NSTS-37452

STS-125
SPACE SHUTTLE
MISSION REPORT

March 2010

**National Aeronautics and
Space Administration**

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

NOTE

The STS-125 Space Shuttle Program Mission Report was prepared from inputs received from the responsible Space Shuttle Program Offices and Subsystem Engineers from other organizations. The following personnel can be contacted should any questions arise concerning the technical content of this document.

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INTRODUCTION

The Space Transportation System (STS) -125 Space Shuttle Mission Report presents a discussion of the Orbiter activities during 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 126 th mission of the Space Shuttle Program.

The primary objectives of this mission were to return the Hubble Telescope (HST) to an operational condition. To achieve the HST objectives, the crew removed and replaced the Rate Sensor Unit System, the Wide Field Camera 3, Science Instrument Command and Data Handling System, the Fine Guidance Sensor and the Battery Module in Bays 2 and 3. The crew also installed the Cosmic Origins Spectrograph and the Soft Capture Mechanism. Also installed were three New Outer Blanket Layers on sections 8, 5, and 7. Repairs were made to the Space Telescope Imaging Spectrograph and the Advanced Camera for Surveys. The completion of all of the tasks required the crew to perform five Extravehicular Activities (EVA's).

STS-125 was the 13th mission since the return to flight following the STS-107 mission, and the 5th servicing mission to the HST. STS-125 was also the 30th flight of the OV-104 Orbiter (Atlantis).

The flight vehicle consisted of the OV-104 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-130; three Block II SSMEs that were designated as serial numbers (S/Ns) 2059, 2044, and 2057 in positions 1, 2 and 3, respectively; and two SRBs that were designated BI-137. The two RSRMs were designated flight set RSRM-105. The individual RSRMs were S/N 360W105A (left) and S/N 360W105B (right). Launch pad 39A and Mobile Launch Platform (MLP) -2 were used as the platform for launch of the STS-125 mission.

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 seven crewmembers that were on the STS-125 flight were Scott D. Altman, Captain U.S. Navy (Retired), Commander; Gregory C. Johnson, Captain, U.S. Navy (Retired), Pilot; K. Megan McArthur, Ph.D., Civilian, Mission Specialist 1; Michael J. Massimino Ph.D, Civilian, Mission Specialist 2; Andrew J. Feustel, Ph.D, Civilian, Mission Specialist

3; Michael T. Good, Captain, U. S. Air Force, Mission Specialist 4; and John M. Grunsfeld, Ph.D, Civilian, Mission Specialist 5.

STS-125 was the fifth flight for Mission Specialist 5, the fourth Shuttle flight for the Commander, the second flight for Mission Specialist 2. STS-125 was the first Shuttle flight for the Pilot, Mission Specialist 1 and Mission Specialist 3, and Mission Specialist 4.

MISSION SUMMARY

Pre-Launch

The objectives for the STS-125 mission were to repair the Hubble Space Telescope (HST). The mission performed on-orbit HST servicing operations including the addition of two new science instruments, the repair of two others and the replacement of other hardware that will extend the HST's life into the next decade. Five Extravehicular Activities (EVA's) were performed to complete the repair and refurbishment of the HST. Also parallel operations were conducted with the STS-400 Launch-On-Need vehicle at Pad B.

The most significant issues going into the T-20 min hold were Day-of-Launch I-Load Update (DOLILU) winds and ice on the LH_2 T-0 area. The DOLILU design was delayed until the Launch (L) -3:35 balloon. There was very low **αβ** margin with both L-6:15 and L-4:50 balloons, therefore an Operations Exception (OE) was processed to document rationale for delaying the I-Load design. There was also an Orbiter Q-plane violation with the L-3:35 hr assessment, DOLILU was officially NO-GO until a later assessment cleared the violation. The L-2:20 balloon data resolved the wind violation. The second issue was associated with ice on the Liquid Hydrogen (LH_2) Time of Launch (T-0) umbilical. The focus inspection team was able to take pictures of the ice and relay the size to the Debris Assessment Team (DAT) for assessment. The mass of the ice was bounded by a previous case and cleared by the DAT and Systems Engineering and Integration (SE&I).

During pre-launch, the three launch times were evaluated for conjunctions. There were eight objects identified by the screening but there were no launch violations.

The STS-125 mission was the first flight of the newly incorporated low-temperature material O-rings in the Reusable Solid Rocket Motor (RSRM) field joints. The new O-rings provide greater resiliency at low temperatures.

