS panel 6 and upper LESS panels 6 and 7 were removed to gain access. The "butterfly" gap filler at the lower LESS panel 6/7 interface was not installed correctly. The aft portion that interfaces the LESS 7 panel, the T-Seal and RCC panel 7 was folded up and pushed away from the intended cavity it was made to fill. The misconfiguration created a substantial flow path. The only seal came from the horse-collar gap filler to the edge of the T-Seal. Inspections of the RCC, insulators and attaching hardware show various signs of overheating. The insulator between RCC panel 7 and the T-Seal appears to have had the outer Inconel cover breached on the lower corner (approximately 1/4-inch diameter). The RCC doesn't show any obvious signs of overheating (e.g. flaking or burnt areas), but further inspections are being conducted. The fittings revealed a

large amount of outgassing deposits and evidence of some elevated temperatures and heating. The fittings do not exhibit any signs of melting or distortion. The RCC panels have been removed and more detailed inspections of this area of hardware are being performed. The PRCB made the resolution of this anomaly a constraint to the STS-106 mission.

Damage sites on the window perimeter tiles was less than usual in quantity and size. Hazing and streaking of forward-facing windows was moderate. An 8-inch long streak on window 2 led to a damage site in an upper-right-corner perimeter tile. The largest damage site, also located in the window-2 perimeter tiles, was approximately 1.5 inches long by 0.75 inch wide.

Gas Sample Bottle Analysis

The gas sample bottle system operated nominally and provided the program with six excellent gas samples on this twenty-ninth flight of the redesigned system. All six bottle pressures were in the range expected. The hydrogen concentration was within the database for all Space Shuttle vehicles. The oxygen data was within the bands of error as determined by the argon measurement, and the amount detected is attributed to air.

EXTRAVEHICULAR ACTIVITY OPERATIONS

All planned tasks for the extravehicular activity (EVA) were satisfactorily completed during the 6 hours and 44 minutes that the two crewmembers were outside of the Orbiter cabin. During the EVA, the U. S. Orbital Replacement Unit (ORU) Transfer Device (OTD) was repositioned, the Russian Strela crane was transferred and assembled, and the Early Communications (ECOMM) antenna was removed and replaced. No significant problems or anomalies were identified from the data.

The crew reported completion of the checkout of the Simplified Aid for extravehicular activity (EVA) Rescue (SAFER) at 142:07:23 G.m.t. (01:21:12 MET). The crew reported a percent-power reading of 99 percent for SAFER serial number 1003. The percent-power value was identical to the preflight checkout value in early April. For SAFER S/N 1007, the crew reported a percent power value of 89 percent, which was 6 percent below the preflight checkout value. The expected values were 92 percent for S/N 1003 and 89 percent for S/N 1007. Since the value for S/N 1003 did not decrease as expected while S/N 1007 did, S/N 1003 appears to have experienced a count-up anomaly and the percent power reading was not accurate.

Both SAFER units were considered acceptable for use during the EVA. This count-up anomaly is a known condition with this particular version of the SAFER battery power gauge. The actual power capability of the battery was not affected by this problem. The problem is isolated to only the gauge.

During the EVA, the EVA handrail that was to be installed in location 8 on Node 1 had interference from a cable and the handrail would not seat in the designated tracks. The handrail was placed in the next set of tracks in rotation on the Nadir side and in line with handrails 5, 6 and 7 near the aft trunnion. Evaluations are in progress to determine if the position is acceptable for future EVAs.

REMOTE MANIPULATOR SYSTEM

All remote manipulator system (RMS) tasks were completed as planned during STS-101, the 55th flight of the RMS during the Space Shuttle program. The primary task of the RMS was to support EVA operations while the Orbiter was docked with the International Space Station.

During the direct-drive portion of the checkout of the RMS, error indications were noted in the caution and warning system as well as a fault message concerning the wrist-roll joint. The arm drove nominally in both the positive and negative directions for all joints. The single/direct switch was held in the negative direction for 12 seconds for the wrist roll joint. The error indications were seen when the switch was released. Data evaluation showed nominal brake operation, and the cause of this problem is being investigated.

