

STS-124 SPACE SHUTTLE MISSION REPORT

February 2009



**National Aeronautics and
Space Administration**

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

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STS-124
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STS-124 CONTENTS LISTING

<u>Section</u>	<u>Page</u>
<u>INTRODUCTION</u>	1
<u>MISSION SUMMARY</u>	3
<u>PAYLOADS AND EXPERIMENTS</u>	16
LAUNCH PACKAGE OVERVIEW	16
CREW ACTIVITIES SUMMARY	16
TRANSFER WEIGHT SUMMARY	17
SIGNIFICANT FIRSTS	18
SIGNIFICANT ISS ANOMALIES	18
MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS	18
<u>VEHICLE PERFORMANCE</u>	23
SOLID ROCKET BOOSTERS	23
REUSABLE SOLID-ROCKET MOTORS	23
EXTERNAL TANK	25
SPACE SHUTTLE MAIN ENGINES	26
SHUTTLE RANGE SAFETY SYSTEM	27
ORBITER SYSTEMS	28
<u>Main Propulsion System</u>	28
<u>Hazardous Gas Concentrations</u>	28
<u>Gas Sample Analysis</u>	28
<u>Purge, Vent, and Drain System</u>	30
<u>Reaction Control System</u>	30
<u>Orbital Maneuvering System</u>	35
<u>Auxiliary Power Unit System</u>	36
<u>Hydraulics/Water Spray Boiler System</u>	37
<u>Power Reactant Storage and Distribution System</u>	38
<u>Fuel Cell System</u>	39
<u>Electrical Power Distribution and Control System</u>	40
<u>Orbiter Docking System</u>	41
<u>Life Support Systems</u>	41
<u>Active Thermal Control System</u>	43
<u>Flight Software</u>	44
<u>Data Processing System Hardware</u>	44
<u>Multifunction Electronic Display System</u>	44
<u>Displays and Controls System</u>	45
<u>Flight Control System</u>	45
<u>Air Data Transducer Assembly</u>	46
<u>Inertial Measurement Unit and Star Tracker System</u>	46
<u>Global Positioning System Navigation</u>	47
<u>Communications and Tracking System and Navigation Aids</u>	47

<u>Section</u>	<u>Page</u>
<u>Operational Instrumentation/Modular Auxiliary Data System</u>	48
<u>Mechanical and Hatch Systems</u>	48
<u>Landing and Deceleration System</u>	48
<u>Aerothermodynamics, Integrated Heating and Interfaces</u>	49
<u>Thermal Control System</u>	50
<u>Thermal Protection System and Post-Landing Assessment</u>	50
<u>Windows</u>	53
<u>Waste Collection System</u>	53
<u>EXTRAVEHICULAR ACTIVITY</u>	54
FIRST EXTRAVEHICULAR ACTIVITY	54
SECOND EXTRAVEHICULAR ACTIVITY.....	55
THIRD EXTRAVEHICULAR ACTIVITY	55
<u>REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM</u>	57
<u>WING LEADING EDGE IMPACT DETECTION SYSTEM</u>	59
ASCENT MONITORING	59
ORBIT MONITORING.....	59
CONCLUSIONS	60
<u>GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT</u>	61
<u>DEVELOPMENT TEST OBJECTIVES</u>	63
<u>POSTLAUNCH PAD INSPECTION</u>	64
<u>LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS</u>	67
 <u>APPENDICES</u>	
A STS-124 MISSION EVENTS LIST.....	A-1
B STS-124 INFLIGHT ANOMALY LIST.....	B-1
ORBITER.....	B-2
SOLID ROCKET BOOSTER	B-10
REUSABLE SOLID ROCKET MOTOR	B-11
EXTERNAL TANK	B-12
SPACE SHUTTLE MAIN ENGINE	B-13
SYSTEM ENGINEERING AND INTEGRATION	B-14
FLIGHT OPERATIONS AND INTEGRATION ANOMALIES.....	B-17
FLIGHT SOFTWARE	B-18
MISSION OPERATIONS	B-19
C DOCUMENT SOURCES.....	C-1
D ACRONYMS AND ABBREVIATIONS.....	D-1

TABLES

<u>Table</u>	<u>Page</u>
TOTAL WEIGHT TRANSFERRED DURING THE MISSION.....	17
ISS MISSION PRIORITIES COMPLETION STATUS.....	18
RSRM PERFORMANCE PARAMETERS AT 60 °F PMBT.....	23
RSRM PROPULSION PERFORMANCE.....	24
HAZARDOUS GAS CONCENTRATIONS AT LAUNCH.....	28
SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION.....	29
HYDROGEN FIRING LEAK RATES.....	29
AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS	30
RCS PROPELLANT LOADING	31
TYVEK COVER RELEASE TIMES AND ALPHA/BETA ANGLES	31
RCS MANEUVERS AND FIRING DATA.....	32
RCS RESIDUAL PROPELLANTS	33
AFT RCS PROPELLANT INTERCONNECT USAGE	33
RCS PROPELLANT CONSUMPTION	33
CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE.....	34
OMS CONFIGURATION.....	35
OMS MANEUVERS.....	36
INTERCONNECT USAGE, %/POUNDS.....	36
PROPELLANT USAGE DATA.....	36
APU RUN TIMES.....	37
APU FUEL CONSUMPTION.....	37
PRSD TANK QUANTITIES.....	38
LANDING PARAMETERS.....	48
ENTRY MAXIMUM TEMPERATURES AND MAXIMUM TEMPERATURE RISE DATA	49
SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE	51
SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 GRMS.....	59
SUMMARY OF MM/OD IMPACTS.....	60

STS-124 SPACE SHUTTLE MISSION REPORT

INTRODUCTION

The Space Transportation System (STS) -124 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 123rd mission of the Space Shuttle Program. The purposes of this mission, designated as Assembly Flight 1J/A, were to deliver and install the *Japanese Kibo Laboratory* to the International Space Station (ISS), exchange the ISS Flight Engineer 2 crewmembers and deliver critical supplies and cargo to the ISS.

STS-124 was the 10th mission since the return to flight following the STS-107 mission, and the 26th mission to the ISS. STS-124 was also the 35th flight of the Orbiter Discovery vehicle.

The flight vehicle consisted of the OV-103 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-126; three Block II SSMEs that were designated as serial numbers (S/Ns) 2047, 2044, and 2054 in positions 1, 2 and 3, respectively; and two SRBs that were designated BI-133. The two RSRMs were designated flight set RSRM-102. The individual RSRMs were S/N 360W102A (left) and S/N 360W102B (right). Launch pad 39A and Mobile Launch Platform (MLP) -3 were used as the platform for launch of the STS-124 mission.

The primary objectives of the STS-124 mission were as follows:

1. Retrieve the Orbiter Boom Sensor System (OBSS) from the Starboard 1 truss.
2. Deliver, install and activate the Japanese Pressurized Module (JPM) named Kibo to the left side of the Harmony Connecting Node.
3. Rotate the ISS Flight Engineer 2 crewmembers and transfer mandatory crew rotation cargo.
4. Perform three Extravehicular Activities (EVA's).
5. Remove and replace the Starboard 1 Truss Nitrogen Tank Assembly.
6. Transfer mandatory quantities of water and nitrogen as well as other critical supplies to the ISS.
7. Transfer experiment data from the ISS to the Orbiter for return.

The STS-124 mission was planned to be a 14-day plus 2-contingency-day flight.

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, 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-124 flight were Mark E. Kelly, CDR U. S. Navy, Commander; Kenneth T. Ham, CDR, U. S. Navy, Pilot; Karen L Nyberg, PhD, Civilian, Mission Specialist 1; Ronald J. Garan, Civilian, Mission Specialist 2; Michael E. Fossum, Colonel, Air Force Reserve, Mission Specialist 3; Akihiko Hoshide, PhD, Civilian, Japanese Aerospace Exploration Agency, Mission Specialist 4; Gregory E. Chamitoff, PhD, Civilian, Mission Specialist 5 up to ISS and Garrett E. Reisman, PhD, Civilian, Mission Specialist 5 (down from ISS).

STS-124 was the second Shuttle flight for the Commander, Mission Specialist 3 and Mission Specialist 5 (down from ISS). STS-124 was the first Shuttle flight for the Pilot, Mission Specialist 1, Mission Specialist 2, Mission Specialist 4 and Mission Specialist 5 (up to ISS).

MISSION SUMMARY

The objectives of the STS-124 mission included retrieving the Orbiter Boom Sensor System (OBSS) from the Starboard 1 truss on the International Space Station (ISS), installing and activating the Japan Aerospace Agency's Japanese Experiment Module (JEM) Pressurized Module (JPM) onto a Harmony port using the Space Station Remote Manipulator System (SSRMS), releasing the Shuttle Remote Manipulator System (SRMS) elbow camera launch locks, rotating the Expedition 16/17 ISS Flight Engineer and NASA Science Officer Garrett Reisman with Expedition 17 Flight Engineer and NASA Science Officer Greg Chamitoff, and performing three Extravehicular Activities (EVA's).

Pre-Launch

During S0007 prelaunch operations, a Wing Leading Edge (WLE) sensor unit was found to be not communicating. Troubleshooting was performed, but the unit remained non-communicative. There was redundancy for ascent and the plan was to fly as is.

Also during the pre-launch operations, a pyrotechnic-shock testing facility issued an industry alert that warned that current testing methods might be overstating the shock-response spectrum by as much as 20 decibel (dB) thus invalidating qualification. The Orbiter Project confirmed that that facility had not been used. The Solid Rocket Booster (SRB) Project has used the facility, but a flight rationale was developed and waiver issued.

A Water Spray Boiler (WSB) 1 Gaseous Nitrogen (GN₂) regulator relief valve exhibited an internal leak (creep). During S0007 hydraulics testing, data showed that the regulator output pressure had exceeded the maximum allowable pressure of 44-psia, as stated in the Orbiter Maintenance and Requirements Specification (OMRS) requirements, due to regulator valve internal leakage. This condition was detected during the STS-124 aft confidence test and was a known condition. A waiver was written to document this condition.

During pre-launch operations, the Space Shuttle Main Engine (SSME) 1 Liquid Oxygen (LO₂) inlet pressure transducer was tracking 10-psi lower than SSME 2 and 3. This 0 - 300 psi transducer was used during the opening of the LO₂ inboard fill and drain valve and has an accuracy of ± 3% and was therefore within its design limits. Historical data shows this offset in previous flights. This was not a Launch Commit Criteria (LCC) or OMRS requirement violation.

During the visor-open pre-launch intercommunications testing that was performed as a part of crew ingress, the Mission Specialist (MS) 2 and Flight Deck crewmembers reported the MS2 transmissions were weak and could barely be heard (IFA STS-124-V-08). As a result, a hardware exchange to a different Communication Carrier Assembly

(CCA) was made prior to hatch closure with no impact to the launch countdown. The post-launch functional check-out of the initial CCA did not replicate the anomaly.

Ascent and Flight Day 1

The STS-124 mission was launched at 152/21:02:12.006 GMT on May 31, 2008, on the twenty-sixth Space Shuttle Program (SSP) mission to the International Space Station (ISS).

The SRB and External Tank (ET) separation were clearly visible from the ET camera. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 152/21:04:24.7 GMT (00/00:02:12.7 MET), and the maneuver was 142.80 sec in duration.

Significant Booster and SSME steering before and after SRB separation was required to control body rates induced by Solid Rocket Motor (SRM) thrust mismatch during tail off (IFA STS-124-I-004). The magnitude of steering commands and actuator responses was greater than typical, but flight-control-steering activity was appropriate for the forces and moments on the vehicle.

Main Engine Cutoff (MECO) occurred at 152/21:10:39 GMT (00/00:08:27 MET). The ET separated from the Orbiter at 152/21:11:00 GMT (00/00:08:48 MET).

The OMS-2 maneuver was a dual engine OMS firing that was performed at 152/21:39:32.7 GMT (00/00:37:20.7 MET). The maneuver was 163.2 sec in duration with a Differential Velocity (ΔV) of 249.0 ft/sec. The achieved orbit was 125.0 by 170.2 nmi. Engine performance was nominal.

The payload bay doors were opened at 152/22:36:39 GMT (00/01:34:27 MET), and radiator flow was satisfactory. The Ku-Band antenna was deployed at 152/22:49:48 GMT (00/01:47:36 MET).

During launch, the east wall of the flame trench experienced a failure. Infrared (IR) video showed a shower of bricks coming out of the flame trench at SRB ignition + 6 sec (IFA STS-124-I-002). The perimeter fence, which was 1,500 ft away, was severely damaged by the flying masonry, and launch photography showed debris splashing down into a retaining pond outside the fence several seconds after Discovery had roared aloft

A preliminary inspection of the trench found that the anchor plates that were used to provide overall system strength and stability during construction and beyond were significantly corroded and had failed. These anchor plates were dovetailed into the bricks and adjacent wall, and had failed in most instances along the brick-to-wall plane. An epoxy was used to develop adhesive strength of the brick to the adjacent wall. There appeared to be evidence of the epoxy being burned or charred significantly in the areas closest to the flame deflector. The risk assessment for the unexpected debris

exceeding allowable mass limits indicated that given the proposed mitigations, the observed debris posed no appreciable increase in risk (IFA STS-124-I 001).

Ascent imagery analysis identified remnants of the Tyvek rain covers that had temporarily remained on the F3D and F4D Reaction Control System (RCS) thruster nozzles after the initial rain cover release (IFA STS-124-V-05 and IFA STS-124-I-003). The F3D and F4D main covers released at 4.65 and 5.86 sec MET (54 mph and 71 mph), respectively, and the remnants (approximately 10%) released at 18.95 and 24.78 sec MET (292 mph and 419 mph).

At 00/00:00:51 MET, both Left OMS Thrust Vector Controller (TVC) secondary position transducers ramped from the nominal ascent stow positions (approximately +6.0 deg for both the pitch and yaw axes) to 0.0 deg in both axes (IFA STS-124-V-01). The change in indicated position took approximately 10 sec. The primary position transducer indications remained nominal during the same timeframe. This failure did not impact the OMS assist and the OMS-2 firings; however, the gimbal check was not performed on the left secondary TVC after the firing. The primary position transducers performed satisfactorily during the Deorbit Maneuver.

During powered flight, fuel cell 3 Oxygen (O₂) data became erratic. This erratic data signature was seen on the last flight (STS-113) of this fuel cell 3. The data began to stabilize after reaching orbit and remained stable throughout the remainder of the flight.

Also, during powered flight, the Main Propulsion System (MPS) SSME 2 Liquid Hydrogen (LH₂) feed-line inlet pressure-transducer showed erratic performance with three downward pressure dips below normal, followed by recovery each time. The transducer was suspected to be the source of this condition since this fluctuation was not seen on the LH₂ Manifold, SSME-1, SSME-3 or any downstream instrumentation.

An OMS-3 Nominal Correction (NC) 1 maneuver was performed nominally at 152/23:58:40.5 GMT (00/02:56:28.5 MET) with the cutoff at 152/23:59:35.8 GMT (00/02:57:23.8 MET) and both OMS engines operated nominally. The maneuver was 55.3 sec in duration with a ΔV of 85.9 ft/sec. The resulting orbit was 165.4 by 177.2 nmi.

Following the OMS-3 maneuver, the Left OMS engine secondary TVC was parked at the End of Mission (EOM) Center of Gravity (c.g.) position, powered off and the engine remained in that position until the Deorbit Maneuver. All remaining OMS maneuvers, except the deorbit maneuver, were performed as single-engine firings using only the right OMS engine. The engine performed satisfactorily during the Deorbit Maneuver, and the secondary TVC pressure transducer began functioning normally through the remainder of the flight.

Flight Day 2

The main crew activities for Flight Day (FD) 2 were rendezvous and docking preparations and the Thermal Protection System (TPS) inspection survey.

The OMS-4 (NC2) maneuver, a right Orbiter Maneuvering Engine (OME) firing, was satisfactorily performed with ignition at 153/14:25:12.6 GMT (00/17:23:00.6 MET) and cutoff at 153/14:25:36.6 GMT (00/17:23:24.6 MET). Engine performance was nominal. The duration was 23.8 sec with a ΔV of 17.5 ft/sec. The resulting orbit was 181.3 by 171.8 nmi.

The Shuttle Remote Manipulator System (SRMS) power-up and checkout was performed satisfactorily with no problems or issues noted.

The FD 2 TPS survey was performed using the SRMS-only since the OBSS was stowed on the ISS during the prior flight. Imagery of the Wing Leading Edge (WLE) Reinforced Carbon-Carbon (RCC) panels showed no gross anomalies as determined by the Damage Assessment Team (DAT). The survey also included the upper Leading Edge Subsystem (LESS) carrier panels and no items of concern were identified. Some upper carrier panel tile locations were not captured in the field of view, but these areas were expected to be visible during the R-bar Pitch Maneuver (RPM).

An area of frayed/outer cover fabric damage on a Flexible Insulation Blanket (FIB) at the aft-inboard portion of the Right OMS pod was noted. Upon further research, it was determined that the damaged area was actually a patch that was frayed or damaged, and it was determined to not be an issue by the DAT.

A waste water dump was performed. The nozzle was newly installed for this flight, and in accordance with the applicable Flight Rules, video was taken of the dump using the SRMS. Based on the downlink video, the nozzle installation was confirmed to be functioning within the designed tolerance because the dump plume pattern was perpendicular to the Orbiter fuselage.

The docking ring extension was completed at approximately 153/18:51:32 GMT (00/21:49:20 MET). The ring extension operation was started approximately 2 hr ahead of the time-line schedule. No anomalies were noted during the ring extension. The ring extension was performed with nominal dual-motor drive to the initial position of 76% ring extension.

The Rendezvous Tools checkout was performed. Initially, the Trajectory Control Sensor (TCS) failed to respond. The crew determined that the Quatech card in the laptop computer was installed incorrectly. After the crew installed the card correctly, the TCS performed satisfactorily.

The NC3 maneuver ignition occurred at 153/23:29:42 GMT (01/02:27:30 MET). The maneuver was a RCS 2-engine firing and the duration was 18.4 sec with a ΔV of 4.3 ft/sec. The resulting orbit was 183.4 by 172.6 nmi.

Micro Meteoroid/Orbital Debris (MM/OD) monitoring started with Wing Leading Edge Impact Detection System (WLEIDS) Group B at 154/10:00 GMT (01/12:57 MET) and ran for 17 hr.

Flight Day 3

The main events for FD 3 were the rendezvous and docking to the ISS. The first maneuver of the day was the OMS-5 NC4 using the Right OME. The time of ignition was 154/13:44:25.8 GMT (01/16:42:13.8 MET) with the cutoff 10.6 sec later. The maneuver had a ΔV of 8.3 ft/sec, and the resulting orbit was 177.2 by 182.9 nmi. Engine performance was nominal.

The Nominal Correction Combination (NCC) maneuver was a 6.5-sec multi-axis RCS firing using 8 primary thrusters. Ignition for the maneuver was at 154/14:18:45 GMT (01/17:16:31 MET). The ΔV delivered was 1.5 ft/sec, which placed the Orbiter in a 177.4 by 182.9 nmi orbit.

The OMS-6 Terminal Initiation (TI) maneuver was a 10.2-sec right OMS firing. Ignition was at 154/15:16:26.2 GMT (01/18:14:14.2 MET) with the cutoff 10.4 sec later. The ΔV delivered was 8.0 ft/sec, and the Orbiter was placed in a 181.3 by 184.7 nmi orbit. Engine performance was nominal.

Midcourse Correction (MC1) was a 1.7-sec multi-axis RCS firing using 5 primary thrusters. Ignition was at 154/15:36:26 GMT (01/18:34:14 MET). The ΔV delivered was 0.4 ft/sec and the Orbiter was placed in a 180.8 by 184.1 nmi orbit. MC2 was a 5.3-sec multi-axis RCS firing using 6 primary thrusters. Ignition occurred at 154/16:13:28 GMT (01/19:11:16 MET). The ΔV delivered was 1.2 ft/sec and the Orbiter was placed in a 181.8 by 184.6 nmi orbit. MC3 was a 5.4-sec multi-axis RCS firing using 7 primary thrusters. Ignition occurred at 154/16:30:20 GMT (01/19:28:08 MET). The ΔV delivered was 1.2 ft/sec and the Orbiter placed in a 181.0 by 183.7 nmi orbit. MC4 was a 2.7-sec multi-axis RCS firing using 10 primary thrusters. Ignition occurred at 154/16:40:20 GMT (01/19:38:08 MET). The ΔV delivered was 0.6 ft/sec and the Orbiter was placed in a 181.8 by 184.1 nmi orbit.

The R-Bar Pitch Maneuver (RPM) started at approximately 154/16:59:22 GMT (01/19:57:10 MET) and ended at 154/17:07:15 GMT (01/20:05:03 MET). The peak pitch-rate during the maneuver was approximately 0.70 deg/sec. The maximum roll error reached approximately 2.87 deg and the maximum yaw error reached 2.31 deg. Performance was nominal.

The Orbiter Docking System (ODS) was activated at 154/17:26:44 GMT (01/19:57:10 MET) and was deactivated after the avionics had operated for 58 min, 13 sec. The

Shuttle captured the ISS at 154/18:03:22 GMT (01/21:01:10 MET). The system was allowed to dampen out for approximately 7 min, 35 sec. Ring retraction was started at 154/18:11:03 GMT (01/21:08:51 MET). Ring retraction, using dual motors, proceeded nominally for approximately 3 min, 24 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 attained at approximately 154/18:18:02 GMT (01/21:15:50 MET) at which time docking operations were complete.

During the rendezvous, the crew commented that they observed momentary "Big Xs" on Cathode Ray Tube (CRT) 3. A momentary "Big X" is possible on one or two CRTs concurrent with display changes due to a timing/resource condition. It is not considered an impact to operations.

During the rendezvous and approach, the Trajectory Control System (TCS) Continuous Wave (CW) laser had difficulty maintaining acquisition of the reflectors on the ISS. The TCS CW laser lost track of ISS retro reflector 2 as it moved closer to the ISS along the R-bar trajectory. It immediately recovered in pulsed-laser mode. The TCS lasers switched continuously along the R-bar trajectory up to the RPM as the CW laser would try to recover, but could not. The unit had 20 instances of tracking losses (IFA STS-124-V-10). At a distance of 630 ft, the CW laser reacquired a stable lock on the ISS as the Orbiter moved away from the R-bar trajectory and maintained tracking of ISS until docking. Reduced beam size could have increased the chances for the loss of tracking. Beam size showed a narrowing of the beam approximately every 20 sec to ensure proper range values.

The Rendezvous Proximity Operations Program (RPOP) did not have issues with the instances of loss of tracking during the mission as it operated nominally, and the internal counters did not have to reset. The TCS was used nominally for undocking and flyaround with no impact to the mission.

All RPM imagery was downlinked and reviewed by the DAT. In addition, the DAT reviewed the FD 2 SRMS survey imagery as well as imagery from surveys performed with the ISS truss cameras after docking. The DAT cleared the Right OMS pod frayed blanket patch for entry. The corner of fabric patch repair broke free and frayed, but the primary blanket remained intact. TPS tile and blanket anomalies requiring additional analysis to clear were documented in IFA STS-124-V-02.

Flight Day 4

The first Extravehicular Activity (EVA) was successfully executed, and the Orbiter Boom Sensor System (OBSS) was handed from the Space Station Remote Manipulator System (SSRMS) to the SRMS, and the Japanese Experiment Module-Pressurized Module (JEM-PM) was successfully unberthed by the SSRMS and installed to the ISS.

The EVA lasted for 6 hr and 48 min. During preparation for the EVA, the Extravehicular (EV) 1 crewmember initially had good communications through the communications

cap; however, during pre-breathe, a loss of communications was experienced. While troubleshooting the problem, it was observed that the communications cap was disconnected. The suit was opened and the communications cap was reconnected. The prebreathe activity in preparation for the EVA was broken for 3 min and 5 sec, and as a result, the start of the EVA was delayed by an hour.

Following the EVA, communications between the EV1 and the EV2 and Intravehicular (IV) crewmembers were weak (IFA STS-124-V-04). After the EV2 crewmember's cap was changed, the problem was corrected and the communications cap that was used for the first EVA was not used for subsequent EVAs.