Ascent and Flight Day 1

The STS-125 mission was launched at 131/18:01:55.992 Greenwich Mean Time (GMT) on May 11, 2009, on the fifth and final HST servicing mission. The launch azimuth was 28.45 deg.

At 131/18:01:56 GMT [00/00:00:01 Mission Elapsed Time (MET)], the Aerosurface Servo Amplifier (ASA) 1 power failed and bypassed across all channel 1 aerosurfaces. In-Flight Anomaly (IFA) STS-125-V-02 was assigned to this anomaly. This condition caused an On-Board Fault Summary (OFS) message to annunciate at lift-off of the Space Shuttle Vehicle (SSV). The Left Outboard (LOB) position feedback transducer showed degradation approximately 2.5 sec prior to lift-off. The degradation caused both

system Remote Power Controllers (RPC's) to trip. The ASA 1 was taken to "OFF" and switch guard installed.

The left Space Shuttle Main Engine (SSME) Gaseous Hydrogen (GH_2) outlet pressure transducer became erratic after engine ignition as the pressure passed through 840 psia (IFA STS-125-V-01). The erratic reading continued through ascent, and the erratic behavior annunciated a Backup Flight System (BFS) Caution and Warning (C&W) a total of four times. The loss of this measurement did not impact the mission. The messages were annunciated at 35 sec MET, 46 sec MET, 7 min 35 sec MET and 7 min 36 sec MET. This measurement is used by the crew as a cue to confirm an SSME shutdown behind a data-path failure. It is used by the Mission Control Center (MCC) as a cue for engine shutdown behind a data path as well as a cue for GH_2 flow control valve position. At Main Engine Cutoff (MECO), the GH_2 outlet pressure reading for all three engines fell to zero as expected. The GH_2 outlet pressure transducers on the other two engines functioned as expected throughout ascent. Additionally, the downstream GH_2 2 in. disconnect pressure reading responded nominally to flow control valve openings and closings and indicated nominal operation of the flow control valves. This failure did not impact SSME operations.

The Reaction Control System (RCS) window-protect firing was initiated at 131/18:03:59 GMT (00/00:02:04 MET) for total duration of 2.08 sec. The F1U, F2U, and F3U thrusters were fired. This pulse essentially deflects any particulate being spewed from the departing SRB separation-motor plume away from the crew compartment windows. This maneuver has been part of the ascent profile since 2001 (STS-98).

The Solid Rocket Booster (SRB) performed satisfactorily and no IFA's were identified from the data. SRB separation occurred at 2 min 4.32 sec MET. MECO occurred at 131/18:10:21 GMT (00/00:08:25 MET). The ET separated from the Orbiter at 131/18:10:42 GMT (00/00:08:46 MET).

The Orbital Maneuvering System (OMS) Assist firing was not required nor was the OMS 1 maneuver.

A nominal OMS-2 maneuver was performed at 131/18:45:41.2 GMT (00/00:43:45 MET). The maneuver was 92.6 sec in duration with a Differential Velocity (ΔV) of 139.6 ft/sec. The achieved orbit was 298 by 187 nmi.

The payload bay doors were opened at 131/19:40:01 GMT (00/01:38:05 MET).

The Multi-Function Electronic Display System (MEDS) reported a Cathode Ray Tube (CRT) 1 luminance control-loop Built-In Test Equipment (BITE) failure. The failure cleared 16 min later. A User note on bright ambient light conditions may cause these errors due to Multifunction Display Unit (MDU) BITE limits being exceeded. This does not affect the performance of the MDU or the quality of the display image. The error condition existed for as long as the bright ambient light was present.

The Data Processing System (DPS) reported a Master Timing Unit (MTU) accumulator miscompare that occurred at 131/18:11:29 GMT (00/00:09:34 MET). The source for this report was an Event Logger (ELOG) that indicated nine different MTU-BITE fail indications, which all occurred concurrently. This would require multiple internal failures of the MTU including both oscillators. Review of the ELOG found no MTU BITE fail indications at that time. Data from the Orbiter Data Reduction Center (ODRC) did not show any MTU BITE fail indications.

