NSTS-37445

STS-120 SPACE SHUTTLE MISSION REPORT

July 2008



National Aeronautics and Space Administration

Lyndon B. Johnson Space Center Houston, Texas

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SPACE SHUTTLE MISSION REPORT

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STS-120 SPACE SHUTTLE MISSION REPORT

INTRODUCTION

The Space Transportation System (STS) -120 Space Shuttle Mission Report presents a discussion of the Orbiter activities on the mission, as well as a summary of the External Tank (ET), the Solid Rocket Booster (SRB), the Reusable Solid Rocket Motor (RSRM) and the Space Shuttle Main Engine (SSME) performance during the 120th mission of the Space Shuttle Program. The purpose of this mission, designated as Assembly Flight 10A, was to deliver and install the *Harmony* Node 2 module on the International Space Station (ISS), exchange the ISS Flight Engineer 2 crewmembers, and deliver critical supplies and cargo to the ISS.

STS-120 was the 7th mission since the return to flight following the STS-107 mission, and the 23rd to the ISS. STS-120 was also the 34th flight of the *Discovery* vehicle.

The flight vehicle consisted of the OV-103 Orbiter; the ET, a super lightweight tank (SLWT) designated ET-120; three Block II SSMEs that were designated as serial numbers (S/Ns) 2050, 2048, and 2058 in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-131. The two RSRMs were designated flight set RSRM-98. The individual RSRMs were S/N 360W098A (left) and S/N 360W098B (right). Launch pad 39A and Mobile Launch Platform (MLP) -2 were used as the platform for launch of the STS-120 mission.

The primary objectives of the STS-120 mission were as follows:

- 1. Install Node 2 in a temporary position on the port side of the *Unity* Node 1 module. (After the completion of the STS-120 mission, the ISS moved Node 2 to its permanent position on the forward end of the *Destiny* Laboratory).
- 2. Exchange the ISS Flight Engineer 2 crewmembers and transfer mandatory crew rotation cargo
- 3. Relocate the Port (P) 6 Truss element to its permanent position, redeploy the solar arrays, and reactivate the P6 systems.
- 4. Perform five Extravehicular Activities (EVAs) to temporarily attach and activate Node 2, and permanently attach and activate P6.
- 5. Transfer mandatory quantities of water and nitrogen as well as other critical items to the ISS.

During the mission, damage occurred to the P6 4B solar array which resulted in the replanning of the fourth EVA to repair the array. The fifth EVA was cancelled because of the planning for the fourth EVA and the delay of the fourth EVA.

The STS-120 mission was planned to be a 14-day plus 0 plus 2-contingency-day flight. An additional docked day was approved during the flight by the Mission Management Team (MMT) originally to provide spacing between EVA 4 and EVA 5 when EVA 4 became a full duration EVA, but ultimately it was used as an additional day of replanning for EVA 4 after EVA 5 was cancelled. The additional day was gained through the saving of consumables, mainly due to the use of the Station-to-Shuttle Power Transfer System (SSPTS).

All times during the flight are given in Greenwich Mean Time (GMT) and Mission Elapsed Time (MET). Appendix A contains the sequence of events. Appendix B provides a table containing all Orbiter, SRB, RSRM, ET, and Integration in-flight anomalies (IFAs) and their status at the time of the publication of this report. Appendix C provides a list of sources of data, both formal and informal, that were used in the preparation of this report. Appendix D provides a list of acronyms, abbreviations and definitions as used throughout this report.

The eight crewmembers (seven up, seven down) that were on the STS-120 flight were Pamela A. Melroy, Colonel, U. S. Air Force Retired, Commander; George D. Zamka, Colonel, U. S. Marine Corp, Pilot; Scott E. Parazynksi, Civilian, M. D., Mission Specialist 1; Stephanie D. Wilson, Civilian, Mission Specialist 2; Douglas H. Wheelock, Colonel, U. S. Army, Mission Specialist 3; Paulo A. Nespoli, Civilian, European Space Agency, Mission Specialist 4; Daniel M. Tani, Civilian, ISS Flight Engineer (up to ISS); and Clayton C. Anderson, ISS Flight Engineer (down from ISS).

STS-120 was the fifth Shuttle flight for Mission Specialist 1, third Shuttle flight for the Commander, second flight for the Mission Specialist 2, ISS Flight Engineer 2 (up) and ISS Flight Engineer 2 (down), and the first flight for the Pilot, Mission Specialist 3 and Mission Specialist 4.

MISSION SUMMARY

Pre-launch

During the final-countdown Ice-Team inspection, clear ice with frost was noted near the LH₂ umbilical pyrotechnic canister closeout [In-Flight Anomaly (IFA) STS 120-I-001]. The ice was 4-in long by 1.5-in wide by 0.5-0.75-in thick. This ice exceeded the requirements of NSTS-08303 and Launch Commit Criteria (LCC) ICE-01. After assessment, a waiver was taken as the ice was attached to the Kapton purge barrier and it was expected to liberate at Space Shuttle Main Engine (SSME) and/or Solid Rocket Booster (SRB) ignition. This decision was based upon Eglin Air Force Base testing that demonstrated that ice does not bond to Kapton. The remainder of the ice (approximately 10-percent) was bonded to the fire retardant paint and was expected to remain through ascent based on testing. In the event that the ice did not release as expected, using the bounding ice-on-tile damage model and the Expected/Mean ice-on tile damage map, the ice release was determined to not cause critical Thermal Protection System (TPS) damage. Launch video later confirmed that the majority of the ice fell off at ignition.

Ascent and Flight Day 1

The Space Transportation System (STS) -120 mission was launched at 296/15:38:18.996 Greenwich Mean Time (GMT) on October 23, 2007, on the twenty-third Space Shuttle Program (SSP) mission to the International Space Station (ISS).

All Orbiter subsystems performed nominally during ascent and post-insertion with the exception of the SSME no. 1 inlet temperature sensor. At approximately 3 min after lift-off, the SSME 1 Liquid Oxygen (LO₂) inlet temperature transducer went to off-scale-high (OSH) (IFA STS-120-V-01). The temperature sensor resumed operation briefly after Main Engine Cutoff (MECO), but again dropped out approximately 2 min later. This condition did not affect the operation of the SSME or impact the ascent.

A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 296/15:40:32.541 GMT [00/00:02:13.545 Mission Elapsed Time (MET)], and the maneuver was 116.3 sec in duration.

MECO occurred at 296/15:46:46 GMT (00/00:08:27 MET). The External Tank (ET) separated from the Orbiter at 296/15:47:06 GMT (00/00:08:48 MET).

The SRB and ET separations were clearly visible from the ET camera.

A nominal OMS-2 maneuver was performed at 296/16:15:38.941 GMT (00/00:37:19.945 MET). The maneuver was 151.2 sec in duration with a differential velocity (ΔV) of 231.1 ft/sec. The achieved orbit was 123.8 by 160.0 nmi.

The payload bay doors were opened at 296/17:19:27 GMT (00/01:41:08 MET), and radiator flow was satisfactory.

The Ku-Band antenna was deployed at 296/17:30 GMT (00/01:51 MET). The system was powered-on at 296/17:33:00 GMT (00/01:54:41 MET), and the Radar self-test was completed satisfactorily at 296:17:43:50 GMT (00/02:05:31 MET).

An OMS-3 Nominal Correction (NC) -1 maneuver was performed nominally at 296/18:31:08.141 GMT (00/02:52:49.145 MET) with the cutoff at 296/18:32:02.1 GMT (00/02:53:43.145 MET), and both OMS engines operated nominally. The maneuver was 54.0 sec in duration with a ΔV of 83.4 ft/sec. The resulting orbit was 160.0 by 171.3 nmi.

The Shuttle Remote Manipulator System (SRMS) initial power-up procedures, which consisted of on-orbit initialization, power-up, checkout and power-down functions, were performed satisfactorily with no problems or issues noted during the SRMS checkout.

Flight Day 2

All mission tasks planned for Flight Day (FD) 2 were successfully completed. Various activities in preparation for the FD 3 docking with ISS were performed, including relocation of the Extravehicular Mobility Units (EMUs) and equipment to streamline subsequent EVA operations during this mission.

An OMS-4 (NC-2) maneuver was performed at 297/08:50:44.5 GMT (00/17:12:25.5 MET) with the cutoff at 297/08:50:57.5 GMT (00/17:12:38.5 MET), and both OMS engines operated nominally. The maneuver was 13.0 sec in duration with a ΔV of 20.2 ft/sec. The resulting orbit was 170.6 by 172.4 nmi.

When the crew moved the SRMS to grapple the Orbiter Boom Sensor System (OBSS) mounted on the starboard sill, the Point Of Resolution (POR) was different in the Orbiter Y-axis by $4\frac{1}{2}$ -in and the Orbiter Z-axis by 1-in from the expected values (IFA STS-120-V-03). The root cause was later determined to be a blanket around the Elbow-Pitch-Joint encoder that was not installed correctly.

During downloading of the Wing Leading Edge System (WLES) data, the system experienced many local timeouts, which are indicative of a communications problem (IFA STS-120-S-005). The teams switched to the backup Payload General Support Computer (PGSC) and data files from all sensors were transferred to the ground personnel for evaluation.

The FD 2 OBSS survey of the WLES and nose-cap was successfully completed. During the survey, an AMES gap filler was identified as protruding near starboard Reinforced Carbon-Carbon (RCC) panel no. 20 (IFA STS-120-V-05). The gap filler was protruding approximately 0.30-in and tapered to zero and was about 6-in long. The Damage Assessment Team (DAT) cleared the item based on previous mission similarities for the TPS.

The Orbiter Docking System (ODS) ring extension to the initial position was nominal, beginning at 297/18:10:51 GMT (01/02:32:32 MET) and ending 3 min, 37 sec later (dual motor time). The ODS ring extension activity was nominal.

During the rendezvous tools checkout, the Rendezvous Proximity Operations Program (RPOP) application failed to initialize (IFA STS-120-S-003). The crew reported a communications error with the COM 2 port with the Trajectory Control Sensor Command and Display (TCS-CAD) application trying to communicate with the Trajectory Control Sensor (TCS) through the Quatech card and the RS422 cable. The crew replaced the Quatech card with a spare and the COM 2 port problem was resolved. The RPOP performed nominally and no issues were reported

Flight Day 3

The primary activities for Flight Day 3 were rendezvous and docking to the ISS, and unberth and handoff of the OBSS.

The OMS-5 Nominal Height (NH) maneuver was a dual-engine firing occurring at 298/07:26:20.141 GMT (01/15:48:01.145 MET) with the maneuver complete at 298/07:26:35.741 GMT (01/15:48:16.745 MET). Both engines performed satisfactorily.

The OMS-6 (NC-4) maneuver was a right engine firing occurring at 298/08:13:12.9 GMT (01/16:34:53.945 MET) with the maneuver complete at 298/08:13:23.1 GMT (01/16:35:04.145 MET). The firing time was 10.2 sec with a ΔV of 7.8 ft/sec. The engine performed satisfactorily.

The Nominal Corrective Combination (NCC) Maneuver was a Reaction Control System (RCS) firing using 9 thrusters occurring at 298/08:57:45 GMT (01/17:19:26 MET). The maneuver was performed as planned.

The OMS-7 Target Intercept (TI) maneuver was a right engine firing occurring at 298/09:55:25.341 GMT (01/18:17:06.345 MET) with the maneuver complete at 298/09:55:36.742 GMT (01/18:17:17.745 MET). Engine performance was nominal.

Mid-course Correction-1 (MC-1) was a multi-axis RCS maneuver that occurred at 298/10:15:24 GMT (01/18:33:05 MET) with a firing duration 0.5 sec, and a Δ V of 0.1 ft/sec. The Out-of-Plane Null maneuver was a RCS firing at 298/10:31:27 GMT (01/18:53:08 MET). MC-2 was a multi-axis RCS maneuver with an ignition time of 298/10:51:08 GMT (01/19:12:49 MET). The firing duration was 6.7 sec with a Δ V of 1.6 ft/sec. MC-3 was a +X RCS maneuver with an ignition time of 298/11:08:07 GMT (01/19:29:48 MET). The Δ V delivered was 0.9 ft/sec. MC-4 was a 4.6-sec +X RCS maneuver. The ignition was at 298/11:18:10 GMT (01/19:39:51 MET). The Δ V

delivered was 1.1 ft/sec and the Orbiter was in a 187.3 by 180.0 nmi orbit. All of these maneuvers were nominal and led to a satisfactory rendezvous and docking.

The R-Bar Pitch Maneuver (RPM) started at 298/11:34:44 GMT (01/19:56:25 MET) and ended 10 min 35 sec later. During the RPM, the ISS crew took photographic imagery of the Orbiter and down-linked the images for analysis by the Photographic Imagery Team. The peak pitch-rate during the maneuver was approximately 0.69 deg/sec. The maximum roll error reached approximately 2 deg. Performance was nominal.

The ODS was activated at 298/12:09:46 GMT (01/20:31:27 MET).

Shuttle's capture of the Space Station occurred at 298/12:39:57 GMT (01/21:01:38 MET). The system was allowed to dampen out for approximately 7 min, 28 sec. Ring retraction was started at 298/12:47:25 GMT (01/21:09:06 MET). Ring retraction, using dual motors, proceeded nominally for approximately 3 min, 19 sec with good ring alignment. The hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the ring final-position being acquired at approximately 298/12:54:40 GMT (01/21:16:21 MET), at which time docking operations were completed nominally.

Shortly after docking, the Space Station Remote Manipulator System (SSRMS) grappled the OBSS in the payload bay of Discovery and handed it off to the SRMS. The SSRMS then maneuvered into a position ready to support the unberthing of Node 2 during the first EVA on FD 4.

The Station-to-Shuttle Power Transfer System (SSPTS) was activated, and the SSPTS was transferring 6.5 kW of power to the Orbiter, which is the maximum power level that can be transferred.

Flight Day 4

On FD 4, the first EVA of the mission was successfully completed in 6 hr 14 min. The previously failed S-band Antenna Support Assembly (SASA) was successfully stowed in the Orbiter Payload Bay (PLB), the Node 2 module was installed on the Node 1 port Common Berthing Mechanism (CBM), and the Port (P) 6 Truss was prepared for relocation to the outboard location of P5. Fluid Quick-Disconnects (QD's) between the Zenith (Z) 1 Truss and the P6 Truss were disconnected and thermal shrouds were installed on the P6 Aft Photovoltaic Radiator (PVR) and the P6 Sequential Shunt Unit (SSU). The Node 2 Starboard CBM hatch window cover that was reported open on FD 1 was closed during the EVA.

It was also discovered that Camera A was at 49 °C, which is an over-temperature condition, but no Closed Circuit Television (CCTV) over-temperature indication was sent from the CCTV system. It was determined that the crew power-cycled the Video Control Unit (VCU) for 3 sec during their post-sleep. This is believed to have caused the logic to lock up, since the VCU was not off longer than 5 sec. The VCU was

subsequently power cycled from the ground, which recovered the CCTV overtemperature indication.

During the Payload Retention Latch Assembly (PRLA) release prior to Node 2 unberthing by the SSRMS, the transition of the PRLA 4 "A" system latch indication was delayed (IFA STS-120-V-02). After the latch was commanded from the latched to the released position, the latched indication required approximately 18 seconds to change from the "on" to the "off" state. The "B" system switch changed state during the first second as expected.

The crew completed the Node 2 installation and the Node 1/Node 2 vestibule leak check was completed near the end of FD 4.

The power transfer from the SSPTS to the Orbiter was deactivated prior to the start of the EVA, and the power transfer from the Orbiter to the Node 2 was deactivated prior to Node 2 removal from the payload bay. SSPTS operation was resumed at the completion of the EVA.

The DAT cleared all of the RCC for entry.

Flight Day 5

On FD 5, the OBSS was handed off to the SSRMS and berthed on the starboard sill of the Orbiter payload bay. In addition, Node 2 vestibule outfitting and crew ingress, and transfer operations continued. The crew also reviewed procedure updates for the second EVA, which included a task to inspect the Starboard Solar Alpha Rotary Joint (SARJ). This inspection was part of an ongoing root-cause-analysis effort to assess higher-than-normal SARJ motor current trends.

The crew completed troubleshooting of the onboard PGSC network, which had been working intermittently throughout the mission. The crew replaced all of the network cables and the COM 3 card in the Ku-Band File Transfer (KFX) PGSC, and the network was functional.

Flight Day 6

On FD 6, the second EVA was successfully completed in 6 hr 33 min. Tasks accomplished during the EVA included detaching the P6 Truss from the Z1 Truss and maneuvering of the P6 Truss by the SSRMS, installation of outfitting hardware on the exterior of Node 2, reconfiguration of the Main Bus Switching Unit (MBSU), and installation of the Node 2 Power Data Grapple Fixture (PDGF). The starboard SARJ was inspected and unidentified debris was found near the teeth of the wheel. A sample of the debris was collected.

During the EVA, both digital cameras stopped functioning and attempts to recover the operation of the cameras were unsuccessful (IFA STS-120-V-10). As a result, no digital pictures of the SARJ condition could be taken.

The Flash Evaporator System (FES) was deactivated to allow more water production.

The power transfer from the SSPTS was deactivated prior to second EVA, and operation was resumed at the completion of the EVA.

The DAT finished their analysis of loads during entry concerning a protruding blanket on the left OMS pod. Analysis of the condition, using a 0.5-in worst case step for the whole blanket length, showed the loads on the tiles still maintained a 2.12 Factor of Safety (FS), with the minimum allowable being 1.4 FS. There was no concern with debris liberation during descent, and the TPS was completely cleared and ready for entry.

Flight Day 7

On FD 7, the SSRMS handed off the P6 truss to the SRMS to allow the Mobile Transporter (MT) and SSRMS to translate to Work Site (WS) 8. The SRMS then handed off the P6 truss back to the SSRMS and maneuvered to the pre-cradle position. The SSRMS held the P6 truss at the hand-off position overnight.

The PGSC for the WLES experienced a blank monitor while the PGSC was powered (IFA STS-120-S-006). A backup PGSC was used.

The MMT added one additional day of docked operations to the mission. The day was originally added between the fourth EVA and the fifth EVA. This additional docked day was to allow the fourth EVA to be a full duration EVA dedicated to starboard SARJ inspection. The SARJ troubleshooting also resulted in the Tile Repair Ablator Dispenser (TRAD) Development Test Objective (DTO) being cancelled for the flight.

Flight Day 8

The third EVA was performed on FD 8, and the duration of the EVA was 7 hr 8 min. During the EVA, the installation of the P6 solar array assembly in its permanent location on the ISS was completed. The 2B solar array of the P6 assembly was deployed satisfactorily. The deployment of the 4B solar array on the P6 assembly was aborted at 25 bays because of a tear in the solar array.

As a result of the starboard SARJ anomaly, an inspection of the port SARJ was added to the third EVA. The inspection of the port SARJ was added to provide a baseline for comparison with the starboard SARJ. No anomalies were noted on the port SARJ

During the third EVA, EMU 3004 demonstrated degraded sublimator performance. Consequently, this EMU was returned instead of remaining on the ISS for future use. As a result of the degraded sublimator performance on the EMU, the RCC Repair team investigated the feasibility of performing a contingency EVA for RCC repair with one EVA crewmember. The team concluded that the repair would be feasible. EV1 would be in the foot restraint on the SRMS performing the repair. The crack repair bag would stay in the airlock and EV1 would take a minimum complement of tools to the worksite. EV2 would stay in the airlock on the service and consumables umbilical until needed.

The ISS team assessed the feasibility of using the SSRMS to grapple the OBSS and use it as a work platform to reach the damaged 4B solar array. The Orbiter team assessed the impact on the Late Inspection as a result of using the OBSS for the solar array repair since the sensors would be without power for significantly longer than the 90 minutes for which they were certified.

Flight Day 9

The crew's primary activity for the day was transfer of items between the two vehicles.

The Nitrogen (N_2) transfer was completed after approximately 30 lb of nitrogen was transferred.

Two new indications were seen by the WLES sensor, for a total of seven on-orbit indications. One of the new indications on panel 1L was 2.74 g, which is the largest seen on any Shuttle flight.

The ISS MMT and Shuttle MMT made the decision to delay the fourth EVA one day from the nominal FD 10 to FD 11 and dedicate the entire EVA to the P6 4B solar array repair. The purpose of the delay was made to allow the planning team additional time to identify a repair method, design a repair, and develop procedures.

Flight Day 10

In preparation for the fourth EVA to repair of the P6 Solar Array Wing (SAW), the crew completed the EMU suit and tool configuration. The crew also completed construction of the Solar Array Hinge Stabilizers. These stabilizers were installed on the 4B SAW during the fourth EVA to prevent further separation of the solar array at the hinge and to repair the damage.

The SSRMS was powered up and maneuvered to its Mobile Transporter (MT) translation stow position.

The Orbiter maneuvered the stack using the Vernier RCS to the water dump attitude at 304/12:52 GMT (07/21:14 MET). The 10-degree roll maneuver was completed in 5 min. The Orbiter maintained attitude control during the water dump for 1 hr 50 min. The Orbiter also performed the maneuver back to Torque Equilibrium Attitude (TEA). The maneuver from water dump to the TEA started at 304/15:13 GMT (07/23:52 MET) and completed 7 min later. The Free Drift mode was selected on the Digital Autopilot (DAP) and attitude control was returned to the ISS. After a period of the ISS Momentum

Management (MM) holding attitude, the Orbiter again took control of the stack for the maneuver to the -XLV +ZVV (ISS +XVV) attitude. This 180-degree maneuver was performed for thermal conditioning and began at 304/18:43:28 GMT (08/03:05:09 MET) and was completed approximately 32 min later. The Free Drift mode was again selected on the Orbit DAP approximately 4 hr later, handing control back to the ISS.

The ISS and SSP Managers deferred the fourth EVA from FD 11 to FD 12 to allow the teams sufficient time to complete all of the operational products and to close the open work.

The landing was set for FD16, November 7, 2007, and a descending-node landing was assessed to provide easier crew-sleep shifts as well as a daylight landing.

Flight Day 11

On FD 11, the crew reviewed procedures for the Solar Array Hinge Stabilizer installation in preparation for EVA 4. The crew successfully completed the tool configuration by modifying certain tools to be nonconductive for EVA use.

After the MT was translated back to WS3 with the SSRMS, the SSRMS un-berthed the OBSS from the Shuttle, and handed it off to the SRMS. The MT was then translated back to WS8 with the SSRMS. The SSRMS maneuvered to the OBSS pre-grapple position and was ready to take the OBSS back from SRMS before EVA-4.

The crew reported that an Advanced Video Interface Unit (AVIU) was damaged. The AVIU Low/High switch was accidentally broken off when a tool was being used ot loosen a tight connector near the switch. The loss of this unit did not impact the mission.

On FD 11, two WLES sensors from Starboard Group 2 reported simultaneously forced triggers, but the third sensor in that group did not indicate that it sent the signal for the two sensors to respond. Analysis shows that either the sensor sent the signal and did not record this activity or the other two units erroneously triggered and recorded the activity incorrectly. This was explained post-flight as a ground commanding issue.

Flight Day 12

The main event for FD 12 was the fourth EVA to repair the ISS 4B solar array. The SSPTS was deactivated during the EVA.

The crew successfully repaired the 4B solar array during the fourth EVA, and the duration of the EVA was 7 hr 19 min. The array was fully deployed during the EVA and has been generating full power. During the EVA, the EV1 crewmember's digital camera experienced focusing problems (IFA STS-120-V-10).

Following the EVA, the OBSS was handed back to the SRMS, and the OBSS was powered at the Undock position. The Laser Dynamic Range Imager (LDRI), the Intensified Television Camera (ITVC) and the Integrated Sensor Inspection System (ISIS) Digital Camera (IDC) were all checked and good images were confirmed. The Laser Camera System (LCS) checkout was halted after error messages were received. No troubleshooting was performed, as the LCS was not required for the Late Inspection or Focused RCC Inspection.

The -Y star tracker was seeing limited stars of opportunity. Flight Control reported that the P6 4B solar array was partially blocking the field-of-view of the star tracker. This condition also accounted for reflected light being seen by the star tracker. A self-test was performed of the star tracker that confirmed that the unit was operating nominally.

The WLES sensors showed a single new indication with a magnitude of 1.01g. The location of the indication was WLE starboard panels 1 and 2.