The first Contingency Water Container (CWC) of the planned seven was filled. In response to reports on the prior day that the galley dispenser needle seemed to be leaking about 8 oz of fluid a day, the crew answered questions relating to the galley dispenser leakage. They stated that the last 10 times that the dispenser was used, there were no leaks.

After reviewing the RPM imagery, the DAT recommended no focused inspection was required. However, the DAT continued to assess four lower surface tile areas that exceeded their standard criteria: nose landing gear door tile damage, base heat shield damage, body flap tile damage, and an unknown protrusion near the right External Tank (ET) door.

The Mission Management Team (MMT) accepted the DAT recommendation that no focused inspection was required, but until the analysis was completed, the TPS was considered "degraded" for the next 24 hr, consistent with the applicable Flight Rule.

Flight Day 5

The main activities for FD 5 were vestibule outfitting, middeck transfers; JEM-PM ingress and initiation of the nitrogen transfer.

The OBSS sensor checkout, the first after 2.5 months on the ISS, showed that the sensor package 1 [Laser Dynamic Range Imager (LDRI) and Intensified Television Camera (ITVC)] checkout operated nominally.

The Sensor Package 2 Laser Camera System (LCS) had an off-nominal checkout. The Integrated Sensor Inspection System (ISIS) Digital Camera (IDC) checkout was nominal. The first LCS scan was nominal followed by stalling in subsequent scans. The second scan stalled and produced a number of error messages (IFA STS-124-V-03). The LCS data was downloaded and analyzed which showed that the Y-galvanometer within the Laser Camera Head had a drive problem. The LCS was still considered operational. However, the auto-exposure function was considered not available and would be disabled if future use of the LCS was required. The LCS was not required for the RCC late inspection.

The Orbiter took control of the mated stack at 156/19:06:45 GMT (03/22:04:33 MET), and the maneuver to the water dump attitude began at 156/19:08:15 GMT (03/22:06:03 MET). The Orbiter maintained attitude-hold throughout the water-dump process. The maneuver back to Torque Equilibrium Attitude (TEA) began at 156/19:51:30 GMT (03/22:49:18 MET) and the ISS assumed control of the mated stack at 156/20:02:23 GMT (03/23:00:11 MET). The Orbiter was in attitude control for approximately 56 min.

The DAT cleared all items except the aft heat shield for entry as the stress/thermal analysis continued. The Nose Landing Gear Door (NLGD) tile damage was in the Quality Assurance process for final clearance.

Flight Day 6

The main activities for FD 6 were rack transfers and the second EVA. The duration of the second EVA was 7 hr 10 min. Activities included installing the JEM external Television (TV) camera assembly, removing the JEM Remote Manipulator System (RMS) thermal cover, and preparing the Nitrogen Tank Assembly (NTA) and External Stowage Platform (ESP) -3 for the third EVA.

The DAT effort was completed pending the Late Inspection results. All areas were cleared for entry.

Flight Day 7

Activities for FD 7 included the SSRMS relocation of the Japanese Experiment Logistics Module – Pressurized Section (JLP) and outfitting of the JPM.

The Fuel Cell (FC) 3 Cell Performance Monitor (CPM) substack 1, 2, and 3 measurements and the Hydrogen (H₂) flow-meter measurement failed to off-scale low at 159/01:18:16 GMT (06/04:16:04 MET) (IFA STS-124-V-06). These four measurements are powered by the Mid-Power Control Assembly (MPCA) 3 through a common 1-ampere (A) fuse. The MPCA 3 amperage measurement stepped down 0.4 A, from 7.2 to 6.8 A, at the time of the loss of the fuel cell measurements. Loss of the CPM measurements results in the loss of insight into monitoring a potential problem developing in a cell. The health of the FC's could be monitored using the Fuel cell Monitoring System (FCMS). With the loss of the H₂ flow-meter, any large external H₂ leakage in the FC could only be detected by excessive H₂ consumption from the Power Reactant Storage and Distribution (PRSD) H₂ tanks. This loss of the FC CPM and H₂ flow-meter instrumentation did not impact the mission.

At 159/07:18 GMT (06/10:16 MET), the Auxiliary Power Unit (APU) 3 injector water cooling line thermostat began to dither (IFA STS-124-V-13). The water system thermostat cycle range shifted from a 9-deg control band between 55 and 64 °F for the first 6.5 days on orbit after which it began a 1-deg dither between 57 and 58 °F. However, the last four cycles of the thermostat were in the nominal 9-deg control band.

Flight Day 8

Activities scheduled for FD 8 included middeck transfers, JEM RMS deployment, vestibule outfitting for the JLP and JPM, and the airlock campout in preparation for the third EVA.

High-resolution imagery of the starboard RCC panels 13 through 18 was taken by the crew prior to their sleep period. These pictures were requested to screen for a possible MM/OD impact detected by the WLEIDS on FD 3. The pictures were downlinked and analyzed with no issues found.

Flight Day 9

Activities for FD 9 included the third EVA, middeck transfers, installation of the S1 truss NTA, installation of Camera Port (CP) 9 External Television Camera Group (ETVCG), removal of the JEM RMS Multi-layer Insulation (MLI) and launch locks, and port Solar Alpha Rotary Joint (SARJ) sample collection.

The third EVA lasted 6 hr and 33 min. The objectives accomplished during the EVA included retrieving the NTA from the External Stowage Platform 3, removing the NTA from the Starboard 1 Truss on the ISS and stowing it on the Flight Releasable Attachment Mechanism (FRAM), and retrieving, installing and connecting the Quick Disconnect to the spare NTA, as well as performing an inspection of the SARJ (Get-Ahead Item) and three other Get-Ahead tasks.

The DAT completed the review of the high-resolution imagery of the starboard RCC panels. There were no issues identified.

Flight Day 10

Activities for FD 10 included maneuvering the JEM RMS to the final deploy position and then to the stow-position, and ISS battery-charger module removal and replacement.

Flight Day 11

Activities for FD 11 included Middeck transfer, JEM RMS backup drive system setup, termination of Nitrogen (N₂) and Oxygen (O₂) transfer, crew off-duty time, and closing of the hatch between the Orbiter and the ISS.

The crew reported communications problems with the Middeck audio. Troubleshooting of the Handheld Microphone (HHM) was performed and the HHM was changed out during the troubleshooting (IFA STS-124-V-07). The communications problems were resolved when the HHM was changed.

The Orbiter took control of the mated stack at 162/11:23:11 GMT (09/14:20:59 MET) and the maneuver to water-dump attitude began 1 min later. The Orbiter maintained

attitude-hold throughout the water-dump activities. An Inertial Measurement Unit (IMU) alignment occurred at 162/12:53:14 GMT (09/15:51:02 MET). The maneuver back to Thermal Equilibrium Attitude (TEA) began at 162/12:53:59 GMT (09/15:51:47 MET) and the ISS assumed control of the mated stack at 162/14:01:31 GMT (09/16:59:19 MET). The Orbiter was in attitude control for approximately 2 hr 40 min for the water-dump activities. The Orbiter again took control of the mated stack at 162/20:28:18 GMT (09/23:26:06 MET) for the ODS depressurization, and the Orbiter held attitude until the hand-off to ISS control at 162/21:49:44 GMT (10/00:47:32 MET).

The rendezvous tool checkout procedure was also completed. The crew did not report any problems with the RPOP during the tool checkout.

The crew had difficulty closing and latching the External Airlock Upper Hatch on FD 11 (IFA-STS-124-V-14). Attempts to position the actuator handle over the decal that indicates the correct pre-closing position were unsuccessful, as a hard stop was encountered prior to reaching that position. After approximately 10 min of attempting various techniques, the crew was able to seat the hatch by moving the handle slightly in the latching direction, and latching was then completed successfully. Post flight troubleshooting determined that the decal was in the wrong location.

Flight Day 12

Activities for FD 12 included the undocking, flyaround, and separation from the ISS, and inspection of the RCC TPS with the OBSS.

The Orbiter undocked from the ISS at 163/11:41:55 GMT (10/14:39:43 MET), and performed a fly-around of the ISS.

The 5.9-sec 1.5-ft/sec +X radial Separation 1 maneuver was performed with the RCS L3A and R3A thrusters at 163/12:50:54 GMT (10/15:48:42 MET). The 6.0-sec 1.5-ft/sec -X posigrade Separation 2 maneuver was performed with the RCS F1F and F2F thrusters at 163/13:18:57 GMT (10/16:16:45 MET). All undocking and separation activities were nominal.

The crew successfully performed the inspection of the RCC with the OBSS. The Starboard RCC Survey began at 163/15:28 GMT (10/18:26 MET), and the Nose Cap Survey commenced at 163/17:04 GMT (10/20:02 MET). The Port RCC Survey lasted from 163/18:02 GMT (10/21:00 MET) to 163/19:11 GMT (10/22:09 MET). Upon completion of the surveys, the RMS was returned to the OBSS Hover position. The survey data were downlinked for review by the DAT.

The IMU 1 Z-axis gyro had been operating at 4-sigma over the course of the mission (IFA STS-124-V-09). However, 3.5 of the 4-sigma had occurred over the last two days. This is greater than expected for this IMU, but considerably less than 10 to 15 sigma per day rate that renders the IMU as unreliable. The ground uplinked a compensation value to the drift on FD 11 and the IMU continued to be monitored for degraded performance.

The last flight of this IMU yielded approximately 1-sigma drift over the entire mission. This Z-axis gyro issue is not related to the x/y redundant rate data spikes seen earlier, and may be due to lubrication issues causing degradation of the gyros.

The DAT completed the Level 1 screening of the inspection data. One Region of Interest (ROI) that was within the damage criteria was found on starboard 15 lower surface (Curry zone-2 region). Subsequent measurements showed this ROI to be within the criteria.

The OBSS Late Inspection scans allowed the TPS DAT to review the areas previously reported to be below the resolution required to detect damage. The team was successful in clearing all upper port LESS carrier panel tiles, the port and starboard chine areas and the forward fuselage sidewalls. The TPS tile remained cleared for entry.

Flight Day 13

FD 13 was designated as a crew off-duty day.

The remaining late inspection imagery data review was completed. A total of 790 ROIs were documented with 238 requiring review by the PRT. The PRT recommended all TPS tile and RCC be cleared for entry.

Since no further inspections were required, the RMS berthed the OBSS to the starboard Manipulator Positioning Mechanism (MPM), and then cradled to the port MPM. Both sets of MPM pedestals were stowed for entry.

An Orbit Adjust (OA) maneuver was performed to adjust the Orbiter for the deorbit opportunity on Saturday. The OA maneuver was a 25.4 sec +X RCS firing. Ignition for the firing was at 164/20:20:12 GMT (11/23:18:00 MET). The ΔV delivered was 6.8 ft/sec and the Orbiter was placed into a 189.9 by 181.9 nmi orbit. Thruster performance was nominal.

Flight Day 14

Primary activities for FD 14 activities included the Flight Control System (FCS) checkout, RCS hotfire, a public affairs event, and cabin stowage for entry.

The FCS checkout was performed satisfactorily. APU 1 operation was started at 165/10:30:35 GMT (12/13:28:23 MET). A total of 14 lb of fuel was used during the 4 min 31 sec of run-time of the APU. All APU parameters were nominal during the FCS checkout.

The RCS hot-fire procedure was initiated at 165/11:13:27 GMT (12/14:11:15 MET) and the hot-fire was completed at 165/11:24:04 GMT (12/14:21:52 MET). All 38 thrusters were fired for at least 0.240 sec per pulse. All thrusters had been fired satisfactorily.

Following the RCS hot-fire, the crew reported two observations. The first was an object that was approximately a foot long, which was observed out the aft window (IFA STS-124-V-11). The object was floating away from the rear of the Orbiter, and was liberated during the aerosurface drive operations. Video of the object was assessed by TPS DAT personnel who determined that the object was most likely the spring seal (thermal barrier) from inside the Rudder Speed Brake (RSB). These clips provide a thermal seal at the edge of the RSB for ascent plume heating, and this particular Inconel piece liberated during the aerosurface drive due to spot-weld failure. There is a history of these clips tearing and liberating. Loss of this component was not an issue for entry.

The second observation noted by the crew was material protruding from the trailing edge of the split line between the upper and lower RSB panels. Pictures were downlinked and evaluated by the TPS DAT which determined that the material was a thermal barrier which is allowed to protrude slightly at the aft of the panel interface. There was no concern for entry as this protrusion was per design.

Flight Day 15

Both Payload Bay Doors (PLBDs) were closed nominally by 166/11:32:14 GMT (13/14:30:02 MET) in preparation for landing.

During Star Tracker door closure, the Closed-2 indication on the Y door failed to turn on (IFA STS-124-V-12). Motor 2 continued to drive as a result until a crewmember removed power. The Closed-1 indication was obtained nominally within the dual-motor run time and current draw was observed on both motors. This condition had no impact on the entry operations.

The Deorbit Maneuver was performed on orbit 217 for the first landing opportunity at Kennedy Space Center (KSC), a dual-engine straight-feed firing, was performed at 166/14:10:12.2 GMT (13/17:08:00.2 MET). The duration of the deorbit firing was 155.4 sec and the ΔV was 291.1 ft/sec. The orbit following the deorbit firing was 23.6 by 190.9 nmi. The engines performed satisfactorily.

Entry interface occurred at 166/14:43:40 GMT (13/17:41:28 MET), and entry was completed satisfactorily.

The main landing gear touchdown occurred on KSC concrete runway 15 at 166/15:15:18 GMT (13/18:13:06 MET) on June 14, 2008. The drag chute was deployed at 166/15:15:20.5 GMT. Nose-gear touchdown occurred at 166/15:15:28 GMT. Drag chute release occurred at 166/15:15:59 GMT. Wheels stop occurred at 166/15:16:18 GMT. The rollout was normal in all respects.

The flight duration was 13 days 18 hr 13 min 06 sec. The last APU was shutdown at 17 min 57 sec after landing.

Post-Flight

During the runway inspection, a region of excessive Type A flow was observed on the right-hand Wing Leading Edge (WLE) tee-seal at rib splice 10 (IFA STS-124-V-15). Inspection revealed a large forward-facing step-and-gap along the lock-side interface to the mating WLE panel 9R that was not apparent before flight. Upon removal of the tee seal, leading edge deterioration was observed along with an abundance of Type A glass flow. Similar observations to a lesser degree have been made on left wing tee seals at rib splices 10 and 11.

PAYLOADS AND EXPERIMENTS

LAUNCH PACKAGE OVERVIEW

The International Space Station (ISS) 1J launch package consisted of the Japanese Experiment Module Pressurized Module (JEM PM), the JEM RMS, a Carbon Dioxide Removal Assembly (CDRA) bed, and the Russian Liquid – Gas Separator Pump.

The ISSP Utilization payloads flown in the Middeck were the National Laboratory Payload (NLP) -1B, LOTTE Xylitol, Communication Support Equipment (CSE), and Area Passive Dosimeter Life Science Experiment in Space (PADLES).

Short Duration Bioastronautics Investigations (SDBIs) performed during the mission included Sleep Long/SDBI 1634 (Sleep Short), and Midodrine Long. Middeck payloads returned included NLP-1B, Commercial Generic Bioprocessing Apparatus (CGBA) Science Insert (CSI-02), Coarsening in Solid Liquid Mixtures (CSLM) Sample Processing Unit (SPU) and Electronic Control Unit (ECU), and Double Cold Insulated Sample Bag with Samples. The Maui Analysis of Upper-Atmospheric Injections (MAUI) was flown as a payload of opportunity, but was not performed.

CREW ACTIVITY SUMMARY

The Space Shuttle Discovery successfully docked to the ISS Pressurized Mating Adapter (PMA) 2 at 1:04 p.m. Central Daylight Time (CDT). Docking was followed by hook closure, which rigidized the vehicle with the ISS stack and allowed the ISS to return to active attitude control in the –XVV attitude. This attitude provides increased Micro-Meteoroid and Orbital Debris (MM/OD) protection for the Orbiter. The crew opened the hatch at 2:37 pm CDT and was followed by a welcome ceremony and safety briefing. The Individual Equipment Liner Kit (IELK) of Flight Engineer (FE) -2 Gregory Chamitoff was successfully installed in the Soyuz vehicle, thus marking the official transition of the FE 2 from a Shuttle to an ISS crewmember, and thus designating FE-2 (1J/A) Garrett Reisman as a Shuttle crewmember.

Three EVAs were successfully performed which included the transfer of the OBSS from the ISS to the Orbiter, installation of the JPM and the JEM RMS, outfitting of the JPM for the JEM Experiment Logistics Module -Pressurized Section (JEM-PS) relocation, installation of the JEM Television Camera Equipment (JTVE), a Nitrogen Tank Assembly (NTA) changeout, and other EVA get ahead's listed in the table at the end of this section. The specific tasks completed during the EVAs are listed in the table at the end of this section.

On FD 4, EVA 1 was successfully performed by the EV1 and EV2 crewmembers, and the duration was 6 hr, 48 min. Robotics ground controllers powered up the Mobile Servicing System (MSS). The EVA crewmember released the OBSS from the ISS, and Mission Specialist (MS) 4 grappled the OBSS with the Space Station Remote

Manipulator System (SSRMS) and handed the OBSS off to the SRMS. The SSRMS then grappled the Node 2 Power and Data Grapple Fixture (PDGF) and moved the arm off the Mobile Remote Servicer Base System (MBS) onto Node 2 in preparation for the JEM PM (JPM) grapple. The SSRMS then grappled the JPM in the Payload Bay, unberthed it, and installed it on the Node 2 port Common Berthing Mechanism (CBM). Early in the EVA, one of the EV crewmembers served as a manual check of the Mobile Common Attachment System (MCAS) Ready-to-Latch (RTL) indicators. The SSRMS remained grappled to the JPM to provide keep-alive power to the module via the arm's payload power bus.

On FD 6, the second EVA was successfully performed by the EV1 and EV2 crewmembers, and the duration was 7 hr 10 min. On FD 8, the third EVA was successfully performed and the EVA had a duration of 6 hr 33 min.

The STS-124 crew reported no difference in air quality between the Shuttle and the ISS on 1J. The flight data correlated well with the model predictions. The Shuttle middeck duct used on this flight was left in PMA 2 for use on future Shuttle missions.

The ISS and Shuttle crews bid farewell and closed the ISS hatch on FD12. The Orbiter was successfully undocked from the ISS, and then completed a flyaround to obtain imagery of ISS with the newly-delivered JPM and the JEM RMS. The addition of the JPM added approximately 4,571 cubic feet (ft³) of internal volume with 1,723 ft³ of habitable volume. The ISS weight in orbit was increased by 32,558 lbm.

TRANSFER WEIGHT SUMMARY

All of the transfers were successfully accomplished during the mission. The following table and discussion provides an overview of the total transfers

TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Parameter	To ISS, lb _m	From ISS, lb _m
Cargo Bay	32,558.5	
Middeck	1,807	1,787
Totals	32,588.5	1,787

1. **Water** – The total quantity of supply water transferred was 783.0 lbm. A total of seven Contingency Water Containers (CWC's) were transferred along with six Portable Water Reservoirs.
2. **Oxygen** – No oxygen was transferred during STS-124; however, 92 lb_m were used for the three EVA's and 29 lb_m were used for the ISS stack maintenance.
3. **Nitrogen** – A total of 15 lbm of Nitrogen was transferred to the Airlock tanks, and an estimated 120 lb_m was provided for cabin repressurization.
4. **Lithium Hydroxide (LiOH)**–A total of three LiOH canisters were transferred from the ISS to the Shuttle.
5. **Food** – No food was transferred to the ISS.

SIGNIFICANT FIRSTS

The significant firsts for the STS-124 mission were as follows:

1. Disconnecting the OBSS from the Orbital Support Equipment (OSE) on the ISS after 2.5 months of stowage and transferring back to the Orbiter to be used for Late Inspection.
2. Deployment and checkout of the Japanese Experiment Module and JEM Remote Manipulator System (JEM RMS).
3. Operation of three RMS robotic arms on the ISS.
4. Robotic relocation of JEM/Experiment Logistics Module – Pressurized (JLP)/ELM-PS from the Node to the JPM.
5. Transfer of racks from the JLP to JPM.
6. Relocate and install middeck ducting to mitigate elevated Carbon Dioxide (CO₂) levels.

SIGNIFICANT ISS ANOMALIES

No significant anomalies occurred during the docked operations.

MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS

The following table provides the status of the mission priorities at the end of the mission.

ISS MISSION PRIORITIES COMPLETION STATUS

	Task	Flight Day Task Completed
	Category 1 Tasks	
1	Release Keep Alive Umbilical (KAU) from OBSS and transfer the OBSS to the Orbiter. Remove and retrieve the KAU Attachment Device (KAD).	FD4
2	Release SRMS elbow camera launch locks.	FD4
3	Rotate E16/17 (1J/A) FE-2 crewmember with E17 (1J) FE-2 crewmember, transfer mandatory crew rotation cargo per Flight 1J Transfer Priority List (TPL) in Appendix I, and perform mandatory tasks consisting of IELK installation, and Sokol suit checkout.	FD3

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
4	Install JEM PM to Node 2 port ACBM using the SSRMS. <ul style="list-style-type: none"> a. Disconnect LTA cables from the JEM PM. b. Remove PCBM contamination covers. c. Perform Node 2 port ACBM sealing surface inspection. d. Perform JEM PM PCBM sealing surface inspection. e. Open Node 2 Hatch window cover to allow Centerline Berthing Camera System (CBCS) operations for JEM PM mate. f. Perform Node 2 port ACBM mate checkout. g. Mate JEM PM to Node 2 port ACBM. h. Provide power to JEM PM heaters via SSRMS. 	FD4-6
5	Activate a single power channel for JEM PM systems and JEM RMS for survival heater power. This activation sequence includes utility jumper connectivity and EPS jumper connectivity to allow for the JEM PM activation. <ul style="list-style-type: none"> Activate JEM PM cooling loop. Activate heaters for the JEM PM. Activate heaters for the JEM RMS. 	FD5
6	Transfer water of mandatory quantities from Shuttle per Flight 1J TPL.	FD3-11
7	Transfer critical items per Flight 1J TPL.	FD3-11
	Category 2 Tasks	
8	Perform minimum crew handover of 12 hours per rotating crewmember which includes crew safety handover.	FD5, 8-11
9	Remove the Node 2 Port Aft Negative Pressure Relief Valve (NPRV) and replace with Intra-Module Valve (IMV).	FD5
10	Configure Pressurized Berthing Adapter (PBA)/ Program Furnished Equipment (PFE) for JEM PM.	FD5
11	Retrieve the JEM RMS system rack from the Experiment Logistics Module-Pressurized Section (ELM-PS), ingress the JEM PM and install and activate the system rack and verify JEM RMS arm joints and temperature readings are within expected ranges. <ul style="list-style-type: none"> a. Uninstall CBCS equipment from Node 2 Port vestibule and remove Control Panel Assemblies (CPAs). b. Relocate JEM RMS rack from JEM ELM-PS1F1 to JEM PM1A6. 	FD5-6