During the power-down procedure following the EVA, the aft system 1 manipulator positioning mechanism (MPM) "stow" microswitch indication failed to indicate closed. The aft system 2 microswitch operated correctly. The failed microswitch did not affect the crew talk-back indications or the MPM motor control. The MPM's were rolled out for Space Vision System (SVS) operations and remained in the rolled-out position until after undocking from the ISS. When stowed, the microswitch once again failed to indicate that the MPM was stowed. The failed microswitch closed indication was received during entry. KSC will perform troubleshooting of the rigging prior to the next flight.

The Orbiter Space Vision System (OSVS) processes an automatic software script that runs the system without crew interaction. The script occasionally generates a large number of status messages that are written to an internal buffer. In this version of the software, the script runs at highest priority, thus permitting a buffer overflow and creating an unrecoverable software error that can be observed on the ground. This condition was not observed during preflight testing. The software halts when it receives an unrecoverable error, which occurred in as little as 1 hour and as much as 24 hours. A workaround was developed that required the crew to power cycle the OSVS unit each day during the post-sleep and pre-sleep periods.

This condition was verified by ground testing during the flight and is understood. A fix has been developed and implemented in version 10 of the software.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The government furnished equipment/flight crew equipment (GFE/FCE) performed well with only minor problems noted. These are discussed in the following paragraphs.

The crew was downlinking ascent video from a video tape recorder (VTR) with a color signal reaching the ground. After a 1-minute loss of signal (LOS), the video appeared black and white on the ground. The crew later recorded video using the same VTR for five minutes and in the "color-bars" mode, and the video produced a good color video image onboard. Troubleshooting of the ground equipment will be performed.

The crew reported periodic shutter lock-up of the Digital Camera System (DCS) that was to support ISS internal photographic operations. The crew cycled the DCS power to clear the shutter lock-up, but the lock-up returned in a few minutes. The camera battery charger power cable was plugged in for the majority of that time, which makes the possibility of a low or dead battery likely. The DCS was stowed and the F5 camera was used in its place. Troubleshooting of the DCS at JSC revealed a stuck shutter.

The color television camera denoted as Camera A gave a blurred or fuzzy image whenever video was downlinked from that camera. There was no mission impact as a result. The video from that camera will be reviewed in a effort to determine the cause. Also, the camera lens will be inspected during the postflight turnaround effort.

CARGO INTEGRATION

Integration hardware performance was nominal throughout the mission.

POSTLAUNCH PAD INSPECTION

The postlaunch pad inspection was performed between 2 and 4 hours after the launch. No flight hardware was found. Overall, the damage to the pad was minimal.

No stud hang-ups were expected and none were found as the lateral acceleration at liftoff were well below the threshold of 0.14g for stud hang-ups.

The LO₂ and LH₂ tail service masts appeared undamaged and the bonnets were closed properly. The Orbiter access arm appeared to be undamaged.

The mobile launch platform (MLP) deck was in generally good condition with only one bolt missing from a deck access panel on the southwest side. This panel is adjacent to the panel that was noted in the launch minus 20-hour inspection as not having peripheral RTV sealant applied.

The GH₂ vent line latched properly in the latching mechanism. Pieces of the T-0 lock weight guide roller assemblies were found on the adjacent deck grating and pad surface.

The gaseous oxygen vent arm, ducts and structure were in good shape with no indications of plume damage. The vent seals were inspected for ET topcoat adherence. Several small spots of topcoat were observed on the northeast seal lower surface, and no topcoat was observed on the southwest seal.

Debris findings on the fixed service structure (FSS) included loose or missing cable tray and conduit covers, and loose electrical cables and broken lighting fixtures. These conditions are normally seen after each launch.

No significant damage was noted in the flame trenches. No flight debris was found on the pad acreage.

An apparent underground gas line, media unknown, was observed venting through the ground. This was observed emanating from the remote environmental control system tunnel that is adjacent to liquid oxygen cable tray. The pad leader was notified for immediate action.

**DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY
OBJECTIVES/HUMAN EXPLORATION AND DEVELOPMENT OF SPACE
TECHNOLOGY DEMONSTRATION**

DEVELOPMENT TEST OBJECTIVES

DTO 623 - Cabin Air Monitoring - The crew collected samples of the cabin air during the mission. These samples will be analyzed during the postflight period and the results will be published in other documentation.