The Ku-Band antenna was deployed at 131/19:47:42 GMT (00/01:45:46 MET). The system was powered ON at 131/19:50:45 GMT (00/01:48:49 MET), and the RADAR self-test was started at 131/19:56:49 GMT (00/01:54:53 MET). Ku-Band system passed the self-test. The crew placed the system in the Communications (COMM) mode at 131:20:00:58 GMT (00/01:59:02 MET) and the system operated normally.

A Nominal Correction (NC) 1 maneuver was performed nominally at 131/21:49:54.65 GMT (00/03:47:59 MET). The maneuver was a series of six –X RCS maneuvers and was 90.88 sec in duration with a ΔV of 19.5 ft/sec. The resulting orbit was 118.3 by 298.1 nmi.

The Remote Manipulator System (RMS) initialization, power-up and checkout were completed without any problems noted. Following the checkout, an End Effector Crew-Cabin survey was performed starting at 131/22:19 GMT (00/04:17 MET). Before maneuvering back to the pre-cradle position at the end of the day, a payload-bay (PLB) survey was performed, including a survey of the Flight Support System (FSS) umbilical area, starting at 131/22:59 GMT (00/04:57 MET).

Ground imagery reported that when the Tyvek rain covers on RCS thrusters F3D's and F4D's Tyvek rain covers released at 131/18:02:03.9 (00/00:00:07.9 MET) at 148 ft/sec (104 mph) and 131/18:02:4.4 (00/00:00:08.4 sec MET) at 163 ft/sec (111 mph), respectively, a piece remained attached to each thruster lip. The F3D piece separated at 131/18:02:15.2 GMT (00/00:00:19.2 MET) at 430 ft/sec (293 mph). The F4D piece separated at 131/18:02:15.8 GMT (00/00:00:19.8 MET at approximately 446 ft/sec (304 mph). The estimated size of each piece was approximately 2 grams, which was below the risk acceptance criteria of 5 grams at 1000 ft/sec. Imagery indicated that the pieces that released late did not impact the Orbiter.

The crew detected a failed microphone key light on panel A2 while performing the Lamp-Test procedure on the aft flight deck at approximately 132/01:44 GMT (00/07:42 MET). It appeared the lamp in the panel was burned out. The light was supposed to illuminate when the microphone is keyed to talk.

The crew also performed the umbilical-well Thermal Protection System (TPS) camera imagery download procedure at approximately 132/01:51 GMT (00/07:49 MET) and were unable to retrieve camera imagery. The crew confirmed that there was 46 images on the camera as expected. The same error message was seen during the retrieval

attempt on-orbit as was seen on the ground during pre-flight testing. The camera was powered off at 132/08:13 GMT (00/14:11:34 MET).

There were two Wing Leading Edge Impact Detection System (WLEIDS) indications identified on the starboard chine area at 131/18:03:40.3 GMT (00/00:01:44.3 MET) and 131/18:03:56.7 GMT (00/00:02:00.7 MET) measuring 2.9 Gravity Root Mean Square (Grms) and 1.8 Grms, respectively.

During the Payload Bay RMS survey of the Space Support Equipment (SSE) using the elbow camera, a thermal cover was found to be protruding. The Velcro appeared to have lifted. This cover is on the Space Telescope Imaging Spectrograph (STIS) Main Electronics Box (MEB) located on the lid of the Axial Scientific Instrument Protective Enclosure (ASIPE). The initial thermal analysis indicated that there was not any impact to the equipment in the ASIPE, and subsequently during the first EVA, the cover was tapped into place by the Extravehicular (EV) 1 crewmember.

The initial checkout of the IMAX Cargo Bay Camera-3D (ICBC3D) was nominal.

Flight Day 2

The main activities for Flight Day (FD) 2 were the TPS survey and Extravehicular Mobility Unit (EMU) checkout.