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
12	<p>Activate the redundant channel for the JEM PM core systems. This activation sequence requires the relocation and activation of racks from the JEM ELM-PS to the JEM PM and EPS jumper connectivity.</p> <ol style="list-style-type: none"> a. Configure Columbus for JEM PM power jumper installation (partial power down), mandatory power to payloads. b. Retrieve two Rack Dummy Panels (Hard) from temporary stow location and install in JEM PM1D4 and JEM PM1F2. c. Relocate JEM EPS1 from JEM ELM-PS1S2 to JEM PM1D2. d. Relocate JEM DMS1 from JEM ELM-PS1P2 to JEM PM105. e. Install second vestibule power jumper. 	FD6
13	Reconfigure the heater controller power from SSRMS to JEM PM power to allow the SSRMS to ungrapple the JEM PM.	FD6
14	<p>Perform JEM RMS preparation and partial deployment.</p> <ol style="list-style-type: none"> a. Remove the JEM RMS Multi-Layer Insulation (MLI) thermal covers. b. Install the JTVE secondary structure/ camera assemblies and activate JTVE heater power. c. Perform partial deployment on JEM RMS. d. Remove the MLI and Launch Locks from JEM RMS Wrist Vision Equipment (WVE) and Elbow Vision Equipment (EVE). 	FD6, FD8
15	<p>Perform EVA to complete the tasks necessary for ELM-PS relocation to the JEM PM.</p> <ol style="list-style-type: none"> a. Release JEM PM Zenith ACBM covers and inspect sealing surface for debris. b. Remove JEM PM Zenith hatch PIP Pin Launch lock. 	FD6
16	Remove and Replace (R&R) the Starboard 1 (S1) Nitrogen Tank Assembly (NTA) using spare NTA located on ESP-3.	FD9
17	<p>Perform tasks to prepare for STS-126.</p> <ol style="list-style-type: none"> a. Open Node 2 Nadir Hatch window flap for CBCS. b. Verify Ready-To-Latch (RTL) (three) operation of the Mobile Servicing System Common Attachment System (MCAS). 	FD6
18	Perform Carbon Dioxide Removal Assembly Bed R&R.	FD5
19	Remove CP9 ETVCG and install dummy box at CP 9 location.	FD6
20	Perform Television Camera Interface Controller (TVCIC) R&R and prepare removed TVCIC for return.	FD8
21	Re-inspect starboard Solar Alpha Rotary Joint (SARJ) Datum-A surface.	FD4
22	<p>Transfer remaining racks from ELM-PS to JEM PM.</p> <ol style="list-style-type: none"> a. Workstation (WS) from JEM ELM-PS1A1 to JEM PM1F4. b. Relocate two Rack Dummy Panels (Hard) from JEM PM to ELM-PS. <ol style="list-style-type: none"> 1. JEM PM1F2 to JEM ELM-PS1F1 2. JEM PM1D4 to JEM ELM-PS1P2 c. Inter-Satellite Communication System/Proximity (ICS/PROX) from JEM ELM-PS1P1 to JEM PM104. 	FD6

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
	<ul style="list-style-type: none"> d. NASDA-Owned Rack (SAIBO) from JEM ELM-PS12A to JEM .PM1A2. e. NASDA-Owned Rack RYUTAI from JEM ELM-PS1F2 to JEM PM1A3 f. JEM PM Resupply Stowage Rack (JRSR)-1 from JEM ELM-PS1S1 to JEM PM103 	
23	Configure Node 2 zenith vestibule for closeout, including disconnecting utilities and installation of Control Panel Assemblies (CPAs).	FD6
24	Relocate ELM-PS from Node 2 zenith to JEM PM zenith location. <ul style="list-style-type: none"> a. Install CBCS equipment in JEM PM zenith hatch. b. Perform JEM ELM-PS PCBM sealing surface inspection. c. Relocate JEM ELM-PS from Node 2 zenith to JEM PM zenith location. d. Perform Node 2 zenith ACBM demate checkout. e. Perform JEM PM zenith ACBM mate checkout. f. De-install CBCS equipment. g. Activate ELM-PS for survival heater power, including connectivity for utility jumpers. 	FD7
25	Perform detailed Starboard SARJ Outer Ring Cleaning Development Test Objective (DTO).	FD4
	CATEGORY 3 TASKS	
26	Node 1 to Airlock Common Cabin Air Assembly (CCAA) Check Valve Hose Installation.	FD5
27	Perform Battery Charger Module (BCM) R&R.	FD10
28	Perform ELM-PS vestibule outfitting, remove CPAs and complete ELM-PS activation.	FD5-8, FD10
29	Perform ISS daily payload status checks as required.	FD3-11
30	Perform daily middeck activities to support payloads.	FD3-11
31	Transfer remaining cargo items per Flight 1J TPL.	FD3-11
32	Reinstall CP9 ETVCG.	FD9
33	Perform the following EVA task if time permits. EVA will not be extended to complete these tasks: <ul style="list-style-type: none"> a. Release two JEM PM ACBM MM/OD shield restraints. b. Install JEM PM trunnion and keel pin covers. c. Release JEM PM window shutter launch locks. d. Install TBA 5 on Starboard SARJ. e. Deploy JEM PM MM/OD Shields. f. Install two EVA gap spanners on Node 2. 	FD4, 6, 9, 10
34	Perform JEM RMS final deploy, maneuver to stow and brake checkout.	FD10
35	Laboratory AmlA Installation/Removal.	FD6, FD8
36	Perform an additional 4 hours for rotating crewmember of ISS crew handover (16 hours per crewmember total).	FD11
37	Perform ISS payload research operations tasks.	FD3-11

ISS MISSION PRIORITIES COMPLETION STATUS (Concluded)

	Task	Flight Day Task Completed
38	Perform imagery survey of the ISS exterior during Orbiter flyaround after undocking, if consumables available.	FD12
39	Transfer required N ₂ from the Orbiter to the ISS Airlock High Pressure Gas Tanks (HPGTs).	FD5-11
40	Transfer O ₂ from the Orbiter to the ISS Airlock HPGTs, if consumables available.	None
41	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, Dedicated Thruster Firing, as consumables allow (IWIS required).	FD10
42	Perform Station Development Test Objective (SDTO) 13005-U, ISS Structural Life Validation and Extension, during JEM PM installation. [ISS Wireless Instrumentation System (IWIS) required if Multispectral Atmospheric Mapping Sensor (MAMS) or Station Acceleration Measurement System (SAMS) unavailable].	FD4
43	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during JEM ELM-PS relocation. (IWIS required if MAMS or SAMS unavailable).	FD7
44	Perform Maui Analysis of Upper Atmospheric Injections (MAUI) as payload of opportunity.	No opportunities
45	Perform the following program-approved EVA get-ahead tasks: <ul style="list-style-type: none"> a. Perform Port SARJ inspection. b. Install MLI covers on S0-Node 2 Port and Starboard Fluid Quick Disconnects (FQDs). c. Perform Starboard SARJ Launch Restraint Removal. d. Install Wireless Video System External Transceiver Assembly (WETA) 3 at CP1. e. Node 1 MM/OD Shield reinstallation. f. Release Flexible Hose Rotary Coupler (FHRC) S1 P-Clamps. g. Release FHRC P1 P-Clamps. h. Install JEM PM EVA handrails and Worksite Interfaces (WIFs). 	All Performed
46	Perform the following program-approved IVA get-ahead tasks: <ul style="list-style-type: none"> a. Relocate six Rack Dummy Panels (Hard) for steady state operations. b. Retrieve 13 Rack Dummy Panels (Soft) from JEM ELM-PS and install in JEM PM and ELM-PS for steady-state operations. c. Set up and check out JEM RMS backup drive system. d. Remove the Positive Pressure Relief Valves (PPRVs) from Node 2, JEM PM and ELM PS hatches and replace with Manual Pressure Equalization Valves (MPEVs). e. Install Hatch Window Hyzod covers on both sides of the Node 2 pot hatch window. 	All Performed

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected during the launch-countdown and ascent of the STS-124 mission. The SRB pre-launch countdown was nominal. No SRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred. One SRB In-Flight Anomaly (IFA) was identified.

The Video Camera Recorder (VCR) in the Data Acquisition System (DAS) unit failed to record both the External Tank (ET) Observation Camera and the Parachute Camera video as well as recording erroneous data (IFA STS-124-B-001). Video should have been recorded from both the ET Observation Camera and the DAS Parachute Camera. All three DAS accelerometers failed to provide valid flight levels of acceleration data.

Both SRBs were successfully separated from the ET and the deceleration subsystems performed as designed. The SRB's were towed back to Kennedy Space Center (KSC) for inspection and teardown.

REUSABLE SOLID ROCKET MOTORS

The STS-124 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. Two in-flight anomalies were identified.

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 following table.

RSRM PERFORMANCE PARAMETERS AT 60° F PMBT

Parameter	CEI specification limit, 60 °F	Left Motor delivered	Right Motor delivered
Web time, sec	105.4 – 116.7	109.8	109.6
Action time, sec	115.2 – 131.2	122.4	121.0
Head end pressure, psia	847.9 – 965.7	921.4	925.7
Maximum Sea Level Thrust, lbf	2.88 – 3.26	3.11	3.13
Web Time Average Pressure, psia	629.9 – 700.5	672.4	673.5
Web Time Average Thrust, Mlbf	2.46 – 2.74	2.63	2.64
Web time total impulse, Mlbf sec	285.8 – 291.6	289.0	289.0
Action time impulse, Mlbf sec	293.7 – 299.7	296.6	296.4

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	268.5	268.3
Loaded propellant weight, lbm	>1103750	1105171	1105204

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

The ambient temperatures recorded during the 98 hr prior to launch of STS-124 varied from 69 to 84 °F. At the time of launch, the ambient temperature was 82 °F.

Igniter joint heaters operated for 13 hr 42 min during the launch countdown. Power was applied to the heating elements 40% (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 13 hr 50 min during the launch countdown. Power was applied to the heating elements 26% (average) of the time during the LCC time frame of the countdown. The aft skirt purge operations were for 11 hr 16 min

Propulsion performance is listed in the following table. The calculated PMBT was 75 °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 0.24% at 80.0 sec (left motor) and 0.90% at 70.0 sec (right motor). These values were within the 3.2% allowable limits.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 75 °F		Right motor, 75 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	65.95	66.47	65.58	66.80
I-60, 10 ⁶ lbf-sec	176.33	176.94	175.50	177.49
1-AT 10 ⁶ lbf-sec	296.82	296.95	296.83	296.70
Vacuum Isp, lbf-sec/lbm	268.6	268.7	268.6	268.5
Burn rate, in./sec @ 60 °F at 625 psia	0.3700	0.3713	0.3687	0.3720
Event times, sec ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	108.2	108.1	108.8	107.9
50-psia cue time	118.2	118.1	118.8	117.0
Action time ^b	120.4	120.5	121.0	119.2
Separation command	123.3	122.5	123.3	122.5

RSRM PROPULSION PERFORMANCE (Concluded)

Parameter	Left motor, 75 °F		Right motor, 75 °F	
	Predicted	Actual	Predicted	Actual
PMBT, °F	75	75	75	75
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	3.4	3.1	3.1
Tailoff impulse imbalance differential ^c	Predicted N/A		Actual 545.0	

^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 Video Camera Recorder (VCR) in Data Acquisition System (DAS) unit failed to record both the ET Observation Camera and the Parachute Camera video (IFA STS-126-B-001). Video should have been recorded from both the ET Observation Camera and from the DAS Parachute Camera. All three DAS accelerometers failed to provide valid flight levels of acceleration data.

Significant Booster and Space Shuttle Main Engine (SSME) steering occurred before and after SRB separation to control body rates induced by Solid Rocket Motor (SRM) thrust mismatch during tail off (IFA STS-124-I-004). The magnitude of steering commands and actuator responses was greater than typical, but flight-control-steering activity was appropriate for the forces and moments on the vehicle. Tailoff behavior was an extreme event from a flight history perspective, however, it appears to be within specification, and induced a larger-than-expected roll rate near SRB separation, which the flight control system handled appropriately.

All Ground Environment Instrumentation (GEI) and OFI sensors operated as expected and no significant hardware problems or weather concerns occurred during the successful countdown. All data were recorded, transmitted and analyzed.

EXTERNAL TANK

All STS-124 objectives and requirements associated with the Super Lightweight Tank (SLWT) External Tank (ET) -128 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. Liquid level and Engine Cutoff sensors performed as designed. No ET LCC or OMRSD violations occurred.

The post-launch camera film review showed two foam losses ((IFA STS-124-T-001 and IFA STS-124-I-004) within the XT 1129 LO₂ Feedline Support Outboard Base Fitting

Closeout. The dimensions of the foam loss events are approximately 6.5 in. long by 9.6 in. wide by 3.4 in. deep with an estimated mass of less than 0.10 lbm. The second lost was 5.4 in. long by 4.7 in. wide by 3.6 in. deep with an estimated mass of less than 0.05 lbm. The two loss event times are approximately 144 and 216 sec MET. The in-depth discussion of this anomaly is contained in Appendix B.

ET separation was nominal. Since Main Engine Cutoff (MECO) occurred within expected tolerances, entry and break-up of the ET occurred within the planned footprint.

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle Main Engine (SSME) parameters were nominal throughout the pre-launch countdown and were typical of previous flights. One in-flight anomaly was identified and is discussed in a later paragraph. The Block II engines were 2051, 2048, and 2058 and these were in positions 1, 2, and 3, respectively. No LCC or OMRSD violations were noted. One IFA was identified during the data analysis. Engine "Ready" was achieved at the proper time, all LCC's were met, and thrust build-up was nominal.

During pre-launch operations, an upward trend in all 3 engine High Pressure Oxidizer Turbo Pump (HPOTP) Intermediate Seal (IMSL) purge pressures was noted during purge sequence 3. This phenomenon is thought to be caused by moisture in the Gaseous Nitrogen (GN₂) purge gas freezing up on the IMSL package and causing a flow restriction. The LCC has a pre-planned contingency that was invoked just after the T-20 min hold that turned on Gaseous Helium (GHe) to the seal areas of all three engines for 2 min to melt the ice. Subsequent to that, the GN₂ pressures returned to normal levels and did not approach the 160-psia level again, precluding any further need for the contingency GHe purge. There was no LCC violation with this item. The HPOTP IMSL purge pressures were nominal during ascent.

During pre-launch operations, the SSME 1 Liquid Oxygen (LO₂) inlet pressure transducer was tracking 10-psi lower than SSME 2 and 3. This 0 - 300 psi transducer was used during the opening of the LO₂ inboard fill and drain valve and has an accuracy of ± 3% and is therefore within its design limits. Historical data shows this offset in previous flights. This was not a LCC or OMRS requirement violation.

Flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown. The HPOTP and High Pressure Oxidizer Fuel Turbo Pump (HPFTP) temperatures were within specifications throughout engine operation. Commanded Max Q throttle down was a two-step throttle to 95% and then 72%, which indicates Adaptive Guidance Throttling (AGT) was initiated. Propellant dump operations data were normal and the time of MECO time was Engine Start +513 sec. The average SSME specific impulse tag value was 452.1 sec at 104.5% power level.

The review of STS-124 Advanced Health Monitoring System (AHMS) vibration measurements indicates nominal performance. No Failure Identifiers (FIDs) were

reported to the Vehicle Data Table (VDT) from start preparation through propellant dump on all engines. All accelerometer measurements appear healthy. The Controller Power Supply temperature measurement on SSME 1 went off-scale high (IFA STS-124-E-001). The anomaly was traced to the 1W7 electrical harness during post-landing troubleshooting in the Orbiter Processing Facility. An intermittent open condition was discovered when the harness was manipulated approximately 18 to 20 in. from the electrical interface panel while electrically monitoring the measurement. A more detailed discussion of this anomaly is contained in Appendix B.

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

All Main Propulsion System (MPS) systems performed as expected during launch countdown and ascent. No MPS-related LCC and OMRSD violations occurred. The MPS pre-launch countdown was nominal, and no IFAs were identified during the post-flight data analysis.

Tabulations for prelaunch, MECO, post-MECO and entry/landing events revealed no anomalous valve movements. All timings were within the required specifications and within the current historical database.

The overall Gaseous Hydrogen (GH₂) system in-flight performance was nominal. All three Flow Control Valves (FCV) performed nominally with 6 cycles on FCV no. 1, 4 cycles on FCV no. 2 and 1 cycle on FCV no. 3.

The Gaseous Oxygen (GO₂) fixed orifice pressurization system performed as predicted. Reconstructed data from engine and MPS parameters closely matched the actual ET ullage pressure measurements.

The SSME 3 mid fuselage Helium supply temperature violated the minimum limit of minus 80 °F. The actual temperature was approximately 80.4 °F and the violation lasted for approximately 4 min. The temperature measurement is on the Helium tank and eventually gets mixed with substantially warmer aft Helium supply tanks (-37 °F). This violation did not pose any concern for MPS hardware and no troubleshooting is required as this condition has been explained. A File IX change is in work prior to the next flight as an explained condition.

Hazardous Gas Concentrations

The aft hazardous gas concentrations during loading were nominal. The following table summarizes the results.

HAZARD GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	11512	8044
Hydrogen	140	32
Oxygen	35.4	9
LD54/55	0	0

Gas Sample Analysis

The measured sample bottle pressures indicate the redesigned Orbiter aft fuselage gas sampler system successfully collected all six samples for STS-124.

Hydrogen concentrations were well below the flammability limit in each bottle. The highest estimated leak rate was 2560 scim from right hand bottle no. 1. All oxygen concentrations were below the flammability limit. There was good correlation in the concentrations of left- hand bottle no. 1 and right hand bottle no. 2, which fire at the same time. All values were below the flammability limit. Measured argon concentrations indicate air as the source of most of the oxygen concentrations and not an MPS leak.

The Helium concentration is the highest measured to date. The previous high value was 11.90% on STS-113. Due to the low pressures and lack of diluting atmosphere, right hand bottle no. 3 had more variation in its Helium concentration. No requirement was violated. The Propulsion Systems Integration Group (PSIG) stated their hardware performed nominally.

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	3.60	0.62	2.72	0.05
2	LH 1	1.35	0.41	1.97	0.05
3	RH 2	1.40	0.67	2.07	0.06
4	LH 2	0.69	0.82	2.54	0.07
5	LH 3	0.14	1.84	1.78	0.13
6	RH 3	0.05	12.91	1.33	0.17

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rate was 2560 scim. The maximum allowable firing leak rate on ascent is 57,000 scim. Hydrogen concentrations were well below the flammability limit in each bottle, and the concentrations are shown in the following table.

HYDROGEN FIRING LEAK RATES

Bottle No.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	2560
2	LH 1	1205
3	RH 2	1485
4	LH 2	1040
5	LH 3	470
6	RH 3	235

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

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS

S/N	Position	Actual pressure, torr	Ar, %	Air from Ar, %	He, %	CO, %	CH ₄ , %	CO ₂ , %	O ₂ from air, %	O ₂ found, %	H ₂ , %	H ₂ pyro corrected, %
1098 FLT-3	RH1	186.2	0.12	12.42	0.62	<0.01	<0.01	<0.01	2.61	2.72	0.05	0.05
1092 FLT-2	LH1	69.8	0.06	8.03	0.41	<0.01	<0.01	<0.01	1.69	1.97	0.05	0.05
1146 FLT-0	RH2	72.5	0.09	9.85	0.67	<0.01	<0.01	<0.01	2.07	2.12	0.07	0.06
1096 FLT-3	LH2	35.6	0.11	12.10	0.82	<0.01	<0.01	<0.01	2.54	2.71	0.07	0.07
1097 FLT-0	LH3	7.11	0.08	8.46	1.84	<0.01	<0.01	<0.01	1.78	1.95	0.13	0.13
1147 FLT-0	RH3	2.55	0.06	6.32	12.91	<0.01	<0.01	0.01	1.33	1.00	0.18	0.17

Purge, Vent, and Drain System

The Purge, Vent and Drain (PV&D) system performed well during launch. Purge readings and hazardous gas detection system readings were nominal near the end of the Liquid Oxygen (LO₂) fast fill.

The PV&D system performed nominally during the entry and landing phases. The post-landing purge was not initiated within 45 min of touchdown (was 54 min). This delay in the purge did not impact the ground operations. The purge was initiated within 30 min (was 20 min) of completion of the upper aft safety assessments.

Reaction Control System

The Reaction Control System (RCS) performed all functions required for successful completion of the mission. One IFA occurred shortly after lift-off and it is discussed in a later paragraph.

During prelaunch operations, the right RCS fuel tank data showed a pressure rise, which indicated internal leakage from a regulator. The leak rate was estimated to be within the allowable limit, but the condition caused some concern in the event of a launch delay. Since the launch occurred on time, the concern was abated. In addition, the performance on-orbit was nominal.

The propellant loading for the mission is shown in the following table.

RCS PROPELLANT LOADING

Parameter	Forward RCS		Left RCS		Right RCS	
	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer	Fuel
Target, %	67.70	67.41	100.48	100.76	100.48	100.76
Target, lbs	1141	712	1523	962	1523	962
Calculated, %	71.61	69.40	100.69	100.67	100.50	100.69
Advertised, %	1193.8	728.9	1525.8	961.2	1523.3	961.4
PASS WHI ^a	4.3864	4.2491	4.3843	4.2547	4.3919	4.2145
BFS WHI ^b	4.3909	4.2521	4.3965	4.2660	4.4033	4.2532

Notes:

^a PASS WHI – Primary Avionics Software System Initial Weight of Helium Load

^b BFS WHI – Backup Flight System Initial Weight of Helium Load

All Tyvek covers released nominally, with the exception of the F3D and F4D thrusters, and on these thrusters, a remnant of the cover remained (IFA STS-124-V-05). These remnants released at velocities greater than the 170 mph certification requirement for these locations. This anomaly is discussed in more detail following this table.

Tyvek cover release speeds and vehicle alpha/beta angles at cover release are shown in the following table.

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1D	4.5	55	-4	13
F3D	4.6	57	-4	13
F2D	5.6	71	-2	10
F4D	5.9	75	-2	93
F1F	8.0	107	0	7
F3L	8.4	114	0	6
F1L	8.4	114	0	6
F2F	8.5	115	0	6
F1U	8.8	120	0	6
F3F	9.2	126	-1	5
F2U	9.5	131	-1	4
F2R	9.7	135	-1	4
F4R	9.9	139	-1	3
F3U	10.5	298	-1	3
REMNANT RELEASE DATA				
F3D	18.9	298	4	-1
F4D	24.8	410	-2	0

Ground imagery showed that when RCS thruster F3D's Tyvek rain cover released at 4.6 sec MET (57 mph), a small piece remained attached to the thruster lip. This piece separated at 18.9 sec MET (298 mph). Similarly, ground imagery showed that when thruster F4D's Tyvek rain cover released at 5.9 sec MET (75 mph), a small piece remained attached to the thruster lip. This piece separated at 24.8 sec MET (410 mph). Imagery shows that neither cover's remnant impacted the Orbiter (IFA STS-124-V-05). No vehicle/mission impacts ensued nor were any crew responses required.

The Orbital Maneuvering System (OMS)/RCS Problem Resolution Team (PRT) reviewed the imagery from the STS-124 flight failures and determined that the F3D and F4D Tyvek cover tears with subsequent late release of the cover remnants were consistent with and enveloped by the post-STS-118 analysis, test, and flight rationale. Thus, the STS-124 Tyvek failure mode has been studied, its risks are understood, and it has already been accepted by the Program and constitutes no increase in risk.

The RCS window-protect firing of the F1U, F2U and F3U thrusters was initiated at 152/21:04:13 GMT (00/00:02:01 MET) for total duration of 2.08 sec. The Forward RCS performance was nominal. The Window protect firing is performed to deflect exhaust from the SRB separation motors away from windows during SRB separation.

The ET Separation maneuver was performed at 152/21:10:59 GMT (00/00:08:47 MET) and was a 6.0-sec, 10-thruster translation. Additionally, the ET separation +X axis and pitch maneuvers were performed satisfactorily.

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

RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	Engine / System	Time of Ignition, GMT	ΔV , ft/sec	Duration, sec
RCS Window Protect	RCS	152/21:02:12	N/A	2.08
ET Separation	RCS	152/21:10:59	N/A	6.0
ET Photo +X	RCS	152/21:11:09	N/A	12.2
ET Photo Pitch	RCS	152/21:13:05	N/A	N/A
NC3	RCS	153/23:29:42	4.3	18.4
NCC	RCS	154/14:18:45	1.5	6.5
MC1	RCS	154/15:36:26	0.4	1.7
MC2	RCS	154/16:13:28	1.2	5.3
MC3	RCS	154/16:30:20	1.2	5.4
MC4	RCS	154/16:40:20	2.7	0.6
Separation 1	RCS	163/12:50:54	N/A	5.9
Separation 2	RCS	163/13:18:57	N/A	6.0
Orbit Adjust	RCS	164/20:20:12	6.8	25.4

RCS MANEUVERS AND FIRING DATA (Concluded)

Maneuver/Firing	Engine / System	Time of Ignition, GMT	ΔV , ft/sec	Duration, sec
RCS Hotfire	RCS	165/11:13:27	N/A	N/A
Forward Reaction Control System Dump	RCS	166/14:25:40	N/A	37.5

The residual propellants at the end of the mission are shown in the following table.