DTO 700-14 - Single String Global Positioning System - The miniature airborne Global Positioning System (GPS) Receiver (MAGR) performed well with no figure of merit (FOM) problems noted. The Operations (OPS) 2 test was performed as planned and the unit was powered off after 45 minutes. The unit remained off for approximately 24 hours after which a successful power-up was completed. Four-satellite navigation was established about two minutes after the power-up was completed. Following the downloading of the current encryption key, precise positioning service (PPS) was accomplished in approximately six minutes. This one data point provides the initial indication that a late power-up of the MAGR can support contingency entry scenarios.

During the final self-test of the MAGR, one of the fault-log words came back with a warning message. Analysis of the condition indicates that the voltage-controlled oscillator (VCO) counts were not within the established tolerance limits. This condition is not a failure indication. A review of the data after the self-test showed that all hardware channels had successfully tracked both channels.

The MAGR continued to perform satisfactorily for the duration of the mission. A memory dump is planned during the postflight turnaround activities to determine the cause of the problem.

DTO 700-21 - SIGI Operational Attitude Readiness - The SIGI Operational Attitude Readiness (SOAR) tasks were performed as planned. SOAR collected six hours of data above the minimum ISS requirements. Two minor anomalies were observed during the mission and these are discussed in the following paragraphs.

Two of the star trackers did not track at any time when the Orbiter payload bay was in daylight or during tracked time when the ISS was reflecting daylight, even though the light shades were designed to reject stray light outside the 40-degree cone from boresight. However, Orbiter attitude data, in conjunction with Star Line Maneuver (SLM) data, were used as a true source to fill in the times of data

dropout on the star trackers. Several hours of night pass data were collected successfully from the star trackers.

The Star Line Maneuver 1 missed a small amount of star data that represents little or no impact to the effectiveness of the SLM. The angular rate data collected during the SLM provided the most valued source of attitude, along with the star data, which slightly improved the accuracy of the Orbiter's absolute attitude. In the worst case scenario, valuable angular data were still collected and three other SLM's were performed successfully during the mission.

The SIGI had more coverage of attitude and position solutions during the docked portion of the flight than was expected based on preflight predictions as well as tracking attitude through more of the SLM's than was anticipated. SIGI behavior at an extra 10 degrees rolled attitude was observed during the fifth CRV data take. SOAR used more of the available telemetry data than was originally expected. Insight from telemetry data allowed the SOAR ground personnel to decide to engage a different set of SIGI tuning parameters than planned preflight. Also, telemetry showed an unexpected subsystem flag that SOAR ground operations reset via a ground-commanded power cycle.

DTO 805 - Crosswind Landing Performance - The crosswinds were not of sufficient magnitude during landing operations, consequently, this DTO of opportunity was not performed.

DTO 847 - Solid Star Tracker Size Limitation - Conditions during the flight did not occur that would have facilitated the performance of this DTO. Consequently, this DTO of opportunity was not performed.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 493 - Monitoring Latent Virus Reactivation and Shedding in Astronauts - Samples were acquired during the flight and these will be assessed during the postflight period. The results will be published in separate documentation.

DSO 498 - Space Flight and Immune Functions - Samples from the crew were taken during preflight and postflight activities, and the samples will be analyzed during the postflight period. The results of this DSO will be reported in separate documentation.

HUMAN EXPLORATION AND DEVELOPMENT OF SPACE TECHNOLOGY DEMONSTRATION

HTD 1403 - Micro-Wireless Instrumentation System - The Micro-Wireless Instrumentation System (Micro-WIS) delivered excellent performance. The

transmitter system was set up eight hours before the normally scheduled time. All 12 transmitters were confirmed operational, including the two in the airlock. The Micro-WIS recorder and transmitter systems collected data to enable the environmental and avionics personnel to address avionics hardware, crew comfort and International Space Station (ISS) Node 1 condensation concerns. There were many downlinks of data to the Mission Control Center during the mission, and all were successful. A note of interest in that it required less than 5 seconds to downlink 12 hours of temperature data through the Ku-band.

PHOTOGRAPHY AND VIDEO DATA ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On launch day, 24 of 24 expected launch videos were reviewed, and no anomalous conditions were noted. Following launch day activities, 28 additional films were screened with no anomalous conditions noted.

The OV-104 vehicle was equipped with three umbilical well cameras (16 mm motion picture with 5 mm lens, and a 16 mm motion picture with a 10 mm lens), both of which were located in the LH₂ umbilical well. The third camera was a 35 mm still camera that was located in the LO₂ umbilical well.