Also during the day, the Wing Leading Edge Impact Detection System (WLEIDS) PGSC experienced four more local timeouts. Troubleshooting was performed and showed that the PGSC was performing nominally.

Flight Day 13

The main events for FD 13 were EVA hardware transfer, crew off-duty, rendezvous tools checkout, and crew farewells and hatch closure.

When the crew turned off the payload bay floodlights, the amperage did not drop the full amount, which indicated that one of the two floodlights on that bus was not working properly. It was determined that the mid port payload bay floodlight (no. 3) was not illuminating (IFA STS-120-V-07).

Video downlink from camera C in the payload bay had a yellow overall hue when viewed on multiple monitors in the Mission Control Center (MCC). Later the images appeared to be normal. This was likely due to a potentiometer problem within the camera, but the issue has not been duplicated.

During the Oxygen (O_2) teardown activity, the crew reported that the plug on the bent end of the Gaseous Oxygen (GO_2) transfer flex-hose assembly could not be installed. The crew was able to soft-mate the plug onto the hose, but not to complete the hardmate. The plug was transferred to the Orbiter for return. The issue was later attributed to an error in a procedure.

The crew reported that one of the Contingency Water Containers (CWCs) that was to be transferred to the ISS was leaking (IFA STS-120-N-001). The CWC was stowed aboard the Orbiter wrapped by a trash bag and was dumped overboard during a water dump after undock.

Also on FD 13, the crew reported that they noticed a Micrometeoroid Orbital Debris (MMOD) strike to the thermal pane of window 2 (Commander's center window). They reported the impact to be approximately 3mm in diameter. The MMOD strike to the thermal pane was cleared for entry.

The farewell ceremony was conducted between the ISS and Discovery crews, followed by egress of the seven Shuttle crew members, hatch closing, ODS vestibule depress, and a leak check between Pressurized Mating Adapter (PMA)-2 and the vestibule. The ISS crew also began EVA tool configurations in preparation for the next Stage EVA scheduled for November 9, 2008.

Flight Day 14

Daylight Savings Time ended at the start of FD 14. This did not cause any problems.

During a handover of attitude control from the ISS to the Orbiter, the crew reported unexpected ISS attitude control mode data on Specialist Function (SPEC) 205 (IFA STS-120-S-001). Use of this data display for this mode was aborted by the crew, and the handover was completed using ground instructions.

The crew reported prior to undocking that the RPOP computer was unable to read the TCS, and was not available for the undocking and flyaround operations. This problem did not impact the overall undocking and flyaround operations.

Undocking from the ISS was performed nominally at 309/10:32:04 GMT (12/18:53:45 MET). The flyaround maneuver was performed nominally.

The RCS separation-1 maneuver was performed satisfactorily at 309/11:46:19 GMT (12/20:11:00 MET). The maneuver was 6.52 sec in duration and the ΔV was 1.7 ft/sec.

The RCS separation-2 maneuver was performed satisfactorily at 309/12:14:29 GMT (12/20:36:10 MET). The maneuver was 6.16 sec in duration and the ΔV was 1.6 ft/sec.

A nominal RCC late inspection was conducted with no issues reported. All imagery was successfully down-linked per the timeline and the RCC DAT began the review.

The WLE sensor system was shutdown for the remainder of the flight after battery depletion.

Flight Day 15

The FCS checkout was performed satisfactorily. Auxiliary Power Unit (APU) 1 was used for the checkout and the APU ran for 4 min, 38 sec.

The RCS hot-fire was initiated at 310/11:32:43 GMT (13/19:54:24 MET) and was completed 8 min 2 sec later. All 38 RCS thrusters were fired at least once with 6 of the thrusters fired twice.

The Maui Analysis of Upper atmosphere Injections (MAUI) firing was a payload of opportunity and was performed satisfactorily. Ignition for the first firing sequence began at 310/14:11:02 GMT (13/22:32:43 MET) and was performed over a 54-sec period. Each firing sequence during the maneuver consisted of 3 sec per pulse.

The FES feedline A high-load line temperature had cycled at higher than its expected range on FD 15. This is believed to be an explained condition as the topping flowed more water and the vehicle sloshed some cold slugs of water by the thermostats during an attitude change.

During the CWC dump through the waste nozzle, the nozzle B temperature diverged from the nozzle A temperature before the waste dump valve was re-opened (IFA STS-120-V-08). The nozzle B temperature climbed to approximately 400 °F (off-scale high) for several seconds before returning back to on-scale and tracking the nozzle A temperature transducer. This condition did not impact the mission or the water dump. It likely is a bad nozzle sensor transducer.

The OMS-8 orbit-adjust maneuver was a dual engine firing occurring at 310/19:54:19.341 GMT (14/04:16:00.345 MET) with the maneuver complete at 310/19:55:13.341 GMT (14/04:16:54.345 MET). The firing time was 54 sec with a ΔV of 99.9 ft/sec. The orbit following the maneuver was 124.2 by 188.0 nmi. The engines performed satisfactorily.

The Late Inspection imagery review was completed and the vehicle was cleared for entry by the DAT.

Flight Day 16: Entry and Landing

The Payload Bay Doors (PLBDs) were closed nominally at 311/14:19:43 GMT (14/22:41:24 MET) in preparation for landing.

The deorbit maneuver was performed on orbit 238 for the first landing opportunity at Kennedy Space Center (KSC), a dual-engine straight-feed firing, was performed at 311/16:58:49.141 GMT (15/02:20:30.135 MET). The duration of the deorbit firing was 114.2 sec and the ΔV was 216.3 ft/sec. The orbit following the deorbit firing was 11.7 by 187.8 nmi. The engines performed satisfactorily.

Entry Interface occurred at 311/17:29:43 GMT (15/01:51:20 MET), and entry was completed satisfactorily. The main landing gear touchdown occurred on KSC concrete runway 33 at 311/18:01:17 GMT (15/02:22:54 MET) on November 7, 2007. The drag chute was deployed at 311/18:01:26.3 GMT. Nose-gear touchdown occurred at

311/18:01:30 GMT. Drag chute release occurred at 311/18:01:53.1 GMT. Wheels stop occurred at 311:18:02:11 GMT. The rollout was normal in all respects.

The flight duration was 15 days 2 hr 22 min 54 sec. The last Auxiliary Power Unit was shutdown at 311/:18:19:43 GMT (18 min 26 sec after landing). The Space Shuttle Atlantis successfully completed the STS-120 mission with a nominal KSC Landing.

PAYLOADS AND EXPERIMENTS

LAUNCH PACKAGE OVERVIEW

The ISS 10A launch package consisted of the Node 2 (Harmony), which is 23.6 ft long, 14.5 ft wide and weighs 31,500 lb, and was carried in the payload bay during ascent. This node is a utility hub, providing air, electrical power, water and other systems essential to support life on the ISS. Node 2 has five Common Berthing Mechanisms (CBMs) for attaching additional international science laboratories and cargo spacecraft.

The Power and Data Grapple Fixture (PDGF) as well as the sidewall-mounted Main Bus Switching Unit (MBSU) Flight Service Equipment (FSE), and the S-Band Antenna Subsystem Assembly (SASA) FSE were located in the payload bay during ascent.

The ISS Program Utilization payloads that were flown in the Middeck were Perceptual Motor Deficits in Space (PMDIS), European Space Agency (ESA) Hand Posture Analysis (HPA), Nutritional Sample Collection Kits (SCKs), SPORE, and Fisher Rat Thyroid Cells (FRTL-5). The SPORE and FRTL-5 payloads were Agenzia Spaziale Italiania (ASI) sortie payloads.

Short Duration Bioastronautics Investigations (SDBIs) performed during the mission included SDBI-1503-S (Midodrine), SDBI 1490B/SDBI 1634 (Promethazine (PMZ)/SLEEP), and SDBI 1900 (Integrated Immune). Two Double Cold-bags were used to return Nutrition, Tropi, and ESA IMMUNO samples.

The Ram Burn Observations (RAMBO) and Maui Analysis of Upper atmospheric Injections (MAUI) were flown as payloads of opportunity. RAMBO was not performed because night passes over the monitoring sites did not exist. The MAUI payload of opportunity was performed on FD15.

Three Shuttle Development Test Objectives (DTOs) were flown on the STS-120 mission and are discussed in the Development Test Objective section of this report. These DTOs were:

- 1. DTO 848 Thermal Protection System (TPS) Tile Repair Techniques.
- 2. DTO 853 In-Flight Evaluation for Areas of Carbon Dioxide (CO₂) Concentration.
- 3. DTO 805 Crosswind Landing Performance (DTO of opportunity).

Three ISS DTOs were also flown on this mission and these were:

- SDTO 17010-J Multi-Protocol Converter, for live High-Definition Television (HDTV) Downlink with Multi-protocol Converter (MPC) and incorporation of the HDTV System.
- 2. SDTO 13005-U ISS Structural Life and Life Validation and Extension.

3. SDTO 15003-U – ISS Microgravity.

CREW ACTIVITY SUMMARY

Discovery docked to the ISS on FD3, October 24, at 7:40 a.m. Central Daylight Time (CDT) [1/21:02 Mission Elapsed Time (MET)]

Shortly after docking, the OBSS was grappled and unberthed from the payload bay by the SSRMS, and handed off to the SRMS. The crew also successfully completed the initial on-orbit activation of the OV-103 Station-to-Shuttle Power Transfer System (SSPTS).

On FD 4, the first EVA was completed and included the SASA retrieval from the Z1 truss, the removal of the side-wall mounted PDGF and temporary attachment to Node 2, and the unberth of Node 2 from the payload bay and installation onto its temporary Node 1 port Active CBM location.

On FD 5, the OBSS was returned to the starboard sill of Discovery's payload bay.

The second EVA was completed on FD 6 and included the detachment of the P6 truss from Z1, installation of outfitting hardware and a PDGF on Node 2, MBSU reconfiguration, and inspection of the starboard SARJ. The Starboard SARJ inspection revealed metal shavings under the Multi-Layer Insulation (MLI) covers. The EV crew collected samples which were returned for analysis on the ground.

During the FD 8 EVA 3, P6 was installed in its permanent location on ISS on the port side of P5. Deployment of the 2B solar array was performed without issue. The crew aborted the deployment of the 4B because of tears in the solar array. The repair of these tears was then planned for the fourth EVA to be performed on FD 12.

The crew successfully repaired the 4B solar array during EVA 4 on FD12. The array was fully deployed during the EVA. The EV crewmember performed the repair from the tip of the OBSS, which was grappled by the SSRMS.

Due to the planning and crew preparations for the SAW repair, the tasks for planned EVA 5 were deferred to ISS-10A Stage. These tasks primarily focused on preparations for the relocation of Pressurized Mating Adapter (PMA) 2 to the end-cone of Node 2 and the relocation of the Node 2/PMA 2 stack to forward end of the US Lab. In addition, the T-RAD DTO that was planned for EVA 4 was deferred to a future Shuttle mission.

Discovery undocked from the ISS on FD 14, November 4, at 4:32 a.m. Central Standard Time (CST) (12/18:54 MET).

TRANSFER WEIGHT SUMMARY

The majority of the ISS-10A transfers were successfully accomplished during this mission. The following table reflects the total weight of the transfers.

	To ISS, Ib	From ISS, Ib
Middeck	1658	1782
Node 2 with PDGF	31648	0
SASA	0	238
MBSU	528	0
Totals	33834	2020

TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Orbiter consumables transferred to the ISS during the mission included:

- 1. **Water –** The total quantity of supply water transferred was 939.1 lbm. This transfer was comprised of 9 Contingency Water Containers (CWCs) (864.3 lbm), and 4 Payload Water Reservoirs (PWRs) (74.8 lb). One leaking CWC was returned to the Orbiter and it was dumped overboard. In addition, one Oxygen Generator System (OGS) PWR was filled twice to support OGS operations.
- 2. **Oxygen –** No oxygen was transferred in accordance with the pre-mission plan.
- 3. Nitrogen The total transfer of nitrogen to the Airlock tanks was 31.6 lbm.
- Lithium Hydroxide Three used Lithium Hydroxide (LiOH) canisters were transferred to the ISS. Nine canisters were transferred to the Orbiter, and these were used during the flight.
- 5. **Food –** Eight food containers were launched in Node 2.

SIGNIFICANT FIRSTS

The significant firsts for the STS-120 mission were as follows:

- 1. The first flight of SSME High Pressure Oxidizer Turbopump (HPOTP) with redesigned knife-edge seals.
- 2. The first flight of the Low Pressure Oxidizer Turbopump (LPOTP) Joint 05 corrosion inhibitor on the threaded inserts.
- 3. The first flight of the OI-32 flight software.
- 4. The first use of all A31P Payload and General Support Computers (PGSC's).
- 5. The first flight of the Station-to-Shuttle Power Transfer System (SSPTS) on the OV-103 vehicle.
- 6. The first International Space Station (ISS) assembly flight with five planned EVAs.
- 7. The first flight with two female Commanders (CDRs) Shuttle CDR Pam Melroy and ISS CDR Peggy Whitson.
- The first planned on-orbit use of T-RAD/STA-54 tile repair material (DTO-848).

9. The first use of the Orbiter Boom Sensor System (OBSS) with EVA on the Space Station Remote Manipulator System (SSRMS) (not planned pre-flight)

SIGNIFICANT ISS ANOMALIES

The starboard Solar Alpha Rotary Joint (SARJ) exhibited higher than expected SARJ currents since ISS Stage 13A.1. The average currents did decrease when the ISS transitioned to the -X Axis on Velocity Vector (-XVV) flight attitude on FD 3. However, the observed currents still remained higher than expected. During the second EVA, an inspection of the starboard SARJ was added.

A 360-deg inspection of the external SARJ structure did not reveal any anomalous configurations or any obstructions. However, upon removing the MLI no. 12 cover, unidentified debris was found near the teeth of the wheel. The race ring near this area was also discolored. A sample of the debris was collected on Kapton tape, which was photographed and downlinked to the ground for specialists to analyze. The sample was returned for subsequent analysis.

An inspection of the port SARJ was added to the third EVA so that data would be available for comparison to the inspection performed during the second EVA on the starboard SARJ. The inspection of the port SARJ did not yield any anomalous configurations, obstructions or Foreign Object Debris (FOD).

During the FD 8 deployment of the P6 Solar Array Wing (SAW) 4B, the crew reported a tear in the inboard side of the right blanket around panels 34-36. Upon further inspection, two different tears were noted in the same area. The root cause appeared to be binding between grommets and the inboard guide wire. Upon noticing the tear, which was difficult due to lighting conditions caused by the high negative solar beta angle, the crew aborted the deployment with approximately 25 bays extended. One bay was then retracted to take tension off the damaged area.

To complete the deployment of the 4B SAW, the fourth EVA was reworked to be exclusively SAW repair. The EV1 crewmember was moved to the damage location, using the SSRMS and OBSS, to clip the tangled guide wire and install support "cufflinks" to restore structural integrity to the blanket. The SAW was successfully deployed and tensioned following the EVA.

MAJOR ISS MISSION PRIORITIES

The following table provides a listing of all the ISS Mission priorities and their status as of the end of the mission.

Mission	Mission Task	Flight Day
priority	• · · · ·	Completed
	Category 1	
1	Install Node 2 to Node 1 Port Common Berthing Mechanism (CBM) and activate Node 2 shell heaters.	FD 4
2	Rotate E15/16 FE-2 (13A) crew member with E16 FE-2 (10A) crew member, transfer mandatory crew rotation equipment and perform mandatory crew rotation tasks (Safety brief, IELK install, Sokol suit checkout).	FD 3
3	Transfer mandatory water quantities per 10A Transfer Priority List (TPL). No mandatory water was required by the TPL.	FD13
4	Transfer critical items per ISS-10A transfer priority list.	FD 3- 5
5	Relocate P6 from Z1 to P5:	
	a. Install P6 aft radiator shroud.	FD 4/EVA 1
	 Install Sequential Shunt Unit (SSU) covers prior to beginning P6 relocation. 	FD 4/EVA 1
	c. Disconnect Z1/P6 utility tray power, data, and fluid umbilicals.	FD 4/EVA 1
	d. Remove P6 from Z1 and install P6 to P5.	FD 6, 8
	e. Connect P5/P6 utility tray power and data umbilicals.	FD 8/EVA 3
	f. Configure Main Bus Switching Unit (MBSU) jumpers to support P6 startup on P5.	FD 6/EVA 2
	Category 2	
6	Transfer Node 2 Power and Data Grapple Fixture (PDGF) to ISS.	FD 4/EVA 1
7	Retrieve S-Band Antenna Sub Assembly (SASA) from Z1 for return in Shuttle Payload Bay.	FD 4/EVA 1
8	Install Main Bus Switching Unit (MBSU) to External Stowage Platform (ESP) 2.	FD 8/EVA 3
9	Perform minimum handover time of 12 hours for rotating crewmember.	FD 4-13
10	Transfer remaining cargo per ISS-10A transfer priority list. Includes water.	FD 4-13
11	Install Node 2 PDGF and Node 2 PDGF terminator and cover (Node 2 relocation/ISS-1E preparatory task). PDGF installed, but connector not mated. Defer to Stage 10A EVA.	FD 6/EVA 2 (partial)
12	Install four Node 2 trunnion covers and one keel pin cover.	FD 6/EVA 2
13	Perform P6 re-activation:	
	 Remove P6 single point grounding plugs and install caps on P6 jacks. 	FD 8/EVA 3
	 Release P6 forward radiator cinches, deploy photovoltaic radiator, and activate photovoltaic thermal control system. 	FD 8/EVA 3
	 c. Configure P6 elements for power generation and deploy P6 (channel 2B and 4B) solar array wings. 	FD 8-12
	d. Activate P6.	FD 8
	d.1 Perform P6 4B SAW Repair. (Added Task)	FD 12/EVA 4
	e. Remove SSU covers after installation is complete	FD 8/EVA 3
	f. Recondition P6 batteries	FD 9

MAJOR ISS MISSION PRIORITIES COMPLETED

Mission priority	Mission Task	Flight Day Completed
_	Category 3	
13.1	Retrieve Articulating Portable Foot Restraint (APFR) 3 and Ingress Aid and perform IVA Inspection.	FD 12/EVA 4
13.2	Perform Interim Resistive Exercise Device (IRED) cord change and calibration.	FD 10
14	Perform Pressur4ized Mating Adapter (PMA) 2 relocation readiness tasks:	Deferred
	a. Demate PMA 2/Laboratory umbilicals	
	 Remove Node 2 Active Common Berthing Mechanism (ACBM) cover (shower cap). 	Deferred
	c. Perform Node 2 forward ACBM sealing surface inspection.	Deferred
	 Demate and temporarily stow PMA 1/Laboratory Station-to-Station Power Transfer System (SSPTS) cables. 	Deferred
15	Preparations for Stage EVA relocation of Node 2 fluid umbilical trays and avionics connections:	
	a. Demate and temporarily stow Node 2 avionics tray cables.	Deferred
	 Install Node 2 external outfitting hardware including the installation of Node 2 handrails (up to 11) and gap spanners (2) (10 of 11 handrails + 1 gap spanner completed. 	FD 6/EVA 2
	 Remove Node 2 avionics caps (16 aft and 5 forward) 	FD 6/EVA 2
16	Mate S0/S1 Service Module (SM) power cable, configure PMA1/FGB H- jumpers [power reconfiguration for Automated Transfer Vehicle (ATV) docking).	Deferred
17	Deploy S1 radiator outer panels:	
	 Connect squib firing units (SFUs) power harness. 	FD 6/EVA 2
	b. Release cinches.	FD 6
	c. Deploy S1 radiator outer panels (two).	FD 7
	 Disconnect the SFUs power harness and reconfigure to power radiator beam line heaters, and activate S1 fluid line secondary heaters. 	FD 6/EVA 2
18	Ready P1 radiator outer panels for deployment: Connect SFUs power harness.	FD 8
19	Remove/replace S0 4BC Remote Power Controller Module (RPCM).	Deferred
20	Perform DTO 848 TPS Repair Techniques (TRAD/STA-54 Tile Repair Demonstration).	Deferred
21	Perform Internal Thermal Control System (ITCS) remediation (install Anti- Microbial Assembly (AMIA), canister run, remove AMIA, take ITCS sample, return sample).	FD 11
21A	Perform operations to restore redundancy of Starboard Thermal Radiator (STR) Service Module Loop.	FD 2
21B	Perform External Wireless Instrumentation System (EWIS) Network Communications Unit (NCU) configuration, activation, and initial checkout	FD 11
22	Perform United States On-orbit Segment (USOS)/Russian Segment (RS) daily ISS payload status checks as required.	Daily
23	Retrieve/return Z1 Baseband Signal Processor (BSP).	Deferred
24	Perform Node 2 Zenith Active Common Berthing Mechanism (ACBM) checkout and petal capture.	FD 5

MAJOR ISS MISSION PRIORITIES COMPLETED (Continued)

Mission priority	Mission Task	Flight Day Completed
25	The following tasks are deemed to fit within the existing EVA timelines; however, they may be deferred if the EVA is behind schedule. The EVA will	
	not be extended to complete these tasks:	Defensed
	a. Install Laboratory gap spanners (4) and preposition tools for stage EVAs.	Deferred
	 Remove US Laboratory Crew and Equipment Translation Aid (CETA) light and stanchion and bring inside. 	Deferred
	c. S1 CETA handrail imagery.	FD 6/EVA 2
	d. Perform starboard Solar Alpha Rotary Joint (SARJ) inspection.	FD 6/EVA 2
	e. Install Node 2 Worksite Interface Fixtures (WIFs) (up to 3).	FD 6
	f. Release Node 2 Zenith ACBM petal restraints	FD 6
	 g. Remove Node 2 Starboard, Zenith, Port, and Nadir hatch latch pins in order of priority. 	FD 6
	h. Open Node 2 Nadir Centerline Berthing Camera System (CBCS) center disk cover flap.	Deferred
26	Perform the following utilization activities:	
	a. SDBI 1503-S Midodrine.	FD 16
	b. SDBI 1409b/1634 Promethazine (PMZ)/Sleep Short.	Multiple
	c. SDBI 1900 Integrated Immune.	Multiple
	 d. Operator for ISS Integrated Immune Long Duration crew subject (can be either SSP or ISS crew). 	Multiple
	e. Rotate Fisher Rat Thyroid Cells (FRTL-5) hardware 90° anytime prior to landing.	FD 11
	f. Hand Posture Analysis (HPA) on ISS for ESA shuttle crewmember only.	FD 9
27	Perform Node 1 Port-to-Node 2 vestibule pressurization and gross leak. Check.	FD 4
28	Perform Node 1 Port-to-Node 2 vestibule configuration for ingress.	FD 5
29	Ingress Node 2 and perform outfitting tasks:	
	a. Install Node 2 forward CBCS.	FD 6
	b. Install temporary Intermodular Ventilation (IMV) ducts.	FD 5
	c. Install Portable Fire Extinguisher (PFE) and Portable Breathing Apparatus (PBA).	FD 6
	d. Install Starboard, Port Positive Pressure Relieve Valve (PPRV) caps.	FD 5
	e. Inspect Port aft and Port forward Negative Pressure relief valves (NPRVs).	FD 5
	f. Remove aft port NPRV and install IMV valve.	FD 6
	g. Perform avionics rack outfitting:	
	 Release rack launch restraints, install knee brace attachment replacements (k-bars) and pivot fittings. 	FD 7
	 Install Direct Current-to-Direct Current Converter Unit (DDCU) parallel connectors for each pair of parallel DDCUs. 	FD 7
	 Install Internal Thermal Control System (ITCS) sample tool and install ITCS protective plate in deck DDCU rack 	FD 9
	h. Deploy Zero-g Stowage Racks (ZSRs) (nod2o5, nod2d5).	FD 9
	i. Install Resupply Stowage Rack (RSR) k-bars.	FD 7
	j. Remove closeout panel launch bolts (approximately 700).	FD 5-10

MAJOR ISS MISSION PRIORITIES COMPLETED (Continued)

Mission priority	Mission Task	Flight Day Completed
	 k. Install hatch latch handle guide assemblies on Node 2 aft, Node 1 port hatches. 	FD 10
	 Remove Node 2 Common Cabin Air Assembly (CCAA) anti-vibration module launch brackets (4). 	FD 9
30	Perform USOS/Russian Segment ISS payload research operations tasks.	Daily
31	Reboost the ISS with the Orbiter as mission resources allow, consistent with ISS trajectory analysis and planning.	Not Required
32	Perform program-approved EVA get-ahead tasks. The following EVA get- ahead tasks do not fit in the existing EVA timelines; however, the EVA team will be trained and ready to perform should the opportunity arise. EVA/Mission Operations Directorate (MOD) has the flexibility to select the tasks to be completed based on efficiencies gained in performing the already scheduled required tasks.	
	 Install protective caps on open Laboratory jacks after PMA 2 umbilical release. 	Deferred
	 Break torque on P1 NTA bolts. 	Deferred
	c. Install Laboratory MMOD shield.	Deferred
	 Install Wireless Video System External Transceiver Assembly (WETA) at Camera Port 1 on S3 Face 4. 	Deferred
33	Prepare U.S. Laboratory forward vestibule for hatch closure and PMA-2 relocation:	
	 Install U.S. Laboratory forward ACBM controller panel assemblies (four) and MLI covers. 	FD 14
	b. Disconnect O₂/N₂ lines between U.S. Laboratory and PMA-2.	FD 13
	c. Disconnect ventilation lines between U.S. Laboratory and PMA-2.	FD 13
	d. Install PMA-2 CBCS target.	FD 14
34	Perform DTO-853 Carbon Dioxide Monitor.	Multiple
	Category 4	
35	Perform imagery survey of ISS exterior during Orbiter flyaround after undocking	FD 14
36	Transfer N2 from Shuttle to ISS HPGTs as Orbiter consumable margins permit.	FD 4-7
37	Perform 4 hr of additional handover time for rotating crewmember.	FD 4-13
38	Perform Ram Burn Observations (RAMBO) and MAUI Analysis of Upper- Atmospheric Injections (MAUI) payloads of opportunity.	MAUI – FD 15
39	Perform IWIS SDTOs:	
	 Perform SDTO 15003-U, Microgravity Environment Definition, for Orbiter Ergometer Exercise (IWIS). 	FD 11
	 b. Perform SDTO 13005-U, ISS Structural Life Validation and Extension, for Node 2 berthing (IWIS). 	Not performed
	c. Perform SDTO 13005-U, ISS Structural Life Validation and Extension, for P6 relocation (IWIS).	FD 8
	 d. Perform SDTO 13005-U, ISS structural life validation and extension for dedicated ISS Russian thruster firing (IWIS) 	FD 4
40	Perform up to two FSA Ham-radio education contacts	FD 7 9
41	Perform SDTO 17010-J/A. Multi-Protocol Converter. for live High-Definition	FD 5
	Television (HDTV) downlink with MPC and incorporation into HDTV system.	