RCS RESIDUAL PROPELLANTS

Parameter	Mission Operations Calculation		PASS Model Calculation ^s	
	%	lb	%	lb
Forward Oxidizer	2.2	30	0.6	8.1
Forward Fuel	0.0	0.0	0.2	1.7
Left Oxidizer	47.6	643	45.6	629.1
Left Fuel	46.6	396	46.6	396.1
Right Oxidizer	43.6	589	43.1	581.9
Right Fuel	43.6	371	43.5	369.8

Note:

^a The official JSC Engineering RCS propellant residuals are those listed under the PASS model

The Aft RCS propellant usage during interconnect operations with the OMS is shown in the following table.

AFT RCS PROPELLANT INTERCONNECT USAGE

Parameter	Total, %	Total, lbs
Left OMS	0.935	121.09
Right OMS	0.694	89.88

The RCS propellant consumption, based on the PASS model advertised load in the RCS residual propellant table is shown in the following table.

RCS PROPELLANT CONSUMPTION

Parameter	Oxidizer, lb	Fuel, lb	Mixture ratio, Oxidizer/Fuel
Forward RCS	916.8	589.0	1.56
Left RCS	688.3	429.8	1.60
Right RCS	734.4	451.3	1.63

The attitude control responsibilities between the ISS and the Orbiter are shown in the following table.

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

Control Responsibility	Control Start, GMT	Orbiter DAP Mode	Comments
Orbiter	154/18:03:13	Free Drift	Docking / ISS Capture
Orbiter	154/18:23:55	LVLH	
ISS	154/18:28:54	Free Drift	
Orbiter	154/18:29:02	Auto	Maneuver to TEA
ISS	154/19:05:41	Free Drift	
Orbiter	156/19:06:45	Auto	Simultaneous Water Dump
ISS	156/20:02:23	Free Drift	
Orbiter	159/13:04:46	Auto	Simultaneous Water Dump
ISS	159/15:00:59	Free Drift	
Orbiter	162/11:23:03	Auto	Simultaneous Water Dump
ISS	162/14:06:41	Free Drift	
Orbiter	162/20:28:18	Auto	
ISS	162/21:49:44	Free Drift	
Orbiter	163/10:12:24	Auto	Maneuver to Undocking Attitude
ISS	163/10:53:56	Free Drift	
Orbiter	163/10:55:05	Auto	Dead-Band Correction
ISS	163/11:13:31	Free Drift	
Orbiter	163/11:14:37	Auto	
ISS	163/11:39:11	DAP Free Drift	For Primary RCS Jet Driver configuration
Orbiter	163/11:39:48	DAP BALT/No Low Z	
Orbiter	163/11:42:02		Undocking

As part of the undocking preparations, thrusters F1U, F2U and F3U were reselected. Undocking was initiated nominally with a +Z pulse at 163/11:42:02 GMT (10/14:39:50 MET). The full flyaround maneuver was initiated with a +X pulse of L3A and R3A at 163/12:04:21 GMT (10/15:02:09 MET), and all thrusters operated properly during the undocking operations.

The RCS Hotfire was initiated at 165/11:13:27 GMT (12/14:11:15 MET) and terminated approximately 13.5 min later. All 38 RCS thrusters were fired at least twice for at least 0.240 sec per pulse. No fail-off or fail-leak problems were detected during the hot fire.

The primary thrusters were fired 3071 times for a total firing time of 942.28 sec. The vernier thrusters were fired 8502 times with a firing time of 13657.92 sec.

Orbital Maneuvering System

The OMS performed nominally throughout the mission, and one IFA was identified in the review and analysis of the data and it is discussed later in this section.

The OMS configuration is shown in the following table.

OMS CONFIGURATION

Vehicle/ equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 01	38 th	L-OME S/N 115	5 th rebuilt flight - 20 th flight
Right Pod (RP) 03	36 th	R-OME S/N 106	9 th rebuilt flight - 33 rd flight

At 51 sec MET, both of the Left OMS Thrust Vector Controller (TVC) secondary position transducers ramped from the nominal ascent stow positions (approximately +6.0 deg for both pitch and yaw) to 0.0 deg in both pitch and yaw axis (IFA STS-124-V-01). The change in the indicated position took approximately 10 sec. The primary position feedback indications remained in the nominal stow positions during the same timeframe.

The left Orbital Maneuvering Engine (OME) was used for the OMS assist, OMS-2 and OMS-3 maneuvers were performed as planned. The OMS-2 was performed using the primary TVC, and a post-maneuver gimbal check was not performed on the left secondary TVC

The Left OMS TVC was parked through the End-of-Mission (EOM) Center of Gravity (c. g.) after the OMS-3 maneuver. The Left OMS remained in this configuration until the deorbit maneuver. As a result, all remaining OMS maneuvers prior to the Deorbit maneuver were performed using the single engine (right) OME. Both engines were used for the deorbit maneuver. The Left OMS TVC secondary position transducers indication returned to nominal just prior to landing. The initial post-flight troubleshooting did not repeat the failure.

The following table shows the maneuvers that were performed during the STS-124 mission.

OMS MANEUVERS

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV , ft/sec/
Assist	Dual Engine	152/21:04:24.7	142.2	N/A
OMS-2	Dual Engine	152/21:39:32.7	163.0	249.0
OMS-3 (NC1)	Dual Engine	152/23:58:40.5	56.2	85.9
OMS-4 (NC2)	Right Engine	153/14:25:12.6	23.8	17.5
OMS-5 (NC4)	Right Engine	154/13:44:25.8	10.2	8.3
OMS-6 (TI)	Right Engine	154/15:16:26.2	10.2	8.0
(Deorbit)	Dual Engine	166/14:10:12.2	155.2	291.1

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

INTERCONNECT USAGE, %/POUNDS

Parameter	Total, %	Total, pounds
Left OMS	0.935	121.09
Right OMS	0.694	89.88

The official propellant residuals should be taken from the following table using the aft gage results for the left oxidizer and both right tanks. The burn-time Integration should be used for the left fuel tank. The Shuttle Operational Data Book (SODB) Flow rates are presented for comparison purposes.

PROPELLANT USAGE DATA

Parameters	Left OMS pod		Right OMS pod	
	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, lbm	7053	4260	7051	4254
Residual, lbm (aft gage)	507	294	507	303
Residual, lbm (burn time integration)	404	239	584	302
Residual, lbm (SODB flow rate)	511	279	532	328

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-124 mission. One In-flight anomaly was identified from the data analysis and review and it is discussed in a later paragraph of this section.

APU RUN TIMES

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
1 (310)	00:18:48	00:04:31	01:01:58	01:25:17
2 (403)	00:19:13	00:00:00	01:27:46	01:46:59
3 (207)	00:19:26	00:00:00	01:02:24	01:21:50

APU FUEL CONSUMPTION

APU (S/N)	Ascent, lb	FCS Checkout, lb	Entry, lb	Total, lb
1 (310)	45	14	114	173
2 (403)	51	0	175	226
3 (207)	49	0	127	176

The APU 3 injector water cooling line thermostat began to dither at 159/07:18 GMT, 06/10:42 MET (IFA STS-124-V-13). The water system thermostat cycle range shifted from a 9-deg control band between 55 and 64 °F for the first 6.5 days on orbit to a 1.5 °F dither between approximately 57 and 58 °F. The thermostat returned to the normal cycle range after two days of dithering. There was no impact to the vehicle/mission and no response or procedural change required from the crew. The thermostat returned to its normal cycle range after two days of dithering. This condition was considered intermittent. The current PRT plan is to remove and replace this thermostat prior to the next flight of the OV-103 Orbiter.

Hydraulics/Water Spray Boiler System

The Hydraulic (HYD) and Water Spray Boiler (WSB) system performance during all phases of the STS-124 was nominal and no in-flight anomalies were identified from the data review and analysis. All system pressures and temperatures were maintained within nominal limits.

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

During Hydraulic system configuration for cryogenic propellant loading, the WSB 1 GN₂ Regulator output pressure indicated 44.1 psia following opening of the WSB 1 GN₂ Isolation Valve, and this level exceeded the Operational Maintenance Requirements and Specifications Document (OMRSD) maximum pressure limit of 44 psia for launch. This was an expected condition and was acceptable for launch. Post-flight analysis of the mission-long GN₂ low pressure and supply tank decay rates for WSB 1, 2 and 3 passed the specification requirements of 0.06 psi/hr and 0.3 psi/hr maximum, respectively.

Post-Ascent, HYD circulation pump 1 was run for 9 min and 48 sec to perform elevon-park. Typically, the elevon park circulation pump run duration is approximately 1 min. No additional circulation pump runs were required on-orbit for thermal conditioning or bootstrap accumulator repressurization.

The HYD/WSB system 1 performed nominally during FCS checkout and all parameters were nominal. Priority valve cracking time was 0.33 sec (specification is equal to or less than 1 sec). The HYD System 1 bootstrap accumulator was 2224 psia prior APU no.1 start and re-seat pressure was approximately 2880 psia (specifications is greater than 2675 psia).

Performance on all three WSB systems during entry showed the hydraulic heat exchanger mode operation was first indicated on WSB 1 prior to Terminal Area Energy Management (TAEM). WSB 2 heat exchanger mode operation occurred prior to landing and WSB 3 after landing.

The WSB (PGME)/Water usage during entry for spray cooling was calculated with the new Kennedy Space Center (KSC) off-load correlation method shows that the usage was as follows:

1. System 1 - 22.4 lb (PGME/Water)
2. System 2 - 39.0 lb (PGME/Water)
3. System 3 - 23.5 lb (PGME/Water)

Power Reactant Storage and Distribution System

The OV-103 Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-124. The PRSD system supplied the fuel cells with 2206 lb_m of oxygen and 278 lb_m of hydrogen for the production of 3265 kWh of electrical energy. The average power level for the 330.24-hour mission was 9.9 kW. A 117-hour mission extension was possible at the 1224 kW average power level with the reactants remaining at touchdown. No in-flight anomalies were identified during the mission or the post-flight analysis of the data.

The following table shows the tank quantities at loading, lift-off and landing.

PRSD TANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb_m
Loaded	94.4	94.4	94.8	94.4	93.9	3686
Landing	93.1	93.1	93.5	93.5	93.1	3642
Landing	45.8	51.9	45.8	14.2	5.9	1278

PRSD TANK QUANTITIES (Concluded)

Hydrogen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb _m
Loaded	101.9	101.5	102.3	101.9	102.8	469.6
Launch	98.4	97.5	98.8	98.4	99.3	453.0
Landing	53.3	63.9	65.7	5.5	2.0	175.2

The total oxygen supplied to the Shuttle/ISS Environmental Control and Life Support System (ECLSS) was 158 lb_m of oxygen. No oxygen was transferred to the ISS.

At two times during the mission, pressure increases to 922 and 917 psia, respectively, were observed on PRSD O₂ manifold 2. It occurred while oxygen tank 5 was supplying 80.7 and 80.3% quantities, respectively, to oxygen manifold 2. The manifold relief valve is specified to crack at 975 psia. In both cases, an increased demand for oxygen was due to cabin pressurization. The pressure increases were caused by cold dense cryogenic oxygen from tank 5 entering the warmer oxygen manifold, which expanded to a gas and subsequent pressure increase. These occurrences are a relatively common occurrence when higher flow-rates are demanded from a nearly full cryogenic tank.

Fuel Cell System

Fuel Cells

The fuel cell electrical power level averaged 9.9 kW and the total load averaged 317 amps. During the 330.24 - hr mission, the fuel cells produced 3265 kWh of electrical energy and 2484 lb_m of potable water. The fuel cells consumed 2206 lb_m of oxygen and 278 lb_m of hydrogen.

The actual fuel cell voltages (200 A load) at the end of the mission were 0.20 Volt (V) above predicted for fuel cell 1, 0.05 V above predicted for fuel cell 2, and 0.10 V above predicted for fuel cell 3. The voltage margins above the minimum performance curves at 200 A at the end of the mission were 1.38 V above minimum for fuel cell 1, 1.06 V above minimum for fuel cell 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. The water relief and water line system A was used prelaunch, ascent, and up to 163/18:03 GMT (10/21:01 MET) then the fuel cells were reconfigured to system B until the end of mission.

The Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages prelaunch, on-orbit, and postlanding. The full-rate on-orbit data was recorded for 12 min beginning at 153/18:23:48 GMT (00/21:21:36 MET). Additional FCMS data takes were performed because of the loss of the fuel cell 3 Cell Performance Monitor (CPM), which is discussed in the following paragraph.

At 159/01:18:15 GMT (06/04:16:03 MET), the instrumentation for fuel cell 3 CPM and hydrogen flowmeter were lost (IFA STS-124-V-06), which resulted in invoking Flight Rule A9-59. This required that the affected fuel cell bus to be tied, except for critical maneuvers, to another so the load sharing can be monitored and for daily FCMS data takes to be performed. Due to Station-to-Station Power Transfer System (SSPTS) operation a Main B to C Bus-tie was already in place. Daily FCMS data takes were performed on FD's 9, 10, 11, 12, 13, and 14 in addition to the nominally scheduled one on FD 2. Although no current increase was observed, post-flight troubleshooting revealed a blown 1 Ampere (A) fuse in Main Power Control Assembly (MPCA) no. 3, which supplies power to the fuel cell 3 CPM and hydrogen flowmeter. Additional troubleshooting revealed the hydrogen flowmeter was the cause of the overload condition.

Station-to-Shuttle Power Transfer System Operation

This was the second flight of SSTPS on OV-103. The system functioned satisfactorily and provided 1195 kWh of power to the Orbiter during the docked period. The system transfers and converts power from the 120-Vdc ISS electrical system to supplement fuel cell power to the Orbiter's 28-Vdc buses. The system is activated when the Orbiter is docked to the ISS, and the SSPTS provides up to approximately 6 kW of power to the Orbiter.

When set at maximum output, the SSTPS attempts to regulate Orbiter bus voltage at 31.8 Vdc up to its maximum output of about 6 kW. During SSPTS operation at low power levels, 12-13 kW total orbiter power, the fuel cell coolant stack exit temperatures were about 185-187 °F. No sustaining heater cycles were observed due to the stack exit temperature not reaching the 183.5 °F turn-on point.

Electrical Power Distribution and Control System

The Electrical Power Distribution and Control (EPDC) system performed nominally during all mission phases of the STS-124 mission. The data review and analysis of all available EPDC parameters was completed and no anomalous conditions were identified.

When the fuel cell 3 CPM and hydrogen flowmeter were lost, no current spikes were observed in the data that would definitively point to a blown fuse, however a 0.4 A drop in the overall current on MPCA-3 was observed. This current drop is consistent with the expected current for the instrumentation lost. As a result of this failure, Main Bus B and Main Bus C remained bus tied after SSPTS deactivation except for critical OMS firings.

As a minimum, the following EPDC parameters are analyzed each mission:

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. MPCA's 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 RPC status
11. Forward, Mid and Aft Motor Control Assemblies ops status
12. Fuel cell to Essential bus switch status
13. Main bus to Essential Bus RPC and switch status
14. Drag chute Pyro Controller Functions

In addition, during a SSPTS portion of the flight, the following additional parameters are analyzed:

1. Assembly Power Converter Unit (APCU) voltages and currents;
2. Orbital Power Converter Unit (OPCU) voltages and currents;
3. APCU and OPCU temperatures;
4. Main Distribution Control Assembly (MDCA) motor switch status;
5. APCU status bits and trips and
6. OPCU trips.

Orbiter Docking System

The Orbiter Docking System (ODS) performed satisfactorily, and no IFA's were identified from the review and analysis of the data.

The initial application of power to the ODS and ring extension were performed nominally during FD 1 and the ODS was activated for 8 min 28 sec, and the avionics hardware was powered for 5 min 42 sec. The system was ready for rendezvous and docking with the ISS.

The application of power for the docking activities was initiated at 154/17:26:43 GMT (01/20:24:31 MET), and the ODS was powered for 58 min 13 sec. The initial contact and capture of the ISS occurred at 154/18:03:24 (01/21:01:12 MET). The initial damping of 1 min 46 sec and performance of the "Disable and Release Dampers" procedure of 3 min 2 sec were necessary to ensure that any stuck dampers were disengaged. The start of the final drive was 154/18:14:20 GMT (01/21:12:08 MET) and lasted for 2 min 12 sec. The capture latches began release at 154/18:17:36 GMT (01/21:15:24 MET) and operated for 2 sec and at that time the docking was completed, and the ODS power was removed from the system.

In preparation for undocking, the ODS was activated at 163/11:39:51 GMT (10/14:37:39 MET). The undocking and separation from the ISS was completed satisfactorily at 163/11:41:55 GMT (10/14:39:43 MET).

Life Support Systems

Atmospheric Revitalization Pressure Control System

The Atmospheric Revitalization Pressure Control System (ARPCS) performed nominally throughout the mission and all of the scheduled in-flight checkout requirements were satisfied. No in-flight anomalies were identified during the review and analysis of the data.

Post launch the ARPCS was configured to system 2. The system 2 oxygen regulator was closed and the 14.7 psi regulator-inlet valve was closed. A minimal leak was seen as the system 2 oxygen pressure sensor started to increase at a rate of approximately 0.028 psi/min. The leak was well within the allowable specification leak rate of both the oxygen regulator (2.87 psi/min) and oxygen check valve (0.57 psi/min). The ARPCS system 1 was configured to avoid system 2 pressure limit changes and used for the majority of the mission until approximately 10 min after undocking to checkout that system.

An Orbiter-to-ISS tank-to-tank nitrogen transfer was performed, with approximately 15 lb transferred. No oxygen was transferred to the ISS during this mission. The Vestibule was leak checked after docking and for undocking operations.

Three Orbiter/ISS stack repressurizations were performed prior to undocking using the Orbiter ARPCS. The repressurizations were performed by opening the payload nitrogen valves with restrictors in line that limited the flow to 7 lb/hr for better cabin air mixing. There was one oxygen repressurization performed before docking and one repressurization after undocking using direct oxygen flow into the cabin. During docked operations, two Orbiter/ISS stack oxygen repressurizations were performed using Orbiter oxygen.

Supply and Waste Water System

The Supply Water and Waste Management Systems performed nominally throughout the mission and all of the scheduled in-flight checkout requirements were satisfied. Supply water was managed through the use of the Flash Evaporator System (FES), water transfer to the ISS and the overboard nozzle dump system. The waste water nozzle was newly installed for this flight and in accordance with the Flight Rules, the first waste water dump was video down linked to verify the performance of the nozzle and was confirmed to be within tolerance. The dump plume pattern was perpendicular to the Orbiter fuselage.

Four Simultaneous (SIMO) supply water nozzle dumps as at a nominal dump rate of 1.57% (2.59 lb/min) and five Portable Water Reservoir (PWR) dumps were performed through the supply line. The line heater maintained the supply water dump line temperature between 74 °F and 93 °F. The waste water nozzle was newly installed for this flight and per the Flight Rule, video of the first waste water dump was down-linked

to verify the performance of the nozzle. The video provided confirmation that the plume spray pattern was perpendicular to the Orbiter fuselage as required.

Seven Contingency Water Containers (CWC's) were filled with supply water and transferred to the ISS, for a total of 662 lb_m. In addition, 6 PWRs of iodinated water for a total 121.5 lb_m were filled and transferred to the ISS.

Vacuum vent line temperature was maintained between 59 °F and 78 °F.

Smoke Detection and Fire Suppression System

The Smoke Detection and Fire Suppression (SDFS) system operated nominally with no issues. The Smoke Detection Test was performed of FD 1 and all Smoke detection A and B Sensor circuits operated nominally. Use of the Fire Suppression system was not required.

Airlock System

All of the Extravehicular Activities (EVA's) were performed from the ISS airlock. As a result, the Airlock was not used during this mission. One in-flight anomaly was reported by the crew and is discussed in the following paragraph.

The crew had difficulty in closing and latching the External Airlock Upper Hatch on FD 11 (IFA STS-124-V-14). Attempts to position the actuator handle over the decal that indicates the correct pre-closing position were unsuccessful, as a hard stop was encountered prior to reaching that position. After attempting various techniques, the crew was able to seat the hatch by moving the handle slightly in the latching direction, latching was completed successfully.

Post-flight troubleshooting has determined that a stop bolt in the latch mechanism was adjusted such that the actuator handle could travel approximately 405 deg from the fully-latched position instead of approximately 440 deg. Post-flight cycling of the latching mechanism has duplicated the crew's inability to reach the pre-closing position and determined that the decal was in the wrong location.

Active Thermal Control System

The Active Thermal Control System (ATCS) performance met all requirements for the entire mission. The radiators were not activated for this flight. No IFAs were identified during the review and analysis of the data.

Fifty cubic feet per minute of conditioned air was added to the middeck supply air flow for this vehicle. This was accomplished through reconfiguring the airlock booster fan air inlet and removing the tape at the middeck-forward air register location. The inlet ducting to the airlock fan was reconfigured to draw air from the Orbiter middeck in lieu of

connecting at the aft middeck air register which drew ARS conditioned air. The duct was left in the Pressurized Mating Adapter (PMA) 2 module of ISS.

The crew compartment Partial Pressure Carbon Dioxide (PPCO₂) was managed to levels below 3.6 mmHg during the docked phase of the mission. The PPCO₂ peaked to 4.19 mmHg during the post-undocking part of the mission. This flight incorporated the flight rule change of managing PPCO₂ levels to 5.0 mmHg or less

Flight Software

The Primary Avionics Software System (PASS) and Backup Flight System (BFS) Flight Software (FSW) performed satisfactorily throughout the mission

At T-20 min, the PASS OPS 9 to OPS 1 transition occurred and was nominal. Subsequently, the BFS was moded from OPS 0 to OPS 1 and was observed to be tracking all four PASS strings. The PASS flight software moded successfully from Major Mode (MM) 101 through MM106, and the BFS maintained tracking during the ascent profile. No unexpected internal errors or fault summary messages were logged or annunciated during ascent.

During deorbit preparation, the PASS General Purpose Computers (GPCs) were transitioned to a four G3 configuration with the BFS in OPS 3 and tracking all PASS strings to support Entry operations. All OPS transitions were nominal and no unexpected errors were observed.

After wheels-stop, the PASS GPCs were transitioned to OPS 9 and the BFS was moded to OPS 0. A subsequent PASS redundant set contraction to Single G9 was performed with GPC 1 commanding all strings. All OPS transitions were nominal and no unexpected errors were observed.

Data Processing System Hardware

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

Multifunction Electronic Display System

The Multifunction Electronic Display System (MEDS) performed satisfactorily with no problems reported.

During the rendezvous, the crew commented that they observed momentary "Big Xs" on Cathode Ray Tube (CRT) 3. A momentary "Big X" is possible on one or two CRTs concurrent with display changes due a to timing/resource condition. It was not an impact to operations.

Displays and Controls System

The Display and Controls (D&C) system, including lighting, performed nominally during all phases of STS-124 and no in-flight anomalies were identified from the review and analysis of the data.

Flight Control System

The Flight Controls System (FCS) performed nominally during the preflight, countdown, ascent, orbit, FCS checkout, deorbit preparations, entry, landing and post-landing operations. One in-flight anomaly was identified from the review and analysis of the data.

The FCS hardware/effector systems performed nominally during ascent through APU shutdown. At all times, 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 Orbiter Rate Gyro Assemblies (ORGAs) and four SRB Rate Gyro Assemblies (SRGAs) tracked one another normally, and there were no Spin Motor Rotation Detector (SMRD) dropouts. The outputs of the four Accelerometer Assemblies (AAs) also tracked one another normally. The Reaction Jet Driver (RJD) operation was also normal with no thruster failures or other anomalies noted. Device Driver Unit (DDU) and controller operations were also nominal. Both the Rotational Hand Controller (RHC) and the Translational Hand Controller (THC) were used and exhibited normal channel tracking.

The OMS TVC File IX requirements were met, and OMS TVC actuator rates were normal. Flight control actuator temperatures were also normal. The Rudder/Speed Brake Power Drive Unit (RSB PDU) motor backdrive did not occur during hydraulic system shutdown.