The 16 mm camera with the 5 mm lens did not run and no data were collected. The film from the 16 mm camera with the 10 mm lens was dark because of the time of launch. Thus, not much detail was discernible.

During ET separation, most of the LH₂ ET/Orbiter umbilical well was in shadow. However, a forward outboard portion of the purge seal was loose and protruding in the +Z direction, which caused it to be in sunlight.

A debris object passed close to the camera lens in a fore and aft direction as the distance between the separated ET and the Orbiter increased. Since the object was silhouetted, no detail such as color or surface finish could be discerned. However, the object's large inner diameter has led to believing that the object is an O-ring of some type and not a washer. The origin has not been determined.

The flight crew obtained 35 excellent quality images of the ET after separation using the hand-held 35 mm camera. The first photograph was taken approximately 8 minutes after main engine cutoff (MECO) with the ET approximately 2.3 km from the Orbiter. In all of the views, the ET was well illuminated by sunlight. The focus was also good. However, the ET was somewhat distant from the Orbiter, making the detection of small features more difficult. Only the -Z side of the ET was not imaged.

A light spot in the LH₂ tank-to-intertank flange closeout on the centerline between the bipods and a light spot in the LH₂ tank-to-intertank flange closeout near the -Y thrust panel may be divots. Likewise, a light spot on the -Y thrust strut to longeron interface (knuckle) TPS closeout midway between the thrust strut knuckle and the vertical strut that may also be a divot.

In other observations, no anomalies were detected on the composite nose cone. Loss of the topcoat and erosion of the foam in the forward ogive sanded area was visible, but the presence of divots could not be confirmed.

Both +Y and -Y intertank thrust panels, including areas not visible in the two SRB video cameras, exhibited no large divots (5 inches in diameter or greater). Smaller divots could not be discerned because of the ET's distance that decreased the resolution.

No anomalies were detected in the LO₂ and the LH₂ tank acreage. As expected, the aft dome TPS was darkened by charring, which did not quite reach the Xt-2058 ring frame.

The left and right SRB thrust panel videos are of excellent quality with good exposure and focus. As in the past videos, the divots began appearing after approximately 100 seconds of flight. As in previous videos, the divots in the vented areas of the thrust panels were smaller and less in number when compared with the non-vented areas. Most of the divots were shallow and less than 0.5 inch in size. No primed substrate was detected. A greater number of divots were visible on the right SRB thrust panel when compared with the left SRB thrust panel. Based on a visual comparison of the STS-101 and STS-103 videos, the STS-101 thrust panels contained more visible divots than STS-103.

Sixty frames of photography were obtained from the 35 mm camera in the wheel well. The film quality was excellent, and the post-separation photography of the ET showed the ET to be in good condition. However, the left side of the view (+Z/-Y axis of the ET) is obscured by shadow and is too dark for analysis.

The analysis showed minor damage sites on the ET, but none of the damage sites (divots) appeared to be of any concern.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No unplanned on-orbit analysis was performed.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

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

TABLE I.- STS-101 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	140:10:06:19.495 140:10:06:20.357 140:10:06:21.593
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	140:10:10:41.96 140:10:10:42.12 140:10:10:42.24 140:10:10:42.36
Main Propulsion System Start ^a	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	140:10:11:03.436 140:10:11:03.557 140:10:11:03.688
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	140:10:11:09.994
Throttle up to 104.5 Percent Thrust ^a	ME-2 Command accepted ME-1 Command accepted ME-3 Command accepted	140:10:11:13.826 140:10:11:13.835 140:10:11:13.839
Throttle down to 96 Percent Thrust ^a	ME-2 Command accepted ME-1 Command accepted ME-3 Command accepted	140:10:11:27.906 140:10:11:27.915 140:10:11:27.919
Throttle down to 72 Percent Thrust ^a	ME-2 Command accepted ME-1 Command accepted ME-3 Command accepted	140:10:11:41.986 140:10:11:41.996 140:10:11:42.000
Throttle up to 104.5 Percent Thrust ^a	ME-3 Command accepted ME-2 Command accepted ME-1 Command accepted	140:10:12:04.376 140:10:12:04.377 140:10:12:04.408
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	140:10:12:10
Both RSRM's Chamber Pressure at 50 psi ^a	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	140:10:13:09.11 140:10:13:09.15
End RSRM ^a Action ^a Time	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	140:10:13:11.39 140:10:13:11.43
SRB Physical Separation ^a	LH rate APU turbine speed - LOS	140:10:13:13.75
SRB Separation Command	SRB separation command flag	140:10:13:14
OMS Assist Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	140:10:13:23.9 140:10:13:24.0
OMS Assist Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	140:10:14:23.3 140:10:14:24.0
Throttle Down for 3g Acceleration ^a	ME-2 command accepted ME-1 command accepted ME-3 command accepted	140:10:18:32.714 140:10:18:32.724 140:10:18:32.728
3g Acceleration	Total load factor	140:10:19:11.0
Throttle Down to 67 Percent Thrust ^a	ME-2 command accepted ME-1 command accepted ME-3 command accepted	140:10:19:28.395 140:10:19:28.405 140:10:19:28.409