MAJOR ISS MISSION PRIORITIES COMPLETED (Continued)

Mission priority	Mission Task	Flight Day Completed
42	Perform the following tasks if time permits.	
	 Install ITCS sample tool, edge router, and ITCS protective plate in overhead DDCU rack, if time permits. 	FD 9, 11
	b. Fill Node 2 Zero gravity Stowage Racks (ZSRs) with cargo.	FD 10
	 c. Install hatch latch handle guide assemblies (X6) (Node 1 starboard, forward, aft; A/L IV; Lab aft, forward) (Node 1 starboard was done on FD10, remainder on FD12). 	FD 12
43	Perform the following increment tasks if time permits (tasks added real-time to accommodate extra crew time due to mission extension).	
	a. Node2 stbd Aft IMV Valve Set Screw Inspection	Deferred
	b. Install W-cable on UOP6.	FD11
	 Perform Utilization (CCISS, CFE-CL1, Holter Check out, BCAT-3 Magnet unstuck) CCISS complete, others deferred. 	FD15 (CCISS)
	d. Food Audit.	FD15
	e. ND1-BF/SD-Inspect.	FD11
	f. UIA System T/S.	Deferred
	g. IMV System cleaning (RS Seg to Lab, Nod1 and Lab Aft Port IMV Fans).	Deferred
	h. MCA SDS Valve R&R, Lab Fwd Location.	Deferred
	 Install Remaining OGS Mod Kit 1 items (Prep for CHeCS rack relocation). 	Deferred
	j. CHeCS rack / WRS 1 rack O2 hose purge w/NOPA.	Deferred
	k. VRS & VES QD Leak Checks.	Deferred
	 Node1 Port NPRV removal and stow in Z1 Dome. 	Deferred
	m. Winscat baseline for Peggy and Dan.	Deferred (GMT 320)
	n. A/L ELPS Inspect (30 min).	Deferred
	 A/L Bacteria Filter/Smoke Detector Inspect. 	Deferred
	p. OBT Medical Contingency Drill.	Deferred
	 q. RED inspections and Bolt Tightening. 	FD10
	r. IV-CPDS troubleshooting.	FD8
	 Photo documentation/inspection of the CMRS. 	Deferred

MAJOR ISS MISSION PRIORITIES COMPLETED (Concluded)

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected during the launchcountdown and ascent. The SRB pre-launch countdown was nominal. No SRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred, and no SRB LCC or OMRSD waivers or exceptions were written.

Both SRBs were successfully separated from the ET and reports from the recovery area, based on visual sightings, indicate that the deceleration subsystem performed as designed. Recovery ships returned the SRBs to Kennedy Space Center (KSC) for disassembly and inspection.

One SRB In-Flight Anomaly (IFA) was identified that occurred post-separation. The Left Hand (LH) Linear Shaped Charge (LSC) failed to cut 22 in. of frustrum/forward skirt ordnance ring (IFA STS-120-B-001).

REUSABLE SOLID ROCKET MOTORS

The STS-120 Reusable Solid Rocket Motor (RSRM) set performed within established and predicted limits (nominal). No RSRM LCC or OMRSD violations were identified. All Ground Environmental Instrumentation (GEI) and Operational Flight Instrumentation (OFI) performed within established requirements.

The motor performance parameters for this flight were within Contractor End Item (CEI) specification limits. Reconstructed performance parameters adjusted to a 60 °F Propellant Mean Bulk Temperature (PMBT) standard are listed in the table below.

Parameter	CEI specification limit, 60 °F	Left motor delivered	Right motor delivered
Web time, sec	105.4 - 116.7	111.8	111.2
Action time, sec	115.2 – 131.2	123.3	123.3
Head end pressure, psia	847.9 - 965.7	908.0	908.6
Maximum Sea Level Thrust, lbf	2.88 – 3.26	3.04	3.06
Web Time Average Pressure, psia	629.9 – 700.5	659.9	664.2
Web Time Average Thrust, Mlbf	2.46 – 2.74	2.58	2.60
Web time total impulse, Mlbf sec	285.8 – 291.6	288.9	289.1
Action time impulse, Mlbf sec	293.7 – 299.7	296.2	296.6

RSRM PERFORMANCE PARAMETERS AT 60° F PMBT

RSRM PERFORMANCE PARAMETERS AT 60° F PMBT (Concluded)

Parameter	CEI specification limit, 60 °F	Left motor delivered	Right motor delivered
ISP average delivered, lbf sec/lbm	266.5 – 270.3	268.0	268.4
Loaded propellant weight, lbm	>1103750	1105962	1105577

Note: All times referenced to liftoff time (when chamber pressure reaches 563.5 psia),

The ambient temperatures recorded during the 70 hours prior to launch of STS-120 varied from 75 to 84 °F. The data recorded during this time frame was at the +0.5 σ to +1.5 σ range from historical October average hourly temperatures. At the time of launch, the ambient temperature was 82 °F. The average historical ambient temperature for the time of launch for the month of October is 80 °F.

Igniter joint heaters operated for 13 hr 58 min during the launch countdown. Power was applied to the heating elements 40-percent (average) of the time during the LCC time frame of the countdown to keep the igniter joints in their normal operating range. Field joint heaters operated for 14 hr 7 min during the launch countdown. Power was applied to the heating elements 27-percent (average) of the time during the LCC time frame of the countdown.

Propulsion performance is listed in the table below. The calculated PMBT was 80 °F at time of launch. The maximum trace shape variation of pressure vs. time during the 62-80 sec time frame was calculated to be 0.480-percent at 67.0 sec (left motor) and 0.432-percent at 80.0 sec (right motor). These values were within the 3.2-percent allowable limits.

Parameter	Parameter Left motor, 80 °F		Right motor, 80 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	66.11	65.39	66.11	65.86
I-60, 10 ⁶ lbf-sec	176.71	175.03	176.68	175.63
I-AT, 10 ⁶ lbf-sec	297.09	296.61	296.99	297.00
Vacuum Isp, lbf-sec/lbm	268.6	268.2	268.6	268.6
Burn rate, in./sec @ 60 °F at	0.3690	0.3671	0.3691	0.3682
625 psia				
Event times, sec ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	108.1	109.4	108.0	108.8
50 psia cue time	118.0	118.6	118.0	118.0
Action time ^b	120.2	120.7	120.2	120.7
Separation command	122.5		122.5	
PMBT, °F	80	80	80	80

RSRM PROPULSION PERFORMANCE

RSRM PROPULSION PERFORMANCE (Concluded)

Parameter	Left mot	or, 80 °F	Right mot	tor, 80 °F	
	Predicted	Actual	Predicted	Actual	
Maximum ignition rise rate, psia/10 ms	90.8	N/A	90.8	N/A	
Decay time, sec (59.4 psia to 85 K)	3.1 2.9		3.1 3.7		
Tailoff impulse imbalance differential ^c	Predicted N/A		Actua 759.4	l	

^aAll times are referenced to ignition command time except where noted by footnote b. ^bReferenced to liftoff time (ignition interval).

^cImpulse imbalance = integral of the absolute value of the left motor thrust minus right motor thrust from web time to action time.

The aft skirt purge was activated four times during the countdown for a total of 5 hr and 28 min. It was not necessary to thermally condition the aft skirt region prior to launch to achieve the nozzle/case joint seals minimum LCC temperature of 75 °F. Therefore, it was also not necessary to thermally condition the flex bearings to meet the 60 °F mean bulk temperature requirement. During the LCC time frame, the left- and right-hand motor nozzle/case joint temperatures ranged from 79 to 83 °F and 80 to 85 °F, respectively. The Flex Bearing Mean Bulk Temperature (FBMBT) was calculated to be $82^{\circ}F$.

Post-flight evaluation showed two in-flight anomalies: IFA STS-120-M-001 for Gas Penetrations thru Nozzle Joints No. 2 (LH and RH), and IFA STS-120-M-002 for Gas Penetration in Nozzle Joint No. 5 (RH). These conditions are recurring, expected and well understood.

EXTERNAL TANK

All STS-120 objectives and requirements associated with the Super Lightweight Tank External Tank (ET) -120 propellant loading and flight operations were met. No significant oxygen or hydrogen concentrations were detected in the Intertank. All ET electrical equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly. No ET LCC or OMRSD violations occurred.

ET-120 underwent a major refurbishment process to return the tank to flight status. Details of the refurbishment are available in the External Tank Project charts presented to the Space Shuttle Program (SSP) Flight Readiness Review (FRR).

No ET related documentation was taken during the count and launch. The Liquid-Level and Engine Cut-off sensors performed as designed.

ET separation was nominal. Since Main Engine Cutoff (MECO) occurred within expected tolerances, entry and breakup is expected to be within the predicted footprint.

Post-launch photography and video indicated that there was foam loss at three locations within the LH₂ acreage (IFA STS-120-T-001) and two locations within the LO₂ Feedline Bracket Base Closeout Adjacent Acreage (IFA STS-120-T-002).

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle Main Engine (SSME) parameters were nominal throughout the prelaunch countdown and were typical of previous flights. The Block II engines were 2050, 2048, and 2058 and these were in positions 1, 2, and 3, respectively. No LCC or OMRSD violations were noted. Engine "Ready" was achieved at the proper time, all LCCs were met, and thrust build up was nominal.

Flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown. High Pressure Oxidizer Turbo Pump (HPOTP) and High Pressure Oxidizer Fuel Turbo Pump (HPFTP) temperatures appeared to be well within specifications throughout engine operation. Commanded Max Q throttle down was a one-step throttle to 72-percent, which was predicted and this indicates Adaptive Guidance Throttling (AGT) was not initiated. Propellant dump operations data appears normal and MECO time was Engine Start plus 512.5 sec. No SSME-related Failure Identifiers (FIDs) occurred during the count and launch.

This is the first flight of the redesigned HPOTP knife edge seal flown on Main Engine 3. This is the second flight with the Advanced Health Monitoring System (AHMS) controller in redline active mode for all engines.

Initial review of STS-120 AHMS vibration measurements indicates nominal performance. No FIDs were reported to the Vehicle Data Table (VDT) from start preparation through propellant dump on all engines. All accelerometer measurements appear healthy. Detailed vibration-data review was performed after the recovery of the on-board Modular Auxiliary Data System (MADS) recorder.

The average SSME specific impulse tag value was 451.9 sec at 104.5-percent power level.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown. There were no OMRSD or LCC violations. All SRSS Safe and Arm (S&A) devices were armed and system inhibits were turned off at the appropriate times. As planned, the SRB S&A devices were safed and SRB system power was turned off prior to SRB separation.

ORBITER SYSTEMS

Main Propulsion System

The overall performance of the Main Propulsion System (MPS) was as expected. There were no LCC or OMRSD violations. One in-flight anomaly was identified and is discussed in a later paragraph.

The maximum hydrogen concentration level in the Orbiter aft compartment, with the normally elevated system backpressure used for fastfill, was 104 ppm (uncorrected) (System A was used to determine the maximum concentration). This compares favorably with previous data for this Orbiter. Data indicate that the LO₂ system performed as planned. The LH₂ pre-pressurization cycle count was 9 cycles with 14 cycles being the LCC limit. Engine inlet net positive suction pressure requirements were met throughout powered flight.

During ascent, the MPS SSME no. 1 Liquid Oxygen (LO₂) engine inlet temperature showed erratic performance and a sudden failure to Off Scale High (OSH) (IFA STS-120-V-01). The anomaly occurred approximately 3 min into ascent and the data somewhat recovered at Main Engine Cutoff (MECO). Additionally, it failed OSH again at MPS dump start after which the data recovered with a significant offset at approximately 24 min into the flight. Post-flight troubleshooting isolated the failure to the temperature transducer (failed open), which was removed and replaced.

The engine inlet temperature readings are used to verify certified inlet temperature conditions during propellant loading and SSME engine start. If the inlet temperature is violated, proper thermal conditioning is not achieved and / or may violate engine-temperature start limits.

Hazardous Gas Concentrations

The aft hazardous gas concentrations during the STS-120 loading for launch were nominal and are shown in the following table.

Parameter	Peak, ppm	Steady State, ppm
Helium	7854	5776
Hydrogen	101	17
Oxygen	17	11
LD54/55	0	0

HAZARD GAS CONCENTRATIONS AT LAUNCH

Gas Sample Analysis

Only the three redesigned gas sampler system bottles on the right hand unit successfully collected samples. The three bottles on the left side did not fire (IFA STS-120-V-09). Tests indicated the microphone that initiates the system above 135 dB (from main engine start) had failed. The three samples that were collected were within the range of acceptable pressures.

Hydrogen concentrations were well below the flammability limit in each bottle. All three oxygen concentrations were below the flammability limit. Argon concentrations indicate air as the major source of the oxygen on all three bottles. The highest helium concentration was in bottle Right Hand 3. The helium concentrations were consistent with previous data samples taken. The following tables provide a summary of the Right Hand (RH) and Left Hand (LH) gas sample data analysis.

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	3.68	0.72	2.32	0.04
3	RH 2	1.33	0.71	1.45	0.07
6	RH 3	0.06	8.70	1.68	0.85

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Note: LH 1, LH 2, and LH 3 bottles did not fire.

HYDROGEN FIRING LEAK RATES

Bottle no.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	2075
3	RH 2	1660
6	RH 3	1430

The complete results of the gas chemical analysis, provided by the Kennedy Space Center Materials and Chemical Analysis Branch, are shown in the following table.

The maximum-allowable firing-leak-rate on ascent is 57,000 scim. A firing leak rate less than 57,000 scim ensures the Orbiter aft compartment environment does not exceed the Lower Flammability Limit (LFL) for hydrogen during ascent. The actual LFL is a function of the trajectory and will vary slightly from flight to flight. The upper limit of 57,000 scim was chosen based on a standardized trajectory and conservatively envelopes the majority of trajectories flown.

S/N	Position	Actual pressure, torr	Ar, %	Air from Ar, %	Не, %	CO, %	CH4, %	CO _{2,} %	O ₂ from air, %	O₂ found, %	H _{2,} %	H₂ pyro corrected, %
1134 FLT-1	RH1	190.01	0.11	11.78	0.72	<0.01	<0.01	<0.01	2.47	2.32	0.04	0.04
1129 FLT-0	RH2	68.98	0.06	6.42	0.71	<0.01	<0.01	<0.01	1.34	1.45	0.07	0.07
1132 FLT-0	RH3	3.09	0.13	13.92	8.70	0.01	<0.01	0.02	2.92	1.68	0.86	0.85

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS

Purge, Vent and Drain System

The Purge Vent and Drain (PV&D) system performed nominally during launch, entry and landing. During the loading of STS-120, purge flow rates and temperatures were as expected with nominal system performance:

- a. Purge circuit 1 flow: 85 lbm/min at approximately 88 °F;
- b. Purge circuit 2 flow: 174 lbm/min at approximately 63 °F; and
- c. Purge circuit 3 flow: 107 lbm/min at approximately 106 °F

The hazardous gas levels were nominal. The aft Hydrogen (H_2) peaked at approximately 100 ppm during fast fill and returned to approximately 10 ppm. The aft Oxygen (O_2) peaked at approximately 17 ppm during loading and returned to approximately 4 ppm after loading. The aft Helium (He) was approximately 500 ppm with a peak near 8,000 ppm during loading.

The vent door positioning for de-orbit, Entry Interface (EI), post-EI and post-landing was nominal.

Reaction Control System

The Reaction Control System (RCS) performed satisfactorily during the STS-120 mission and no in-flight anomalies were identified during the review and analysis of the data.

The following table presents the pre-launch propellant target and loaded parameters for the mission.

Parameter	Forwar	d RCS	Left	RCS	Right RCS		
	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer	Fuel	
Target, percent	67.70	67.41	100.48	100.76	100.48	100.76	
Target loaded, lb	1141.0	712.0	1523.0	962.0	1523.0	962.0	

RCS PROPELLANT LOADING
RCS PROPELLANT LOADING (Concluded)

Parameter	Forwa	rd RCS	Lef	t RCS	Right	RCS
Calculated load, percent	69.10	68.96	100.66	100.69	100.58	100.69
Advertised Load, lb	1159.8	725.2	1525.4	961.4	1523.7	961.4

During ascent, the Tyvek covers released nominally. The following table shows the release times, speeds and Alpha/Beta angles.

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1D	4.6	54	-7	6
F3D	5.9	72	-5	6
F4D	6.5	81	-4	5
F1F	7.2	91	-3	5
F1L	7.3	93	-3	5
F3L	7.5	95	-3	4
F3U	8.0	103	-3	4
F2D	8.4	110	-2	3
F2R	8.5	111	-2	3
F4R	8.7	115	-2	3
F1U	9.1	121	-2	2
F2U	9.1	121	-2	2
F2F	9.5	127	-2	1
F3F	10.1	136	-2	0

RCS window protect firing of F1U, F2U and F3U was initiated at 296/15:40:21:26 GMT for total duration of 2.08 seconds. FRCS performance was nominal. Window protect firing is intended to deflect exhaust from the SRB separation motors away from windows during SRB separation.

The ET Separation maneuver was performed at 296/15:47:05 GMT and was a 7.9-second, 10-thruster translation. The ET Photo +X maneuver was performed at 296/15:47:16.5 GMT and was a 10.7-second, 4-thruster translation.

The RCS firings, times initiated Differential Velocities (Δ Vs), and firing times are listed in the following table.

Maneuver/Firing	Time of Ignition, GMT	∆V, ft/sec	Firing Time, sec
RCS Window Protect	296/15:40:28	N/A	2.08
ET Separation	296/15:47:12	N/A	7.9

RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	Time of Ignition, GMT	∆V, ft/sec	Firing Time, sec
ET Photo +X	296/15:47:16.5	N/A	10.7
NC3	297/19:35:41	3.5	15.2
NCC	298/08:57:45	0.9	4.1
MC1	298/10:15:24	0.1	0.5
Out of Plane Null	298/10:31:27	0.0	Not Reported
MC2	298/10:51:08	1.6	6.7
MC3	298/11:08:07	0.9	3.8
MC4	298/11:18:10	1.1	4.6
R-Bar Pitch	208/11.24.44	NI/A	Maneuver Time:
Maneuver	290/11.34.44	IN/A	10 min 35 sec
Docking Approach	298/11.45.59	N/A	Maneuver Time:
Maneuver	200/11:10:00		15 min 1 sec
Separation 1	309/11:46:19	N/A	6.5
Separation 2	309/12:14:29	N/A	6.2
RCS Hotfire	310/11:32:43	N/A	N/A
MAUI	310/14:11:02	N/A	N/A
Forward Reaction			
Control System	311/17:11:44	N/A	17.3
Dump			

RCS MANEUVERS AND FIRING DATA (Concluded)

Prior to docking, F1F and F2F were deselected at 298/12:28:32 GMT. Docking with the ISS was completed at 298/12:39:56 GMT when the Digital Autopilot (DAP) was moded to Free Drift. Primary thrusters F1L, F3L, F2R, F4R, F1U, F2U, and F3U were then deselected at 298/12:58:02 GMT after docking.

As part of the undocking preparations, the previously de-selected thrusters (with the exception of F1F and F2F) were reselected at 309/09:47:30 GMT. Undocking was initiated with a +Z pulse at 309/10:32:11 GMT. The ISS undocking was nominal. Thrusters F1F and F2F were reselected at 309/10:37:48 GMT after undocking. Fly-Around was initiated with a +X pulse of L3A and R3A at 309/10:59:58 GMT. The Separation 1 maneuver was a 6.48-sec +X burn performed at 309/11:46:19 GMT. The Separation 2 maneuver was a 6.16-sec -X maneuver performed at 309/12:14:29 GMT.

There were no reboost sessions planned or performed this mission.

Attitude control responsibilities are summarized in the table below.

Control Responsibility	Control Start, GMT	Orbiter DAP Mode	Comments
Orbiter	298/12:39:56	FREE	Docking / ISS Capture
Orbiter	298/13:00:20	LVLH	Maneuver to TEA
Station	298/13:23:46	FREE	

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

Control Responsibility	Control Start, GMT	Orbiter DAP Mode	Comments
Orbiter	298/13:24:38	AUTO	
Station	298/13:52:29	FREE	
Orbiter	301/06:25:08	AUTO	Water Dump
Station	301/09:07:14	FREE	
Orbiter	303/05:34:31	AUTO	Maneuver to ISS -XVV TEA
Station	303/06:08:43	FREE	
Orbiter	304/12:52:03	AUTO	Waste water, supply water and CWC dumps
Station	304/15:35:49	FREE	
Orbiter	307/20:05:26	AUTO	Maneuver to ISS –XVV TEA
Station	307/20:53:27	FREE	
Orbiter	309/09:18:36	AUTO	Maneuver to Undock attitude
Station	309/10:08:09	FREE	
Orbiter	309/10:10:44	AUTO	
Station	309/10:29:19	FREE	
Orbiter	309/10:30:15	ALT	Primary thrusters – No down-firing thrusters
Orbiter	309/10:32:11		Undock

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE (Concluded)

RCS Hotfire began at 310/11:32:43 GMT and concluded at 310/11:40:46 GMT. All RCS jets were fired at least once for at least 0.240 seconds on each pulse. No fail off nor fail leak problems were detected during hot fire.

RCS pressurization and propellant isolation valves were configured for entry at 311/16:32:59 GMT. Heaters were configured for entry at 311/16:37:28 GMT. The forward RCS Dump (4 thrusters) was initiated at 311/17:11:44 GMT and lasted 17.3 sec. The dump consumed 213.1 lb of the forward RCS propellant.

The primary thrusters were fired 3048 times for a total firing time of 919.8 sec. The vernier thrusters were fired 10,916 times, with a firing time of 19344.32 sec.