The left OMS TVC Controller secondary position indicator failed at approximately 48 sec MET (IFA STS-124-V-01). The OMS assist, OMS-2, and NC1 maneuvers were performed nominally with the primary controller selected. Following the NC1 maneuver the left OMS engine was moved to the Nominal End-Of-Mission (NEOM) c.g. position and remained there until the deorbit firing. All subsequent maneuvers except the Deorbit maneuver were performed with the only the right engine. The on-orbit left OMS gimbal checks were performed using the primary controller only. During deorbit preparations, the left OMS engine was moved to the deorbit position with the primary controller. The deorbit maneuver was nominal and the OMS engines were moved to the entry stow position. The left OMS Actuator secondary position indicator remained failed until the Orbiter was flying on the Heading Alignment Circle (HAC). There were no roll reversals or acceleration events coinciding with the indicator returning to normal function.

Air Data Transducer Assembly

The Air Data Transducer Assemblies (ADTAs) performed nominally during preflight, countdown, orbit, FCS checkout, deorbit preparation, entry, landing and post-landing operations. No in-flight anomalies were identified from the results and analysis of the data.

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 elevon-park activity.

The ADTA was in the OPS-8 mode for FCS checkout performance was nominal. Power-on and self-tests were performed with no anomalies. All 16 transducer outputs showed nominal responses.

Entry performance was nominal from the deorbit maneuver through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.9, 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 was retrieved and reviewed, and no anomalies were observed.

Inertial Measurement Unit and Star Tracker System

The Inertial Measurement Unit (IMU) system performed satisfactorily throughout the STS-124 mission. One in-flight anomaly was identified during the analysis of the data. The IMU's required one adjustment of the onboard IMU accelerometer compensation values during the mission. Also, seven adjustments were performed for the IMU drift compensation values.

Starting on GMT Day 162, the Z-gyro restraint drift on IMU 1 began increasing. The increase was four sigma over the last two days or two sigma per day (IFA STS-124-V-09). Uplinks updating drift compensation satisfactorily controlled IMU 1 platform drift, through landing, with no change in procedures under these conditions. These sigma values were unusually high for this unit. The last time this unit flew its drift error was 1 sigma for the entire flight. The unit will be removed and sent to JSC for testing and checkout.

The Star Tracker (ST) performed nominally during the STS-124 mission in acquiring navigation-stars. The -Y ST acquired navigation-stars 273 times, and also missed a navigation-star 290 times (28.6%) during the mission. Data evaluation showed that 73.1% (212) of the missed stars belonged to one stars 27 and 55. This condition did not impact the mission.

The -Z ST acquired a star 74 times and missed a star 40 times (35%). Data showed that most of these stars were missed during the docking and undocking activities. This condition also did not impact the mission. An anomaly was encountered with the -Z star tracker door (IFA-STS-124-V-12), and the anomaly is discussed in the Mechanical section of this report.

Global Positioning System Navigation

Overall, Global Positioning System (GPS) operation during STS-124 was nominal. The GPS was powered at 152/16:09:28 GMT, approximately 04 hr 52 min prior to launch and remained ON for the mission duration. There were no indications of any anomalous conditions. During entry, the GPS high Figure of Merit (FOM) period usually encountered in the Plasma region cleared well before GPS incorporation into PASS NAV. No "Data Invalid" or FOM Chimneys occurred during the critical phase of Entry (below 140,000 ft altitude), where the GPS satellite geometry is less dynamic.

STS-124 was a nominal 1-String GPS Entry operational flight. Per the plan for all 1-String GPS (OV-103 and OV-104) flights, the GPS state vector was incorporated into both PASS and BFS in MM304 after performance confirmation with high speed C-band tracking. This occurred at approximately 156,000 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 as designed. Likewise, the BFS navigation state vector residuals remained consistently low from GPS incorporation all the way through rollout as designed since BFS does not process the MLS data.

Communications and Tracking System and Navigation Aids

During the STS-124 mission, the Communications and Tracking systems performed nominally.

The Navigation Aids (NAV AIDS) performed nominally throughout the STS-124 mission. In addition, S-Band system 1 was in operation for 22 hr 58 min, which satisfied the OMRSD requirement to operate the S-Band Backup string continuously for 24 ± 4 hr.

During rendezvous and approach, the TCS Continuous Wave (CW) laser had difficulty maintaining acquisition of the reflectors on the ISS. The TCS CW laser lost track of ISS retro-reflector 2 as it moved closer to the ISS along the R-bar trajectory. It immediately recovered in the Pulsed laser mode. The TCS lasers switched continuously along the R-bar trajectory up to the RPM as the CW laser would try to recover, but could not. At a distance of 630 ft, the CW laser reacquired a stable lock on the ISS as the Orbiter moved away from the R-bar trajectory and maintained tracking of ISS until docking.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) and Modular Auxiliary Data System (MADS) performed nominally throughout the STS-124 mission. No in-flight anomalies were identified during the mission and the post-flight review of the mission data. The MADS Pulse Code Modulation (PCM) ascent data was recorded on the Solid State Recorder and dumped to the ground. Evaluation of the MADS data review showed no anomalous problems in the data.

Mechanical and Hatches System

All mechanical and hatch systems performed nominally, with the exception of the -Z star tracker door. During the star tracker door closure, the system 2 indication on the -Y door failed to come on, resulting in Motor 2 driving until the crew removed power (IFA STS-124-V-12). The system 1 indication was obtained nominally within dual-motor run time, and current draw was observed for both motors, thus no concern existed concerning the door closure. There was no impact to the flight.

Landing and Deceleration System

The 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. It was the first flight of the nose landing gear tire set, which were in good condition and performed nominally. The main landing gear tires appeared nominal. Normal 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. The drag parachute and main parachute performed satisfactorily and no issues were identified in the review of the photography and sensor data.

LANDING PARAMETERS

Parameter	From threshold, ft	Time from MLG touchdown, sec	Speed, keas^a	Speed, kgs	Sink rate, ft/sec	Pitch rate, deg/sec
Main Landing gear touchdown	2,157.9	0.0	208.3	208.8	-0.79	N/A
Drag Chute Deployment	3,333.1	3.4	186.3	195.9	N/A	N/A
Drag Chute Disreef	5,242.6	9.7	156.6	164.9	N/A	N/A
Nose Landing Gear Touchdown	5,613.8	11.2	144.3	154.8	N/A	-5.96
Brakes On	9,564.6	32.5	75.0	79.8	N/A	N/A
Drag Chute Jettison	10,650.9	42.0	OSL	54.0	N/A	N/A
Wheels Stop	11,512.1	60.1	0	0	N/A	N/A

LANDING PARAMETERS (Concluded)

Parameter	Data	
Brake Initiation Speed, keas	75.0	
Brake On Time, sec	27.6	
Rollout Distance, ft	9344.2	
Rollout Time, sec	60.1	
Runway Location, Surface and Degrees	KSC/15 Concrete	
Orbiter Weight at Landing, lb	203754.9	
Parameter	Maximum Brake Pressure, psia	Total Brake Energy, Mft/lb
Left inboard	1047.7	8.61
Left outboard	1021.2	9.03
Right inboard	938.3	8.42
Right outboard	828.9	5.94

^aKnots equivalent air speed

Aerothermodynamics, Integrated Heating and Interfaces

Visual 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. However, sensors at location P4 (Tmax = 83 °F) and RP (Tmax = 83 °F) experienced the most temperature rise for the OV-103 vehicle. From MADS surface thermocouples and the Best Estimated Trajectory (BET), Boundary Layer Transition (BLT) onset time was 1283 sec after entry interface and occurred at Mach 6.6 and located at XL= 0.6. The thermal sensor data indicated a symmetrical BLT.

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

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Lower fuselage forward center (B1)	132.5	118.9
Lower fuselage forward left-hand (B2)	179.8	171.3
Lower fuselage forward mid left-hand (B3)	153.5	162.7
Lower fuselage mid center (B4)	148.2	152.4
Lower fuselage mid aft center (B5)	166.6	163.2
Lower fuselage aft center (B6)	169.3	142.9
Left-wing center (LW)	111.6	131.0
Right wing center (RW)	122.0	128.8
Port side FRCS forward (P1)	158.7	137.4
Port side fuselage forward center (P2)	90.8	100.1
Port side fuselage forward mid center (P3)	88.2	95.0

**ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA
(Concluded)**

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Port side fuselage mid aft center (P4)	83.0	102.5 ^b
Port side fuselage aft center (P5)	83.0 ^a	72.0 ^a
Starboard side FRCS Forward (S1)	169.3	132.6
Starboard side fuselage forward center (S2)	137.7	126.7
Starboard side fuselage forward mid center (S3)	109.0	80.0
Starboard side fuselage mid-aft center (S4)	75.3 ^a	66.7 ^a
Starboard side fuselage aft center (S5)	88.2	66.9
Left-hand OMS pod side forward (LP)	83.0	61.7
Right-hand OMS pod side forward (RP)	83.0 ^{ab}	38.7 ^a
Lower body flap center	116.8 ^a	90.4 ^a
Right-hand PLBD forward	80.5 ^a	115.0 ^a
Left-hand PLBD forward	83.0 ^a	132.8 ^a
Right-hand PLBD aft	85.6 ^a	107.6 ^a
Left-hand PLBD aft	85.6 ^a	120.2 ^a
Right wing upper center	103.8 ^a	115.6 ^a
Left wing upper center	111.6 ^a	131.0 ^a
Forward RCS center	106.4 ^a	82.6 ^a
Forward fuselage upper center	80.5	97.3

Notes

^a Maximum temperature occurred 30 min after wheel stop.

^b Maximum temperature ever experienced on the OV-105 vehicle.

Thermal Control System

The Passive Thermal Control systems performed nominally during STS-124, and no in-flight anomalies or significant issues were identified from the review and analysis of the data. The APU 3 water line heater dithered for two days but resumed normal cycling. All other heater systems performed normally. This is the first flight for OV-103 with all three of the APU Gas Generator Valve Module (GGVM) line heater modification (APU 2 had the modification on STS-120) and all three heaters operated normally.

Thermal Protection System and Post-Landing Assessment

Post-Landing Assessment

The final debris-related tile damage numbers are shown in the following table.

SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE

Orbiter Surface	Impacts greater than 1 in.	Total impacts
Lower surface	10	104
Upper Surface/Window	4	24
Right OMS pod	1	12
Left OMS pod	1	7
Totals	16	147

A post landing walk-down of the runway was performed. The only flight hardware found was a silver TCS blanket strap. A non-flight bolt was found at the 3700-ft location, 65-ft west of the centerline. The bolt was 1-in. in length and had surface rust on it.

All components of the drag parachute were recovered. The drag parachute hardware and components appeared to have functioned nominally. Both reefing line cutter pyrotechnic devices were expended. One reefing line was found 3450-ft aft of the main parachute, the other was found 900-ft aft.

There was Flexible Insulation Blanket (FIB) blanket damage on the starboard side of the Orbiter, in the Emergency Rescue Door perimeter. It measured approximately 4-in. by 3-in.

Part of a tile near the base of SSME no. 2 was missing. The film review identified the tile loss occurred during SSME startup.

Tire material loss on the Main Landing Gear (MLG) and nose landing gear tires was nominal.

The nose landing gear door and the MLG doors did not have any corner tile chips.

The Orbiter nose cap appeared to be in nominal condition. The Left-Hand (LH) RCC T-Seal 21 had discoloration with streaking. The Right Hand (RH) RCC T-Seal 9 had white discoloration with possible type A sealant flow.

The SSME Dome Mounted Heat Shield (DMHS) blankets all appeared to be in excellent condition, with a very low amount of fraying.

The LH₂ and LO₂ umbilicals both appeared to be nominal. The ET/Orbiter (EO) -3 had 2 clips bent around the perimeter.

Following the RCS hot-fire, the crew reported two observations. The first was an object observed out the aft window, floating away from the rear of the Orbiter, about a foot long that was liberated during the aerosurface drive (IFA STS-124-V-11). Video of the object was assessed by TPS DAT personnel who determined that the object was most likely the spring seal (thermal barrier) from inside the Rudder Speed Brake (RSB). These

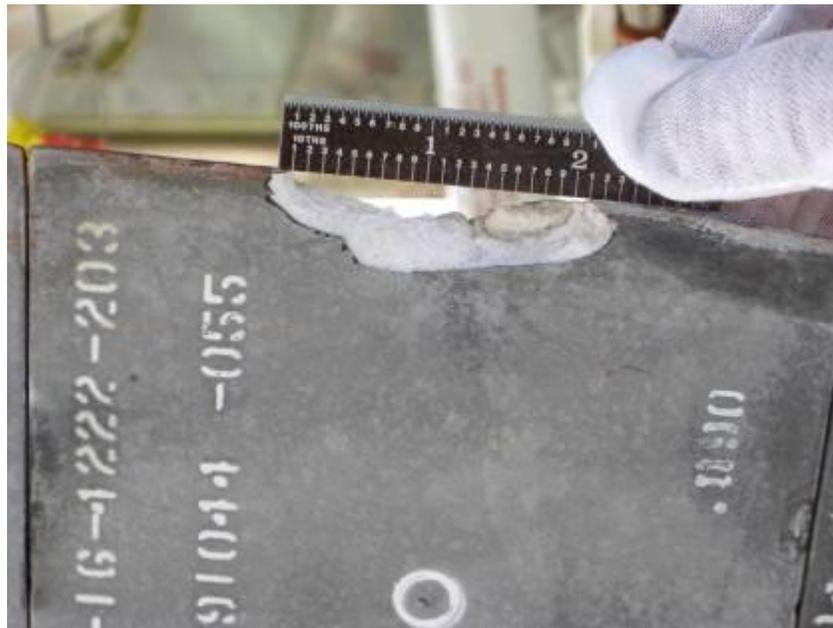
clips provide a thermal seal at the edge of the RSB for ascent plume heating, and this particular Inconel piece liberated during the aerosurface drive due to spot-weld failure. There is a history of these clips tearing and liberating. Loss of this component was not an issue for entry

The second observation noted by the crew was material protruding from the trailing edge of the split line between the upper and lower RSB panels. Pictures were downlinked and evaluated by the TPS DAT which determined that the material was a thermal barrier which is allowed to protrude slightly at the aft of the panel interface. There was no concern for entry as this protrusion was per design.

Tile and Blanket Flight Assessment

The overall performance of the TPS was satisfactory. One in-flight anomaly was identified for all of the Thermal Protection System anomalous conditions (IFA-STS-124-V-02) Appendix B provides more details on this anomaly.

All Nose Landing Gear Door (NLGD) thermal barriers exhibited typical fraying. The NLGD tile damage on the V070-391044-055 tile (photograph below) was measured to be 2.3-in. by .6-in. by 0.5 in. The tile was also cracked adjacent to damage approximately 2-in., noted on sidewall. No charring noted on adjacent thermal barrier



Photograph of Tile Damage

A fray was shown on the middle of the outboard thermal barrier on the left-hand Main Landing Gear Door (MLGD), and all other MLGD thermal barriers were in good condition.

A gap-filler was protruding at the inboard thermal barrier of the starboard ET door from the on-orbit imagery and was measured to be 0.175 in. in comparison with the on-orbit imagery that was 0.23 in. by 0.46 in. The damage site condition appeared to be unchanged.

Body flap tile damage on two tiles was noted on the on-orbit imagery and appeared to be further eroded and slumping was evident on the aft portion of the damage site.

RCC Flight Assessment

The Reinforced Carbon-Carbon (RCC) performed satisfactorily, with one in-flight anomaly identified. The FD 2 Imagery of the Wing Leading Edge (WLE) RCC panels showed no gross anomalies as noted by the DAT. The survey also included the upper Leading Edge Subsystem (LESS) carrier panels and no items of concern were noted. Some upper carrier panel tile locations were not captured in the field of view, but these areas were visible during the RPM.

The post-flight inspection of OV-103 RCC showed that Tile no. V070-399441 gap filler between the chin panel and nose cap expansion seal had minor frays and no charring was noted. Excessive Type A flow was noted at the right-hand side panel T-seal no. 9 and lower surface curly zone no. 3.

During the post-flight inspection on the runway, a region of excessive Type A flow was observed on the right-hand wing leading edge tee seal at rib splice 10 (IFA STS-124-V-15). The inspection revealed a large forward-facing step-and-gap along the lock-side interface to the mating WLE panel 9R that was not apparent before flight. Upon removal of the tee seal, leading edge deterioration was observed along with an abundance of Type A glass flow. Similar observations to a lesser degree have been made on left wing tee seals at rib splices 10 and 11. Analysis is continuing to determine corrective action.

Windows

The post-flight inspection of the Orbiter Windows showed the following items:

1. Window no. 2 had hazing on the upper outboard corner.
2. Window no. 3 had hazing on the upper inboard corner.
3. Window no. 4 had hazing on the upper edges.
4. Window no. 5 had hazing on the upper edges.

Waste Collection System

The Waste Collection System operated properly with no reported problems.

EXTRAVEHICULAR ACTIVITY

The crew performed three Extravehicular Activities (EVAs) on STS-124 in a total EVA time of 20 hr, 32 min. Space Shuttle Mission Specialists Mike Fossum and Ron Garan were designated as EV1 and EV2, respectively, and the pair completed all three EVAs.

The primary EVA mission objectives were to retrieve the Orbiter Boom Sensor System (OBSS), prepare the Japanese Experiment Module Pressurized Module (JPM) for installation, and Remove and Replace (R&R) the S1 Nitrogen Tank Assembly (NTA). To reduce the risk of EVA glove damage, which had been experienced on previous missions, the EVA crew wore gloves that had been modified with high strength protective patches. The Airlock campout prebreathe protocol was utilized in preparation for all of the EVAs.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was performed on Flight Day (FD) 4. The highest priority objective on the first EVA was to transfer the OBSS from its stowage location on the International Space Station (ISS) S1 truss to the Orbiter Payload Bay for return. The EV2 crewmember completed the preparatory steps for that task, which included releasing the cable straps and retrieving the sensor bag, while the EV1 crewmember performed alternate tasks en route to the OBSS worksite. During his translation to the S1 truss, the EV1 crewmember released the launch locks from the elbow camera on the Shuttle Remote Manipulator System (SRMS), thereby allowing the camera to pan and tilt. He also performed a check-out of the Mobile Base System Common Attachment System (MCAS) ready-to-latch indicators and prepared Node 2 hatches for future berthing operations. Upon successful completion of those tasks, the EV1 crewmember joined the EV2 crewmember to finish preparing the OBSS for transfer. Together, the crewmembers worked to release the boom support stands and stow the keep-alive power equipment.

Once the Space Station Remote Manipulator System (SSRMS) had maneuvered the OBSS away from the ISS, the EVA crew translated to the Orbiter Payload Bay (PLB) to begin JEM activities. The crew released and stowed the Launch-to-Activation (LTA) power cable, removed the Passive Common Berthing Mechanism (PCBM) covers, and released the window launch locks to prepare the JEM for installation onto Node 2. All tasks were completed nominally.

Next, the crew translated to the Starboard Solar Alpha Rotary Joint (SARJ) where they performed a series of SARJ-related tasks. The EV2 crewmember installed a Trundle Bearing Assembly (TBA) to replace a unit that had been previously removed for failure analysis. The EV1 crewmember worked simultaneously, removing protective covers to inspect and photograph the SARJ race-ring surface. The EV1 crewmember also completed a Development Test Objective (DTO) to evaluate SARJ cleaning techniques. Upon completion of the TBA install, the EV2 crewmember removed several SARJ launch restraints, which had been designated as a get-ahead task. All EVA 1 objectives

were achieved in a total EVA time of 6 hr and 48 min. The glove inspections and post-EVA photographs indicated no glove damage had been incurred during the EVA.

SECOND EXTRAVEHICULAR ACTIVITY

The EVA crew successfully completed EVA 2 on FD 6 in a total EVA time of 7 hr and 10 min. The crew began the EVA by egressing the Quest Airlock and translating to the newly installed JPM to perform outfitting tasks. First the crewmembers installed two JEM Television Electronics (JTVE) cameras. Then the crew worked together to remove several thermal covers from the JEM Remote Manipulator System (JEM RMS) before moving to the zenith side of the JEM to prepare the Active Common Berthing Mechanism (ACBM) for the relocation of the Japanese Experiment Logistics Module-Pressurized Section (JLP). The crew removed the ACBM Multi-Layer Insulation (MLI), retrieved the hatch pip pin, and released the Micrometeoroid D Orbital Debris (MM/OD) shield launch restraints. The crew also adjusted additional MLI to protect against a potential interference issue that was discovered post-launch. Finally, the EVA crew installed trunnion and keel covers to thermally protect the hardware.

Upon completion of the JEM outfitting activities, the EVA crew began tasks to prepare for the removal and replacement of the S1 truss NTA on the third EVA. The EV1 crewmember translated to the External Stowage Platform (ESP) -3 to ready the spare NTA while the EV2 crewmember broke bolt torques and disconnected fluid lines and electrical connectors on the S1 truss NTA. The crew then reunited on the P1 truss to retrieve the External Television Camera Group (ETVCG) from Camera Port 9 to allow for in-flight maintenance of the hardware. While the EV2 crewmember was installing the protective dummy box on the Camera Port, the EV1 crewmember translated to the port SARJ to perform the get-ahead task of inspecting of the port SARJ race-ring. The EV1 crewmember removed a thermal cover and photographed the underlying area before returning to the Airlock to conclude the second EVA. Glove inspections were performed as required by the procedures and no damage was noted throughout the EVA.

THIRD EXTRAVEHICULAR ACTIVITY

On FD 8, the crew performed the third and final EVA in 6 hr and 33 min. The primary objective of third EVA was to remove and replace the S1 truss NTA. The EV1 crewmember began the EVA by translating to the ESP-3 on the P3 truss, where the spare NTA was released and temporarily stowed on the ESP-3 pallet. Meanwhile, the EV2 crewmember ingressed the SSRMS, and used it as a work platform while removing the S1 NTA from the truss. The SSRMS then maneuvered the EV2 crewmember, while holding the old S1 NTA, to ESP-3. With assistance from the EV1 crewmember, the EV2 crewmember secured the old NTA onto ESP-3 and removed the new NTA from its temporary stowage location. Riding the SSRMS, the new NTA was maneuvered to the S1 truss and installed in its final location. The installation was performed nominally, all connectors were mated, and the thermal shroud was reattached.

After cleaning up the ESP-3 worksite, the EV1 crewmember translated to the port SARJ to take samples and additional photographs that were requested following the inspection during the second EVA. Following the completion of the port SARJ task, the EV1 crewmember moved to the JEM Pressurized Module to complete the outfitting tasks, which included removing the launch locks from the Wrist and Elbow Vision Equipment, releasing the remaining window launch lock, and deploying the forward and aft ACBM MM/OD shields. Next, the EV1 crewmember inspected the forward JTVE camera bolt to investigate a unexpected motion that had been observed after installation. Although the EV1 crewmember reported that the bolt was flush, the crewmember also noted some relative motion between the base-plate and the slider, consequently, the bolt was re-torqued at a higher setting. Upon completion of the NTA R&R, the EV2 crewmember re-installed the newly refurbished ETVCG on Camera Port 9. The crew performed two additional get-ahead tasks before concluding the third EVA. The EV1 crewmember installed thermal blankets on Node 2 Quick Disconnects while the EV2 crewmember released an additional Starboard SARJ launch restraint. All glove inspections were nominal and the photographs taken after the EVA confirmed that the glove patch modifications had been effective.

REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Shuttle Remote Manipulator System (SRMS) performed nominally during the mission. The SRMS configuration was identical to the previous mission except the Orbiter Boom Sensor System (OBSS) was not transported up to the International Space Station (ISS) as an OBSS had been left attached to the ISS during the previous mission, and would be retrieved from the ISS after the docking was completed.

The SRMS on-orbit Initialization began at 153/00:16 GMT (00/03:16 MET) on Flight Day (FD) 1. The port and starboard Manipulator Positioning Mechanisms (MPMs) were deployed and the SRMS shoulder brace was released. The Starboard Manipulator Retention Latches (MRLs) were also released on FD 1.

On FD 2, the SRMS checkout began at 153/14:41 GMT (00/17:39 MET) and completed 45 min later, after which the SRMS was used to perform a special inspection of the starboard and port Wing Leading Edge System (WLES) using the SRMS End Effector (EE) camera in lieu of the OBSS. These EE surveys began at 153/16:11 GMT (00/19:09 MET) and were completed 50 min later. The SRMS was also used to perform a Payload Bay (PLB) survey starting at 153/17:45 GMT (00/20:43 MET) and a supply/waste water dump nozzle survey on FD 2 at 153/19:28 GMT (00/22:26 MET). The SRMS was then returned to the pre-cradle position.