^aMSFC supplied data

**TABLE I.- STS-101 SEQUENCE OF EVENTS
(Continued)**

Event	Description	Actual time, G.m.t.
SSME Shutdown ^a	ME-2 command accepted	140:10:19:34.875
	ME-1 command accepted	140:10:19:34.886
	ME-3 command accepted	140:10:19:34.889
MECO	MECO command flag	140:10:19:35
	MECO confirm flag	140:10:19:37
ET Separation	ET separation command flag	140:10:19:54
APU Deactivation	APU-2 GG chamber pressure	140:10:25:15.195
	APU 1 GG chamber pressure	140:10:25:35.013
	APU 3 GG chamber pressure	140:10:25:51.472
OMS-1 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
OMS-1 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	
OMS-2 Ignition	Right engine bi-prop valve position	140:10:54:14.2
	Left engine bi-prop valve position	140:10:54:14.3
OMS-2 Cutoff	Left engine bi-prop valve position	140:10:55:07.5
	Right engine bi-prop valve position	140:10:55:07.6
Payload Bay Doors (PLBDs) Open	PLBD right open 1	140:12:16:24
	PLBD left open 1	140:12:20:28
OMS-3 Ignition	Left engine bi-prop valve position	141:01:48:22.4
	Right engine bi-prop valve position	141:01:48:22.5
OMS-3 Cutoff	Right engine bi-prop valve position	141:01:49:24.2
	Left engine bi-prop valve position	141:01:49:24.3
Cabin Depressurization to 10.2 psia	Cabin pressure	N/A
OMS-4 Ignition	Right engine bi-prop valve position	141:10:51:38.7
	Left engine bi-prop valve position	Right engine only
OMS-4 Cutoff	Right engine bi-prop valve position	141:10:53:02.5
	Left engine bi-prop valve position	Right engine only
OMS-5 Cutoff	Right engine bi-prop valve position	Right engine only
	Left engine bi-prop valve position	142:01:39:42.7
Docking with ISS	Docking ring final position	142:04:44:09
Begin Extravehicular Activity	Airlock differential pressure no. 1	143:01:52:51
Cabin Repressurization to 14.7 psia	Cabin pressure	143:07:49
End Extravehicular Activity	Airlock differential pressure no. 1	143:08:31:58
Reboost Maneuver 1 Ignition	As reported	145:00:02:11
Reboost Maneuver 1 Cutoff	As reported	145:01:02:42
Reboost Maneuver 2 Ignition	As reported	146:01:15:51
Reboost Maneuver 2 Cutoff	As reported	146:02:14:01
Reboost Maneuver 3 Ignition	As reported	146:23:32:38
Reboost Maneuver 3 Cutoff	As reported	147:00:28:53
Undocking from ISS	Undock complete	147:23:02:38