Orbital Maneuvering System

The Orbital Maneuvering System (OMS) performed satisfactorily throughout the mission. There were no deviations from documented OMRSD or LCC violations during the pre-flight operations. All prelaunch operations were nominal. No in-flight anomalies were identified from the post-mission evaluation, however, two issues were raised and these are discussed in later paragraphs.

The OMS configuration and the propellant loading data are shown in the following two tables.

OMS CONFIGURATION

Vehicle/ equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 01	37 th	L-OME S/N 115	4 th rebuilt flight - 19 th flight
Right Pod (RP) 03	35 th	R-OME S/N 106	8 th rebuilt flight - 32 nd flight

OMS PROPELLANT LOADING DATA

Left OMS pod		Right OMS pod	
Oxidizer	Fuel	Oxidizer	Fuel
7050	4254	7050	4254
507	228	546	294
110	220	535	265
419	220	555	200
531	283	519	317
	Left OMS Oxidizer 7050 507 419 531	Left OMS pod Oxidizer Fuel 7050 4254 507 228 419 228 531 283	Left OMS pod Right OM Oxidizer Fuel Oxidizer 7050 4254 7050 507 228 546 419 228 535 531 283 519

The following table shows the maneuvers that were performed during the STS-120 mission.

OMS MANEUVERS

Maneuver Designation	Configuration	Time of Ignition, GMT	∆V, ft/sec	Firing Time, sec
Assist	Dual Engine	296/15:40:32	N/A	116.3
OMS-2	Dual Engine	296/16:15:38	231.1	151.2
OMS-3 (NC1)	Dual Engine	296/18:31:08	83.4	54.0
OMS-4 (NC2)	Dual Engine	297/08:50:44	20.2	13.0
OMS-5 (NH)	Dual Engine	298/07:26:20	23.6	15.6
OMS-6 (NC4)	Right Engine	298/08:13:12	7.8	10.2
OMS-7 (TI)	Left Engine	298/09:55:25	8.9	11.4
OMS-8 (Orbit Adjust)	Dual Engine	310/19:54:19	99.9	54.0
OMS-9 (Deorbit)	Dual Engine	311/16:58:49	216.3	114.2

The interconnect usage from the OMS to the RCS is shown in the following table.

Parameter	Interconnect usage, percent	Interconnect usage, Ib
Left interconnect	2.328	301.5
Right interconnect	2.099	271.8
Total Usage	4.427	573.3

INTERCONNECT USAGE, PERCENT/POUNDS

During the Deorbit maneuver, the Left OMS fuel propellant quantity (Totalizer) and the fuel aft probe output ended at approximately 4.4-percent and 4.7-percent, respectively. Since these quantities were below the 5-percent low-level alert, a Left OMS Quantity Alert was generated. The duration of the planned Deorbit maneuver and the value of the propellant quantity gaging prior to the burn execution would have indicated that a low level alert would occur. The close agreement of the gaging-indicated residuals and the burn-time-Integration-determined residual values shows that the actual gaging quantity was correct, and it did not show any indications of any failure within the propellant quantity gaging system.

The purge valves operated as commanded. Gaseous Nitrogen (GN_2) usage during these purges was as expected, except during the OMS-3 maneuver when the right OMS engine's GN_2 usage was 215 psi. This is 15 psi greater than the not-more-than 200 psi per firing usage. This usage includes opening the ball valves and purging after the firing. The GN_2 usage during the ball valve opening was 50 psi, which was within the requirement, thus indicating a larger usage for the purge following the firing. The average right GN_2 usage per firing over the 8 maneuvers of this mission was 180 psi. During the previous flight of this engine (STS-116), the GN_2 usage did satisfy the File IX requirement for every firing. A review of previous flight data shows that during the OMS-3 firing, the typical GN_2 usage is usually the highest of any other firing and typically hits the 200 psi limit. This condition will be monitored on future flights, but there is no required action during the postflight turnaround activities.

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-120 mission. No in-flight anomalies were identified from the STS-120 data analysis. The run times and fuel consumption for the APUs during STS-120 are summarized in the following tables.

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
1 (310)	00:19:22	00:04:38	01:02:31	01:26:31
2 (403)	00:19:25	00:00:00	01:25:38	01:45:03
3 (207)	00:19:28	00:00:00	01:02:43	01:22:11

APU RUN TIMES

APU FUEL CONSUMPTION

APU (S/N)	Ascent, Ib	FCS Checkout, Ib	Entry, Ib	Total, Ib
1 (310)	49	15	120	184
2 (403)	53	0	165	218
3 (207)	51	0	131	182

During the APU 2 confidence run performed prior to flight, the Exhaust Gas Temperature 2 (EGT 2) became erratic but returned to normal for the latter portion of the run. Since this occurred late in the flow, the condition was documented and was accepted for flight with APU 2 EGT 2 sensor removal and replacement post-flight. This sensor was also erratic during the APU run for ascent and during heat soak back after the APU run. Since the EGT 2 sensors are not in the downlink Telemetry Format Load (TFL) for entry, the EGT 2 performance was not visible during the entry. The EGT sensors are in a high-vibration high-temperature environment and have a history of failing by exhibiting an erratic signature. The sensor was replaced during post-flight turnaround operations.

Hydraulics/Water Spray Boiler System

Hydraulic (HYD) and Water Spray Boiler (WSB) system performance during STS-120 was nominal with no in-flight anomalies identified during the data analysis.

No hydraulic LCC or OMRSD violations were identified during the prelaunch operations. There were no unexpected decreases in reservoir quantities indicating no gross leaks in the hydraulic systems. Priority valve cracking times at APU activation were all less than the 1 sec specification limit. All HYD System priority valve reseats at APU shutdown were nominal.

Bootstrap pressures remained above 2100 psi, so no additional bootstrap accumulator recharges were required. At circulation-pump start, the hydraulic system pressure was between 250 and 300 psia, then the TVC isolation valves were opened and the system pressures increased to between 450 and 500 psia. SSME hydraulic temperatures were 73 °F minimum which is above the 60 °F minimum limit required for the Main Engine Controller (MEC) to issue a go for engine-start.

All three WSB system cores were loaded with approximately 5 lb of the additive mixture [53-percent water; 47-percent Propylene Glycol Monomethyl Ether (PGME)]. Initial water tank load for each system was 133.8 lb of the PGME/Water mixture.

Power Reactant Storage and Distribution System

The Power Reactant Storage and Distribution (PRSD) system performance was nominal during the STS-120 mission. The initial loading of the five PRSD tank sets was performed on October 21, 2007. The prelaunch reactant boiloff rate averaged 0.069 lb/hr/tank for hydrogen and 0.19 lb/hr/tank for oxygen.

A 133-hr mission extension capability existed at landing, based upon the PRSD O_2 (the limiting reactant) tank landing quantities at the average fuel-cell flight power level of 10.24 kW. The SSPTS supplied 1267.45 kWh to the Orbiter. When combined, the Orbiter average electrical power level was 13.74 kW. At the mission extension day power level of 12.524 kW, a 109-hour mission extension was available.

The loading data for the STS-120 mission is shown in the following table.

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, Ib
Loaded	101.8	101.8	100.9	100.9	100.8	3961
Launch	100.9	100.5	99.6	100.1	100.5	3917
Landing	51.0	40.9	44.0	16.4	5.9	1236
ý						
Hydrogen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, Ib
Hydrogen Loaded	Tank 1 , % 102.3	Tank 2, % 102.3	Tank 3, % 102.8	Tank 4, % 102.3	Tank 5, % 103.2	Total Mass, Ib 471.9
Hydrogen Loaded Launch	Tank 1, % 102.3 99.3	Tank 2, % 102.3 98.8	Tank 3, % 102.8 99.7	Tank 4, % 102.3 99.3	Tank 5, % 103.2 100.1	Total Mass, Ib 471.9 457.4

PRSD TANK QUANTITIES

The tank pressure data showed that the check valve in Oxygen Tank 3 indicated the valve did not fully seat for 3 heater cycles of Oxygen tanks 1 and 2. Similar occurrences were observed on STS-116 and STS-115 Orbiter vehicles.

Instances of de-stratification and pressure collapses were observed during STS-120, and the most notable were on Oxygen Tanks 3 and 5. This is in family with previous flights where the Orbiter experiences negligible acceleration for long periods followed by a maneuver which de-stratifies the stratified layers of cryogenic oxygen. The Flight Control Team used a cryogenics depletion plan that used the tanks more evenly and this resulted in less stratifications/de-stratifications, less severe pressure drop, and faster pressure recovery.

Fuel Cell System

Fuel Cells

The overall performance of the Fuel Cell system was nominal for STS-120. This was the second flight of Station-to-Shuttle Power Transfer System (SSPTS) and the first flight on the OV-103 vehicle. No in-flight anomalies were identified from the review and analysis of the data.

Fuel Cell startup was initiated on October 22, 2007 at 7:32:36 p.m. Central Daylight Time (CDT). Startup and prelaunch operations were nominal. Fuel cell operating times, which are the times accumulated on the fuel cells prelaunch, on-orbit, and postlanding, were 412:47:48 for fuel cell 1, 412:29:56 hr:min:sec for fuel cell 2, and 411:27:09 for fuel cell 3. The end-of-mission accumulated operating times for these fuel cells are 1207, 856, 2166 hr, respectively.

The Orbiter fuel cell electrical power level averaged 10.24 kW and the total Orbiter load averaged 330 amperes (A). The Station-to-Shuttle-Power-Transfer-System (SSPTS) supplied 1267.45 kWh to the Shuttle while docked to ISS. When combined, the Orbiter average electrical power level was 13.74 kW for the mission duration. During the 362.40-hour mission, the fuel cells produced 3711 kWh of electrical energy and 2833 lb_m of potable water. The fuel cells consumed 2517 lb_m of oxygen and 317 lb_m of hydrogen. Five fuel cell purges were performed, occurring at approximately 19, 99, 219, 338, and 353 hours MET.

The actual fuel cell voltages (200 amp load) at the end of the mission were 0.15 Volt (V) above predicted for fuel cell 1, 0.10 V above predicted for fuel cell 2, and 0.20 V above predicted for fuel cell 3. The voltage margins above the minimum performance curves at 200 amps at the end of the mission were 1.06 V above minimum for fuel cell 1, 1.06 V above minimum for fuel fell 2, and 0.90 V above minimum for fuel cell 3.

The overall thermal performance of the fuel cell water relief, water line, and reactant purge heater systems was nominal. System A on the water relief and water line systems was used during prelaunch, ascent, and up to 309/14:20 GMT (12/58:42 MET), and were then reconfigured to the B system until the end of mission.

Station to Shuttle Power Transfer System (SSPTS) Operation

The SSPTS transferred and converted power from the 120-Vdc ISS electrical system to the Orbiter 28-Vdc power buses. The system was activated when docked to the ISS, and was deactivated during Extravehicular Activities (EVAs) as a safety precaution. The SSPTS supplied 1267.45 kWh of power to the Orbiter. The configuration of the Orbiter for acceptance of the power from the ISS was that power was supplied to fuel cell 1, main bus A, and fuel cell 2, main bus B, which were connected to SSPTS Power Transfer Units (PTUs) 1 and 2, respectively. SSPTS power was transferred to fuel cell 3, main bus C through main bus A-to-C bus-tie.

When set at maximum output, SSTPS attempts to regulate Orbiter bus voltage at 31.8 Vdc up to its maximum output of about 6.4 kW. The fuel cells assume the remainder of the Orbiter electrical load. Based on observations during STS-118, SSPTS utilization can be maximized with lower performing fuel cells. This requires less power from the fuel cells and in turn uses less cryogenics which in turn increases the cryogenics consumable margins.

The Flight Control Team requested an evaluation that went beyond the 0.2- Vdc decay before purging the fuel cells to maximize SSPTS and consume less cryogenics. After an evaluation of the past mission data as well as discussions with the vendor, a recommendation was made to allow a 0.3-V decay before purging.

Electrical Power Distribution and Control System

The EPDC subsystem performed nominally during all mission phases of STS-120. The data review and analysis of all available EPDC parameters were completed and no abnormal conditions were identified. STS-120 was the first flight of the SSPTS for OV-103. The calculated energy transferred was 1267.45 kWh during docked operations.

As a minimum, the following EPDC parameters were analyzed:

- 1. Fuel cell voltages and currents;
- 2. Power Transfer Unit voltages and currents;
- 3. Essential bus voltages;
- 4. Control bus voltages;
- 5. Forward Power Control Assemblies voltages and currents;
- 6. Mid Power Control Assemblies voltages and currents;
- 7. Aft Power Control Assemblies voltages and currents;
- 8. AC bus voltages and currents;
- 9. AC bus Monitor/auto switch status and overload/over-voltage alarm;
- 10. Main bus to Control bus Remote Power Controller (RPC) status;
- 11. Forward, Mid and Aft Motor Control Assemblies ops status;
- 12. Fuel cell to Essential bus switches status;
- 13. Main bus to Essential Bus RPC and switch status; and
- 14. Drag chute Pyrotechnic Controller Functions.

In addition, when the SSPTS was in operation, the following parameters were analyzed.

- 1. APCU voltages and currents;
- 2. OPCU voltages and currents;
- 3. APCU and OPCU temperatures;
- 4. MDCA motor switch statuses;
- 5. APCU status bits and trips; and
- 6. OPCU trips

Orbiter Docking System

This Orbiter Docking System (ODS) performed satisfactorily during all phases of the STS-120 mission. The active ODS parameters were monitored throughout the flight, thus indicating nominal operation throughout the duration of the flight.

The ODS was activated at 297/18:06:40 GMT (01/02:28:21 MET). Power-on time for the avionics was 8 min, 59 sec. Ring extension to the initial position was nominal, beginning at 297/18:10:51 GMT (01/02:32:32 MET) and ending 3 min, 37 sec (dual motor time) later. The ODS ring extension activity was nominal.

The ODS was activated at 298/12:09:46 GMT (01/20:31:27 MET) and was deactivated after the avionics had operated for 51 min 39 sec. The Orbiter captured the ISS at 298/12:39:57 GMT (01/21:01:38 MET). The system was allowed to dampen out for approximately 7 min, 28 sec. Ring retraction was started at 298/12:47:25 GMT (01/21:09:06 MET). Ring retraction, using dual motors, proceeded nominally for 3 min, 19 sec with good ring alignment. The hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the ring final-position being acquired at approximately 298/12:54:40 GMT (01/21:16:21 MET), at which time docking operations were complete.

The ODS was activated for undocking at 309/10:27:09 GMT (12/18:48:50 MET) and the ODS system operated for 46 min 54 sec for complete the undocking sequence. The Orbiter was undocked from the ISS at 309/10:32:04 (12/18:53:45 MET)

Atmospheric Revitalization and Active Thermal Control and Airlock Systems

Atmospheric Revitalization System

The Atmospheric Revitalization Pressure Control System performed satisfactorily during all phases of the mission. No in-flight anomalies were identified during the flight.

All pre-launch and in-flight checkout requirements were performed nominally. The prelaunch 2-psid cabin leak check was successful at 16.84 psia was maintained for approximately 24 min with no detectable out-of-family decay. All EVAs and campouts were conducted from the ISS Airlock.

The pressure was equalized with the ISS upon docking at 14.12 psi followed by a repressurization of the Orbiter/ISS combined vehicle to 14.42 psi. When the Orbiter undocked, the ISS pressure was at 14.68 psi, and following the undocking the Orbiter was repressurized to 14.74 psi.

A total of 31.6 Ib_m of Nitrogen was transferred to the ISS by re-pressurizing and tank-to-tank transfer. No Oxygen was transferred to the ISS on this flight

Active Thermal Control System

The Active Thermal Control System (ATCS) supported all Orbiter and ISS operations nominally for the duration of the mission. No in-flight anomalies were identified from the analysis of the data.

During the Flight Control System (FCS) checkout, the vehicle attitude placed the accumulator A controlling thermostat in an environmental sensing position that kept the FES High-Load feedline heater A cycling even though the high-set-point of 85 °F was exceeded. The high-load system was not in operation at that time, and this allowed the stagnant water line to heat to 250 °F for 1 hr 25 min. This condition is allowed by the Shuttle Operational Data Book (SODB) as long as the nominal heater cycling is verified by the accumulator feedwater line temperature.

Airlock System

The Airlock performed satisfactorily during all phases of flight, and all heater checkouts were performed successfully. The ODS hatch valves were used during the docking and undocking operations. After docking, the planned vestibule/Pressurized Mating Adapter (PMA) 2 pressurization and leak check was performed successfully. The vestibule depressurization valves were used to depressurize the vestibule to space before undocking.

The external airlock A and B structural heaters were cycled successfully, and the active system monitor parameters indicated normal output throughout the duration of the flight.

In preparation for undocking and during the oxygen disassembly activity, the crew reported that the plug on the bent end Quick Disconnect (QD) of the oxygen transfer flexible hose could not be installed. The report was that the Gaseous Oxygen (GO_2) transfer hose was able to be mated and de-mated to the GO_2 transfer panel in the ODS vestibule. However, the plug could not be fully mated to the GO_2 transfer hose. The plug was returned on the Orbiter for evaluation following the flight.

Supply and Waste Water System

The Supply Water and Waste Management Systems (SWWMS) performed nominally throughout the mission and all of the scheduled in-flight checkout requirements were satisfied except for the waste water dump nozzle heater B temperature transducer. One in-flight anomaly was identified and it is discussed in the following paragraph.

A leaking Contingency Water Container (CWC) as well as two Shuttle-condensate CWCs were dumped through the waste dump nozzle. During the nozzle heat-up prior to dumping the second CWC, data from the Nozzle temperature-B data diverged at approximately 184 °F from the waste dump Nozzle temperature-A data and climbed to approximately 327 °F (IFA STS-120-V-08). The B-sensor data began tracking the

waste dump nozzle-temperature-A data after the dump valve was opened. A second occurrence of the anomaly was seen during bake-out after the third CWC dump when the temperature went Off Scale High (OSH), which is 397.9714 °F. The temperature-B transducer again started tracking approximately 30 min after the nozzle heater had been deactivated for some time. All three CWCs were dumped successfully as planned. The waste dump nozzle heater functionality was verified as working using the nozzle temperature-A transducer. This anomaly was a violation of the OMRSD File IX requirements.

Supply water was managed through the use of the Flash Evaporator System (FES), water transfer to the ISS, and the overboard nozzle-dump system. The supply waterline heaters maintained the supply water dump line temperature between 76 °F and 94 °F throughout the mission. Four waste-water nozzle dumps (from the waste tank) were performed at an average rate of 1.97 percent/min (3.25 lb/min) and two supply-water overboard dump from the supply tanks were performed at an average rate of 1.65 percent/min (2.7 lb/min). In addition, one Payload Water Reservoir (PWR) dump was made through the supply line and three CWCs were dumped through the waste line. The waste-water dump line temperature was maintained between 61.5 °F and 85 °F throughout the mission.

Nine CWCs were filled with supply water and transferred to the ISS, for a total of 864.3 Ib_m . In addition, 4 PWRs of iodinated water were filled and transferred to ISS for a total 74.8 Ib_m . The tenth CWC that was filled (95.3 Ib_m) was reported leaking and was dumped overboard (IFA STS-120-N-001).

At 300/15:38:45 GMT (04/00:00:26 MET), the supply water tank quantity sensor A exhibited a quantity dropout at a tank quantity of 73-percent. The tank quantity dropped to 5-percent for 1 sec and recovered. In addition, the tank quantity sensor exhibited a few more temperature drops at different quantity level during the mission. Such dropouts have been experienced in previous flights and the problem was attributed to either contamination of the collector bar and/or a surface defect on the collector bar of the potentiometer which causes an intermittent loss of continuity. These dropouts are explained problems and are deferred for a quantity sensor replacement later in the Space Shuttle Program (SSP).

Vacuum vent line temperature was maintained between 61.6 °F and 79.6 °F.

Smoke Detection and Fire Suppression System

The Smoke Detection and Fire Suppression (SDFS) system operated nominally with no issues for the mission. The Smoke Detection Test was performed on FD 1 with satisfactory results. All Smoke detection A and B sensor-circuits passed after the retest on the Smoke Detection Circuits. Smoke Detection Checks were all performed according to the Flight Plan. Use of the Fire Suppression system was not required.

Flight Software

The Flight Software (FSW) performed satisfactorily throughout the mission. One inflight anomaly was identified during the review of the data, and it is discussed in the following paragraph.

Inaccurate data were displayed on the SPEC 205 page, which is used for transitioning ISS attitude control from the Orbiter (IFA STS-120-S-001). The inaccurate data on the display were caused by an inconsistent frame counter within the ISS/Command and Control Software (ISS/CCS) to Space-to-Space Communication System (SSCS) transfer. A joint Shuttle and ISS effort identified the cause of the anomaly through Shuttle Avionics Integration Laboratory (SAIL) testing, and a User Note was created to resolve this anomaly.

Integrated Data Processing System Hardware

The data review and analysis of Data Processing System (DPS) parameters was completed and no abnormal conditions were identified. The Integrated DPS system performed nominally. All DPS hardware and software performed satisfactorily.

Multifunction Electronics Display System

The Multifunction Electronics Display System (MEDS) performed satisfactorily.

Displays and Controls System

The Displays and Controls (D&C) system, which includes lighting, performed nominally during all phases of the mission. One in-flight anomaly was identified and is discussed in a later paragraph.

At 310/16:02 GMT (14/00:34:37 MET), contact B of the three contact pushbutton of the PLT R/Y AUTO pushbutton switch on Panel F4 indicated closed. This is a normally open pushbutton switch and the data indicated that the contact was stuck in the closed (depressed) configuration. However, in Operations (OPS) 2 only contact B was downlisted and the pushbutton light was not operational in OPS 2; therefore, there was no crew indication of the switch configuration. The previous Flight Control System (FCS) checkout had not indicated any problem with the switch. A request was made to the crew to push the switch once and contact B cleared. The issue did not impact the mission.

At 2007/ 307:08:15 GMT (10/16:37 MET), the data indicated that all six Payload Bay Floodlights were activated by the crew in support of EVA 4. Downlink video later revealed that the Mid Port Payload Bay Floodlight was not illuminated (IFA STS-120-V-07). When the crew turned the lights off the data showed that the current did not drop the full amount, thus indicating that only one of the two floodlights on this bus was working properly. Crew was instructed to consider Floodlight no. 3 failed for the rest of the mission. The postflight turnaround inspection of the floodlight in the Orbiter Processing Facility (OPF) showed that the bulb was cracked.

Flight Controls System

The Flight Controls System (FCS) performed nominally during the preflight, countdown, ascent, orbit, FCS checkout, deorbit preparation, entry, landing and post landing operations. No in-flight anomalies were found in aerosurface drive data, individual channel test data, Orbiter Rate Gyro Assemblies (ORGAs) and Accelerometer Assemblies (AAs) test data, nose-wheel steering test data, and Data Display Unit (DDU)/controller data.

During ascent through APU shutdown, the SRB Thrust Vector Controller (TVC), MPS TVC, and aerosurface actuators were positioned as commanded with normal driver currents, secondary differential pressures, and elevon primary differential pressures. The rate outputs of the four ORGAs and four Station Rate Gyro Assemblies (SRGAs) tracked one another normally, and no Spin Motor Rotation Detector (SMRD) dropouts occurred. The outputs of the four AAs also tracked one another normally. Reaction Jet Driver (RJD) operation was also normal with no thruster failures or other anomalies noted. DDU and controller operations were nominal as well. Both the Rotational Hand Controller (RHC) and the Translation Hand Controller (THC) were used and exhibited normal channel tracking.

Entry performance was nominal from the deorbit maneuver through vehicle touchdown. The pre-Time of Ignition (TIG) OMS gimbal profile was as expected with the OMS actuator active and standby channels reaching nominal drive rates. All aerosurface actuators performed normally. Secondary differential pressures for all actuators were well within the equalization threshold, and all actuator positions closely tracked General Purpose Computer (GPC) commands. Entry hydraulic system temperatures were comparable to previous flights with aerosurface actuator temperatures being within the normal limits. The MPS TVC actuator performance was normal, with secondary differential pressures within threshold and TVC actuator positions and GPC commands following each other closely.

Air Data Transducer Assembly

The Air Data Transducer Assemblies (ADTA) performed nominally during preflight, countdown, orbit, FCS checkout, deorbit preparation, entry, landing and post-landing operations. STS-120 was the first flight of ADTAs retrofitted with newly built power supply input/output circuit card assemblies.