On FD 3, Discovery docked with the ISS while the SRMS was in the pre-cradle position.

On FD 4, prior to the start of the first Extravehicular Activity (EVA), the Space Station Remote Manipulator System (SSRMS) was used to perform a partial grapple of the OBSS in preparation for the unberthing the OBSS. The SRMS was maneuvered to a position near the ISS Destiny Lab Module in preparation for removing the elbow Camera launch restraint straps at 155/13:05 GMT (02/16:03 MET). Once the Extravehicular (EV) crewmembers were outside, the crewmembers removed the camera straps, released the OBSS from the Orbital Support Equipment (OSE) stanchions, and disconnected the Keep Alive Umbilical (KAU), KAU Attachment Device (KAD), and P411 Connector Cover from the OBSS. The SRMS then maneuvered to the handoff position at 155/17:00 GMT (02/19:58 MET) and grappled the OBSS at 155/18:00 GMT (02/20:58 MET). After grappling the OBSS, the SRMS was maneuvered at 155/18:53 GMT (02/21:51 MET) to the Japanese Pressurized Module (JPM) installation viewing position.

On FD 5, the SRMS was maneuvered to the OBSS sensor-checkout position at 156/12:49 GMT (03/15:47 MET), where the health of the sensors was assessed. Following the checkout, the SRMS maneuvered to the second EVA viewing position at 156/14:35 GMT (03/17:33 MET)

On FD 6, the SRMS provided a viewing platform for the second EVA and then returned to the JLP installation viewing position after the completion of the-EVA.

On FD 7, the SRMS was maneuvered to the JLP relocation viewing position at 158/16:21 GMT (05/19:19 MET). A Focused Inspection was not required, thus the SRMS remained in the JLP relocation viewing position.

On FD 8, the SRMS was maneuvered to the viewing position for the third EVA at 159/12:13 GMT (06/15:11 MET).

On FD 9, during the latter part of the third EVA, the SRMS was maneuvered to the Japanese Experiment Module (JEM) SRMS viewing position for the JEM deployment position at 160/17:24 GMT (07/20:22 MET). A slight adjustment of the Wrist Roll joint (from -70 deg to -90 deg) was made to this position for improved viewing of the JEM RMS before returning to the JEM RMS deployment viewing position for overnight parking.

On FD 10, a slight Wrist Roll joint adjustment was made to the SRMS, which was the same as previous, for improved viewing of the JEM RMS, and then the SRMS was maneuvered to the OBSS undocking position at 161/14:43 GMT (08/17:41 MET).

There were no SRMS operations on FD 11.

Discovery undocked on FD 12, after which the SRMS and OBSS were used to perform a Late Inspection which started at 163/15:28 GMT (10/18:26 MET) and was completed at 163/19:11 GMT (10/22:09 MET). The SRMS then maneuvered to the OBSS hover-position after completion of the Late Inspection.

On FD 13, the SRMS was used to berth the OBSS at 164/18:27 GMT (11/21:25 MET) and was cradled 29 min later. The Port and Starboard Manipulator Positioning Mechanisms (MPMs) were stowed at 164/19:04 GMT (11/22:02 MET) and 164/19:06 GMT (11/22:04 MET), completing the SRMS operations for the STS-124 mission.

WING LEADING EDGE IMPACT DETECTION SYSTEM

ASCENT MONITORING

Within 0.15 sec of each other after Space Shuttle Main Engine (SSME) ignition, all units of the Wing Leading Edge Impact Detection System (WLE IDS) triggered and began recording data with the exception of units 1015 and 1021; both of which triggered early. Unit 1015 triggered 0.55 sec early and unit 1021 triggered 0.61 sec early, but these small time differentials did not significantly impact the ascent analysis. The Mission Elapsed Time (MET) was set to 9.14 sec behind the Data Elapsed Time (DET). The MET equaled the DET minus 9.14 sec for port side units and minus 9.17 sec for the starboard side units. A total of three impact indications above the 1.0 Grms threshold were found and reported for this flight, and automatic scanning of the post-flight data yielded no additional indications above this threshold.

SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 GRMS

Times ^a		Location			Magnitude		Criteria				Impact ^b	
MET, Hr	DET, hr	Wing	RCC	Unit-Channel	Max. Grms	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post-Flt
57.7	66.8	Port	9-10	1119-J2	2.0	16.70	+	+	+	+	P	P
88.1	97.2	Stbd	1U	1161-J1	0.50	8.87	+	+	+	+	P	P
106.1	115.2	Port	2/3L	1230-J2	0.66	5.52	+	+	+	+	P	P

^aAdjusted to correct for known differences between the onboard laptop and actual GMT times.

^bP = Probable

ORBIT MONITORING

On-Orbit monitoring of the port and starboard wings was initiated at approximately the same time and was performed when the risk of critical damage from MicroMeteoroid Orbital Data (MM/OD) was expected to be highest. Analysis showed this risk to be increased during early and late mission Reinforced Carbon-Carbon (RCC) surveys and during the attitudes flown for docking and undocking with the ISS. The total MM/OD monitoring time for this mission was relatively balanced from wing-to-wing with approximately 63 hr on the port wing and 62 hr on the starboard wing.

As performed on the four previous missions, three composite sensor groups, (A, B, and C), that consisted of combinations of the original seven on-orbit groups that were used to provide on-orbit monitoring with a denser array of accelerometers.

Because of sensor-unit battery-life limitations, continuous on-orbit monitoring of each RCC panel was not possible. The MM/OD monitoring reports were presented to the Orbiter Project Office (OPO) on Flight Day (FD) 4, FD 7 and FD 13.

In addition to the reports discussed in the previous paragraph, a presentation was provided to the FD 10 OPO that described the correlation of 26 on-orbit triggers at the port RCC 11/12 interface with Reaction Control System (RCS) thruster firings during the Orbiter approach and docking. These triggers were investigated and supplemental data that described the history of this RCC 11/12 interface ‘noise’ and an explanation of why this did not represent a structural integrity issue to the wing were provided to the OPO

SUMMARY OF MM/OD IMPACTS

Times ^a	Location			Magni- tude	Criteria				Impact ^b	
	GMT	Wing	RCC		Unit- Channel	Max. G	Transient	Local	Spectral	Shock
154/12:20:03	Port	Chine:1	1123-J1	0.41	+	+	+	+	P	P
154/16:13:07	Port	12:13	1014-J3	0.40	+	+	+	+	P	P
154/17:06:13	Stbd	14:16	1054-J1	1.41	+	+	+	+	P	P
155/00:29:59	Port	5:6	1123-J3	0.84	+	+	+	+	P	P
155/02:28:45	Port	Chine:1	1123-J1	0.59	+	+	+	+	P	P
163/20:33:03	Stbd	16:17	1026-J2	0.45	+	+	+	+	P	P

^aAdjusted to correct for known differences between the onboard laptop and actual GMT times.

^bP=Probable

During the post-flight runway inspection, a region of excessive Type A flow was observed on the right-hand wing leading edge tee seal at rib splice 10 (IFA STS-124-V-15). The inspection revealed a large forward-facing step-and-gap along the lock-side interface to the mating Wing Leading Edge (WLE) panel 9R that was not apparent before flight. Upon removal of the tee seal, leading edge deterioration was observed along with an abundance of Type-A glass flow. Similar observations to a lesser degree have been made on left wing tee seals at rib splices 10 and 11.

CONCLUSIONS

The WLEIDS system performed well for ascent impact monitoring, allowing an initial ascent report to be published at 14 hr MET. There were three ascent impact indications above the 1.0 Grms reporting threshold reported during the mission. No additional ascent indications were found during the postflight review of the data.

For the on-orbit monitoring while the Orbiter was still docked to the ISS, a decision was made to photograph the upper surface of Starboard RCC Panels 13-19 through the Aft Flight Deck window using a DCS 760 camera with a 800mm lens. This request was based on obtaining supplemental information on FD 6 with respect to the 1.41 G indication on RCC Panels 14-16. The team reported no issues or concerns based on this imagery. A recommendation to not obtain focused inspection imagery for the other on-orbit impact indications was made by the OPO based on the relatively low magnitude of the indications, their locations and comparisons to similar ground test data. A late mission survey inspection was performed on the RCC to visually inspect for damage after the Orbiter undocked and prior to entry.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The overall performance of the Government Furnished Equipment (GFE) and Flight Crew Equipment (FCE) was nominal throughout the prelaunch and flight operations. Three in-flight anomalies were identified and none of them impacted the successful completion of the mission.

During the visor-open pre-launch intercommunications testing that was performed as a part of crew ingress, the Mission Specialist (MS) 2 and Flight Deck crewmembers reported the MS2 transmissions were weak and could barely be heard (IFA STS-124-V-08). As a result, a hardware exchange to a different Communication Carrier Assembly (CCA) was made prior to hatch closure with no impact to the launch countdown. The post-launch functional check-out of the initial CCA did not replicate the anomaly.

During the rendezvous and approach, the Trajectory Control System (TCS) Continuous Wave (CW) laser had difficulty maintaining acquisition of the reflectors on the ISS. The TCS CW laser lost track of ISS retro reflector 2 as it moved closer to the ISS along the R-bar trajectory. It immediately recovered in Pulsed laser mode. The TCS lasers switched continuously along the R-bar trajectory up to the RPM as the CW laser would try to recover, but could not. The unit had 20 instances of tracking losses (IFA STS-124-V-10).

1. Seven for the performance of a long calibration;
2. Six for a reflector switch;
3. Four for unknown reasons;
4. Two for handoff from the Pulsed to the CW laser; and
5. One for the Rendezvous Pitch Maneuver (RPM).

The Rendezvous Proximity Operations Program (RPOP) did not have issues with the instances of loss of tracking during the mission as it operated nominally. The RPOP can handle data losses for time durations less than 30 sec without recycling internal counters. There was only one instance during the RPM with a TCS dropout duration greater than 12 sec. Reduced beam size could have increased the chances for the loss of tracking. Beam size showed a narrowing of the beam approximately every 20 sec to ensure proper range values. The TCS was used nominally for undocking and flyaround with no impact to the mission.

The Sensor Package 2 [Laser Camera System (LCS) and ISIS Digital Camera (IDC)] had an off-nominal checkout. The IDC checkout was nominal. The first LCS scan was nominal followed by stalling in subsequent scans. The second scan stalled and produced a number of error messages (IFA STS-124-V-03). The LCS data was downloaded and analyzed which showed that the Y-galvanometer within the Laser Camera Head had a drive problem. The LCS was still considered operational. However, the auto-exposure function was considered not available and would be disabled if future use of the LCS were required. The LCS was not required for the RCC late inspection.

Following the EVA, communications between the EV1, EV2 and IV crewmembers was weak (IFA STS-124-V-04). After the EV2 crewmember's cap was changed, the problem was corrected and the communications cap that was used for the first EVA was not used for subsequent EVAs.

The crew reported communications problems with the Middeck audio. Troubleshooting of the Handheld Microphone (HHM) was performed and the HHM was changed out during the troubleshooting (IFA STS-124-V-07). The communications problems were resolved when the HHM was changed.

DEVELOPMENT TEST OBJECTIVES

DTO 805 CROSSWIND LANDING PERFORMANCE

The Development Test Objective (DTO) 805, which was a DTO of opportunity, was not performed during landing because the crosswind did not meet the minimum requirements of the DTO.

POST-LAUNCH PAD INSPECTION

The post launch inspection of the Main Launch Platform (MLP) -3, Pad A Fixed Service Structure (FSS), and Pad A apron was conducted on May 31, 2008, from Launch +02 hr 23 min to 5 hr 23 min. The inspection proceeded relatively quickly after Safing Teams secured the Pad. The entire Pad, FSS and MLP were inspected.

No flight hardware was found other than minimal Solid Rocket Booster (SRB) nozzle throat-plug foam and Room Temperature Vulcanizing (RTV) material from the plug.

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

Inspections of the SRB holddown posts were performed and the results of those inspections are as follows:

HDP No. 1 – The EA934 poured sidewalls were nominal with some acceptable delamination on the South wall. The Phenolic shim had minor acceptable blistering and both firing lines were missing. No galling or chatter marks were noted in the chamfer of the through-hole.

HDP No. 2 – The EA934 poured sidewalls were nominal with no delamination from the shoe, but with an acceptable $\frac{3}{4}$ in. void. The Phenolic shim experienced an acceptable 2 in. diameter blister. Approximately 26 in. of Range Safety System (RSS) cable was present and both firing lines were missing. No galling or chatter marks were noted in the chamfer of the through-hole.

HDP No. 3 – The inspection showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP No. 4 – The inspection showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP No. 5 – The EA934 poured sidewalls were nominal with minor acceptable delamination from the shoe on the East wall. The Phenolic shim was nominal with typical erosion and both firing lines each had approximately 6 in. remaining. No galling or chatter marks were noted in the chamfer of the through hole.

HDP No. 6 – The EA934 poured sidewalls were nominal with acceptable minor delamination from the shoe on the West and East wall. The Phenolic shim was nominal without visual blistering and approximately 12 in. of one firing line present. No galling or chatter marks were noted in the chamfer of the through hole.

HDP No. 7 – The inspection showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

HDP No. 8 – The inspection showed nominal indications of erosion on the RTV-coated blast shield with proper closure and the RSS cable was missing.

The Inspections of the GN₂ purge lines were performed and the results are as follows:

1. The Left Hand (LH) probe was erect and slightly bent to the Southwest (SW) with about 50% of the protective tape layering remaining and three sections of exposed braiding were noted. The O-ring was not present.
2. The Right Hand (RH) probe was erect and slightly bent to the SW with about 70% of the protective tape layering remaining with no exposed braiding. The O-ring was present.

The inspections of the SRB T-0 Ground Carrier Assemblies (GCAs) were performed and the results are as follows:

1. The LH SRB lift-off (T-0) GCAs appeared to be in nominal condition with proper demating having occurred.
2. The RH SRB lift-off (T-0) GCAs appeared to be in nominal condition with proper demating having occurred.

The LO₂ and LH₂ Tail Service Masts (TSMs) appeared to be undamaged and both bonnets appeared to have closed properly.

The MLP deck was in nominal 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. Two ¼" in. nuts and one ¼ in. lock washer were retrieved from the West side. The Z-bracket located on Northwest (NW) side and adjacent to the sound suppression water pipe was damaged and the adjacent brackets were loose.

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 slidewire baskets were still secured at the 195-ft level with no evidence of damage. The no.1 basket sign had three Push in Pull (PIP) pins not engaged but the PIPs were present. The no. 2 basket sign had one PIP pin not engaged but the PIP was present, and the no. 4 basket sign had 2 PIP pins not engaged but the PIP pins were present.

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 the 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. The arresting cable was not engaged on the contact plate and the Southern bridle cable was inside the GUCP leg castings. The ET GUCP exhibited typical blast damage and the pyrotechnic bolt fired nominally. The aluminized blanket on the 24-ft vacuum-jacketed flexible hose was damaged.

A piece of white RTV ablative material from the back of the camera facing the latching mechanism was retrieved and verified to be from the back of the camera housing. Also, the Southern 3000-psi GN₂ supply line was leaking.

The Gaseous Oxygen vent hood at the 255-ft level, as well as the windows and structure appeared to be in nominal condition and the latch mechanism locked properly. The Liquid Hydrogen flexible duct blanket was damaged and torn. The Gaseous Nitrogen (GN₂) control panel pressure-gauge face-plate was missing.

Numerous items were found, however, the PAD facility was found to be in good condition while the SRB flame trench experienced excessive liberation of brick from the East retention wall and lifted cement plating on the North-Northwest (NNW) apron. As a result, the North perimeter fence was extensively damaged. The most notable debris items using the new debris collection criteria are as follows:

1. Minor pieces of SRB throat plug material were found on the PAD surface;
2. West PAD surface – Two clear capsules with white substance in a bag;
3. West PAD surface – One 5/8-in. nut;
4. West PAD surface – A 3/4-in. positioning shaft with cotter pin;
5. West PAD surface – Fondue fyre;
6. South PAD surface – Large fondue fyre;
7. East PAD surface – Metal fan piece from a turbine or blower;
8. East PAD surface – Metal connector cover;
9. East PAD surface – Tie-wrap was found near the flame deflector;
10. East PAD surface – Facility foam gap filler (cylindrical in shape, approximately 14-in. in length);
11. 75-ft level – West side unistrut bracket and rust scale;
12. 95-ft level – NW and SE speakers were melted as well as the firex pull cover;
13. 115 ft level – SE light near elevator is loose and leaning towards the SW, a rubber O-ring approximately 3-in. in diameter was found on the South side and a 3/8-in. flat washer was found on the West side;
14. 135-ft level – Electrical outlet cover fell off in front of the outlet on East side. The SE and NW speakers were melted and a cabinet latch and bolt was found on the West side;
15. 155-ft level – Tie-wrap was found on the North side;
16. 175-ft level – A 5/16-in. broken bolt with nut was found on the West side and a blowout plug on the South side;
17. 235-ft level – Pressure gauge was broken off the potable water service line on the South side; and
18. 275-ft level – Operational Television (OTV) camera fell off the mounting stand at the SW corner and half of a conduit clamp on the North side.

LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

The launch photography provided data for the evaluation by the Debris Assessment Team to determine the condition of the Thermal Protection System (TPS).

VEHICLE OBSERVATIONS

The launch photography provided data for the evaluation by the Debris Assessment Team to determine the condition of the Thermal Protection System (TPS).

At -2.029 sec debris was observed near the Space Shuttle Main Engine (SSME) engine bell. Analysis was performed to determine if this possible loss of material seen in the R-Bar Pitch Maneuver (RPM) imagery of the closeout panel to the dome mounted heat shield of SSME 2.

A dark piece of debris was observed at -3.538 sec during the SSME ignition on the near-left side of the right stinger pod and it was falling aft. Also, debris was observed at -3.588 sec. The debris originated near-right side of the right stinger pod.

The Tyvek cover on Reaction Control System (RCS) thruster F3D released as two pieces at separate times. The larger piece, which was approximately 90% of the cover, was released at 4.026 sec MET; and the smaller remaining piece, was still intact at approximately 13 sec MET. This condition is outside of the nominal 12-sec release window.

The Tyvek cover on RCS thruster F4D released as two pieces at separate times. The larger piece, which was approximately 90% of the cover, released at 5.243 sec MET. The smaller remaining piece released at 24.159 sec MET, which is outside of the nominal 12 sec release window.

Purge barrier material was noted at 20.431 sec, and the material appears to impact the Orbiter near the right elevon. The observation was postulated from the change of direction of the material.

A piece of debris was noted at 36.764 sec falling aft under the left wing.

Vapors were seen that were possibly coming from the External Tank (ET) access door at 52.094 sec MET. At 52.244 sec MET, a small piece of debris was seen falling aft. It is uncertain whether these events are related. The small debris may be typical SRB slag.

A discoloration of the Solid Rocket Booster (SRB) plume was noted at 111.088 sec. The discoloration is typically noted at approximately 2 sec prior to SRB separation; however the discoloration on this flight was approximately 11 sec prior to SRB separation.

Multiple pieces of debris was released near the Ice Frost Ramp ((IFR) 1151 at 141 to 142 sec and it originated from outboard of the LO₂ feedline and fell aft under the wing. No contact was observed with the vehicle.

Two pieces of ET Thermal Protection System (TPS) were released just aft of the port bipod foot at 181 to 182 sec. At least one of the two pieces appeared to contact the Orbiter.

Debris was observed at 212 to 214 sec originating from outboard of the LO₂ feedline near Xt 1151 and appeared to contact the Orbiter on the starboard mid fuselage. Additionally, several smaller pieces of debris were noted travelling outboard of the vehicle slightly before the release of the larger piece. These smaller pieces did not appear to contact the Orbiter.

Debris was observed at 240 to 241 sec from the port side near the port bipod foot and appeared to impact the Orbiter (change of direction was noted) and the debris fell aft.

A single piece of debris was released and it originated from between the cable tray and the LO₂ feed line near the IFR 1205 and fell aft under the wing. No contact was observed with the vehicle.

A large divot was noted on the -Y LH₂ ET intertank flange and stringer. The location of the loss was approximately at Xt 1120. The time of the observation was not available.

A piece of missing Thermal Protection System (TPS) material was observed at approximately Xt 1123 on the LH₂ ET intertank flange between the pressurization line and the cable tray. The time of the observation was not available.

A divot was noted at approximately Xt 1130 on the aft face of the port bipod foot. The divot appears to have depth, but is small. The time of the observation was not available.

A divot was noted at approximately Xt 1131 on the LH₂ ET acreage aft face of the port bipod foot. The divot appears to have depth. The time of the observation was not available.

A missing piece of TPS was noted outboard of Xt 1362 LO₂ feedline flange between the cable tray and the pressurization line. The time of the observation was not available.

A possible loss of ET TPS material was noted at approximately Xt1360 between the cable tray and the pressurization line. The time of the observation was not available.

A probable loss of ET TPS material was noted at approximately Xt 985 access door area at approximately 217 deg. The time of the observation was not available.

LAUNCH PAD OBSERVATIONS

Between -4.3 sec and -1.6 sec, debris (rust) was observed near the liquid oxygen Tail Service Mast (TSM). Likewise, at -2.830 sec, debris (rust) was observed that was released from the left TSM.

At 1.527 sec MET, the deceleration cable of the GH₂ vent line was observed not engaged on the contact plate during capture.

At 1.617 sec, the GH₂ vent line pivot arm rebounded slightly before coming to rest in the fully retracted position.

At 2.021 sec, four pieces of debris emanating from the plume and exiting from the flame trench on the -Z side of the vehicle.