The Reinforced Carbon-Carbon (RCC) and tile surveys were successfully completed with no issues. The RMS grappled the Orbiter Boom Sensor System (OBSS) at 132/11:30 GMT (00/17:28 MET). This was followed by release of the Starboard Manipulator Retention Latch (MRL) at 132/11:47 GMT (00/17:45 MET) and a maneuver to the OBSS Hover Position at 132/11:53 GMT (00/17:51 MET). The starboard RCC survey started at 132/13:20 GMT (00/19:18 MET) and paused at 132/13:26 GMT (00/19:24 MET). The starboard underside surface tile survey started at 132/13:34 GMT (00/19:32 MET) and was completed at 132/14:06 GMT (00/20:04 MET). The starboard RCC survey was restarted at 132/14:15 GMT (00/20:13 MET), and was completed at 132/15:08 GMT (00/21:06 MET). The Nose RCC survey was started at 132/15:18 GMT (00/21:16 MET) and was completed at 132/16:05 GMT (00/22:03 MET). The port RCC survey was started at 132/16:29 GMT (00/22:27 MET). The port underside surface tile survey was started at 132/17:02 GMT (00/23:00 MET) and was completed at 132/19:07 GMT (01/01:05 MET). The port RCC survey was then resumed and was completed at 132/19:30 GMT (01/01:28 MET). The port-chine and crew-cabin survey was completed at 132/19:54 GMT (01/01:52 MET). The Time of Launch (T-0) port umbilical and OMS pod survey was completed at 132/20:53 GMT (01/02:51 MET) with OBSS berthing at 132/21:29 GMT (01/03:27 MET).

Beginning at approximately 132/14:01:55 GMT (00/19:59:59 MET), the Hydraulic System 3 right-outboard elevon return-line temperature began to exhibit erratic behavior. The erratic operation was characterized by several off-nominal temperature increases and subsequent decreases. No corresponding temperature fluctuations were

observed in any of the nearby temperature transducers. During STS-122, a similar occurrence was observed.

Special emphasis was placed on the starboard chine area that was associated with the two WLEIDS indications during ascent. A line of small damages approximately 21 in. long was imaged in the starboard chine area (IFA STS-125-V-14). The DAT analyzed the images and the starboard chine area was cleared at the FD 3 Mission Management Team (MMT) meeting.

The EMU checkout was successfully completed at 132/17:59 GMT (00/23:57 MET). No issues or concerns were reported.

At 132/20:55 GMT, current signatures indicated four Payload Bay Floodlights were activated by the crew [each floodlight draws approximately 6.6 Amperes (A)]. When all four floodlights were deactivated at 132/23:08 GMT (01/05:06 MET), the current signature on Main Bus B (MNB) Mid-Power Controller 2 (MPC2) showed only a 2-Ampere (A) decrease instead of the expected approximately 6.6 A, indicating a floodlight had failed. During the first Extravehicular Activity (EVA), the crew noted that the starboard floodlight was not operating (IFA STS-125-V-03).

A NC3 OMS maneuver was performed nominally at 132/22:27:19 GMT (01/04:25:23 MET). The maneuver was a right OMS maneuver for 9.6 sec with a ΔV of 7.3 ft/sec. The resulting orbit was 122.7 by 297.6 nmi.

The RCS thruster R5R was deselected at 133/00:38:41 GMT (01/06:36:45 MET) due to repeated low pressure in the chamber pressure (approximately 50 psi) (IFA STS-125-V-07). The R5R chamber pressure had been sporadically indicating between 50- to 90-psi during firings. The Redundancy Management (RM) system did not deselect the thruster. To avoid waking the crew, the R5R thruster was deselected and attitude control was maintained with the remaining five vernier thrusters during crew sleep.

Following ascent, when attempting to downlink the crew-cabin video, the crew reported that there was no video available for downlink (IFA STS-125-V-08). After attempting the downlink, the crew reviewed the tape and reported the Mini-Camcorder tape was blank with just a few prelaunch blips. Initial indications point to a failed cable between the Audio Video Interface Unit (AVIU) and the video recorder.

The HST completed all preparations for rendezvous on FD 2. The third Rate Sensor Gyroscope (no. 4) was activated and added to the control loop, the aperture door was closed, the high-gain antennas were stowed, and the HST was transitioned to the capture attitude.

The Solar System Exploration (SSE) activation also was completed. The Flight Support System (FSS) carrier completed its checkouts and the Berthing and Positioning System (BAPS) ring was pivoted up to the berthing position.

The Relative Navigational System (RNS), located on the Multi-Use Lightweight Equipment (MULE) carrier in the payload bay, is an imaging system consisting of optical and navigation sensors and supporting avionics. The RNS collected imagery data during the capture and deployment of the HST. The data will enable NASA to pursue rendezvous options in the future to support the safe de-orbit of the HST.

The ICBC3D checkout was completed. The camera housing window was opened and the film was advanced in the camera through 20 frames of film (equivalent to about 1 second of footage) in preparation for Scene 1 HST berthing on FD 3.