All four ADTAs functioned nominally from power-on until nominal data loss at the T-minus-20-min transition on launch day. The ADTA self-tests performed shortly after power-on were nominal. There is no insight into ADTA performance during the ascent

phase until after the elevons are parked during the post-insertion period. All ADTA mode/status words were nominal during the parking of the elevons.

ADTA data during the FCS checkout performance was nominal. Power-on and selftests were performed with no anomalies. All 16 transducer outputs showed nominal responses.

Entry performance was nominal from de-orbit through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.7, and deployment timing was within specification at less than 15 sec. ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at about Mach 2.6. No ADTA dilemmas or Redundancy Management (RM) failures occurred during deployment through wheels-stop. Entry data were retrieved and reviewed, and no anomalies were observed.

The total temperature measurement for ADTA 2 was erratic and was similar to occurrences observed on STS-121 and STS-116. Previous troubleshooting has cleared the ADTA. Further troubleshooting efforts would require removal of the probe or the Forward Reaction Control System (FRCS). The measurement is not used by the ADTA subsystem, flight software, or the LCC. The erratic behavior of this measurement will not cause a Built-In Test Equipment (BITE) annunciation and is not an impact to the ADTA subsystem performance or operation.

Inertial Measurement Unit and Star Tracker System

The Inertial Measurement Unit (IMU) system performed satisfactorily throughout the STS-120 mission. No in-flight anomalies or problems were identified during the analysis of the data. The IMUs required one adjustment of the onboard IMU accelerometer compensations during the mission. Also, two adjustments were performed for the IMU drift compensation values.

The Star Tracker (ST) performed nominally during the STS-120 mission in acquiring navigation-stars. The –Y ST acquired navigation-stars 1197 times, but also missed a navigation-star 722 times (37.6 percent) during the mission. This condition did not impact the mission.

The –Z ST acquired a star 253 times and missed a star 96 times (27.5 percent). Data showed that most of these stars were missed during docking and undocking activities. This condition also did not impact the mission.

Global Positioning System Navigation

The Global Positioning System (GPS) operation during STS-120 was nominal. The GPS was powered approximately 4 hr 41 min prior to launch and remained powered for the mission duration. There were two occurrences of a known condition [Y-Code Erroneous Tracking Incident (YETI)], which occurred while docking or docked to the

ISS. In both occurrences, there were no significant performance impacts and the known condition was cleared when the crew executed the documented workaround procedures prior to the crew-sleep period. During entry, the GPS high Figure of Merit (FOM) period, which is usually encountered in the Plasma region, cleared well before GPS incorporation into PASS NAV. No issues were noted during the critical phase of entry (below 140,000 feet altitude) where the GPS satellite geometry is less dynamic.

STS-120 was the first nominal single string GPS entry operational flight. Hence, the plan for all future flights of the OV-103 and OV-104 vehicles will be to use single-string GPS.

On STS-120, the GPS state-vector was incorporated in parallel with Tactical Air Navigation (TACAN) into Primary Avionics Software System (PASS) and Backup Flight System (BFS) after performance confirmation with high-speed C-band tracking. This incorporation occurred at approximately 148,000 ft altitude. The effect was that the PASS and BFS navigation state residuals were reduced significantly, as expected. The PASS navigation state vector residuals remained consistently low from GPS incorporation down to Microwave Landing System (MLS) incorporation where the PASS automatically stops taking GPS updates per design. Likewise, the BFS navigation state vector residuals remained consistently low from GPS incorporation all the way through rollout as designed, even though the BFS does not process MLS data.

Communications and Tracking System and Navigation Aids

The Communications and Tracking (C&T) systems performed nominally during STS-120, and no in-flight anomalies were identified from the analysis and review of the data.

The Navigation Aids (NAVAIDS) data analysis identified nominal performance and all File IX requirements were satisfied. In addition, the S-Band system 1 was operational for 23 hr 16 min, which satisfied the File IX requirement.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) and the Modular Auxiliary Data System (MADS) performed satisfactorily during the overall mission. The OI/MADS sensors and signal conditioners are working as expected, except for the two IFAs identified:

1. During ascent, the MPS SSME no. 1 Liquid Oxygen (LO₂) engine inlet temperature showed erratic performance and a sudden failure to Off Scale High (OSH) (IFA STS-120-V-01);

2. During a waste dump nozzle heat-up, the nozzle temperature transducer B diverged at approximately 184 °F from the redundant waste dump nozzle temperature transducer A and climbed to approximately 327 °F (IFA STS-120-V-08).

These two IFAs are discussed in more detail in the Main Propulsion System and Supply and Waste Water System sections, respectively.

Mechanical and Hatches System

The mechanisms and hatches performed their designed functions. However, one inflight anomaly was identified and is discussed in the following paragraph.

During the unberthing operations of the Node 2 payload, the starboard aft longeron Payload Retention Latch Assembly (PRLA) exhibited an off-nominal position indication while the latch was moving from latch to the release position (IFA STS-120-V-02). After the latch was commanded to release, the system A latch-indication required 18 seconds to change state while the system B latch-indication changed state in the first second. This anomaly did not impact the mission and no additional crew action was required. Similar switches have exhibited symptoms that are consistent with the observations from this flight. Post-flight tests will be performed during turnaround operations in the OPF.

Landing and Deceleration System

The STS-120 landing system performance at KSC was nominal. This assessment includes all events from landing gear deployment, main gear touchdown, nose gear touchdown, through roll out, and including drag chute deployment and brake/deceleration.

A post-landing walk-down of the runway was performed. There was no unexpected flight hardware found. All components of the drag chute were recovered. The drag chute hardware and components appeared to have functioned nominally. Both reefing and line cutter pyrotechnic devices were expended. One reefing line was found 400-ft aft of the main parachute, the other was found with the main parachute.

STS-120 was the second flight of the nose landing gear tires. They were in good condition and performed nominally. The main landing gear tires appeared nominal. There was the appearance of tread cord materials on areas of the tire's surface which is a known expected condition characteristic of the new tire design.

Parachute deployment and jettison occurred nominally. Video of the drag chute deployment captured a reefing line floating away from the drag chute. This not unexpected and in no way affects the performance of the drag chute. An inspection of the flown parachute at the KSC Parachute Refurbishment Facility indicated no anomalies.

LANDING PARAMETERS

Parameter	Fro thresho	m old, ft	Time from MLG touchdown, sec	Speed, keas ^a	Speed, kgs	Sink rate, ft/sec	Pitch rate, deg/sec		
Main Landing gear touchdown	1314	.8	0.0	217.5	202.8	-5.37	N/A		
Drag Chute Deployment	4308	.2	9.71	187.2	167.9	N/A	N/A		
Nose Landing Gear Touchdown	5403	.6	13.70	163.0	150.5	N/A	-5.13		
Drag Chute Disreef	5784	.1	15.29	147.6	141.4	N/A	N/A		
Brakes On	7051	.3	21.22	117.3	110.4	N/A	N/A		
Drag Chute Jettison	9103	.9	36.58	66	52.6	N/A	N/A		
Wheels Stop	967	4	50.57	50.57 0		N/A	N/A		
Parame			Data						
Brake Initiation Speed	, keas			117.3					
Brake On Time, sec			29.85						
Rollout Distance, ft			8359.2						
Rollout Time, sec			50.57						
Runway Location, Sur	face and I	Degree	S	3 Concrete					
Parameter	Maximum Bra Pressure, ps	Total Brake Energy, Mft/Ib							
Left inboard			1152.6	14.05					
Left outboard			1071.9		13.91				
Right inboard		783.7				11.47			
Right outboard		780.4 7.65				7.65			

^aKnots equivalent air speed

Aerothermodynamics, Integrated Heating and Interfaces

Post-flight reports indicated overall Orbiter TPS looked normal. The lower structural temperature data indicated normal entry heating. The recorded structure temperatures are within the flight experience of OV-103. From the thermocouples data, Boundary Layer Transition (BLT) occurred at around Mach 6.4 based on a pre-flight End-of-Mission (EOM) trajectory. Two centerline thermocouples indicated that the frayed Arrowhead blanket protrusion (0.15") did not cause early BLT. A quick look runway report indicated that the tile damages on the Right Hand (RH) chine and the aft inboard edge of the Left Hand (LH) External Tank (ET) door appeared to be in the same condition. However, damage on the V070-394029-060 tile appeared to have slumping around edges.

The following table shows the maximum temperatures and maximum temperature rise during entry.

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Lower fuselage forward center (B1)	127.3	116.2
Lower fuselage forward left-hand (B2)	166.6	168.3
Lower fuselage forward mid left-hand (B3)	140.4	162.3
Lower fuselage mid center (B4)	143.0	149.7
Lower fuselage mid aft center (B5)	161.4	163.0
Lower fuselage aft center (B6)	169.3	142.9
Left-wing center (LW)	101.2	133.3
Right wing center (RW)	119.4	123.6
Port side FRCS forward (P1)	156.1	134.8
Port side fuselage forward center (P2)	88.2	100.0
Port side fuselage forward mid center (P3)	83.0	94.9
Port side fuselage mid aft center (P4)	70.1 ^a	89.5 ^a
Port side fuselage aft center (P5)	70.1 ^a	61.6 ^a
Starboard side FRCS Forward (S1)	179.8	132.9
Starboard side fuselage forward center (S2)	153.5	121.9
Starboard side fuselage forward mid center (S3)	119.4	80.2
Starboard side fuselage mid-aft center (S4)	75.3	56.5
Starboard side fuselage aft center (S5)	85.6	54.1
Left-hand OMS pod side forward (LP)	80.5	59.2
Right-hand OMS pod side forward (RP)	83.0	33.5
Lower body flap center	93.4 ^a	72.1 ^a
Right-hand OMS-pod side forward	83.0	33.5
Left-hand OMS-pod side forward	80.5	59.2
Right-hand PLBD forward	64.9 ^a	97.0 ^a
Left-hand PLBD forward	67.5 ^a	117.2 ^a
Right-hand PLBD aft	72.7 ^a	89.6 ^{°a}
Left-hand PLBD aft	72.7 ^a	104.8 ^ª
Right wing upper center	85.6 ^a	94.9 ^ª
Left wing upper center	83.0 ^a	117.6 ^a
Forward RCS center	93.4 ^a	69.6 [°]
Forward fuselage upper center	75.3	92.2

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA

^aMaximum temperature occurred at 30 minutes after wheel stop.

Thermal Control System

All passive thermal temperatures were maintained within acceptable limits with the exception of the OBSS sensor packages which exceeded their lower certification limits during the fourth EVA solar array repair. The model data for the OBSS Sensor Package

(SP) 2 sensors showed an under-prediction of about 5 to 7 °F. The data for the SP 1 sensors were not available at the time of power-up because of constraints which required power to be applied slowly to prevent thermal shock to the hardware. By the time the sensors were available, the temperatures were within heater cycling range.

The Starboard Main Landing Gear (MLG) rim temperatures got as low as -19.5 °F on the outboard side and -16.6 °F on the inboard side. Model prediction for the as-flown Attitude Time Line (ATL) on the corresponding outboard rim was -20.5 °F. The coldest prediction on the tire material was -25.6 °F. The proposed attitude switching plan maintained the tire material temperatures above their limit of -43 °F.

Thermal Protection System

Tile and Blanket Flight Assessment

The TPS tiles and blankets performed satisfactorily, and a consolidated in-flight anomaly (IFA STS-120-V-05) was assigned for all identified on-orbit issues.

During the FD 2 surveys, an AMES gap filler was identified as protruding near starboard Reinforced Carbon-Carbon (RCC) panel no. 20. The gap filler was protruding approximately 0.30-in. and tapered to zero and was about 6-in. long. The Damage Assessment Team (DAT) cleared the item based on previous mission similarities for the TPS.

The DAT analyzed loads during entry concerning a protruding blanket on the left OMS pod. Analysis of the condition, using a 0.5-in. worst case step for the whole blanket length, showed the loads on the tiles still maintained a 2.12 Factor of Safety (FS), with the minimum allowable being 1.4 FS. There was no concern with debris liberation during descent, and the TPS was completely cleared for entry.

RCC Flight Assessment

The FD 2 survey data review was completed by the DAT and the RCC was cleared for the mission.

On FD 13, the MMOD late inspection of the port, starboard, and nose-cap RCC was successfully completed. All of the inspection data were downlinked for review by the DAT.

The review of the imagery from the FD 13 OBSS late-inspection was completed, and no issues were identified. The vehicle was cleared for entry, and the Wing Leading Edge Impact Detection System (WLEIDS) was powered down.

The post-flight inspection revealed that the RCC panels did have some pinhole locations from outgas on entry. The left-hand RCC panel 9 had pinholes that were the

most prominent. There was a chip on the expansion seal of the nose cap at the -Y edge. There were two hypervelocity impacts at the 12 o'clock position of the nose cap just below the expansion seal.

Post-landing Assessment

The Thermal Protection System (TPS) performed satisfactorily. There were a significant number of hits aft and inboard of the LH_2 umbilical. The main landing gear and nose landing gear door corner tiles did not have any chips. The Orbiter nose cap, LH RCC, and RH RCC panels all appeared to be in nominal condition.

The SSME Dome Mounted Heat Shield (DMHS) blankets all appeared to be in excellent condition, with a very low amount of fraying. The base heat shield tiles had little damage between the engines.

The LH_2 umbilical appeared to be nominal. The LO_2 umbilical had charred ash-like umbilical purge barrier material still attached. There was also a black char smudge on the interior of the door.

SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE

Orbiter Surface	Impacts greater than 1 in.	Total impacts
Lower surface	12	247
Upper Surface/Window	0	8
Right side	1	9
Left side	0	8
Right OMS pod	2	36
Left OMS pod	0	8
Totals	15	317

The total debris count is shown in the following table.

The inspection of the forward underbody showed the following:

- 1. The chin panel gap filler looked good with no obvious tears or defects noticed. The gap at time of early access was 0.200-in. at the centerline, 0.160-in. on the left side, and 0.180-in on the right.
- 2. The Nose Landing Gear Door (NLGD) was nominal with no tile damage found.
- 3. Typical charred Ames gap fillers were noted on the perimeter. The centerline thermal barriers were found to be frayed at the ends and three instances of fraying on the Right-Hand (RH) Outer Mold Line (OML) thermal barriers. The thermal barrier on the aft edge of the NLGD adjacent to the arrowhead was rolled.

- 4. A portion of the arrowhead blanket 0.1-in. wide was protruding approximately 0.15-in. on the aft edge around the center connection point.
- 5. A missing putty repair was noted immediately outboard of forward Left-Hand (LH) corner of NLGD, with dimensions of approximately 1.0-in. by 0.4-in. by 0.2-in.
- 6. A large frayed area was noted on the upper-surface Forward RCS blanket, next to the upper thrusters. Excessive discoloration was also noted on the lower LH Forward RCS thermal barrier.
- 7. One frayed area was noted on the aft edge of the RH main landing gear door thermal barrier. No thermal barrier damage on LH main landing gear door.

The inspection of the mid-underbody showed the following:

- 1. Protruding gap filler was found between two tiles on the mid-body and the protrusion was less than 0.1 in.
- 2. A frayed edge of pillow gap-filler was protruding between two tiles.
- 3. Protruding gap filler was found between two tiles and it had been noted on orbit.
- 4. Protruding gap filler was found between two tiles and it had been noted on orbit.
- 5. Protruding gap filler was noted between two tiles.
- 6. Protruding gap filler was noted between two tiles and it protruded less than 0.1in.
- 7. The damage noted on-orbit on the RH chine appeared not to have grown. The damaged area was approximately 2.0-in. by 1.0-in. by 0.05-in.
- 8. A missing putty repair was noted on one tile.
- 9. Damage on one tile with dimensions of approximately 1.0-in. by 0.5-in. by 0.1in. and the tile was slumping around the edges.
- 10. Late in the mission, potential MMOD damage was reported on the right wing. No damage was apparent from the inspection.
- 11. A large, shallow damaged area was noted on a tile coating and shaved area.
- 12. Damage was noted on the tile next to the columbium seal on the LH inboard elevon.

The inspection of the aft underbody showed the following:

- 1. The damage that was noted from the on-orbit imagery on the aft and inboard edges of the LH External Tank (ET) door appeared to be in the same condition as the imagery showed.
- 2. Both ET-door thermal barriers were nominal with no noted damage. Typical purge barrier remnants were left around edges.
- 3. The upper body flap and base heat shield had typical peppering.

<u>Windows</u>

Windshield windows 1 through 6 were removed in the Orbiter Processing Facility (OPF) and sent to the NASA Shuttle Logistics Depot (NSLD) for inspections. Window 7 was inspected and, due to one damage site of 0.0079 in depth which results in a negative margin, was scrapped. Window 8 was inspected and one damage site, which was acceptable for flight, was identified. Window 11 was inspected and the window was acceptable for flight.

Waste Collection System

The Waste Collection System (WCS) performed satisfactorily and no significant issues were reported by the crewmembers.

EXTRAVEHICULAR ACTIVITY

SUMMARY

The preflight plan for the STS-120/10A mission was to conduct five Extravehicular Mobility Unit (EMU) Extravehicular Activities (EVAs) that would be based from the International Space Station (ISS) Airlock. The preflight plan was as follows:

- 1. Deliver the new pressurized element, Node 2, to its temporary Common Berthing Mechanism (CBM) on Node 1 port;
- 2. Relocate the P6 element delivered on STS-97 from it initial position to its permanent home outboard of P5;
- 3. Perform a Tile Repair Ablator Dispenser (T-RAD) Detailed Test Objective (DTO), and other miscellaneous tasks.

The EVAs were to be conducted by five different EVA crewmembers from the Shuttle and ISS crews. The EVA crewmembers were to be Mission Specialist (MS) Scott Parazynski (designated EV1), MS Douglas Wheelock (designated EV2), ISS Flight Engineer (FE) Dan Tani (designated EV3), ISS Commander Peggy Whitson, and ISS FE Yuri Malenchenko. However, because of anomalies with the starboard Solar Alpha Rotary Joint (SARJ) and a tear in a hinge line of the 4B Solar Array Wing (SAW) during re-deployment after it had been relocated resulted in the EVA plan being changed in real-time. The following paragraphs discuss the actual tasks completed during STS-120/10A EVAs.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was conducted on Flight Day (FD) 4 by the EV1 and EV2 crewmembers with crewmember Paulo Nespoli monitoring the EVA as the Intravehicular (IV) crewmember. The total EVA Phase Elapsed Time (PET) for EVA 1 was 6 hr 14 min.

The first task completed by the crewmembers was retrieval and subsequent stowage of the S-band Antenna Sub-Assembly (SASA) from its ISS stowage location on the starboard bulkhead of Z1 to its Flight Support Equipment (FSE) on the starboard sill of Discovery's Payload Bay (PLB) for return and subsequent ground repairs. The crewmembers then prepared Node 2 for removal from the Payload Bay (PLB). These tasks included the removal of eight Passive Common Berthing Mechanism (PCBM) covers from Node 2's PCBM and the release and removal of the Node 2 Launch-to-Activation (LTA) cable from Node 2 and the PLB. Other preparatory tasks completed in the PLB were a partial release of the Node 2 Power and Data Grapple Fixture (PDGF) horseshoe electrical connectors, and release and subsequent temporary stowage of the Node 2 PDGF from its sidewall Flight Support Equipment (FSE) and temporary stowage location on the forward end-cone of Node 2. The crewmembers then proceeded to start preparing the P6 element for its relocation from Z1 to P5 outboard. The P6 preparatory tasks completed were:

- 1. Release and stowing of the Z1-to-P6 fluid umbilicals,
- 2. Deployment and installation of the P6 aft radiator shroud, and
- 3. Installation of two thermal shrouds on the P6 Sequential Shunt Units (SSU).

In addition to these tasks, the crewmembers closed the Node 2 starboard Centerline Berthing Camera System (CBCS) flap that opened inadvertently during launch.

SECOND EXTRAVEHICULAR ACTIVITY

The second EVA was conducted on FD 6 by the EV1 and EV3 crewmembers with Paulo Nespoli as the IV. The second EVA duration was 6 hr 33 min.

The first task of the EVA was to complete preparations for P6 relocation which required disconnecting and stowing the Z1-to-P6 electrical umbilicals, and manual release of the Rocketdyne Truss Attachment System (RTAS) bolts so that Space Station Remote Manipulator System (SSRMS) could relocate P6.

The EV1 crewmember completed the following Node 2 outfitting tasks:

- 1. Installation of Trunnion Pin and Keel Pin covers,
- 2. Removal of electrical caps,
- 3. Release of CBM launch restraints,
- 4. Installation of all but one handrail (HR) and worksite interfaces (WIFs) and Gap Spanners.

The EV3 crewmember Tani completed the following tasks:

- 1. Inspection of the Crew and Equipment Translation Aid (CETA) HRs.
- 2. Inspection of the starboard SARJ;
- 3. Configure the S1 Squib Firing Unit (SFU) for S1 radiator deployment; and
- 4. Complete the Main Bus Switching Unit (MBSU) final configuration.

The crewmembers then performed the structural installation of the PDGF on Node 2 and also performed an Articulating Portable Foot Restraint (APFR) inspection. Because of the EVA time restrictions, the crewmembers were unable to complete the Remote Power Controller Module (RPCM) removal and replacement as well as the electrical installation of the Node 2 PDGF. Of note is that the Node 2 nadir CBM launch restraint Push-in-Pull (PIP) pin became loose during removal and was last seen free-floating beneath the CBM cover.

THIRD EXTRAVEHICULAR ACTIVITY

The third EVA was conducted on FD 8 by the EV1 and EV2 crewmembers with Paulo Nespoli as the IV crewmember. The EVA duration was 7 hr 08 min. The crewmembers started the EVA by providing visual robotics clearance calls as P6 was maneuvered into place for installation onto P5. Once in position, the crewmembers installed the P5-P6

Rocketdyne Truss Attachment System (RTAS) bolts and subsequently installed the P5-P6 electrical umbilicals and removed a Single Point Ground (SPG) connector that needed to be removed prior to the P6 SAWs being redeployed. Crewmembers prepared the P6 outboard radiator through removal of its cinches and winches for deployment, and removed the Sequential Shunt Unit (SSU) shrouds that were installed during the first EVA. A comparison of the starboard port SARJ was made while performing a port SARJ inspection. The P1 SFU was configured for the port radiator deployment while the S1 SFU was reconfigured to its post radiator deployment configuration. The crewmembers then transferred the spare Main bus Switching Unit (MBSU) from its sidewall FSE to its stowage location on the nadir side External Stowage Platform (ESP) 2. In addition, the crew was able to perform the following getahead tasks: APFR relocations, Vent Tool Adapter relocation to the Vent Tool Extender bag and S0 Gap Spanner install.

FOURTH EXTRAVEHICULAR ACTIVITY

The fourth EVA was performed by the EV1 and EV2 crewmembers with IV duties shared between Paulo Nespoli and Joe Tanner (Ground IV). The EVA duration was 7 hr 19 min. The fourth EVA was dedicated to an unplanned, contingency on-orbit repair of the torn hinge-line of the 4B Solar Array Wing (SAW). During the EVA, the EV1 crewmember cut and removed a tangled guide wire and installed five cuff-links that provided support to prevent the hinge-line from "zippering" open further during the remaining deployment of the SAW. The EV1 crewmember performed the repair from the end of the Orbiter Boom Sensor System (OBSS) on the Space Station Remote Manipulator System (SSRMS), which was the only way to reach the damage on the SAW. After the on-orbit repair was affected, the SAW was successfully deployed. The crewmembers were also able to retrieve two APFRs to bring into the crew quarters for a thorough IV inspection for a potential sharp edge. Also of note during this EVA was that two needle-nose pliers were lost. Post-flight, the crew believes that the Russian Dynocutters were also lost; as these cutters were not found in the crew quarters.

CONCLUSIONS

Although only four EVAs were conducted as opposed to the pre-flight plan of five, the EVAs conducted were successful and allowed the subsequent-stage EVAs to relocate Node 2 to its final location on the Laboratory forward CBM in position to support the continued ISS assembly.

SHUTTLE REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Shuttle Remote Manipulator System (SRMS) and Orbiter Boom Sensor System (OBSS) performed satisfactorily and supported all planned RMS/OBSS activities in a nominal manner. One In-Flight Anomaly (IFA) was identified early in the mission and this IFA did not impact the successful completion of all mission activities.