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APPENDIX A

STS-124 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	152/20:57:25.758 152/20:57:26.942 152/20:57:28.105
SRB HPU Activation	LH HPU System A Start Command LH HPU System B Start Command RH HPU System A Start Command RH HPU System B Start Command	152/21:01:43.996 152/21:01:44.156 152/21:01:44.316 152/21:01:44.476
Main Engine Start	SSME-3 Start Command Accepted SSME-2 Start Command Accepted SSME-1 Start Command Accepted	152:21:02:05.444 152/21:02:05.575 152:21:02:05.688
SRB Ignition	SRB Ignition Command	152/21:02:12.006
Throttle Up 104.5 Percent	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:02:15.925 152/21:02:15.932 152/21:02:15.941
Throttle Down to 95 Percent	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:02:29.365 152/21:02:29.372 152/21:02:29.381
Throttle Down to 72 Percent	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:02:45.045 152/21:02:45.052 152/21:02:45.061
Throttle Up to 104.5 Percent	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:03:03.285 152/21:03:03.292 152/21:03:03.302
Maximum Dynamic Pressure (Max Q)	Derived Ascent Dynamic Pressure	152/21:03:15
Both SRMs to less than 50 psi	RH SRM Chamber Pressure LH SRM Chamber Pressure	152/21:04:08.966 152/21:04:10.206
End SRM Action	RH SRM Chamber Pressure LH SRM Chamber Pressure	152/21:04:11.106 152/21:04:12.406
SRB Separation Command	SRB Separation Command Flag	152/21:04:14
SRB Physical Separation	LH APU A Turbine Loss of Signal RH APU B Turbine Loss of Signal LH APU B Turbine Loss of Signal RH APU A Turbine Loss of Signal	152/21:04:14.526 152/21:04:14.526 152/21:04:14.566 152/21:04:14.566
OMS Assist Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/21:04:24.7 152/21:04:24.9
OMS Assist Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/21:06:47.3 152/21:06:47.5
Throttle Down for 3g	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	152/21:09:37.372 152/21:09:37.380 152/21:09:37.392
3G Acceleration	Total Load Factor (g)	152/21:10:17.7
Throttle down to 67 percent for Cutoff	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:10:31.773 152/21:10:31.781 152/21:10:31.794
SSME Shutdown	SSME-1 Command Accepted SSME-2 Command Accepted SSME-3 Command Accepted	152/21:10:38.373 152/21:10:38:381 152/21:10:38 394
Main Engine Cutoff (MECO)	MECO Command Flag MECO Confirmed Flag	152:21:10:39 152:21:10:40
ET Separation	ET Separation Command Flag	152:21:11:00

APPENDIX A

STS-124 MISSION EVENTS

EVENT	DESCRIPTION	
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	152/21:16:11.408 152/21:16:36.882 152/21:16:52.875
OMS 1 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	N/A
OMS 1 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	N/A
OMS 2 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/21:39:32.7 152/21:39:32.9
OMS 2 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/21:42:15.9 152/21:42:15.9
Payload Bay Doors Open	Right Payload Bay Door Open 1 Left Payload Bay Door Open 1	152:22:36:20 152:22:37:39
OMS 3 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/23:58:40.5 152/23:58:40.6
OMS 3 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	152/23:59:35.8 152/23:59:35.9
OMS 4 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	153/14:25:12.6
OMS 4 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	153/14:25:36.6
OMS 5 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	154/13:44:25.8
OMS 5 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	154/13:44:36.4
OMS 6 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	154/15:16:26.2
OMS 6 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	154/15:16:36.6
Docking	Capture	154/18:03:22
Undocking	Undocking Complete	163/11:41:55
Flight Control System Checkout – APU 1 Start	APU-3 Gas Generator Chamber Pressure	165/10:30:33.978
APU 1 Stop	APU-3 Gas Generator Chamber Pressure	165/10:35:04.238
Payload Bay Door Close	Left Payload Bay Door Close Right Payload Bay door Close	166/11:29:47 166/11:32:14
APU Activation	APU-2 Gas Generator Chamber Pressure APU-1 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	166/14:05:13.082 166/14:30:47.128 166/14:30:48.685
Deorbit Maneuver Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	166/14:10:12.2 166/14:10:12.3
Deorbit Maneuver Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	166/14:12:47.6 166/14:12:47.7
Entry Interface	Orbital Altitude Referenced to Ellipsoid	166/14:43:40
Blackout End	Data Locked (High Sample Rate)	No Blackout
Terminal Area Energy Management (TAEM)	Major Mode Code (305)	166/15:08:49
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure Main Landing Gear Right Hand Tire Pressure	166/15:15:18 166/15:15:18
Main Landing Gear Weight on Wheels	Main Landing Gear Right-Hand Weight on Wheels Main Landing Gear Left Hand Weight on Wheels	166/15:15:18 166/15:15:19

APPENDIX A
STS-124 MISSION EVENTS

EVENT	DESCRIPTION	
Drag Chute Deployment	Drag Chute Deploy 1 CP Volts	166/15:15:20.5
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	166/15:15:28
Nose Landing Gear Weight on Wheels	Nose Landing Gear Weight on Wheels	166/15:15:29
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	166:15:15:59.0
Wheels Stop	Velocity with respect to Runway	166:15:16:18
APU Deactivation	APU-1 Gas Generator Chamber Pressure	166/15:32:42.598
	APU-2 Gas Generator Chamber Pressure	166/15:32:59.062
	APU-3 Gas Generator Chamber Pressure	166/15:33:12.245

APPENDIX B

STS-124 IN-FLIGHT ANOMALIES

INTRODUCTION

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-124 mission.

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

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-01	Left OMS Secondary Pitch/Yaw Position Indication Failed	<p>At 0/00:00:51 MET, both Left Orbital Maneuvering System (OMS) Thrust Vector Controller (TVC) secondary position transducers ramped from the nominal ascent-stow positions (approximately +6.0 deg for both pitch and yaw) to 0.0 deg in both the pitch and yaw axes. The change in indicated position took approximately 10 sec. The primary position feedback indications remained in the nominal stow positions during the same timeframe. The left OMS was used for the OMS assist, OMS-2, and OMS-3 (NC1) maneuvers as planned. The OMS-2 maneuver was performed using the primary TVC, and the gimbal check that follows the maneuver was not performed on the left secondary TVC. The Left OMS TVC was parked through the End-of-Mission (EOM) c.g. following the NC1 maneuver. The Left OMS remained in that configuration until the deorbit maneuver. All remaining on-orbit OMS maneuvers were performed as single engine OMS firings using only the right OMS engine. The indication returned to nominal just prior to touchdown.</p> <p>Post-flight Action: KSC performed troubleshooting but was not able to reproduce the anomaly. Secondary controller was removed and replaced.</p>
STS-124-V-02	TPS Anomalies	<p>A complete listing 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</p> <p>A total of 13 items were identified that either exceeded pre-defined screening criteria or for which no criteria exists. Nine of these items were evaluated using standard procedures/tools. The following 4 required additional analysis:</p> <ol style="list-style-type: none"> 1. D-124-RPM-941-001 - Tile was damaged adjacent to NLGD thermal barrier; 2. D-124-RPM-330-003 - Aft fuselage just forward on the body flap; 3. D-124-RPM-330-004 – SSME no. 2 dome heat shield carrier panel tile damage-- PR AFT-3-36-9948; and 4. D-124-RPM-600-2-001- Unknown protrusion next to RH ET door. <p>No focused inspection was required based on the data available from the R-Bar Pitch Maneuver (RPM) images and Flight Day (FD) 2 inspections with the Orbiter Boom Sensor System (OBSS). The remaining four TPS tile damage sites (listed previously) were cleared based on additional analysis.</p> <p>Post-flight Action: Perform repairs as required in preparation for the upcoming flight.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-03	Laser Camera System (LCS) Scan Aborted	<p>Error messages were received during the STS-124 FD5 LCS checkout. The checkout included three scans of the underside of the nosecone and some surrounding tile. The first scan (Area Scan 11) was completed with errors, the second and third scans (Area Scan 12) were aborted with errors, and the fourth scan (Area Scan 13) was completed with errors. The errors annunciated during the scans include:</p> <ol style="list-style-type: none"> 1. Auto-exposure was unable to reach the acceptable criteria; 2. GCP software error; and 3. Galvanometer stability threshold was exceeded. <p>The root cause is still under investigation. All data as of FD6 points to a Y-galvanometer drive problem which does not affect the 3D data and measurement accuracies. However, the auto-exposure feature should not be used. On-orbit workarounds are available. The possible causes under investigation include:</p> <ol style="list-style-type: none"> 1. Y-galvanometer mechanical problem; and 2. Y-galvanometer drive circuitry on the Laser-Galvanometer Card <p>Post-flight Action: Returned the LCS unit (S/N 503) to vendor for a complete investigation where it was determined the Y-galvanometer had a mechanical problem. The galvanometer was removed and replaced.</p>
STS-124-V-04	EV2 Crew Communications Cap (CCA) Degraded Audio	<p>At the conclusion of the first Extravehicular Activity (EVA) while in the International Space Station (ISS) Airlock, the EV2 transmissions to EV1 and the Intravehicular (IV) crewmember were considered weak. At the time, EV2 was donning Communication Carrier Assembly (CCA) s/n 1204 and Crew Communications Electronics Module (CCEM) s/n 1023. Post-EVA, limited troubleshooting was performed, and EV2 CCA was changed out and the new unit (CCA s/n 1197) performed well in both the hard-line and PRI communication modes as well as during the second and third EVAs. This CCA will likely be transferred to Shuttle for contingency EVA use after EVA 3. CCA s/n 1204 was returned for post-flight troubleshooting.</p> <p>Post-Flight Action: Failure confirmed during troubleshooting.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-05	RCS Tyvek Partial Cover Late Release	<p>Ground imagery showed that when Reaction Control System (RCS) thruster F3D's Tyvek rain cover released at 4.6 sec MET (57 mph), a small piece remained attached to the thruster lip. This piece separated at 18.9 sec MET (298 mph). Similarly, ground imagery showed that when thruster F4D's Tyvek rain cover released at 5.9 sec MET (75 mph), a small piece remained attached to the thruster lip. This piece separated at 24.8 sec MET (410 mph). Imagery has shown that neither cover's remnant impacted the Orbiter. No vehicle/mission impacts ensued nor are any crew responses required.</p> <p>Concern is that Tyvek covers as a debris source may cause window, LESS, or TPS damage. Review of launch video showed that neither Tyvek remnant impacted the Orbiter.</p> <p>Previous impact testing enveloped these worst-case Window and OMS pod impact conditions and resulted in damage below critical levels. No TPS damage has been attributed to Tyvek cover releases on any previous flight. This failure did not affect the Forward RCS thruster performance. Thrusters F3D and F4D were first fired at ET Separation and performed nominally throughout the mission. No vehicle/mission impacts occurred as a result of this failure.</p> <p>Post-flight Action: No KSC actions identified.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-06	Fuel Cell 3 CPM and Hydrogen Flowmeter Instrumentation Loss	<p>The fuel cell 3 Cell Performance Monitor (CPM) substack 1, 2, and 3 measurements and the hydrogen flowmeter measurement failed to off-scale low at 159/01:18:16 GMT (06/04:16:04 MET). These four measurements are powered by the Mid-Power Control Assembly (MPCA) 3 through a common fuse. The fuse was recently changed from a 3 Ampere (A) to a 1A fuse due to overheating concerns. During the flight, It could not be determined whether the fuse actually opened from current data from MPCA-3. There were no current spikes observed in the data that would definitively point to an open fuse, however a 0.4A drop in the overall current on MPCA-3 was observed. This current drop is consistent with the expected current for the instrumentation lost.</p> <p>The CPM measures the fuel-cell substack differential voltages: the sum of the voltages of the first 16 cells in a substack compared to the sum of the voltages of the last 16 cells in the same substack. A gradual change in this measurement indicates a cell problem. Loss of this measurement results in loss of insight into monitoring a potential problem that may develop in a cell. The workaround for an occurrence was to use the Fuel Cell Monitoring System (FCMS). The FCMS records all 96 individual cell voltages. FCMS data recording is done once per mission. Flight Rules dictate that with the loss of a CPM, the FCMS will be powered up daily to record and download individual cell data.</p> <p>The fuel cell hydrogen flowmeter is used to measure the flow rate of hydrogen into the fuel cell, to monitor proper purge valve operation by observing the increase and decrease in flow, and to detect large external leakage in the fuel cell. The oxygen flowmeter can be used as a means to infer hydrogen purge valve operation since both the oxygen and hydrogen purge valves are powered from the same source. Large external hydrogen leakage in the fuel cell can only be detected by excessive hydrogen consumption from the Power Reactant Storage and Distribution (PRSD) hydrogen tanks. As a result of this failure, Main Bus B and Main Bus C will remain bus tied after the Station-to-Shuttle Power Transfer System (SSPTS) deactivation except for critical OMS engine firings.</p> <p>Post flight plan: The 1 A fuse F6 in Mid PCA3 was removed and confirmed to be open. Continuity and isolation checks will be performed to further troubleshoot this problem.</p>
STS-124-V-07	Hand Held Microphone Intermittent Transmission	<p>During Flight Day 10, the crew initiated a call to the ground via Air-to-Ground (A/G) 2 from the Middeck Handheld Microphone (HHM). The ground heard only the sidetone, and no voice. There was an indication that the transmission did successfully reach the ground because the downlink Forward End Processor (FEP) exhibited solid lock on A/G 2. During FD 11, the crew exchanged the HHM for a different HHM and successfully performed a communications check with the ground.</p> <p>Post-flight Action: Standard KSC destowing and returned to JSC for troubleshooting where the microphone boom was found to be damaged.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-08	Communication Carrier Assembly (CCA) Low Volume Pre-launch	<p>During the onboard visor-up pre-launch Intercommunications (ICOM) checks with the MS2-crewmember check as part of crew insertion, the Astronaut Support Person (ASP) and crewmembers reported low volume and could barely hear any Mission Specialist (MS) 2 microphone transmissions.</p> <p>The Shuttle Crew Escape Equipment (CEE) Problem Resolution Team (PRT) discussed whether or not there was a need to swap MS2 Launch and Entry Helmet (LEH) and Headset Interface Unit (HIU) with MS5, to ensure that the MS2 (Flight Engineer) integrated communications system was not suspect in the event of an entry contingency. After considerable discussion, the PRT recommended to fly-as is for entry for the following reasons:</p> <ol style="list-style-type: none"> 1. No additional data exists suggesting existence of suspect communications; 2. The MS2 integrated communications configuration was operationally verified during pre-launch A/G communications checks, and no subsequent anomalies reported; and 3. Since the Commander (CDR), Pilot (PLT) and MS2 are first to suit-up and activate communications, sufficient time will be available to recover as prescribed in the "pre-plan." <p>Recommended entry pre-plan: If any communications anomalies are discovered during entry preparations, MS2 is to swap LEH and HIU with MS5 (along with LEH Velcro color/alpha code). MS2 and MS5 to re-perform ICOM and suit-pressure check</p> <p>Post-flight Actions: Following the end of the STS-124 mission, the individual as well as integrated level inspection/functional were performed on suspect CCA, LEH, and HIU to isolate suspect component. No discrepancies were found during troubleshooting.</p>
STS-124-V-09	IMU1 Z Gyro Excessive Drift	<p>Starting on GMT Day 162, the Z-gyro restraint drift on Inertial Measurement Unit (IMU) 1 began increasing. The increase was approximately 4 sigma over the previous two days or 2 sigma per day. Uplinks updating the drift compensation can satisfactorily control IMU 1 platform drift, through landing, with no change in Flight Procedures under the current conditions. These values of sigma are unusually high for this unit. The last time this unit flew its drift error was 1 sigma for the entire flight.</p> <p>Post-flight Action: The unit was removed from the vehicle and sent to Johnson Space Center (JSC) for planned calibration. The replacement unit will be shipped back to KSC after work is completed.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-10	TCS Dropouts During Rendezvous	<p>During the rendezvous and docking portion of the STS-124 mission, the Trajectory Control System (TCS) unit had 20 instances of tracking losses, and these are categorized as follows:</p> <ol style="list-style-type: none"> 1. Seven for the performance of a long calibration; 2. Six for a reflector switch; 3. Four for unknown reasons; 4. Two for handoff from the Pulsed to the Continuous Wave (CW) laser; and 5. One for the Rendezvous Pitch Maneuver (RPM) <p>Only one instance (during RPM) had a time duration greater than 12 sec. The Rendezvous Proximity Operations Program (RPOP) accepts data losses for time durations of less than 30 sec without recycling the internal counters. Reduced beam size could have increased the chances for the loss of tracking. Beam size showed a narrowing of the beam approximately every 20 sec to ensure proper range values.</p> <p>The RPOP did not have issues with the instances of loss of tracking during the mission (it operated nominally), and did not have to reset the internal counters. TCS was used nominally, in the as-is condition, for undocking and flyaround.</p> <p>Post-flight Action: KSC removed the TCS sensor and returned the unit to JSC. The PRT will evaluate sensor performance.</p>
STS-124-V-11	Rudder Speedbrake Thermal Clip Debris Liberation	<p>Approximately 15 sec after the conclusion of aerosurface drive during the Flight Control System (FCS) checkout, the crew reported seeing an object float away from the vertical stabilizer. Video and still photographs were downlinked for evaluation. The TPS Debris Assessment Team (DAT) personnel determined that the object was most likely the spring seal (thermal barrier) from inside the Rudder Speed Brake (RSB). These clips provide a thermal seal at the edge of the RSB for ascent plume heating, and this particular Inconel steel piece was liberated during the aerosurface drive as a result of a spot-weld failure. There is a history of these clips tearing and liberating. Loss of this component was not an issue for entry</p> <p>Post-flight Action: Inspect and replace clip. A Structures Problem Report (PR) was assigned after confirmation of clip liberation. The Structures PRT was assigned an action by the Mission Management Team to "Review the history of the rudder speed brake on thermal spring tab hardware performance in previous design considerations". The results of the review were presented to the Program Requirements Control Board (PRCB) by 7/17/08.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-12	Y-Star Tracker Door SYS 2 Indication Not Closed	<p>During Star Tracker Door closure, the CLOSED 2 indication on the Y door failed to turn on, and as a result, Motor 2 continued to drive until the crew removed power. The CLOSED 1 indication was obtained nominally within dual-motor run time, and the ac current draw was observed for both motors. There was no impact to the flight.</p> <p>Post-flight Plan: Perform door open/close cycles in the Orbiter Processing Facility (OPF) to attempt to repeat the failure, and inspect for debris. Problem isolated to the door/actuator assembly. Assembly was removed and replaced.</p>
STS-124-V-13	APU 3 Water Line Thermostat Dithering	<p>The Auxiliary Power Unit (APU) 3 injector water cooling line thermostat began to dither at 159/07:18 GMT (6/10:42 MET). The water system thermostat cycle range shifted from a 9 deg control-band between 55 to 64 °F for the first 6.5 days of on-orbit operation to a 1.5 °F dither between approximately 57 and 58 °F as indicated by the APU 3 Water Line Temperature. The thermostat returned to the normal cycling range after two days of dithering. There was no impact to the vehicle/mission and no response or procedure change is required from the crew even if the dithering recurs. This condition can be considered intermittent. No troubleshooting or analysis is planned or required.</p> <p>Post-flight Action: The PRT recommendation was to remove and replace the thermostat during the STS-119 processing flow.</p>
STS-124-V-14	External Airlock Upper Hatch Latching Difficulty	<p>The crew reported difficulty when closing and latching the External Airlock Upper Hatch on FD 11. Attempts to position the actuator handle over the decal that indicates the correct “pre-closing” position were unsuccessful, as a hard stop was encountered prior to reaching that position. After approximately 10 min of attempting various techniques, the crew was able to seat the hatch by moving the handle slightly in the latching direction. Latching was then completed successfully.</p> <p>Post-flight Action: Troubleshooting has determined that a stop bolt in the latch mechanism was adjusted such that the actuator handle could travel approximately 405 deg from the fully-latched position (should be approximately 440 deg). Ground cycles have duplicated the crew’s inability to reach the “pre-closing” position. It is not yet known whether this condition was caused by improper rigging or a problem with the rigging specification itself.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-124-V-15	Excessive Type A Flow on Wing Leading Edge Tee Seal Rib Splice 10	<p>Following STS-124, a region of excessive Type A flow was observed on the right-hand Wing Leading Edge (WLE) tee seal at rib splice 10 during the runway inspection. Inspection revealed a large forward-facing step-and-gap along the lock-side interface to the mating WLE panel 9R that was not apparent before flight. Upon removal of the tee seal, leading edge deterioration was observed along with an abundance of Type A glass flow. Similar observations to a lesser degree have been made on left wing tee seals at rib splices 10 and 11.</p> <p>Post-flight Action: The most probable cause for the discoloration and loss of sealant was heating caused by the lock-side gap condition which was exacerbated during entry due to loading from the adjacent panel 10R's slip-side surface, causing a "clocking" of the T-seal in it's cavity. The single mission temperature was not exceeded and no damage to the SiC was noted, however, the Type A sealant will be repaired. Corrective action is being implemented to take pre- and post-installation step-and-gap data at the lock-side interface for comparison with original vendor data.</p>

**APPENDIX B
STS-124 IN-FLIGHT ANOMALIES**

SOLID ROCKET BOOSTER ANOMALIES

IFA Number	Title	Comments
STS-124-B-001	RH Data Acquisition System Failed to Record Video and Obtained Erroneous Accelerometer Data	The Video Camera Recorder (VCR) in Data Acquisition System (DAS) unit S/N 2M6 failed to record both the ET Observation Camera and the Parachute Camera video. Video should have been recorded from both the ET Observation Camera and from the DAS Parachute Camera. All three DAS accelerometers failed to provide valid flight levels of acceleration data. The DAS Field Computer should have recorded valid flight acceleration data.

**APPENDIX B
STS-124 IN-FLIGHT ANOMALIES**

REUSABLE SOLID ROCKET MOTOR ANOMALIES

There were no Reusable Solid Rocket Motor Anomalies during the STS-124 Mission

**APPENDIX B
STS-124 IN-FLIGHT ANOMALIES**

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-124-T-001	Postlaunch Camera Film Review Showed Two Foam Losses	Two events of foam loss within the XT 1129 LO ₂ Feedline Support Outboard Base Fitting Closeout were noted. The dimensions of the foam loss events are approximately 6.5 in. long by 9.6 in. wide by 3.4 in. deep with an estimated mass of less than 0.10 lbm. The second loss was 5.4 in. long by 4.7 in. wide by 3.6 in. deep with an estimated mass of less than 0.05 lbm. The two loss event times are approximately 144 and 216 sec MET. The Imagery is from the ET LO ₂ Feedline Fairing Camera. This is the first time that the ET camera views are the lone basis of size/mass. Imagery quality was insufficient for a detailed assessment.

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

SPACE SHUTTLE MAIN ENGINE ANOMALIES

IFA Number	Title	Comments
STS-124-E-001	During Ascent Erratic Data Occurred for the PSE Temperature	<p>The Controller Power Supply Temperature Measurement on Space Shuttle Main Engine 1 went off-scale high during STS-124. The anomaly was traced to the 1W7 Electrical Harness during post-landing troubleshooting in the Orbiter Processing Facility. An intermittent open condition was discovered when the harness was manipulated approximately 18 to 20 in. from the electrical interface panel while electrically monitoring the measurement.</p> <p>The harness was removed from the engine and returned to Canoga Park for failure analysis. Functional testing further isolated the fault to wire "A" near the backshell region of the J6 interface connector. Real-time radiographic examination disclosed an apparent broken conductor adjacent to the pin "A" contact. The J6 connector backshell was disassembled and the conductor at pin "A" was confirmed to be broken adjacent to the contact crimp joint. The evaluation of the pin "A" contact and a segment of the broken conductor confirmed that the crimp was proper and that the fracture was entirely ductile in nature.</p> <p>The data show that the 1W7 harness began to fail during the gimbal excursion of the pitch actuator (Z axis at approximately 9.9 deg), completely opened coincident with near maximum of the pitch actuator (Z axis at approximately 10.1 deg) and recovered coincident with relaxation from maximum yaw actuation. The failure event appeared as a "ratcheting" step failure as the conductor resistance changed, which indicates that the conductor strands were breaching as the gimbal angles increased.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-124-I-001	Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Liftoff Debris)	The risk assessment indicates that given the proposed mitigations, the observed debris poses no appreciable increase in risk. Lift-off debris risk is currently characterized as infrequent catastrophic due to significant limitations in controls and significant uncertainties in analysis. Debris release is mitigated for identified potential sources of critical debris by adding inspections for system-level components (e.g. electrical enclosure latch, and FIREX Gage). Ongoing mitigations include Foreign Object Damage (FOD) awareness, attrition-based removal of hardware, routine inspections and monitoring for facility corrosion. No updates to existing documentation are recommended as part of this In-Flight Anomaly (IFA) closure. The closure rationale was presented to the Program Requirements Control Board (PRCB) on August 12, 2008. The recommendation was accepted and the IFA was closed.
STS-124-I-002	Liberated Refractory Brick, NE Flame trench Wall Pad A	During the STS-124 lift-off, the east wall of the launch pad's North Solid Rocket Booster (SRB) flame trench suffered damage, with broken sections of the brick wall scattered from the flame trench to the pad perimeter fence. A vehicle risk assessment investigation associated with the flame trench debris liberation event was performed and documented in this IIFA closure. The reports and imagery results reviewed by the PRCB showed instances of debris liberating from the flame-trench, but there were no documented or observed instances of this debris causing damage to the Space Shuttle Vehicle (SSV). Various debris models with known limitations were applied conservatively to the postulated transport mechanisms for use in performing a Debris Transport Analysis (DTA) on brick and Fondu-Fyre fragments liberated from all locations along the flame-trench. The risk assessment suggests that catastrophic damage to SSV is unlikely due to flame-trench debris. The Pad 39A flame trench repair has been completed so that large losses of refractory bricks or Fondu Fyre will be precluded and hence, remain classified as unexpected debris above the Main Launch Platform (MLP) deck.