Flight Day 3

The main activities for FD 3 were the HST grapple and berthing as well as a survey of the HST.

The RCS thruster R5R was reselected at 133/10:41:56 GMT (01/16:40:00 MET) to support rendezvous operations. After R5R was reselected, the lowest indicated chamber pressure reached was approximately 75 psi. There were no issues with the thruster during rendezvous.

The Ku-Band self-test was started at 133/11:58:37 GMT (01/17:56:41 MET). The Ku-Band system failed the self-test because of a known Hot-Receiver condition. The system was placed in the RADAR mode at 133/13:57:44 GMT (01/19:55:48 MET) and detected the HST at a range of 141,000 ft and began tracking at 139,000 ft.

The Nominal Height (NH) OMS-4 maneuver was a dual-engine, straight-feed firing occurring at 133/12:17:16 GMT (01/18:15:21 MET). The firing time was 197.4 sec with a ΔV of 308.2 ft/sec. The resulting orbit was 303.1 by 297.5 nmi. The NC4 maneuver was not required. The Nominal Corrective Combination (NCC) maneuver was a 7.0 sec multi-axis RCS maneuver that occurred at 133/13:41:50 GMT (01/19:39:55 MET). The ΔV delivered was 1.6 ft/sec, and the Orbiter was placed into a 303.0 by 297.4 nmi orbit. The Transfer Initiation (TI) OMS-5 maneuver was a 12.0-sec, straight feed left- engine maneuver that had an ignition time of 133/14:41:56 GMT (01/20:40:01 MET). The ΔV delivered was 9.4 f/sec, and the Orbiter was placed into a 303.0 by 303.3 nmi orbit.

The Midcourse Correction (MC)1 and 2 maneuvers were not required. The MC3 maneuver was a 0.2-sec multi-axis RCS maneuver, which began at 133/15:53:26.3 GMT (01/21:03:31 MET). The ΔV delivered was 0.9 ft/sec and the Orbiter was placed in a 303.3 by 303.6 nmi orbit. The MC4 was a 8.9-sec multi-axis RCS maneuver, which began at 133/16:03:26.5 GMT (01/22:01:31 MET). The ΔV delivered was 2.1 ft/sec and the Orbiter was placed into a 303.3 by 304.6 nmi orbit.

During rendezvous, there was difficulty establishing communications between the Orbiter and the HST. Commanding of the HST was lost during the transition from the Tracking and Data Relay Satellite (TDRS) to the Shuttle communication systems. The rendezvous was temporarily stopped while the HST systems were reconfigured to

establish the new communication path to the HST ground system at the Goddard Space Flight Center. The fault was isolated to the HST Data Management Unit Communications Module that had not been reconfigured from the 1 Mbps science-format to the 32 Kbps rate, which is required for downlink through the Shuttle Payload Interrogator (PI). Rendezvous was completed without incident once the Shuttle communication path was established. Due to the delay in commanding, the final roll maneuver for the HST vehicle was not performed, and Orbiter performed a manual flyaround by the crew to achieve the capture orientation and HST grapple.

The RMS captured the HST at 133/17:24:09 GMT (01/23:22:14 MET) and the HST was berthed in the FSS in the Orbiter's cargo bay at 133/18:13:01 GMT (02/00:11:06 MET). After the HST was berthed, the RMS was used to perform a HST and solar panel survey.

A small amount of particulate contamination was noted by the HST team on the Wide Field Camera Scientific Instrument Protective Closure (WSIPE) lid, which may have come from underneath the blanket liner. This debris does not appear to be a contamination concern.

The DAT presented the tile analysis results to the MMT, and all areas were cleared for entry with the exception of a set of tiles in the port-chine region.

The TDRS satellite no. 46 appeared to transmit at a slightly lower signal-strength when compared to other TDRS satellites. This signature seemed to point to a possible degradation of the satellite. As a result, the Orbiter K-Band was frequently unable to use the forward link. Note: The International Space Station (ISS) ceased using satellite 46 and was using satellite 41 because of this behavior.

The RCS thruster R5R chamber-pressure continued to be lower than expected. As a result, the thruster was deselected at 133/23:05 GMT (02/05:03 MET) to prevent possible alarms during crew sleep. It was reselected at 134/09:46 GMT (02/15:44 MET). This thruster was planned to be deselected each day during the crew-sleep period, and reselected each day after the completion of the crew-sleep period.