STS-120 was the 76th flight of the SRMS, the 10th flight of SRMS S/N 202, the 7th flight of the OBSS, and the 1st flight of Inspection Boom Assembly (IBA) S/N 203.

SRMS shoulder brace was released in a nominal time of 8 sec and the port starboard Manipulator Positioning Mechanisms (MPMs) were deployed. The SRMS initialization, power-up and checkout were successfully completed on Flight Day (FD) 1.

On FD 2, the SRMS unberthed the OBSS so that the port and starboard wing leading edge (WLE) Reinforced Carbon-Carbon (RCC) and nose cap surveys could be performed. The SRMS maneuvered to the OBSS Pre-Grapple position and upon the grapple and rigidization of the End Effector (EE), the Point of Resolution (POR) and joint angles of the SRMS were inconsistent with the values in the procedures (IFA STS-120-V-03). This anomaly did not affect the successful completion of all planned activities.

The POR position showed the Elbow pitch-joint angle was -133.6-deg versus the expected value of -134.6-deg, which determined the location was approximately 3 in. outboard (+Y direction) of its expected position and 1 in. above (-Z direction). The Y-axis displacement was initially 4.3 in. and eventually drifted down to 3.4 in. The POR position is computed from the SRMS joint angles and is considered to be accurate to within 2 in. After the OBSS was berthed following FD 2 inspections, the computed POR position returned to a location much closer to nominal (less than 2 in. from the expected position). Multiple SRMS activities after this showed nominal behavior. Real-time ground tests determined that the likely cause of the anomaly was an improperly installed thermal blanket on the elbow joint of the SRMS. As installed, the blanket interfered with the encoder torque arm and this caused a slight drag on the encoder. The encoder measures the joint angle, and this resulted in the reporting of an incorrect joint angle. The elbow angle difference accounts for the larger-than normal Y-axis offset seen during the OBSS grapple. After the joint drove through the blanket interference, the blanket appeared to have been displaced and the interference reduced.

On FD 3, the Orbiter docked with the International Space Station (ISS) while the SRMS was in the pre-cradle position. The Space Station Remote Manipulator System (SSRMS) grappled and unberthed the OBSS for a hand-off to the SRMS.

On FD 4, the SRMS was maneuvered to the Node 2 viewing position where the OBSS provided viewing support for the SSRMS installation of Node 2 on the Common Berthing Mechanism (CBM) during the first Extravehicular Activity (EVA).

On FD 5, the SRMS handed the OBSS back to the SSRMS to berth in the starboard MPMs and the RMS was then maneuvered to the Pre-Cradle position. The SRMS later maneuvered back to the Node 2 installation-viewing position to put the SRMS in a cooler position as the Arm Based Electronics (ABE) temperature of the shoulder joint had been rising at a steady rate toward the alarm limit.

On FD 6, the SRMS was maneuvered back to the Pre-cradle position and powered off.

On FD 7, the SRMS was maneuvered to grapple the P6 Truss from the SSRMS. The SRMS handed the P6 Truss back to the SSRMS after the SSRMS/Mobile Transporter (MT) translated to Worksite 8 on P3. After ungrappling P6, the SRMS was maneuvered to the Pre-Cradle position and powered off.

On FD 8, the SRMS began its maneuver from Pre-Cradle to the P6-installation-viewing position. After P6 was installed during the third EVA, the SRMS maneuvered to the Articulating Portable Foot Restraint (APFR) installation position. The SRMS was also used as a work platform for supporting EVA transfer of a MBSU on to ESP 2. After supporting the EVA, the SRMS was maneuvered to the Pre-Cradle position and powered off.

The SRMS was cradled, latched, and powered down on FD 9. There were no SRMS activities on FD 10.

On FD 11, the SRMS was powered up, uncradled and the SRMS began its maneuver to the Worksite 3 OBSS pre-grapple position. After the SRMS reached the pre-grapple position, the SRMS maneuvered to grapple the OBSS from the SSRMS. After grappling the OBSS, the SRMS maneuvered to the undocking position.

On FD 12, in support of the fourth EVA, the OBSS remained unpowered for approximately 9 hr. The SRMS maneuvered to the port-OBSS handoff position where it was grappled by the SSRMS. After ungrappling the OBSS, the SRMS maneuvered to the fourth EVA viewing position. After the EVA repair of the P6 4B Solar Array, the SRMS grappled the OBSS and maneuvered to the undocking position.

On FD 13, the SRMS maneuvered the OBSS to the sensor-checkout position. The sensor checkout on FD 13 allowed the imagery team to verify the sensors were in working order. After the sensor checkout, the SRMS maneuvered the OBSS back to the undocking position.

On FD 14, The SRMS/OBSS was used to perform the Late Inspection. After performing the Late Inspection, the OBSS was berthed, the SRMS was cradled and latched, and the MPMs for both systems were stowed. The SRMS/OBSS activities were completed for the STS-120 mission.

WING LEADING EDGE IMPACT DETECTION SYSTEM

ASCENT MONITORING

During downloading of the Wing Leading Edge System (WLES) data on Flight Day (FD) 2, the system experienced many local timeouts, which are indicative of a communications problem (IFA STS-120-S-005). At approximately 14 hr MET, the backup laptop was converted to primary, and downloading of summary and detailed data resumed. At that time, the analysis team issued its initial findings of two indications on the starboard wing, while still lacking Grms summary data for 3 units, and data from 3 requested half-second G-time histories. These data were provided by 16:43 MET, and were evaluated on FD 2. A report with a revised executive summary was issued at L+22 hr, but the indications listed in the 14 hr report were unaltered. The ascent analysis was completed for this mission with periodic G and filtered periodic Grms summary data alone; a complete set of unfiltered periodic Grms was not downlinked for all units.

All units triggered and began data recording on Space Shuttle Main Engine (SSME) ignition within 0.15 sec of each other except for unit 1054 which was triggered early by 0.68 sec and unit 1022 which triggered 226 sec early. The transients that induced these units to begin collecting data did not appear to satisfy the specified trigger criteria (invalid triggers). The possibility of invalid triggers was a known issue with this revision of the system's firmware, although invalid triggers are more commonly seen during on-orbit monitoring. The summary of all probable impacts above 1.0 Grms for this flight is shown in the following table.

Tir	nes	Location			Magnitude			Crit	Impact ^a			
MET	DET	Wing	RCC	Unit- Channel	Max. Grms	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post- Flt
85.9	95.1	Starboard	5-6	1040-J3	1.1	5.5	+	+	+	+	U	Р
99.7	108.9	Starboard	7-8	1044-J1	1.8	9.4	+	+	+	+	Р	Р
146.7	155.9	Starboard	12	1057-J3	1.7	7.8	+	+	+	+	Р	Р

SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 Grms

^{†a} P=probable, Q=questionable, N=no, U=unfound

Automatic scanning of postflight data acquired from 10-500 sec MET revealed a total of 63 probable ascent debris impacts on the wing leading edge (18 on the port and 45 on the starboard wing) ranging from 0.1 to 1.8 Grms.

Of the 63 probable ascent impacts, two probable impact cases above 1.0 Grms (on the starboard wing) were found and reported during the flight. Postflight analysis identified an additional probable impact above 1.0 Grms. This impact indication was not found by reviewing the summary data during the flight because it was near the aero-acoustic noise floor at the time of Maximum Dynamic Pressure (Max Q α). Automatic scanning of the full set of postflight raw data allowed this impact indication to be detected.

ORBIT MONITORING

The monitoring of the port and starboard wings for Micrometeroid Orbital Debris (MMOD) was initiated at approximately the same time and monitoring was planned to occur when the highest risk of critical damage from MMOD was expected. Analysis indicated that this risk was increased during the Reinforced-Carbon-Carbon (RCC) early and late mission surveys and during the attitudes flown for docking and undocking with the International Space Station (ISS). In addition, the MMOD risk was expected to increase twice mid-mission when specific attitudes were flown to thermally condition the landing gear of the Orbiter. The total MMOD monitoring time for this mission was fairly balanced from wing to wing with approximately 83.7 hr on the port wing and 80 hr on the starboard wing.

Unlike previous flights that monitored each wing using seven separate groups comprised of 3 units each, composite groups consisting of combinations of these original seven groups were planned for this mission. This was to ensure a denser array of accelerometers was monitoring during the highest-risk periods. During the mission, a decision was made to extend the duration of the second landing gear thermal conditioning attitude while analysis was being completed for the ISS solar-array investigation/repair. Following this decision, monitoring was performed as had been done in the past to ensure that some monitoring would continue throughout all of the higher-risk periods. As a result of sensor-unit battery-life limitations, continuous on-orbit monitoring of each RCC panel was not possible.

For this mission, the WLEIDS recorded 12 valid triggers, 10 of which satisfied all impact criteria. The 10 triggers were equivalent to 8 MMOD impact indications. One additional MMOD indication was found post-flight in an invalid trigger acquisition. Six of the nine impact indications occurred in the period from initial activation until docking at approximately 45 hr MET. The summary of all WLEIDS MMOD probable impacts for this flight is shown in the following table.

Times		Locatio	n	Magnitude		Impact ^a				
GMT	Wing	RCC	Unit- Channel	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post- Flt
297/09:43:46	Port	5/6	1033-J3	1.15	+	+	+	+	Р	Р
297/13:32:47	Port	14/15	1022-J1	0.36	+	+	+	+	U	Р
297/16:39:23	Starboard	6/7	1047-J3	0.63	+	+	+	+	Р	Р
297/17:28:28	Starboard	6/7	1047-J3	0.63	+	+	+	+	Р	Р
297/18:36:27	Port	16	1024-J2	0.64	+	+	+	+	Р	Р
298/07:16:20	Port	Chine/1	1028-J1	1.01	+	+	+	+	Р	Р
303/03:00:05	Port	Chine/1	1123-J1	2.74	+	+	+	+	Р	Р
303/05:55:06	Port	6/7	1013-J3	0.95	+	+	+	+	Р	Р
305/09:03:06	Starboard	Chine/3	1049-J1	1.01	+	+	+	+	Р	Ρ

SUSPECTED MMOD IMPACTS

P=probable, Q=questionable, N=no, U=unfound

SUPPLEMENTAL DATA COLLECTED

No supplemental data were collected.

CONCLUSIONS

The WLEIDS system performed well for ascent impact monitoring, allowing an initial ascent report to be published at 14 hr MET. The reported ascent impact indications were near to the 1.0 Grms reporting threshold.

The new MMOD monitoring plan that used a denser array of accelerometers during periods of high-risk from critically damaging MMOD impacts was implemented this flight. The MMOD monitoring capability was limited due to lack of continuous wing coverage associated with battery/thermal considerations, gaps in coverage due to lack of Ku-band antenna communications, and the time required to request units be brought out of and placed into the MMOD monitoring mode. The MMOD monitoring did detect nine impact indications, eight of which were reported during the mission.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

When the crew moved the SRMS to grapple the Orbiter Boom Sensor System (OBSS) mounted on the starboard sill, the point of resolution (POR) was different in the Orbiter Y-axis by $4\frac{1}{2}$ -in and the Orbiter Z-axis by 1-in from the expected values (IFA STS-120-V-03). The root cause was later determined to be a blanket around the Elbow-Pitch-Joint encoder that was not installed correctly.

During EVA 2, both digital cameras stopped functioning and attempts to recover the operation of the cameras were unsuccessful (IFA STS-120-V-10). As a result, no digital pictures of the SARJ condition could be taken.

The crew conducted troubleshooting on the onboard Payload General Support Computer (PGSC) network which had been working intermittently throughout the mission (IFA STS-120-S-004). The crew replaced all of the network cables and the COM 3 card in the Ku-Band File Transfer (KFX) PGSC, and the network was functional.

The PGSC for the WLES experienced a blank monitor while the PGSC was powered (IFA STS-120-S-006). The preliminary conclusion was that the Liquid Crystal Display (LCD) backlight on the monitor failed. A backup PGSC was used.

The crew reported that an Advanced Video Interface Unit (AVIU) was no longer operating as the AVIU Low/High switch broke off and all of the lights on the unit went out. The loss of this unit did not impact the mission and the unit will be inspected after landing when it is removed from the Orbiter.

The crew reported that one of the Contingency Water Containers (CWCs) that was to be transferred to the ISS was leaking (IFA STS-120-N-001). The CWC was stowed aboard the Orbiter wrapped by a trash bag and the contents were dumped overboard during a water dump after undock.

Camera A was at 49 °C, which is an over-temperature condition, but no Closed Circuit Television (CCTV) over-temperature indication was sent from the CCTV system. It was determined that the crew power-cycled the Video Control Unit (VCU) for 3 sec during their post-sleep. This is believed to have caused the logic to lock up, since the VCU was not OFF longer than 5 sec. The VCU was subsequently power cycled from the ground, which recovered the CCTV over-temperature indication.

Video downlink from camera C in the payload bay had a yellow overall hue when viewed on multiple monitors in the Mission Control Center (MCC). Later the images appeared to be normal.

DEVELOPMENT TEST OBJECTIVES

Development Test Objective (DTO) 805 Crosswind Landing Performance - This DTO was not performed because the crosswinds were less than the 10 mph, which was the minimum requirement.

DTO 848 Thermal Protection System (TPS) Tile Repair Technique – This DTO was not performed due to the replanning of the EVAs to perform the P6 solar array repair.

DTO 853 In-Flight Evaluation for Areas of Carbon Dioxide (CO₂) Concentration - This DTO was performed by the Shuttle crew during multiple crew sleep to crew wake periods.

POST-LAUNCH PAD INSPECTION

The post-launch inspection of the Main Launch Platform (MLP) -2, Pad A Fixed Service Structure (FSS), and Pad A Apron was conducted on October, 23 2007, from Launch +2.0 hr to 6.0 hr. The inspection proceeded relatively quickly after Safing Teams secured the Pad. The entire PAD, FSS, MLP and infield were inspected.

No flight hardware was found other than minimal SRB nozzle throat plug foam and Room Temperature Vulcanizing (RTV) material.

Two concrete pillars were no longer erect and fell towards the North perimeter road fence in the direction of the SRB flow.

HOLD-DOWN POSTS

The Orbiter lift-off lateral-acceleration data indicated a maximum of 0.15g. Hold-down stud hang-ups are typically noted with lateral accelerations above 0.19g.

1. Inspections of the Solid Rocket Booster (SRB) Holddown Posts (HDP) were performed and are as follows:

HDP #1 – The EA934 poured sidewalls were nominal with some acceptable visible voids present on the North, Southwest and Southeast areas, and no delamination from the shoe. The Phenolic shim was nominal with a minor blister near the through-hole and neither of the two firing lines remained. No galling or chatter marks were noted in the chamfer of the through-hole.

HDP #2 – The EA934 poured sidewalls were nominal with an acceptable visible void on the East wall and with acceptable delamination from the shoe on the West, East, and Southeast. The Phenolic shim was nominal without visual blistering. Approximately 2-ft of the Range Safety System (RSS) cable was present, but the firing lines were not present. No galling or chatter marks were noted in the chamfer of the through-hole.

HDP #3 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP #4 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP #5 – The EA934 poured sidewalls were nominal with some acceptable visible voids present on the North and East wall and no delamination from the shoe. The Phenolic shim was nominal with typical erosion, and 1 of the 2 (West) firing lines remained (approximately 16 in). No galling or chatter marks were noted in the chamfer of the through-hole.

HDP #6 – The EA934 poured sidewalls are nominal with acceptable visible voids present on Southwest, South, Northwest, North and East wall (2" length & ³/₄" height) and without any delamination from the shoe. The Phenolic shim was nominal without visual blistering. Approximately 2-ft of both firing lines was present. No galling or chatter marks were noted in the chamfer of the throughhole.

HDP #7 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP #8 – This HDP showed typical indications of erosion on the RTV-coated blast shield with proper closure and the RSS cable was missing.

2. Inspections of the GN_2 purge lines were performed and the results are as follows:

Left-Hand Probe - The Left-Hand (LH) probe was erect and slightly bent to the Southeast with about 85-percent of the protective-tape layering remaining and no exposed braiding. The O-ring was not present.

Right-Hand Probe - The Right-Hand (RH) probe was erect and slightly bent to the South with about 85-percent of the protective tape layering remaining and no exposed braiding. The O-ring was present.

3. Inspections of the SRB T-0 Ground Carrier Assemblies (GCAs) were performed and are as follows:

The LH SRB T-0 GCAs appeared to be in nominal condition with the proper demate. The 3J1 housing had a broken sidewall.

The RH SRB T-0 GCAs appeared to be in nominal condition with the proper demate. The 3J1 and 4J1 housing had broken sidewalls.

- 4. The LO₂ and LH₂ Tail Service Masts (TSM) appeared undamaged and both bonnets appeared to have closed properly. The LH₂ bonnet has a run of hydraulic fluid on the center of the closure panel.
- 5. The Main Launch Platform (MLP) deck was in excellent condition. Typical blast erosion was observed in and around the SRB flame holes with some indication of a Westerly accent. All sound suppression shims appeared to be in place.
- 6. The Orbiter Access Arm (OAA) at the 195-ft level was not accessible for a walkdown, but it appeared to be intact with no evidence of plume damage. All slide-wire baskets were still secured at the 195-ft level with no evidence of damage. Two ¼-in bolts were recovered in the grating at that level.

- 7. The GH₂ vent line Ground Umbilical Carrier Plate (GUCP) at the 215-ft level was latched on the eighth tooth (of eight) on the latching mechanism. The vent line was in between the gimbal struts and slightly south of center in the latching mechanism as seen from the FSS. The External Tank (ET) GUCP 7-in GH₂ Quick-Disconnect (QD) probe was accessible for inspection and appeared to be undamaged. Both the QD probe sealing surface and the poppet valve assembly were in good condition with minor SRB plume speckles on the poppet probe, while the South electrical connector was slightly bent. The deceleration cable was in nominal configuration and the GH₂ vent-line blanket was mostly torn away by plume impingement. The ET GUCP exhibited typical blast damage and the pyrotechnic bolt fired nominally.
- 8. At the 255-ft level, the Gaseous Oxygen (GO₂) Vent Arm, vent hood, ducts and structure appeared to be in nominal condition. The sensor lines leading into the flexible hose appeared to have excessive corrosion, as well as the upper and lower shock absorbers. An electrical cable was wrapped around the secondary horizontal screw jack and the latch mechanism locked properly.
- 9. Although numerous items were found, the Pad facility was found to be in very good condition. The most notable debris items using the new debris collection criteria are as follows:
 - a. Major damage at two areas (one was a previous repair) on the North SRB flame deflector measuring a combined 5-ft by 5-ft area. The average size of expelled deflector material was 1.5-ft in length by 6-in in width by 3-in in thickness.
 - b. Pad area findings:
 - 1) Pieces of SRB throat plug material were found on the Pad apron.
 - 2) A welding rod was found on the West Pad surface under the MLP.
 - 3) A cap and plug were found on the West Pad surface under the MLP.
 - 4) A rubber gasket was found on the West Pad surface.
 - 5) A piece of ceramic light socket was found on the West Pad surface.
 - 6) Some fondue fyre was found on the East Pad surface.
 - 7) A piece of a eyewash sign was found on the East Pad surface.
 - 8) A tie-wrap was found on the East Pad surface.
 - 9) A bungee cord was found on the East Pad surface.
 - c. On the 95-ft level, a light housing and a fixture were found near the North service elevator.
 - d. On the 115-ft level, a warped speaker, a broken-off red painted bolt-head and a black plastic cylindrical selector were found.
 - e. On the 130-ft level crossover, a metal angled bracket approximately 4-in in length was found.
 - f. On the 135-ft level, the Orbiter Work Platform (OWP) was locked and in place. On that level, the Southeast-corner speaker was warped, and a conduit/pipe union was broken and demated.
- g. On the 155-ft level, a loose cable, a ¼-in bolt, rust scale, a cast iron electrical fitting and a grating clip were found at various locations.
- h. On the 203-ft level, a welding rod was found near the stairs. A stainless steel band that was possibly securing some hoses was found.
- i. On the 235-ft level, a piece of a cable tray was found under the stairs.
- j. On the 255-ft level, a storage box had a broken corner off the forward corner.
- k. On the 275-ft level, a metal cover that had the approximate dimensions of 18-in in length by 4-in in width by ¼-in in thickness was found. Also, the upper Guide Vane Assembly (GVA) hinge cover had an excessive puddle of acid water.

LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

The ground cameras, both film-type and television, provided very good coverage of the launch and ascent of the STS-120 vehicle. Numerous observations were made, and these are presented in the following list.

- 1. Orange-colored debris was seen falling between the Space Shuttle Main Engines (SSMEs). The assessment from the Imagery Assessment Teams (IATs) was that this was most likely butcher paper.
- 2. Debris released from the External Tank (ET) mid- to-upper-tank region. No Orbiter impact was noted.
- 3. A possible piece of water baggie or purge barrier seen starboard of body flap. No vehicle impact noted.
- 4. A single piece of debris was noted falling along outboard side of LO₂ feedline. The debris appeared cube-shaped and possibly contacted the ET LH₂ Thermal Protection System (TPS) outboard of Xt1529 Ice-Frost Ramp (IFR). No Orbiter impact was noted.
- 5. ET debris was released for Xt 1377 bracket and fell aft. No Orbiter impact was noted.
- 6. Vapor was seen on the –Z side of the ET. Most likely source was condensate. Contributing factors were lighting angle and high humidity.
- 7. An ET TPS debris cloud and particles fell along ET cable tray. There was possible contact with ET cable tray. The most likely ET release location is between Xt 1129 and 1270. No Orbiter impact was noted.
- 8. Multiple pieces of debris were observed near the LO₂ feedline. Possible acreage origin inboard of feedline near Xt 1399. No Orbiter impact was noted.
- ET acreage foam debris release outboard of the Xt 1871 LO₂ feedline bracket impacted the starboard Main Landing Gear Door (MLGD), and broke into multiple pieces and fell aft. There was no apparent damage to Orbiter tile in any other imagery.
- 10. Multiple pieces of debris were released on the outboard side of the LO₂ feedline at approximately 146 sec after lift-off. The debris source appeared to be the feedline bracket base at Xt 1129. At least 7 pieces fell aft and outboard and over the starboard wing. No Orbiter impact was visible in the imagery.
- 11. Single piece of debris, possibly acreage foam, were released near inboard side of LO₂ feedline aft of bipod, and appeared to contact the Orbiter fuselage. The debris was seen breaking into several pieces.
- 12. Possible popcorn debris was seen falling aft and the possible source was near the bipod. No Orbiter impact noted.
- 13. Debris was seen emanating from +Y side of bipod and appeared to contact the Orbiter near the midline of the Nose Landing Gear Door (NLGD) before falling aft.
- 14. Debris was released aft of the starboard bipod and inboard of LO₂ feedline. No Orbiter impact noted.

15. At approximately 277 sec after lift-off, additional pieces of debris were seen originating outboard of the LO_2 feedline. One piece appeared to have contacted the Orbiter lower surface.