**TABLE I.- STS-101 SEQUENCE OF EVENTS
(Concluded)**

Event	Description	Actual time, G.m.t.
Flight Control System Checkout		
APU Start	APU 1 GG chamber pressure	149:00:17:05.946
APU Stop	APU 1 GG chamber pressure	149:00:22:38.563
OMS-6 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	Right engine only 149:09:22:10.3
OMS-6 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	149:09:22:31.1 Right engine only
Payload Bay Doors Close	PLBD left close 1 PLBD right close 1	150:02:32:53 150:02:36:29
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	150:05:07:10.040 150:05:35:31.926 150:05:35:32.995
Deorbit Burn Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	150:05:12:10.2 150:05:12:10.3
Deorbit Burn Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	150:05:15:17.4 150:05:15:17.5
Entry Interface (400K feet)	Current orbital altitude above	150:05:48:27
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Management	Major mode change (305)	150:06:13:55
Main Landing Gear Contact	LH main landing gear tire pressure 1 RH main landing gear tire pressure 2	150:06:20:19 150:06:20:19
Main Landing Gear Weight on Wheels	LH MLG weight on wheels RH MLG weight on wheels	150:06:20:19 150:06:20:19
Drag Chute Deployment	Drag chute deploy 1 CP volts	150:06:20:22.1
Nose Landing Gear Contact	NLG LH tire pressure 1	150:06:20:29
Nose Landing Gear Weight On Wheels	NLG weight on wheels 1	150:06:20:30
Drag Chute Jettison	Drag chute jettison 1 CP Volts	150:06:20:57.1
Wheel Stop	Velocity with respect to runway	150:06:21:17
APU Deactivation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	150:06:36:43.814 150:06:37:00.289 150:06:37:10.981

TABLE II- STS-101 SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-101-V-01	Left OMS Engine Bipropellant Valve 2 Indicates Open	141:01:49:24 G.m.t. 00:15:38:14 MET IPR 106V-0005 CAR 101RF02	<p>Following the NC2 maneuver at 141:01:49:24 G.m.t. (00:15:38:14 MET), the left OMS engine bipropellant valve 2 (BPV-2) continued to indicate open. The valve position remained at 98.4 percent and should have been 0 ± 5 percent. The first two firings of the engine were nominal with 98.7 percent open with 0.6 second opening period and 0.4 second closing period for the OMS assist firing. On the OMS-2 firing, the indication was 98.9 percent open with 0.4 second opening period and 0.4 second closing period. This was the first flight of OMS engine S/N 111 since it was rebuilt at White Sands Test Facility (WSTF) in 1997. In accordance with the flight rules, the engine was not used until the deorbit maneuver, where it performed nominally. The BPV-2 open indication remained open throughout the engine firing and continued to indicate open after shutdown. Chamber pressure, injector temperatures and inlet pressures indicated nominal engine performance throughout the burn and the BPV-1 valve indication showed nominal closure. As determined by the PRCB, this anomaly is a constraint to the launch of STS-106</p> <p>KSC: Troubleshooting was performed during ball valve draining operations.</p>
STS-101-V-02	Left OMS Engine GN ₂ Regulator Pressure Low During Post-Firing Purges	140:10:14:25 G.m.t. 00:00:03:15 MET CAR 101RF06 IPR 106V-0007	<p>During the OMS assist start transient and the post-dump purge as well as the OMS-2 post-dump purge, the left OMS engine GN₂ regulator pressure indicated 296, 295, and 297 psia, respectively, all of which are below the fault detection and annunciation (FDA) limit of 299 psia. As a result, FDA alarms were generated. Upon completion of the start transients and purges, the regulated pressure returned quickly to a nominal value of 312 psia. There was no mission impact from this condition.</p> <p>KSC: During postflight safing operations, the OMS engine GN₂ vent was performed at 150:08:43 G.m.t. Regulator performance was nominal with the pressure indicating 316 psia with a bit toggle to 315 psia. However, because of the in-flight concerns, a decision was made to remove and replace the regulator prior to the next flight. KSC will perform the replacement while the engine remains installed on the vehicle.</p>