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-124-I-003	Late Tyvek Partial Cover Releases	<p>During STS-124 ascent, the Tyvek rain covers on the RCSF3D and F4D thrusters tore and released in two fragments. For the F3D thruster, the parachute and the portion of the Tyvek covering roughly 90-percent of the nozzle exit released at 4.0 sec (72 ft/sec) and the approximate 2 gram remnant released at 18.3 sec (approximately 417 ft/sec). For the F4D thruster, the parachute and the portion of the Tyvek covering roughly 90 percent of the nozzle exit released at 5.2 sec (96 ft/sec) and the approximate 2-gram remnant released at 24.2 sec (approximately 585 ft/sec). The release of both thruster remnants exceeded the certification requirement of 170 mph. A very similar tearing failure occurred during STS-118. The late-release data of F3D Tyvek cover remnant on STS-118 was presented to the PRCB on October 18th, 2007, where the Space Shuttle Program (SSP) accepted the risk of late release of partial Tyvek covers. The documentation concerning the late release as well as the analysis and testing will be updated in NSTS 60559. Based on the results of the above testing and analysis as well as the inclusion of partial Tyvek cover releases in NSTS 60559, it was recommended that this Integrated IFA be closed.</p>
STS-124-I-004	Roll Moment during SRB Tailoff	<p>There was significant Booster and Space Shuttle Main Engine (SSME) steering before and after SRB separation to control body rates induced by Solid Rocket Motor (SRM) thrust mismatch during tail off. The magnitude of steering commands and actuator responses was greater than typical, but flight-control-steering activity was appropriate for the forces and moments on the vehicle. Tailoff behavior was an extreme event from a flight history perspective, however, it appears to be within specification, and induced a larger-than-expected roll rate near SRB separation, which the flight control system handled appropriately. The roll/yaw moments were added to extend the current phantom moment model, other models were verified as being adequate for system capabilities verification, and the Flight Control System (FCS) capabilities were re-verified using the extended phantom moment model and twice the FMODEL6 thrust imbalance and SRB separation capability verified for roll rates 2.5 times the current requirement of 3 deg/sec. Based on this modeling, no FCS or SRB separation issues were identified and no flight safety issues were identified during the IFA hazard analysis. Approved closure of IIFA.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-124-I-005	ET TPS Loss at ~Xt 1129, near LO ₂ Feedline Bracket	<p>Several pieces of debris released in the LO₂ feedline bracket area at approximately 141 and 213 sec. The maximum estimated dimensions for the losses were approximately 6.5 by 9.6 by 3.4 in. and approximately 5.4 by 4.7 by 3.6 in. No NSTS-60559 debris requirements were defined in this area for cryogenic pumping. For this reason, an IIFA was taken to define these requirements. The risk from this debris source is very low primarily because releases due to cryopumping typically occur well after the Aerodynamic Sensitive Transport Time (ASTT). The risk to Tile Shear, Reinforced Carbon-Carbon (RCC), and Special Tile is 1/10,000 and the risk to Tile is 1/2,500. NSTS-60559 will be updated with the Risk Assessment Mass (0.077 lbm) for cryopumping failure in this area. In addition, SE&I will employ a release rate of 0.5 losses per flight for both inboard and outboard sides in the Probabilistic Risk Assessment (PRA). A redesign of the lower outboard and inboard LO₂ feedline bracket closeouts is currently in work and scheduled to be implemented on ET-131. The redesign will eliminate the internal voids and is expected to mitigate debris loss in the Inboard and Outboard LO₂ feedline bracket closeouts.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
AR3176	Battery-Powered Speaker Microphone Unit (BPSMU) Cables Not Onboard ISS As Expected	The 22-ft and 4-ft cables that support the drag-through ISS airlock BPSMU operations on the Shuttle-side were not onboard the ISS. These cables were inadvertently returned on STS-122, instead of being left on the International Space Station (ISS). With loss of the docked Intercommunications (ICOM), the crew only had one Intercommunications (ICOM) loop available rather than the planned two ICOM loops. The cables were labeled to stay on ISS, but were inadvertently returned. The cables that were inadvertently brought home on STS-122 are planned to be manifested and pre-routed on the next Shuttle flight (STS-124).
AR3175 Note: These two anomalies are being reported as one problem because the issues appear to be the same.	ISS-to-Orbiter Intercommunications (ICOM) A Failed	After docking, the ICOM A audio from ISS-to-Orbiter failed, while ICOM A audio from Orbiter-to-ISS was satisfactory. On previous missions, ICOM A has failed from Orbiter-to-ISS. This is a different signature in that the failure is reversed, which is a variation of the ICOM problems that occurred on STS-115, 116, 117, 118, 120, and 122. No in-flight troubleshooting was performed due to the pre-planned contingency of using the BPSMU's for ICOM audio links between the Orbiter and ISS. Based on STS-118 (ISS-13A.1) troubleshooting, the root cause of the problems with the Docked Audio Interface Unit (DAIU) audio channels is determined to be at the Pressurized Mating Adapter (PMA) 2 X3 connector. Operationally, this issue had a low mission impact (loss of redundant ICOM loop from the ISS-to-Orbiter). The crew used a BPSMU for ICOM discussions.
AR3232	ISS C&W Not Heard on Shuttle	The ISS Caution and Warning (C&W) could not be heard in the Orbiter on the "Page" loop. The C&W alerts will be transmitted from ISS-to-Shuttle via hard-line and/or through Portable Computer System (PCS) workstations. Post-flight troubleshooting will be performed on OV-105. These two anomalies are not a constraint to STS-124 as other onboard radios are available onboard to provide the necessary communications

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE ANOMALIES

IFA Number	Title	Comments
STS-124-S-001	Rendezvous Proximity Operators Program (RPOP) I-Load Data Not Updated on PGSC	<p>Training versions of the RPOP I-Load files were not replaced with updated flight versions on the flight Payload and General Support Computes (PGSC's). The problem was discovered during the standard post-docking analysis of downlinked RPOP and Trajectory Control Sensor (TCS) data just after docking.</p> <p>Rendezvous and docking\undocking operations were not impacted: The RPOP is only used for crew situational awareness. The crew is trained for rendezvous operations without RPOP. The difference between the training versions and flight version mass properties was minimal.</p> <p>The flight version of I-loads was uplinked prior to undocking. The re-verification of all essential PGSC applications was performed in the PGSC laboratory (with MS oversight)</p> <p>Note: The I-Load data includes mass property and other configuration data for the RPOP program</p> <p>Postflight Plans: PGSC Software Load Process to "require" all PGSC data owners to verify flight configuration data after final software load assembled and before SAIL Testing.</p>

APPENDIX B STS-124 IN-FLIGHT ANOMALIES

MISSION OPERATIONS

IFA Number	Title	Comments
STS-124-D-001	ODRC Unable To Provide ADI Rates on OI-32	<p>The Orbiter Attitude Direction Indicator (ADI) rate indicator flight data could not be pulled from the Operational Data Reduction Complex (ODRC) on FD 3 when requested by the Guidance, Navigation and Control (GNC) flight controllers for review of on-board rate indicator performance reported by the crew. No impacts to STS-124 operations. The downlinked flight data was properly recorded by ODRC. This condition was caused by a coding error in the ODRC output calibration configuration file.</p> <p>The Attitude Direction Indicator (ADI) data-rate issue that was encountered during STS-124 was traced to the way that the ODRC software retrieved ADI data rate calibration information. There are two sets of calibration files in ODRC, one set utilizing the Shuttle Data Tape (SDT) files, and the second using MCC calibration files. The SDT calibration files use one Measurement and Stimulus Identifiers (MSID) to perform the calibration and the MCC calibration files utilize two MSID's to perform the calibration. When the user runs ODRC in the MCC configuration mode ODRC defaulted to only using the MSID's from the SDT calibration (ODRC defaulted to using SDT first). This results in missing MSID's causing the ADI calibration to be invalid. On 6/18/08, the SDT calibration file was removed from ODRC as a temporary work-around. This prevented ODRC from using the SDT calibrations and forced ODRC to use the MCC calibration files. Subsequently, to restore full functionality to ODRC, the developers performed a code update to the ODRC software to correct the Attitude Direction Indicator (ADI) data rate issue. The issue of using the correct calibration source has been corrected in ODRC 10.2 that was released to OPS on 9/27/08. Consequently, in 10.2 when users select the MCC configuration for calibrating the ADI information it uses the correct calibration file.</p>

APPENDIX C

DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-124 MER Daily Reports by Luis Saucedo, Lead MER Manager:

- First Daily Report (Ascent Plus 2-Hour Report), dated May 31, 2008
- Second Daily Report, dated June 1, 2008
- Third Daily Report, dated June 2, 2008
- Fourth Daily Report, dated June 3, 2008
- Fifth Daily Report, dated June 4, 2008
- Sixth Daily Report, dated June 5, 2008
- Seventh Daily Report, dated June 6, 2008
- Eighth Daily Report, dated June 7, 2008
- Ninth Daily Report, dated June 8, 2008
- Tenth Daily Report, dated June 9, 2008
- Eleventh Daily Report, dated June 10, 2008
- Twelfth Daily Report, dated June 11, 2008
- Thirteenth Daily Report, dated June 12, 2008
- Fourteenth Daily Report, dated June 13, 2008
- Landing Plus 2 Hour Report, dated June 14, 2008
- Mission Summary Report, dated June 16, 2008

ET/SRB/RSRM/SSME REPORTS

- STS-124 Anomalies, David W. Morr, USA-Huntsville, August 14, 2008
- STS-124 Console Flash Report, David W. Morr, USA-Huntsville, May 31, 2008
- STS-124 Initial Event Times, David W. Morr, USA-Huntsville, May 31, 2008
- STS-124 Final Event Times, David W. Morr, USA-Huntsville, June 2008
- STS-124 RSRM Flash Report, Robert Zahl, ATK--Huntsville, May 31, 2008
- STS-124 SRB Debris Open Assessment, Thomas F. Ford, NASA-KSC, June 3, 2008

ORBITER REPORTS

- STS-124 Consolidated Landing Report, Lonnie W. Jenkins, June 14, 2008
- STS-124 Landing and Deceleration Report, C. C. Heinol, Boeing-Houston, June 30, 2008
- STS-124 Communications and Tracking Report, C. J. Stafford, Boeing-Houston, June 19, 2008
- STS-124 Ascent Hazard Analysis Report, Emma J. Joseph, Boeing-Houston, July 25, 2008
- STS-124 Descent Postflight Summary, Rosalyn R. Mark, USA-Houston, Data Unknown
- STS-124 Displays and Controls and Lighting Report, Q. P. Ngo, Boeing-Houston, August 6, 2008
- STS-124 Shuttle Remote Manipulator System, Nik Doshewnek, MDA-Houston, July 10, 2008
- STS-124 HYD/WSB Subsystem Charles A. Ritrivi, Boeing-Houston, August 4, 2008
- STS-124 PRSD System Mission Report, Johnny D. Wong, Boeing-Houston, July 3, 2008
- STS-124 Main Propulsion System Report, Trina A. Martingano, Boeing-Houston, July 3, 2008
- STS-124 Mechanical Systems Report, Jeff Goodmark, Boeing-Houston, June 30, 2008
- STS-124 Auxiliary Power Unit System, Christopher N. Adi, Boeing-Houston, July 3, 2008
- STS-124 OI/MADS Mission Reports, Dwight A. Favors, Boeing-Houston, June 30, 2008
- STS-124 MADS Recorder and MMU Report, Quoc P. Ngo, Boeing-Houston, July 1, 2008
- STS-124 MADS Data Review, Dwight A. Favors, Boeing-Houston, July 15, 2008

STS-124 OI/MADS Sensors, Signal Conditioners and Fuel Cell Monitoring System, Dwight A. Favors, Boeing-Houston, June 30, 2008
STS-124 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, July 1, 2008
STS-124 Data Processing System Integrated Report, Lynna Wood, Boeing-Houston, July 2, 2008
STS-124 EPDC Mission Report, William D. Peterson, Boeing-Houston, June 18, 2008
STS-124 ATCS Post-Flight Mission Report, Carmelo Asuncion, Boeing-Houston, July 3, 2008
STS-124 Life Support Systems Report (ARPCS and Airlock Systems; Supply Water and Waste and Water Management, Jamie M. Haynes, Boeing-Houston, June 30, 2008
STS-124 Orbiter Docking System Summary, Robert E. Davis, NASA-JSC, June 17, 2008
STS-124 OMS Report, Donald E. Varanauski, Boeing-Houston, July 31, 2008
STS-124 RCS Mission Report, Donald E. Varanauski, Boeing-Houston, July 31, 2008
STS-124 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, June 27, 2008
STS-124 Fuel Cells Mission Report, Johnny D. Wong, Boeing-Houston, July 3, 2008.
STS-124 Global Positioning System Report, Hiep M. Bui, Boeing-Houston, July 1, 2008
STS-124 Thermal Control System Summary, Kent K. Rowley, Boeing-Houston, July 11, 2008
STS-124 Purge, Vent and Drain Report, C. C. Heinol, Boeing-Houston, June 30, 2008
STS-124 Flight Controls and ADTA Mission Report, Howard A. Damoff, Boeing-Houston, July 3, 2008
STS-124 Final Mission Events List, Vernon C. Hill, ESCG-Houston, June 23, 2008
STS-124 WLE IDS Post Flight Report, Jon N. Maynard, Boeing-Houston, September 3, 2008
STS-124 SE&I In-Flight Anomalies, Robert L. Morehead, NASA-JSC, September 4, 2008
STS-124 Flight Operations and Integration Anomalies, Ray Serna, NASA-JSC, November 11, 2008
STS-124 MOD Anomalies, Gregory Lange, NASA-JSC, October 31, 2008
STS 124 Station-to-Shuttle Power Transfer System, Johnny D. Wong, Boeing-Houston, August 6, 2008

OTHER REPORTS

STS-124 CSR Report, Michael Darnell, NASA-JSC, August 22, 2008
STS-124 Final Landing Debris Report, Thomas F. Ford, NASA-KSC, June 14, 2008
STS-124 Extravehicular Activity Report for EVA 1, Shannon L. Cagle-Strimple, Hamilton Standard, June 3, 2008
STS-124 Extravehicular Activity Report for EVA 1, Jennifer A. Johnson, Hamilton Standard, June 5, 2008
STS-124 Extravehicular Activity Report for EVA 3, Shannon L. Cagle-Strimple, Hamilton Standard, June 8, 2008
STS-124 Significant Firsts, Michael Darnell, NASA-JSC, October 21, 2008
STS-124 Final Extravehicular Activity Report, Bridget R. Ziegelaar, NASA-JSC, August 14, 2008
STS-124 MLP Post-Launch Walkdown, Kevin D. Vega, NASA-KSC, May 31, 2008
STS-124 L-1 Day Walk Down, Thomas F. Ford, NASA-KSC, May 30, 2008
STS-124 prop30 Aeroscience Report, Barbara C. Schill, United Space Alliance, June 17, 2008

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
A	Ampere
AA	Accelerometer Assembly
ACBM	Active Common Berthing Mechanism
ADTA	Air Data Transducer Assembly
AGT	Adaptive Guidance Throttling
AHMS	Advanced Health Monitoring System
APCU	Auxiliary Power Converter Unit
APU	Auxiliary Power Unit
ARPCS	Atmospheric Revitalization Pressure Control System
ATCS	Active Thermal Control System
BCM	Battery Charger Module
BET	Best Estimate Trajectory
BFS	Backup Flight System
BLT	Boundary Layer Transition
c. g.	center of gravity
CBCS	Centerline Berthing Camera System
CBM	Common Berthing System
CCA	Communications Carrier Assembly
CCAA	Common Cabin Air Assembly
CDR	Commander
CDRA	Carbon Dioxide Removal Assembly
CDT	Central Daylight Time
CEE	Crew Escape Equipment
CEI	Contract End Item
CGBA	Commercial Generic Bioprocessing Apparatus
CO ₂	Carbon Dioxide
CP	Camera Port
CPA	Control Panel Assembly
CPM	Cell Performance Monitor
CRT	Cathode Ray Tube
CSE	Communications Support Equipment
CSLM	Coarsening in Solid Liquid Mixtures
CW	Continuous Wave
CWC	Contingency Water Container
DAS	Data Acquisition System
DAT	Debris Assessment Team
dB	decibel

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
D & C	Display and Control
DDU	Data Display Unit
DET	Data Elapsed Time
DMHS	Dome Mounted Heat Shield
DPS	Data Processing System
DTO	Development Test Objective
ΔV	Differential Velocity
ECLSS	Environmental Control and Life Support System
ECU	Electronic Control Unit
EE	End Effector
ELM- PS	Experiment Logistics Module-Pressurized Section
EO	External Tank/Orbiter
EOM	End-of-Mission
EPDC	Electrical Power Distribution and Control
ESP	External Stowage Platform
ET	External Tank
ETVCG	External Television Camera Group
EV	Extravehicular (Crewmember)
EVA	Extravehicular Activity
EVE	Elbow Vision Equipment
FC	Fuel Cell
FCE	Flight Crew Equipment
FCMS	Fuel Cell Monitoring System
FCS	Flight Control System
FCV	Flow Control Valve
FD	Flight Day
FE	Flight Engineer
FES	Flash Evaporator System
FIB	Flexible Insulation Blanket
FID	Failure Identifier
FOM	Figure of Merit
FR	Flight Rule
FRAM	Flight Releasable Attachment Mechanism
FSE	Flight Service Equipment
FSS	Fixed Service Structure
FSW	Flight Software
GCA	Ground Carrier Assembly
GEI	Ground Environmental Instrumentation

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
GFE	Government Furnished Equipment
GGVM	Gas Generator Valve Module
GHe	Gaseous Helium
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
GUCP	Ground Umbilical Carrier Plate
H ₂	Hydrogen
HAC	Heading Alignment Circle
HDP	Holddown Post
HHM	Hand Held Microphone
HPFTP	High Pressure Fuel Turbopump
HPGT	High-Pressure Gas Tank
HPOTP	High Pressure Oxidizer Turbopump
HYD	Hydraulic
ICS/PROX	Inter-Satellite Communications System/Proximity
IDC	ISIS Digital Camera
IELK	Individual Equipment Liner Kit
IFA	In-Flight Anomaly
IFR	Ice Frost Ramp
IMSL	Intermediate Seal
IMU	Inertial Measurement Unit
IMV	Intra-Module Valve
IR	Infrared
ISS	International Space Station
ISIS	Integrated Sensor Inspection System
ITVC	Intensified Television Camera
IV	Intravehicular
JEM	Japanese Experiment Module
JEM-PM	Japanese Experiment Module-Pressurized Module
JLP	Japanese Experiment Logistics Module-Pressurized Section
JPM	Japanese Experiment Module Pressurized Module
JSC	Johnson Space Center
JTVE	JEM Television Electronics
KAD	KAU Attachment Device
KAU	Keep Alive Umbilical

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
keas	knots estimated air speed
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LCS	Laser Camera System
LDRI	Laser Dynamic Range Imager
LEH	Launch and Entry Helmet
LESS	Leading Edge Structure System
LH	Left Hand
LH ₂	Liquid Hydrogen
LiOH	Lithium Hydroxide
LO ₂	Liquid Oxygen
LP	Left Pod
LTA	Launch to Activation
MADS	Modular Auxiliary Data System
MAUI	Maui Analysis of Upper Atmosphere Injections
MBS	Mobile Remote Servicer Base System
MCAS	Mobile Base System Common Attachment System
MC	Midcourse Correction
MDCA	Main Distribution Control Assembly
MECO	Main Engine Cutoff
MEDS	Multifunction Electronics Display System
MET	Mission Elapsed Time
MLG	Main Landing Gear
MLGD	Main Landing Gear Door
MLI	Multilayer Insulation
MLP	Main Launch Platform
MLS	Microwave Landing System
MM	Momentum Manager/Major Mode
MM/OD	MicroMeteoroid/Orbital Debris
MMT	Mission Management Team
MPCA	Mid Power Control Assembly
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MRL	Manipulator Release Latches
MS	Mission Specialist
MSS	Mobile Servicing System
N ₂	Nitrogen
NASA	National Aeronautics and Space Administration
NAVAIDS	Navigation Aids

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
NC	Nominal Correction
NCC	Nominal Correction Combination
NEOM	Nominal End of Mission
NLGD	Nose Landing Gear Door
NLP	National Laboratory Payload
NW	Northwest
NNW	North-Northwest
NPRV	Negative Pressure Relief Valve
NTA	Nitrogen Tank Assembly
O ₂	Oxygen
OA	Orbit Adjust (Maneuver)
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
ODS	Orbiter Docking System
OFI	Operational Flight Instrumentation
OI	Operational Instrumentation
OME	Orbital Maneuvering Engine
OMRS	Operational Maintenance and Requirements Specification
OMRSD	Operational Maintenance and Requirements Specification Document
OMS	Orbital Maneuvering System
OPCU	Orbiter Power Converter Unit
OPO	Orbiter Project Office
ORGA	Orbiter Rate Gyro Assembly
OSE	Orbital Support Equipment
OV	Orbiter Vehicle
OTV	Operational Television
P	Port
PADLES	Passive Area Dosimeter Life Science Experiment in Space
PASS	Primary Avionics Software System
PCBM	Passive Common Berthing System
PCM	Pulse Code Modulation
PDGF	Power and Data Grapple Fixture
PDU	Power Drive Unit
PFE	Program Furnished Equipment
PGME	Propylene Glycol Monomethyl Ether
PIP	Push In Pull
PLB	Payload Bay
PLBD	Payload Bay Door

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
PLT	Pilot
PMA	Pressurized Mating Adapter
PMBT	Propellant Mean Bulk Temperature
P _{PCO₂}	Partial Pressure Carbon Dioxide
PR	Problem Report
PRA	Probabilistic Risk Assessment
PRSD	Power Reactant Storage and Distribution System
PRT	Problem Resolution Team
PS	Pressurized Section
PSIG	Propulsion Systems Integration Group
PV&D	Purge, Vent and Drain
PWR	Payload Water Reservoir
QD	Quick Disconnect
R & R	Remove and Replace
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
ROI	Regions of Interest
RP	Right Pod
RPCM	Remote Power Controller Modules
RPM	R-Bar Pitch Maneuver
RPOP	Rendezvous Proximity Operations Program
RSB	Rudder Speed Brake
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System
RTL	Ready to Latch
RTV	Room Temperature Vulcanizing (material)
S&A	Safe and Arm
SARJ	Solar Alpha Rotary Joint
SDBI	Short Duration Bioastronautics Investigation
SDTO	Station Development Test Objective
SDFS	Smoke Detection and Fire Suppression
SIMO	Simultaneous
SLWT	Super Lightweight Tank
SMRD	Spin Motor Rotation Detector

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
S/N	Serial Number
SODB	Shuttle Operational Data Book
SPU	Sample Processing Unit
SRB	Solid Rocket Booster
SRGA	Station Rate Gyro Assembly
SRM	Solid Rocket Motor
SRMS	Shuttle Remote Manipulator System
SRSS	Shuttle Range Safety System
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
ST	Star Tracker
STS	Space Transportation System
SW	Southwest
TBA	Trundle Bearing Assembly
TCS	Thermal Control System/Trajectory Control Sensor
TEA	Torque Equilibrium Attitude
THC	Translation Hand Controller
TI	Terminal Phase Initiation/Transfer Initiation
TPL	Transfer Priority List
TPS	Thermal Protection System
TSM	Tail Service Mast
TV	Television
TVC	Thrust Vector Controller
TVCIC	Television Camera Interface Controller
V	Volt
VCR	Video Cassette Recorder
VDT	Vehicle Data Table
WLE	Wing Leading Edge
WLEIDS	Wing Leading Edge Impact Detection System
WLES	Wing Leading Edge Subsystem
WSB	Water Spray Boiler
WVE	Wrist Vision Equipment

APPENDIX D

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

<u>Unit of Measure</u>	<u>Explanation</u>
°F	Degree Fahrenheit
deg	degree
deg/sec	degree per second
ft	feet
ft/sec	feet per second
ft ³	cubic feet
g/G	gravity
Grms	gravity root mean square
Hr	hour
In.	inch
Keas	knots estimated air speed
Kgs	knots ground speed
kW	Kilowatt
kWh	Kilowatt hour
lb	pound
lbf	pound force
lb/hr	pound per hour
lb _m /lbm	pound mass
Mlbf	Million pound force
min	minute
mmHg	millimeters Mercury
mph	miles per hour
nmi	nautical mile
%	percent
ppCO ₂	partial pressure carbon dioxide
ppm	parts per million
psi	pound per square inch
psia	pound per square inch absolute
psi/min	pound per square inch per minute
scim	standard cubic inch per minute
sec	second
Vdc	Volt direct current