APPENDIX A

STS-120 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-1 Gas Generator Chamber Pressure	296:15:33:32.298
	APU-2 Gas Generator Chamber Pressure	296:15:33:35.313
	APU-3 Gas Generator Chamber Pressure	296:15:33:38.585
SRB HPU Activation	LH HPU System A Start Command	296:15:37:51.096
	LH HPU System B Start Command	296:15:37:51.256
	RH HPU System A Start Command	296:15:37:51.416
	RH HPU System B Start Command	296:15:37:51.576
Main Engine Start	SSME-3 Start Command Accepted	296:15:38:12.448
	SSME-2 Start Command Accepted	296:15:38:12.557
	SSME-1 Start Command Accepted	296:15:38:12.676
SRB Ignition	SRB Ignition Command	296:15:38:18.996
Throttle Up 104.5 Percent	SSME-2 Command Accepted	296:15:38:22.914
	SSME-3 Command Accepted	296:15:38:22.925
	SSME-1 Command Accepted	296:15:38:22.932
Throttle Down to 72 Percent	SSME-2 Command Accepted	296:15:38:52.514
	SSME-3 Command Accepted	296:15:38:52.525
	SSME-1 Command Accepted	296:15:38:52.532
Maximum Dynamic Pressure	Derived Ascent Dynamic Pressure	296:15:39:09
(Max Q)		
Throttle Up to 104.5 Percent	SSME-2 Command Accepted	296:15:39:14.115
	SSME-3 Command Accepted	296:15:39:14.126
	SSME-1 Command Accepted	296:15:39:14.133
Both SRMs to less than 50 psi	RH SRM Chamber Pressure	296:15:40:16.836
	LH SRM Chamber Pressure	296:15:40:17.756
End SRM Action	RH SRM Chamber Pressure	296:15:40:19.696
	LH SRM Chamber Pressure	296:15:40:19.696
SRB Separation Command	SRB Separation Command Flag	296:15:40:22
SRB Physical Separation	LH APU B Turbine Loss of Signal	296:15:40:22.116
	LH APU A Turbine Loss of Signal	296:15:40:22.156
	RH APU B Turbine Loss of Signal	296:15:40:22.156
OMC Assist Instition	RH APU A TUrbine Loss of Signal	296:15:40:22.196
OMS Assist ignition	E Engine Bipropellant Valve Position	296:15:40:32.4
OMS Assist Cutoff	R Engine Dipropellant Valve Position	290.13.40.32.3
OIVIS ASSIST CUTOII	R Engine Dipropellant Valve Position	290.13.42.28.9
Throttle Down for 3g		290.13.42.29.0
Througe Down for Sg	SSME-2 Command Accepted	290.13.43.43.082
	SSME-5 Command Accepted	290.15.45.45.090
3G Acceleration	Total Load Factor (g)	296.15.46.21 4
Throttle down to 67percent for	SSME 2 Command Accented	206.15.46.28 122
Cutoff	SSME-2 Command Accepted	290.13.40.36.123
Cuton	SSME-5 Command Accepted	290.15.40.38.138
SSME Shutdown	SSME-2 Command Accepted	296.15.46.44.403
	SSME-3 Command Accepted	296.15.46.44.418
	SSME-1 Command Accepted	296.15.46.44 419
Main Engine Cutoff (MECO)	MECO Command Flag	296.15.46.44
	MECO Confirmed Flag	296:15:46:46
ET Separation	ET Separation Command Flag	296:15:47:06
APU Deactivation	APU-1 Gas Generator Chamber Pressure	296:15:52:50.629
	APU-2 Gas Generator Chamber Pressure	296:15:52:57.532
	APU-3 Gas Generator Chamber Pressure	296:15:53:05.225

APPENDIX A

STS-120 MISSION EVENTS

EVENT	DESCRIPTION	
OMS 1 Ignition	L Engine Bipropellant Valve Position	N/A
	R Engine Bipropellant Valve Position	
OMS 1 Cutoff	L Engine Bipropellant Valve Position	N/A
	R Engine Bipropellant Valve Position	
OMS 2 Ignition	R Engine Bipropellant Valve Position	296:16:15:38.8
	L Engine Bipropellant Valve Position	296:16:15:38.9
OMS 2 Cutoff	R Engine Bipropellant Valve Position	296:16:18:10.2
	L Engine Bipropellant Valve Position	296:16:18:10.3
Payload Bay Doors Open	Right Payload Bay Door Open 1	296:17:18:09
	Left Payload Bay Door Open 1	296:17:19:28
OMS 3 Ignition	L Engine Bipropellant Valve Position	296:18:31:08.1
, , , , , , , , , , , , , , , , , , ,	R Engine Bipropellant Valve Position	296:18:31:08.1
OMS 3 Cutoff	L Engine Bipropellant Valve Position	296:18:32:02.1
	R Engine Bipropellant Valve Position	296:18:32:02.3
OMS 4 Ignition	L Engine Bipropellant Valve Position	297:08:50:44.5
Ũ	R Engine Bipropellant Valve Position	297:08:50:44.5
OMS 4 Cutoff	L Engine Bipropellant Valve Position	297:08:50:57.7
	R Engine Bipropellant Valve Position	297:08:50:57.7
OMS 5 Ignition	L Engine Bipropellant Valve Position	298:07:26:20.1
3 1 3 1	R Engine Bipropellant Valve Position	298:07:26:20.1
OMS 5 Cutoff	L Engine Bipropellant Valve Position	298:07:26:35.9
	R Engine Bipropellant Valve Position	298:07:26:35.9
OMS 6 Ignition	L Engine Bipropellant Valve Position	
	R Engine Bipropellant Valve Position	298:08:13:12.9
OMS 6 Cutoff	L Engine Bipropellant Valve Position	
	R Engine Bipropellant Valve Position	298:08:13:23.3
OMS 7 Ignition	L Engine Bipropellant Valve Position	298:09:55:25.3
	R Engine Bipropellant Valve Position	
OMS 7 Cutoff	L Engine Bipropellant Valve Position	298:09:55:37.1
	R Engine Bipropellant Valve Position	
Docking	Capture	298:12:39:58
Undocking	Undocking Complete	309.10.32.02
Flight Control System	APU-1Gas Generator Chamber Pressure	310.10.42.20 429
Checkout – APU 1 Start		010.10.42.20.420
APU 1 Stop	APU-1Gas Generator Chamber Pressure	310.10.46.56.278
OMS 8 Ignition	L Engine Bipropellant Valve Position	310:10:54:10.3
	R Engine Bipropellant Valve Position	310.19.54.19.3
OMS 8 Cutoff	I Engine Bipropellant Valve Position	310:19:55:13.5
	R Engine Bipropellant Valve Position	310.19.55.13.5
Payload Bay Door Close	Left Payload Bay Door Close	311.14.16.21
	Right Payload Bay door Close	311.14.10.21
	APIL 2 Gas Cenerator Chamber Pressure	211.14.10.45
AFO Activation	APUL1 Gas Generator Chamber Pressure	311.10.33.35.703
	APIL-3 Gas Generator Chamber Pressure	311.17.10.30.385
Deorbit Maneuver Ignition	L Engine Bipropellant Valve Position	311.17.17.00.705
Deorbit Maneuver Ignition	R Engine Bipropellant Valve Position	311.10.58.49.2
Deorbit Maneuver Cutoff	I Engine Bipropellant Valve Position	311.10.30.49.2
	R Engine Bipropellant Valve Position	311.17.00.43.6
Entry Interface	Orbital Altitude Referenced to Ellipsoid	311.17.20.43
Blackout End	Data Locked (High Sample Data)	No Blackout
DIACKUUL ETIU	Data Luckeu (nigii Sallipie Kale)	INU DIAGKUUL

APPENDIX A

STS-120 MISSION EVENTS

EVENT	DESCRIPTION	
Terminal Area Energy	Major Mode Code (305)	311:17:55:03
Management (TAEM)		
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure	311:18:01:17
	Main Landing Gear Right Hand Tire Pressure	311:18:01:17
Main Landing Gear Weight	Main Landing Gear Right-Hand Weight on Wheels	311:18:01:17
on Wheels	Main Landing Gear Left Hand Weight on Wheels	311:18:01:17
Drag Chute Deployment	Drag Chute Deploy 1 CP Volts	311:18:01:26.3
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	311:18:01:30
Nose Landing Gear Weight	Nose Landing Gear Weight on Wheels	311:18:01:31
on Wheels		
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	311:18:01:53.1
Wheels Stop	Velocity with respect to Runway	311:18:02:11
APU Deactivation	APU-1 Gas Generator Chamber Pressure	311:18:19:24.578
	APU-2 Gas Generator Chamber Pressure	311:18:19:32.133
	APU-3 Gas Generator Chamber Pressure	311:18:19:42.944

STS-120 IN-FLIGHT ANOMALIES INTRODUCTION

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-120 mission.

- 1. Orbiter
- 2. Solid Rocket Booster (SRB)
- 3. Reusable Solid Rocket Motor (RSRM)
- 4. Space Shuttle Main Engine (SSME)
- 5. External Tank (ET)
- 6. Systems Engineering and Integration (SE&I)
- 7. Flight Software
- 8. Flight Operations and Integration

STS-120 IN-FLIGHT ANOMALIES

ORBITER

IFA Number	Title	Comments
STS-120-V-01	MPS E1 LO ₂ Inlet Temperature Erratic	During ascent, MPS Engine-1 Liquid Oxygen (LOX) inlet temperature showed erratic performance and a temperature drift to Off Scale High (OSH). The anomaly occurred during ascent at 2:56 MET and then somewhat recovered at Main Engine Cutoff (MECO). Additionally, it failed OSH at Main Propulsion System (MP S) dump-start, and then finally recovered at about 23:40 MET. The engine inlet temperature readings are used (2 of 3) to verify certified inlet temperature conditions during propellant loading and Space Shuttle Main Engine (SSME) start. If the inlet temperature is violated, proper thermal conditioning is not achieved and/or may violate engine temperature start limits. Both cases are protected by the Launch Commit Criteria (LCC). An additional failure during loading would cause a scrub. However, an additional failure during a mission is considered benign. The most likely cause is an erratic temperature transducer or associated connector/wiring. Multiplexer/Demultiplexer (MDM) FA01 card-14 contains two other MPS measurements which functioned correctly. Dedicated Signal Conditioner (DSC) OA1 card 26 contains only this one MPS measurement. Post-flight troubleshooting isolated the failure to the temperature transducer (failed open) which was removed and replaced.
STS-120-V-02	PRLA 4 Latch Indication Delayed (On to Off)	During Node 2 deberthing operations, the starboard aft longeron latch exhibited an off- nominal position indication while the latch was moving from latched to release. After the latch was commanded from latch to release, the system A latched indication took approximately 18 sec to change state from on to off. The system B switch changed state in the first second as expected. Redundancy remains as designed for this mission. The observed delay was consistent with off-nominal conditions that may prevent the switch from changing state during future latch motion from latched to released. Should this occur, redundancy would be lost when subsequently commanding the latch from release to latch. This motion (latch to release) was not planned for the remainder of the STS-120 mission. Similar switches have exhibited symptoms consistent with these observations. The Payload Retention Latch Assembly (PRLA) 4 latch was removed and replaced during the STS-124 flow. The failed unit will be TT&E tested at the NASA Shuttle Logistics Depot (NSLD)

STS-120 IN-FLIGHT ANOMALIES

ORBITER (Continued)

IFA Number	Title	Comments
STS-120-V-03	RMS OBSS Grapple Position Delta From Expected	On FD 2, when the Orbiter Boom Sensor System (OBSS) was grappled by the Shuttle Remote Manipulator System (SRMS) just prior to unberthing, the Point of Resolution (POR) position was determined to be located approximately 3 in. outboard (+Y) of its expected position and 1 in. above (-Z). The Y displacement was initially 4.3 in. and eventually drifted down to 3.4 in. The POR position is computed from the SRMS joint angles and is considered to be accurate to within 2 in. After the OBSS was berthed following FD 2 inspections, the computed POR position returned to a location much closer to nominal (less than 2 in. from expected). The OBSS Sensor team determined there was only minimal effect on TPS inspection coverage during the FD 2 inspection. Multiple SRMS activities after this showed nominal behavior (within historical deviations). There were no restrictions to future RMS operations during the mission. The OBSS grapple position was nominal for last flight of OV-103. The cause was determined to be an improperly installed thermal blanket on the elbow joint of the SRMS. As installed, the blanket interfered with the encoder torque arm, thus causing a slight drag on the encoder. The encoder measures the joint angle, and as a result, the encoder reported an incorrect joint angle. The elbow-angle difference accounted for the larger-than-normal Y-offset seen during the OBSS grapple. After the joint drove through the blanket interference, the blanket seems to have been displaced and the interference reduced. A test was performed at the Contractor with the blanket installed as seen in a KSC close-out photograph. The test successfully repeated the behaviors observed on orbit which were a similar displacement of the elbow joint, a relaxation of the offset when motion stopped, and an eventual reduction of blankets are installed correctly. KSC procedures are being reviewed and will be updated as needed. Additional inspections are also being considered. The blankets on the OV-103 arm were corrected.
STS-120-V-04	Prime WLES PGSC Monitor Blank	This anomaly has been reassigned to be documented as STS-120-S-006. This anomaly will be discussed in the appropriate area of this Appendix.

STS-120 IN-FLIGHT ANOMALIES

ORBITER (Continued)

IFA Number	Title	Comments
STS-120-V-05	TPS Tile and Blanket Anomalies	All of the Thermal Protection System (TPS) tile, blanket, and Reinforced Carbon-Carbon (RCC) Regions of Interest (ROI) evaluated by the Tile and RCC Damage Assessment Teams are documented in the TPS Imagery Inspection Management System (TIIMS) Database located at:
		http://isal-web1.jsc.nasa.gov/tiims/TIIMS.htm
		The following are notable TPS Tile and Blanket ROI's reviewed by the Damage Assessment Team in flight and cleared for entry: - ROI D-120-RPM-942-001 Frayed thermal barrier (H= 0.40") - ROI D-120-RPM-130_3-001 Protrusion on the Arrowhead Plate (H=0.38") CAR 120RF03 - ROI D-120-RPM-230_1-001 Protruding Ames Gap Filler (H= 0.21") CAR 120RF04 - ROI D-120-LDRI-600_3-001 Protruding Ames Gap Filler (H= 0.29") CAR 120RF05 - ROI D-120-AFD-550-001 Blanket is Lifted on Left (Port) OMS Pod CAR 120RF06.
STS-120-V-06	Contingency Water	The damage sites will be repaired using the standard TPS procedures. This anomaly has been reassigned to be documented as STS-120-N-001. This anomaly will be discussed in the appropriate area of this Appendix
STS-120-V-07	Payload Bay Floodlight No. 3 Failed	At 307/08:15 GMT, the current signatures on Main Bus A (MNA) Main Power Controller (MPC) no. 1, Main Bus B (MNB) MPC no. 2 and Main Bus C (MNC) MPC no. 3 indicated all six Payload Bay (PLB) floodlights were activated by the crew in support of the fourth Extravehicular Activity (EVA). When the crew turned the lights off at 307/21:52:21 GMT, the MNB MPC no. 2 current did not drop the full amount indicating that only one of the two floodlights on that bus was working properly. Downlink video later revealed that the Mid-Port PLB floodlight (no. 3) was not illuminated. Post-flight inspection verified cracked bulb. All PLB floodlights were removed and replaced with reworked spares during the STS-124 flow.
STS-120-V-08	Waste Nozzle Temperature Sensor B Erratic	During the CWC dump through the waste nozzle, the nozzle B temperature diverged from the nozzle A temperature before the waste-dump valve was re-opened. The nozzle B temperature climbed to approximately 375° F for several seconds before returning back on-scale and tracking with the nozzle A temperature. Analysis of the temperature data shows an erratic climb in the slope that too steep to be real. Failure cause attributed to the surface-mounted temperature sensor within the nozzle, which has had a known history of failures. The defective temperature sensor was removed and replaced (along with the dump nozzle assembly where it is embedded).

STS-120 IN-FLIGHT ANOMALIES

ORBITER (Concluded)

IFA Number	Title	Comments
STS-120-V-09	Left-Hand Orbiter Aft Fuselage Gas Sampler System Unit Failed To Take Atmospheric Samples	During STS-120 post-flight testing, the Left-Hand (LH) Orbiter Aft Fuselage Gas Sampler System (OAFGSS) unit failed to take atmospheric samples. A system test determined that the control unit had failed. Testing isolated the problem to the microphone used to detect engine start. The microphone did not register engine start and as a result, the timers were never initiated. All microphones are being checked for proper operation. The faulty microphone has been replaced.
STS-120-V-10	Digital Cameras (S/N 1013 and 1014) Failed	During the second EVA, Digital Camera System (DCS) 760 camera S/N 1013 that was configured for EVA operation (no flash) would not function. This camera had no power indication. The post-EVA images indicate that the camera firmware had changed from the primary to secondary load, either before or during the EVA. After taking the S/N 1013 camera inside, the camera was checked and worked nominally when operating on vehicle power. It was determined that the issue with S/N 1013 was a drained battery which was not caught prior to going EVA due to missed step. The S/N 1013 camera was already planned to be returned this mission. During the fourth EVA, the S/N 1014 camera exhibited the same issue as S/N 1013. The S/N 1014 camera remained on the ISS. It was determined that the most likely cause was a grommet on the thermal blanket, and the ISS crew was instructed to remove the grommet from the blankets for use during the Stage EVAs. The grommet sits on top of the shutter release and when the blanket is pulled too tight, the grommet pushes down on the shutter release, thus draining the battery. By removing the grommet, this allows more play in the blanket. Work performed on the ground showed that this will fix the potential problem. The grommet will be removed from all blankets that are planned to be flown on subsequent flights.
STS-120-V-11	Foot Restraint Equipment Device (FRED) Assembly Failed	During the post-flight crew debriefing, it was determined that the Foot Restraint Equipment Device (FRED) assembly came apart. This occurred while the crewmember was sitting on the FRED and the failure resulted from the center adjusting mechanism coming apart. A secondary locking screw was added durint post-flight testing to prevent the knob from coming loose.

STS-120 IN-FLIGHT ANOMALIES

SOLID ROCKET BOOSTER

IFA Number	Title	Comments
STS-120-B-001	Non-linear Separation On Left	The LH Linear Shaped Charge (LSC) failed to cut 22 in. of frustrum/forward skirt ordnance
	Hand Frustrum/Forward Skirt	ring. It was determined that the 22 in. no-cut area resulted from a rotated LSC
	Ordnance Ring	subassembly. The LSC angle was too great for the jet penetration to cut. There is no
	(CLOSED)	concern for the crew or the mission. This is a post-separation recovery event with a
		criticality of 3.

<u>APPENDIX B</u>

STS-120 IN-FLIGHT ANOMALIES

REUSABLE SOLID ROCKET MOTOR

IFA Number	Title	Comments
STS-120-M-001	Nozzle Joint No. 2 Gas Penetration (CLOSED-EXPLAINED)	For the LH RSRM, intermittent, non-distinct gas penetration was observed on the full circumference through the Joint 2 Room Temperature Vulcanizing (RTV) material. Soot to the bolt circle centerline was observed intermittently for the full circumference. Very slight heat effects were observed to the CCP and the GCP in the dogleg at approximately 137 deg. No heat effects to the SCP were observed in the joint. No heat effects were observed on the nose inlet or flex bearing flange point, joint metal surfaces or adhesive. For the RH RSRM, intermittent, non-distinct gas penetrations were observed on the full circumference through the Joint 2 RTV. Soot to the bolt circle centerline was observed intermittently around the full circumference. No heat effects to the GCP, CCP, or SCP were observed in the joint. No heat effects were observed on the nose inlet or flex bearing flange paint, joint metal surfaces or adhesive. RTV gas paths are PRACA reportable. However, it should be noted that both gas penetrations documented on RSRM-98 are well understood and are within previous joint 2 occurrences. Gas penetrations through nozzle-joint no. 2 RTVmaterial on both the Left-Hand (LH) and Right-Hand (RH) motors were noted during post-recovery inspections. Non-distinct gas penetrations were observed through the joint RTV intermittently over the full circumference on both motors. Very slight heat effects to paint, SCP, adhesive, joint metal surfaces, or Orings in either joint. Joint No. 2 performed as expected and was consistent with flight history. Same condition has existed and has been documented on every flight since Return to Flight As a corrective action, use of carbon-fiber rope is planned for STS-123
STS-120-M-002	Nozzle Joint No. 5 Gas Penetration (CLOSED EXPLAINED)	A gas penetration through the nozzle-joint no. 5 RTV non-contact area at 225 deg on the RH RSRM was noted during post-recovery inspections. Soot was only observed adjacent to the gas-path location; no heat effects to the RTV, phenolics, metal, or O-rings were observed. This recurring observation has not always been PRACA reportable because it was considered an in-family occurrence. Recent changes in the ground rules (NSTS 08126 Revision J, eliminated the in-family screen), which now make this observation PRACA reportable and because this condition occurred between cryogenic-tanking and booster separation, it has been documented as an IFA. Gas penetration through Joint 5 RTV is not consistent with original design intent, but is not unexpected at this point in the program with the accumulated flight experience. This phenomenon is well understood and each occurrence is carefully evaluated for any challenge to flight rationale and level of risk assessment. This non-optimum performance of the thermal barrier constitutes an unsatisfactory condition per the PRACA document .

STS-120 IN-FLIGHT ANOMALIES

SPACE SHUTTLE MAIN ENGINE

There were no in-flight anomalies identified for the Space Shuttle Main Engines.

STS-120 IN-FLIGHT ANOMALIES

EXTERNAL TANK

IFA Number	Title	Comments
STS-120-T-001	LH ₂ Tank Acreage Losses (Closed)	 Post launch photography and film review depicted LH₂ Acreage foam loss at three locations: 1. Station 1139 aft of the minus (-) Y Bipod Fitting. The dimensions of the foam loss at this location were determined to be approximately 5.0 in. length by 3.0 in. width by 1.02 in. deep. Using the NCFI 24-124 as-sprayed density, the mass of this defect was determined to be 0.009 lbm. The timing of this foam loss is unknown. NSTS 60559 requirements for foam loss less than or equal to 135 seconds is 0.004 lbm and for foam loss greater than 135 seconds is 0.015 lbm. Because the timing of the foam loss is unknown, the foam loss may have occurred at less than the 135 sec timeframe, which would violate the NSTS 60559 requirements. 2. Station 1146 aft of the plus (+) Y bipod Fitting. The dimensions of the foam loss at this location were determined to be approximately 6.4 in. length by 5.3 in. wide by 1.19 in. deep. Using the NCFI 24-124 as-sprayed density, the mass of this defect was determined to be 0.019 lbm. The foam loss mass coupled with the timing of the loss does violate the NSTS 60559 requirements for greater than 135 sec. This foam loss at this location were determined to be approximately 8.0 in. length by 4.1 in. width by 1.08 in. deep. Using the NCFI 24-124 as-sprayed density, the mass of the foam loss at this location were determined to be approximately 8.0 in. length by 4.1 in. width by 1.08 in. deep. Using the NCFI 24-124 as-sprayed density, the mass of this defect was determined to be 0.019 lbm. This foam loss occurred at 238 sec MET. The foam loss mass coupled with the timing of the loss does violate the NSTS 60559 requirements for greater than 135 sec. This foam loss at this location were determined to be approximately 8.0 in. length by 4.1 in. width by 1.08 in. deep. Using the NCFI 24-124 as-sprayed density, the mass of this defect was determined to be 0.019 lbm. This foam loss occurred at 238 sec MET. The foam loss mass coupled with the timing of the loss does violate the NSTS 60
STS-120-T-002	LO ₂ Feedline Bracket Base Closeout Adjacent Acreage (Closed)	 Postlaunch camera and film review showed loss of foam at two locations.: 1. Station 1129 in the LO₂ Feedline Bracket Base closeout, LH₂ acreage and LH₂/Interfank flange foam adjacent to the outboard LO₂ feedline support bracket base closeout. The dimensions of the foam loss event are 8.0 in. length by 6.5 in. width by 1.0 in deep with a total mass of 0.027lb (0.006 lbm for PDL; 0.014 lbm for NCFI; 0.007 lbm for BX). This foam loss is documented as a multiple piece (7) debris event. The event time was approximately 146 seconds MET. The individual masses did not violate NSTS 60559 as associated with their time of release: 2. Station 1377 in the LH₂ acreage foam adjacent to the outboard LO₂ feedline support bracket base closeout. The dimensions of the foam loss are approximately 7.0 in. length by 6.6 in. width by 0.75 in. deep, with a total mass of 0.025lb. The event time was approximately 277 sec MET. This foam loss was documented as a multiple piece debris event with individual sizes unknown. The foam loss mass coupled with the timing of the loss does violate the NSTS 60559 requirements for greater than 135 sec.