TABLE II- STS-101 SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

<p>STS-101-V-03</p>	<p>Ku-Band Radiating Within the RF Protect Box</p>	<p>146:09:32 G.m.t. 05:23:21 MET</p>	<p>While the Orbiter was docked to the ISS, on two occasions the Ku-Band traveling wave tube (TWT) radiated into the RF protect box. The first occurrence was at 146:09:32 G.m.t. (05:23:21 MET), and the second occurred at 147:08:26 G.m.t. (06:22:15 MET). On each occasion, the duration was approximately 1 to 2 seconds. The radiation took place when the antenna was driving from the TDRS East satellite to the TDRS West satellite. To prevent future occurrences, the ground controllers turned the transmitter off if the TDRS was predicted to be within the box at TDRS acquisition of signal. The cause of these occurrences is being investigated. KSC: An action team was formed to further investigate this condition. Several actions have been assigned.</p>
<p>STS-101-V-04</p>	<p>PRSD Oxygen Tank 4 Heater Temporarily Failed</p>	<p>141:00:02 G.m.t. 00:13:51 MET 101RF07 IPR 106V-0010</p>	<p>During the flight day 2 post sleep cryogenics reconfiguration, the O₂ tank 4 A and B heaters were placed in auto. Following the first heater cycle at 141:00:02 G.m.t. (00:13:51 MET), which was nominal, the A heater did not come on during subsequent cycles. The heater switch was cycled to the off position and then back to the auto position at 141:02:22 G.m.t. (00:16:11 MET). At 141:02:25 G.m.t. (00:16:14 MET), both the A and B heaters cycled, and the functionality of the heater was regained. The heater performed nominally for the remainder of the mission with several switch throws, and was used to deplete the tank to residual quantity. KSC: Troubleshooting was performed, and the data are under review. No problems have been noted thus far in the data.</p>
<p>STS-101-V-05</p>	<p>Collins TACAN BITE Faults</p>	<p>150:05:51:10 G.m.t. 09:19:40:00 MET 101RF08 IPR 106V-0018</p>	<p>The Collins TACAN in position 3 experienced two BITE faults during landing. The two BITE faults lasted for 3 seconds and 10 seconds, respectively. This BITE signature is the first occurrence for a Collins TACAN. Once the TACAN locked onto the ground station, the TACANs performance was nominal. Data retrieval has determined that the event occurred during Plasma and what role this might have played in the event is being investigated. A decision was made to remove and replace that TACAN unit. The hardware was removed and returned to the vendor where troubleshooting will be performed. One Collins TACAN spare is available. OV-104 must fly all Collins TACANs because of the cooling modification made during the OMDP.</p>

TABLE II- STS-101 SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

<p>STS-101-V-06</p>	<p>Slump Tile at the Wing Leading Edge with Internal Flow</p>	<p>Post-landing Post-landing 101RF-12</p>	<p>During the TPS inspection, tile no. V070-199712-051 was discovered slumped with a 0.262-inch gap to the RCC T-seal. The indications were found that flow did exist. The lower LESS panel 6 and upper LESS panels 6 and 7 were removed to gain access. The "butterfly" gap filler at the lower LESS panel 6/7 interface was not installed correctly. The aft portion that interfaces the LESS 7 panel, the T-Seal and RCC panel 7 was folded up and pushed away from the intended cavity it was made to fill. The misconfiguration created a substantial flow path. The only seal came from the horse-collar gap filler to the edge of the T-Seal. Inspections of the RCC, insulators and attaching hardware show various signs of overheating. The insulator between RCC panel 7 and the T-Seal appears to have had the outer Inconel cover breached on the lower corner (approximately ¼-inch diameter). The RCC doesn't show any obvious signs of overheating (e.g. flaking or burnt areas), but further inspections are being conducted. The fittings show a lot of outgassing deposits and some evidence that experienced some elevated temperatures and heating. The fittings do not exhibit any signs of melting or distortion. The RCC panels have been removed and more detailed inspections of this area of hardware are being performed. The PRCB made the resolution of this anomaly a constraint to the STS-106 mission.</p>
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DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for the STS-101 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. MER In-Flight Anomaly List
7. MER Problem Tracking List
8. MER Event Times
9. Subsystem Manager Reports/Inputs
10. MOD Systems Anomaly List
11. MSFC Flash Report
12. MSFC Event Times
13. MSFC Interim Report
14. Crew Debriefing comments
15. Shuttle Operational Data Book
16. STS-101 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.

ABS	ammonia boiler system
AOS	acquisition of signal
APCU	assembly power converter unit
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARS	atmospheric revitalization system
AST	Astroculture (experiment)
ATCS	active thermal control system
BioTube	BioTube Precursor Experiment
BITE	built-in test equipment
CPCG	Commercial Protein Crystal Growth
CPM	cell performance monitor
CRT	cathode ray tube
CWC	contingency water container
DCS	digital camera system
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔP	differential pressure
ΔV	differential velocity
ECLSS	Environmental Control and Life Support System
ECOMM	Early Communications System
EMU	extravehicular mobility unit
EO	ET/Orbiter
EOM	end of mission
EPDC	electrical power distribution and control
e.d.t.	eastern daylight time
ET	External Tank
EVA	extravehicular activity
FCE	flight crew equipment
FCL	Freon coolant loop
FCMS	fuel cell monitoring system
FCP	fuel cell powerplant
FCS	flight control system
FDA	fault detection and annunciation
FES	flash evaporator system
FGB	Functional Cargo Block
FM	frequency modulation
FOM	figure of merit
FPV	flow proportioning valve
FSS	fixed service structure
ft/sec	feet per second
g	gravity
GAS	Getaway Special