STS-120 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION

IFA Number	Title	Comments
STS-120-I-001	LH2 Umbilical Ice Exceeded Limits of NSTS08303	During the STS-120 prelaunch countdown, the final inspection team (FIT) reported clear ice (4-in. long by 1.5-in. wide by 0.5-0.75-in. thick) attached to Kapton and foam in the Orbiter/External Tank (ET) LH ₂ umbilical area. Analysis, testing, and flight experience provided flight rationale for STS-120, and the countdown proceeded with a waiver to the Launch Commit Criteria (LCC). Review of on-orbit imagery identified no damaged areas to the ET LH ₂ umbilical door tiles adjacent to the observed ice location, and no damaged areas downstream of the ET LH ₂ umbilical door that exceeded on-orbit inspection criteria. Testing performed at Eglin AFB to demonstrate the behavior of ice adhesion and release on the LH ₂ Umbilical using SILC (Shuttle Ice Liberation Coating) seems to indicate a low adherence of ice to umbilical baggie material. Launch video confirmed that the majority of the ice did fall off at ignition.
STS-120-I-002	Ground Umbilical Carrier Plate (GUCP) Ice Bridged to ET Intertank Foam	Imagery from high-speed film revealed ice/frost bridging between the ET Ground Umbilical Carrier Assembly (GUCA) and the Ground Umbilical Carrier Plate (GUCP) and it extended onto the Thermal Protection System (TPS) of the adjacent ET Intertank (I/T) stringer. At T-0, when separation of this interface occurred, the film imagery showed that the ice/frost bridge [approximately 3 in. long by 1 in. wide/thick (maximum dimensions)] pulled away a section of TPS from the I/T stringer. The detached TPS and an undetermined amount of adhering ice/frost then broke free of the GUCP assembly and fell aft as the GH ₂ Vent Arm (GHVA) retraction continued. Official Shuttle documentation does not allow observed ice bridging between the ET GUCA and GUCP. The Final Inspection Team did not observe this ice bridging prior to launch and therefore, no exceedance to official documentation was reported prelaunch. After the condition was identified in the post-launch imagery review, the observed debris was not capable of causing unacceptable damage to any Space Shuttle Vehicle (SSV) element based on the Day-of-Launch (DOL) winds and the observed debris size and worst-case assumed mass. Lift-off and ascent imagery did not identify any concern that additional liberation of ET TPS had occurred due to the ice-bridging damage.
STS-120-I-003	ET LH2 Acreage Foam Losses	Ascent and post-ET-separation imagery revealed LH ₂ tank acreage debris losses at: Xt 1146, LH2 tank acreage aft of +Y bipod at 156 sec MET. Xt 1150, LH2 tank acreage aft of +Y bipod at 238 sec MET. Xt 1139, LH2 tank acreage aft of -Y bipod fitting closeout (time unknown). A determination was made that the LH ₂ acreage TPS losses were due to cryopumping and are within the Space Shuttle Program's risk assessment.

STS-120 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION (Concluded)

IFA Number	Title	Comments
STS-120-I-004	Unexpected Debris/Expected	Unexpected debris and expected debris exceeding mass allowables were experienced
	Debris Exceeding Mass	prior to pad clearance. The findings were:
	Allowable Prior to Pad	 A total of 28 debris items were found during postlaunch inspections.
	Clearance (Liftoff Debris)	A total of three were found in launch imagery.
STS-120-I-005	Debris Release on Outboard side of LO ₂ Feedline at 277 sec	Multiple releases were observed on ET outboard of the Xt 1377 LO_2 feedline bracket at the base closeout acreage around 277 sec. Although multiple releases were observed, the total liberated mass was 0.025 Ib_m and this exceeded the NSTS60559 risk assessment
		mass for releases after 135 sec. The root cause of these releases was cryopumping due to voids in Payload Development Laboratory (PDL) closeout. Voids in the PDL closeout are susceptible to cyropumping, which results in a release of surrounding North Carolina Foam Insulator (NCFI) foam upon warm-up to cryopumping conditions.

<u>APPENDIX B</u>

STS-120 IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE

IFA Number	Title	Comments
STS-120-S-001	SPEC 205 Displaying Incorrect Data	The Shuttle crew reported that unexpected data were displayed on SPEC 205 during testing of the capability to command the ISS attitude control at docking and undocking and attitude-control handover procedures. Specifically, the Orbiter crew can command the ISS to free drift upon contact, or to activate attitude control upon separation. All data were as expected per ISS ground control (ADCO). The procedure was aborted and the crew was directed to wait for a ground call to complete the handover. A minor timeline delay was incurred. The ADCO and Guidance and Control (GNC) team executed a command to handover attitude control to the Orbiter to complete the handover. Postflight data analysis showed the frame count discrepancy associated with the Radio Frequency (RF) link because the discrepancy was not observed in the hard-line interface. An integrated ISS/Shuttle Avionics Integration Laboratory (SAIL) test performed reproduced the problem in the RF link and verified correct operation of the hard-line configuration. The cause was determined to be a difference in the ISS/Command and Control Software (CCS) for the Space-to-Space Communication System (SSCS) and the Shuttle Orbiter Interface Unit (OIU) software. There has been no program requirement identified for the SPEC 205 functionality, and there are no plans to fix the software as a result of this occurrence.
STS-120-S-002	PGSC WinDecom Anomaly	The crew reported on FD 2 that the WinDecom application was experiencing an anomalous condition. Data from WinDecom would exist for 5-6 sec, then disappear with an error denoting loss of data. This error repeated itself several times during FD 2, causing the crew to deactivate the WinDecom application. On FD 14, the WinDecom application was not activated during separation and the flyaround, causing the Rendezvous/Proximity Operations Program (RPOP) to be nonfunctional. The crew later reactivated the WinDecom application, and the intermittent data anomaly recurred. Post-flight, a SAIL test was performed with the PCMMU hardware and the Fuel Cell Monitoring System (FCMS) simulated data. The WinDecom application's basic functionality to decode PCMMU data verified was verified. The FCMS data collection problem on STS-120 was reproduced. An update to the driver configuration file was tested and verified to correct the issue.

STS-120 IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE (Continued)

IFA Number	Title	Comments
STS-120-S-003	Trajectory Control Sensor (TCS) Error Message During Rendezvous Tools Checkout	During Rendezvous Tools Checkout on FD 2, the crew got an error message when starting up the Trajectory Control Sensor (TCS) application. The error was due to the TCS application not recognizing the RS-422 card on the COM 2 port. The crew swapped out the Quatech RS-422 PCMCIA card and the RS-422 TCS Y-data cable successfully. The card settings were verified as good when the procedure was run, and the TCS operated nominally with the spare TCS cable. The RPOP/TCS subsequently supported rendezvous and docking without any reported issues. The cable or Quatech card failure is suspected as the cause of anomaly. The A31p laptop system including the cables and the Quatech cards were tested post-flight and no problems were found. Integration testing was performed at SAIL for STS-124.
STS-120-S-004	PGSC Network Communication Issues	The onboard network experienced intermittent network down-time until FD 5. Both the crew and Mission Control Center (MCC) personnel could not access the standard network Payload General Support Computers (PGSC's) during these times. Generically, when the network is down, no uplink/downlink capability exists, nor does onboard file and data transfer capability. Delays in data-file uplink and downlink were experienced during the intermittent down time. On FD 5, the crew had time to replace all the coaxial cables, T-connectors, and the two terminators. Once the replacement hardware was put into place, no network issues were encountered by the crew. The coaxial cable was augmented by ISS transfer to accomplish a complete replacement. A cable, terminator, or connector failure is suspected to be the cause of the anomaly. An on-vehicle test of the STS-122 system was performed with no issues identified.
STS-120-S-005	Wing Leading Edge Laptop Local Timeouts	Several Wing Leading Edge System (WLES) laptop local timeouts occurred primarily during crew- sleep periods. During the crew day, the commands were executed nominally. There was no change in the laptop configuration prior to crew sleep. The backup laptop, STS5 RPOP2, was switched to the Primary mode and nominal operation was restored. The A31p laptop system including the cables and Quatech cards were tested post-flight and no problems were found. Integration testing was performed at SAIL for STS-124.

STS-120 IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE (Concluded)

IFA Number	Title	Comments
STS-120-S-006	STS6 PGSC Loss of Monitor	The crew reported that the STS 6 (WLES) PGSC had a dark screen on the monitor even
		though the machine appeared to be powered. The MCC confirmed that the PGSC was still
		visible on the network. A reboot of the PGSC did not clear the problem. The crew verified
		that the mechanism that engages the screensaver when the monitor pane is closed was
		still mechanically functional. The preliminary conclusion is that the LCD backlight on the
		monitor failed. The WLES application was transferred to the backup STS 5 (RPOP2) unit.
		There have been several occurrences of backlight failures of these computers on ISS.
		Most of these units have about 13,000-15,000 hr. This unit, however, had a very low
		number of hours. Testing revealed that the inverter card internal to the laptop failed
		resulting in the repeated condition. This is not a common failure mode for the A31p laptop.
STS-120-S-007	Suspect Power Cable to	WinDecom PGSC displayed error message during WinDecom application initialization.
	WinDecom PGSC	The Indicator light on the docking station was not illuminated. The crew replaced the
		power cable from the A31p PGSC power supply to docking station with a spare cable and
		the WinDecom application started nominally.

STS-120 IN-FLIGHT ANOMALIES

FLIGHT OPERATIONS AND INTEGRATION

IFA Number	Title	Comments
STS-120-N-001	Leaking CWC	On GMT 308, The Shuttle CDR reported that CWC S/N 1006 that had been filled with potable water on GMT 305 was leaking. It was discovered while the ISS CDR was moving items around in the Node 2 looking for an EVA item. The end of the CWC (by the label) was found to be saturated. The area around the fittings was noted to be dry. The CWC was put in a Russian water-proof trash bag and transferred to the Shuttle to be dumped after undocking. The CWC was likely punctured when it was initially stowed or stowed such that it was under pressure which caused it to rupture. A failure analysis will be performed on the CWC to determine the real cause of the failure.

APPENDIX C

STS-120 DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-120 MER Daily Reports by Michael D. Wright, Lead MER Manager: First Daily Report (Ascent Plus 2-Hour Report), dated October 23, 2007 Second Daily Report, dated October 24, 2007 Third Daily Report, dated October 25, 2007 Fourth Daily Report, dated October 26,, 2007 Fifth Daily Report, dated October 27, 2007 Sixth Daily Report, dated October 28, 2007 Seventh Daily Report, dated October 29, 2007 Eighth Daily Report, dated October 30, 2007 Ninth Daily Report, dated October 31, 2007 Tenth Daily Report, dated November 1, 2007 Eleventh Daily Report, dated November 2, 2007 Twelfth Daily Report, dated November 3, 2007 Thirteenth Daily Report, dated November 4, 2007 Fourteenth Daily Report, dated November 5, 2007 Fifteenth Daily Report, dated November 6, 2007 Sixteenth Daily Report, dated November 7, 2007 Landing Plus 2 Hour Report, dated November 7, 2007 Landing Plus 2 Day Report, dated November 9, 2007

ET/SRB/RSRM/SSME REPORTS

STS-120 (360W098) RSRM Flash Report, Glen A. Ricks, NASA-MSFC, dated October 23, 2007 STS-120 Executive Summary SRB and SRSS, David W. Morr, MSFC-USA, October 17, 2007 STS-120 SRB, RSRM and ET Console Flash Report, Robert Zahl, USA-Huntsville, October 23, 2007

STS-120 Final Event Times, David W. Morr, MSFC-USA, November 5, 2007

STS-120 RSRM-98 FET Executive Summary, L. J. Manuel, MSFC-Huntsville, November 19, 2007

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STS-120 Launch + 2 Day Report Ascent Performance Report, David Blake, Boeing-Houston, August 9, 2007

STS-120 Landing and Deceleration Summary Report, Chip C. Heinol, Boeing-Houston, November 27, 2007

STS-120 ADTA Report, Howard A. Damoff, Boeing-Houston, November 14, 2007.

STS-120 Flight Control System, Donald e. Marquith, Boeing-Houston, November 14, 2007

STS-120 Communications and Tracking Report, Charles J. Stafford, Boeing-Houston, November 13, 2007

STS-120 Ascent Hazard Analysis Report, Lillian P. Gibson, Boeing-Houston, November 27, 2007 STS-120 Displays and Controls and Lighting Report, Q. P. Ngo, Boeing-Houston, November 29, 2007

STS-120 Shuttle Remote Manipulator System, Nik Doshewnek MDA-Houston, January 17, 2008 STS-120 HYD/WSB/Actuators Final Report, Jeffrey S. Goza, Boeing-Houston, November 30, 2007 STS-120 EPDC Post Mission Report, William D. Peterson, Boeing-Houston, November 13, 2007 STS-120 PRSD System Mission Report, Johnny D. Wong, Boeing-Houston, September 12, 2007 STS-120 Main Propulsion System Report, Mohammed M. Jebril, Boeing-Houston, November 29, 2007

STS-120 Ingress/Egress Hatch Report, Jeffrey A. Goodmark, Boeing-Houston, August 8, 2007

STS-120 Mechanisms Systems Report, Link Salvador, Boeing-Houston, November 30, 2007

STS-120 Auxiliary Power Unit System, Christopher N. Adi, Boeing-Houston, November 29, 2007

STS-120 OI/MADS Mission Reports, Bruce S. Woods, Boeing-Houston, November 30, 2007

STS-120 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, November 30, 2007

STS-120 Data Processing System Integrated Report, James T. Westergard. Boeing-Houston, November 30, 2007

STS-120 ATCS Post-Flight Mission Report, Michael R. Houle, Boeing-Houston, November 14, 2007

STS-120 Life Support Systems Report (ARPCS and Airlock Systems; Supply Water and Waste Water Management, and Fire and Smoke Detection System), Menghis G. Hagos, Boeing-Houston, November 26, 2007

STS-120 Orbiter Docking System Summary, Robert E. Davis, NASA-JSC, October 29, 2007

STS-120 OMS Report, Donald E. Varanauski, Boeing-Houston, November 30, 2007

STS-120 RCS Mission Report, James M. Garza, Boeing-Houston, November 30, 2007

STS-120 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, November 16, 2007

STS-120 Fuel Cells Mission Report, Johnny D. Wong, Boeing-Houston, November 30, 2007.

STS-120 Global Positioning System Report, Hiep M. Bui, NASA-JSC November 28, 2007

STS-120 Thermal Control System Report, Mark J. Flahaut, NASA, JSC, November, 2007.

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STS-120 Mechanical Systems, Jeff Goodmark, Boeing-Houston, November 26, 2007

STS-120 Purge, Vent and Drain Report, Chip C. Heinol, Boeing-Houston, November 15, 2007

STS-120 Final Mission Events List, Vernon C. Hill, ESCG-Houston, received November 7, 2007.

STS-120 WLE IDS Post Flight Report, Jennifer C. Hodge, Boeing-Houston, December 20, 2007.

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STS-120 L-1 Day Walkdown, Thomas F. Ford, NASA-KSC, October 22, 2007

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STS-120 ExtraVehicular Activity Report for EVA 1, Shannon Cagle-Strimple, Hamilton-Standard, October 26, 2007

STS-120 ExtraVehicular Activity Report for EVA 2, Jeff Outlaw, Hamilton Standard, October 28, 2007

STS-120 ExtraVehicular Activity Report for EVA 3, Dennis Dawson, Hamilton Standard, October 30, 2007

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STS-120 ExtraVehicular Activity Report for EVA 4, Jon C. Golden, Hamilton Standard, November 3, 2007

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

ΔV	Delta Velocity/Differential Velocity
AA	Accelerometer Assembly
ABE	Arm Based Electronics
ac	alternating current
ADTA	Air Data Transducer Assembly
AGT	Adaptive Guidance Throttling
AHMS	Advanced Health Monitoring System
AMES	Ames Research Center
APFR	Articulating Portable Foot Restraint
APCU	Auxiliary Power Converter Unit
APU	Auxiliary Power Unit
ASI	Agenzia Spaziale Italiania
ATCS	Active Thermal Control System
ATL	Attitude Time Line
AVIU	Audio Visual Interface Unit
BFS	Backup Flight System
BITE	Built In Test Equipment
BLT	Boundary Layer Transition
C&T	Communications and Tracking (System)
C&W	Caution and Warning
CBCS	Centerline Berthing Camera System
CBM	Common Berthing System
CCS	Command and Control Software
CCTV	Closed Circuit Television
CDR	Commander
CDT	Central Daylight Time
CEI	Contract End Item
CETA	Crew Equipment Transition Aid
CMG	Control Moment Gyroscope
CO_2	Carbon Dioxide
CSA	Canadian Space Agency
CST	Central Standard Time
CTVC	Color Television Camera
CWC	Contingency Water Container
DAP	Digital Autopilot
DAT	Damage Assessment Team
D&C	Display and Control
DDU	Data Display Unit
DMHS	Dome Mounted Heat Shield
DPS	Data Processing System
DTO	Development Test Objective
EDT	Eastern Daylight Time

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/Abbreviation	Explanation
EE	End Effector
EI	Entry Interface
EGT	Exhaust Gas Temperature
EMU	Extravehicular Mobility Unit
EOM	End of Mission
EPDC	Electrical Power Distribution and Control
ESA	European Space Agency
ESP	External Stowage Platform
ET	External Tank
EV	Extravehicular
EVA	Extravehicular Activity
FBMBT	Flexible Bearing Mean Bulk Temperature
FCS	Flight Control System
FD	Flight Day
FE	Flight Engineer
FES	Flash Evaporation System
FID	Failure Identifier
FOD	Foreign Object Debris
FOM	Figure of Merit
FRCS	Forward Reaction Control System
FRR	Flight Readiness Review
FS	Factor of Safety
FSE	Flight Service Equipment
FSS	Flight Service Structure
FSW	Flight Software
GCA	Ground Carrier Assembly/Ground Control Assist
GEI	Ground Environmental Instrumentation
GFE	Government Furnished Equipment
GH ₂	Gaseous Hydrogen
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GN_2	Gaseous Nitrogen
GO_2	Gaseous Oxygen
GPC	General Purpose Computer
GPS	Global Positioning System
GSE	Ground Support Equipment
GUCP	Ground Umbilical Carrier Plate
GVA	Guide Vane Assembly
H ₂ O ₂	Hydrogen-Oxygen
Не	Helium
HDP	Holddown Post
HDTV	High-Definition Television

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

HPA	Hand Posture Analysis
HPFTP	High Pressure Fuel Turbopump
НРОТР	High Pressure Oxidizer Turbopump
HR	High Resolution/Hand Rail
Hyd/HYD	Hydraulic
IDS	ISIS Digital Camera
IFA	In-flight Anomaly
IFR	Ice Frost Ramp
IMU	Inertial Measurement Unit
ISIS	Integrated Sensor Inspection System
Isp	Specific Impulse
ISS	International Space Station
ITVC	Intensified Television Camera
IV	Intravehicular
ITS	Integrated Truss Segment
JSC	Johnson Space Center
KFX	Ku-band File Transfer
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LCD	Liquid Crystal Display
LCS	Laser Camera System
LDRI	Laser Dynamic Range Imager
LESS	Leading Edge Structure System
LFL	Lower Flammability Limit
LH	Left Hand
LH ₂	Liquid Hydrogen
LO ₂	Liquid Oxygen
LPOTP	Low Pressure Oxidizer Turbopump
LSC	Linear Shaped Charge
LTA	Launch to Activation
LVLH	Local Vertical Local Horizontal
MADS	Modular Auxiliary Data System
MAUI	Maui Analysis of Upper atmosphere Injections
MAGR	Miniature Airborne-to-Ground Receiver
Max Q	Maximum Dynamic Pressure
MBSU	Main Bus Switching Unit
MC	Midcourse Correction
MCC	Mission Control Center
MEC	Main Engine Controller
MECO	Main Engine Cutoff
MEDS	Multifunction Electronic Display System
MER	Mission Evaluation Room

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

MET	Mission Elapsed Time
MLG	Main Landing Gear
MLGD	Main Landing Gear Door
MLI	Multi-Layer Insulation
MLP	Mobile Launch Platform
MLS	Microwave Landing System
MM	Momentum Manager
MMOD	Micro Meteoroid Orbital Debris
MMT	Mission Management Team
MPC	Multi-Protocol Converter
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MRL	Manipulator Retention Latch
MS	Mission Specialist
МТ	Mobile Transporter
N_2	Nitrogen
NASA	National Aeronautics and Space Administration
NAVAIDS	Navigation Aids
NC	Nominal Correction (Maneuver)
NCC	Nominal Corrective Combination (Maneuver)
NLGD	Nose Landing Gear Door
NSLD	NASA Shuttle Logistics Depot
O_2	Oxygen
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
ODS	Orbiter Docking System
OFI	Operational Flight Instrumentation
OGS	Oxygen Generator System
OI	Operational Instrumentation
OME	Orbital Maneuvering Engine
OML	Outer Mold Line
OMRSD	Operational Maintenance and Requirements Specification
	Document
OMS	Orbital Maneuvering System
OPCU	Orbiter Power Converter Unit
OPF	Orbiter Processing Facility
OPO	Orbiter Project Office
ORGA	Orbiter Rate Gyro Assembly
OSH	Off-Scale-High
OV	Orbiter Vehicle
OWP	Orbiter Work Platform
Р	Port

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

PASS	Primary Avionics Software System
PCBM	Passive Common Berthing System
PDGF	Power and Data Grapple Fixture
PET	Phase Elapsed Time
PGME	Propylene Glycol Monomethyl Ether
PGSC	Payload and General Support Computer
PiP	Plug-in Plan
PIP	Push In Pull
PLB	Payload Bay
PLBD	Payload Bay Door
PLT	Pilot
PMA	Pressurized Mating Adapter
PMBT	Propellant Mean Bulk Temperature
POR	Point of Resolution
PRLA	Payload Retention Latch Assembly
PRSD	Power Reactant Storage and Distribution System
PTU	Pan and Tilt Unit/Power Transfer Unit
PV&D	Purge, Vent and Drain
PVR	Photovoltaic Radiator
PWR	Payload Water Reservoir
QD	Quick Disconnect
RAMBO	Ram Burn Observation
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RH	Right Hand
RHC	Rotational Hand Controller
RJD	Reaction Jet Driver
RM	Redundancy Management
RMS	Remote Manipulator System
RPCM	Remote Power Controller Modules
RPM	R-Bar Pitch Maneuver
RPOP	Rendezvous Proximity Operations Program
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System
RTAS	Rocketdyne Truss Attachment System
RTV	Room Temperature Vulcanizing (material)
S	Starboard
S&A	Safe and Arm
SAIL	Shuttle Avionics Integration Laboratory
SARJ	Solar Alpha Rotary Joint
SASA	S-band Antenna Structural Assembly
SAW	Solar Array Wing

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

SDBI	Short Duration Bioastronautics Investigation
SDFS	Smoke Detection and Fire Suppression
SFU	Sauib Firing Unit
SLWT	Super Lightweight Tank
SMRD	Spin Motor Rotation Detector
S/N	Serial Number
SODB	Shuttle Operational Data Book
SPEC	Specialist Function
SPG	Single Point Ground
SRB	Solid Rocket Booster
SRGA	Station Rate Gyro Assembly
SRMS	Shuttle Remote Manipulator System
SRSS	Shuttle Range Safety System
SSCS	Space-to-Space Communications System
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSPTS	Station_to_Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
SSIANS	Sequential Still Unit
ST	Star Tracker
SI Sthd/STDD	Starboard
STO STO	Statuoalu Space Transportation System
	Space Management System
SWWMS	Supply and waste water Management System
	Shoulder Yaw (John) Testical Air Navigation System
TACAN	Thermol Control System (Trajectory Control Sensor
	Thermal Control System/Trajectory Control Sensor
	Telementer Format Land
	Telemetry Format Load
TEA	Translational Hand Controller
1 EA	Torque Equilibrium Attitude
	Terminal Phase Initiation/Transfer Initiation
TIG	lime of Ignition
TPS	Thermal Protection System
TRAD	Tile Repair Ablator Dispenser
TSM	Tail Service Mast
TVC	Thrust Vector Controller
UA	Unexplained Anomaly
USAF	United States Air Force
VCR	Video Cassette Recorder
VCU	Video Control Unit
VDT	Vehicle Data Table
WCS	Waste Collection System

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/Abbreviation	Explanation
WIF	Worksite Interface
WLEIDS	Wing Leading Edge Impact Detection System
WLES	Wing Leading Edge System
WS	Work Site
WSB	Water Spray Boiler
YETI	Y-Code Erroroneous Tracking Incident
	U
Unit of Measure	Explanation
А	Ampere
°F	Degrees Fahrenheit
deg/sec	degree per second
ft	feet
ft/sec	feet per second
g/G	Gravity
Grms	Gravity root mean square
hr	hour
in	inch
kW	Kilowatt
kWh	Kilowatt hour
lb	Pound
lbm/lb _m	Pound Mass
lb/min	Pounds Per Minute
min	minute
mmHg	Millimeters Mercury
mph	miles per hour
nmi	nautical mile
ppCO ₂	partial pressure Carbon Dioxide
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
scch	standard cubic centimeters per hour
scim	standard cubic inches per minute
sec	second
V	Volt
Vdc	Volts direct current