GFE	Government furnished equipment
GH ₂	gaseous hydrogen
G.m.t.	Greenwich mean time
GN ₂	gaseous nitrogen
GO ₂	gaseous oxygen
GPS	Global Positioning System
H ₂	hydrogen
HEDS	Human Exploration and Development of Space
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
HTD	HEDS Technology Demonstration
ICC	Integrated Cargo Carrier
IMU	inertial measurement unit
IMV	intermodule ventilation
In/sec	inch per second
IPR	Interim Problem Report
I _{sp}	specific impulse
ISS	International Space Station
IVA	intravehicular activity
JSC	Johnson Space Center
km	kilometer
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt/hour
lb	pound
lbm	pound mass
LCC	Launch Commit Criteria
LESS	leading edge structure subsystem
LH ₂	liquid hydrogen
LMSO	Lockheed Martin Space Operations
LO ₂	liquid oxygen
LOS	loss of signal
MADS	Modular Auxiliary Data System
MAGR	miniature airborne GPS receiver
MARS	Mission to America's Remarkable Schools
MDU	multifunction display unit
MECO	main engine cutoff
MEDS	multifunction electronic display system
MET	mission elapsed time
MLGD	main landing gear door
MLP	Mobile Launch Platform
mm	millimeter
MPM	manipulator positioning mechanism
MPS	main propulsion system
MSFC	Marshall Space Flight Center
MSU	mass storage unit
N ₂	Nitrogen
NASA	National Aeronautics and Space Administration
NC2	rendezvous maneuver
nmi.	nautical mile

NSTS	National Space Transportation System (i.e., Space Shuttle Program)
O ₂	Oxygen
ODS	Orbiter docking system
OMDP	Orbiter Maintenance Down Period
OME	orbital maneuvering engine
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPS	Operations
ORU	Orbital Replacement Unit
OST	operational self test
OSVS	Orbiter Space Vision System
OTD	ORU Transfer Device
PAL	protuberance air load
PCG-BAG	Protein Crystal Growth-Biotechnology Ambient Generic
PCS	pressure control system
PDU	power drive unit
PGME	Propylene Glycol Monomethyl Ether
PGSC	payload and general support computer
PMA	pressurized mating adapter
PMBT	propellant mean bulk temperature
ppm	parts per million
PPS	precise positioning service
PRSD	power reactant storage and distribution
psia	pound per square inch absolute
psid	pound per square inch differential
RCC	radial carbon carbon
RCS	reaction control subsystem
RF	radio frequency
RFI	radio frequency interference
RMS	Remote Manipulator System
RSB	rudder speedbrake
RSRM	Reusable Solid Rocket Motor
RTV	room temperature vulcanizing (material)
S&A	safe and arm
SAFER	Simplified Aid for EVA Rescue
SEM	Space Experiment Module
SHOSS	Spacehab-Oceanering Space System
SIGI	Space Integrated Global Positioning System/Inertial Navigation System
SLF	Shuttle Landing Facility
SLM	Starline Maneuver
SLWT	super lightweight tank
S/N	serial number
SOAR	SIGI Operational Attitude Readiness
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSD-MOMO	Spacehab Commercial Experiment
SSME	Space Shuttle main engine
STS	Space Transportation System
SVS	Space Vision System
SWAR	sea water activated release

TACAN	Tactical Air Navigation
TAL	transAtlantic Abort
TCS	trajectory control sensor/thermal control system
TDRS	Tracking and Data Relay Satellite
TPS	thermal protection system/subsystem
TVC	thrust vector controller
TWT	traveling wave tube
UCP	Unpressurized Cargo Pallet
V	Volt
VCO	voltage-controlled oscillator
VTR	video tape recorder
WCS	waste collection system
WSB	water spray boiler
WSTF	White Sands Test Facility