Flight Day 4

The main activity for FD 4 was the first EVA for the repair of the HST. The first EVA duration was 7 hr 20 min. The EV crewmember assigned as the 'free floater' was John Grunsfeld and the RMS EV crewmember was Drew Feustel.

The pre-breathing for the first EVA began at 134/11:36 GMT (02/17:34 MET). The start time for the depressurization was 134/12:38 GMT (02/18:36 MET). The official EVA start time was 134/12:51 GMT (02/18:49 MET) when power was switched to battery on both EMU's. The Airlock egress was 134/12:59 GMT (02/18:57 MET).

The Wide Field and Planetary Camera 2 (WF/PC2), one of the Radial Scientific Instruments that was installed on the previous SM1/STS-61, was replaced by the WFC3.

The Science Instrument Command and Data Handling unit (SI C&DH-2) was also successfully installed during the first EVA. The A-Side of the SIC&DH had failed in September of 2008, which was the cause of the delay of the SM4 mission from Oct 11, 2008 to allow engineers time to develop the hardware and a plan to replace the equipment located inside of the Bay 10 door. It provides the electronics to command HST science instruments from the ground and to flow science and engineering data back to the ground.

The EVA crew also completed the transfer of the Soft Capture Mechanism (SCM) from the FSS to HST. The SCM will enable the future rendezvous, capture, and safe disposal of HST by either a manned or a robotic mission.

During the first EVA, the crew installed 2 of 3 Latch Over Centerline Kits (LOCK) onto the –V2 door. Due to a concern that installing the third LOCK might bend the doors in such a way as to allow light to enter the telescope, which was not acceptable to HST, the crew installed one Aft Shroud Door Latch Repair (ASLR) kit on the lower middle latch of the –V2 door.

Removal of two Bay 5 New Outer Blanket Layers (NOBL) vent plugs and the application of lubricant to several door-latch bolts were performed as Get-Ahead tasks during this EVA.

The RMS completed EVA support activities at 134/19:39 GMT (03/01:37 MET), and the RMS was maneuvered to the extended park position at 134/19:59 GMT (03/01:57 MET). Airlock ingress occurred at 134/21:11 GMT (03/03:09 MET).

After the first EVA, the crew reported a faint burning odor from the middeck sometime after initiating charging of the EVA battery. The atmospheric measurements were taken and all readings were nominal. The crew checked the chargers and narrowed the issue down to the EVA Helmet Interchangeable Portable Light (EHIP) charger (IFA STS-125-V-15). The crew switched to the spare charger, and the failed charger was not used during the rest of the mission.

The post-EVA electrical testing showed both SI C&DH and WFC3 were operating nominally. There were a few problems that were resolved by the EVA and ground teams. One of the issues was a high breakaway torque on the WF/PC2 A-latch. The crew was required to use contingency tools to release the A-latch on this instrument to release it from HST. Also, during the execution of the WFC3 Functional Test the instrument entered suspend mode. Troubleshooting isolated the problem to a voltage limit within one of the instrument's two detectors. The issue was resolved and the test was successfully completed. Post-test data review confirmed the Functional Test was successful. The functional test of the SIC&DH was also successfully completed.

The WLEIDS group 1 monitoring began at 134/13:05 GMT (02/19:03 MET) and ended at 134/15:50 GMT (02/21:48 MET) with no triggers recorded.

A minor destratification, which did not impact the mission, was observed in oxygen tank 5 starting at 134/13:58 GMT (02/19:56 MET).

The DAT presented the RCC areas of interest to the MMT, and all RCC was cleared for entry. An area of 40 tiles on the Port Forward Fuselage that was missed during the initial survey was identified and an inspection of the area was added to the FD 5 plan.

Flight Day 5

The main activity for FD 5 was the second EVA for the repair of the HST. The duration of the second EVA was 7 hr 56 min. The EV crewmember assigned, as the 'free floater' was Mike Massimino, and the RMS EV crewmember was Mike Good during EVA2.

The RMS was maneuvered to the Airlock Manipulator Foot Restraint (MFR) ingress-position at 135/11:40 GMT (03/17:38 MET). The second EVA started at 135/12:50 GMT (03/18:48 MET) with both EMU's switching power to the battery. The airlock egress was initiated at 135/12:52 GMT (03/18:50 MET). The MFR ingress occurred at 135/13:12 GMT (03/19:10 MET).

The second EVA planned activities were completed by installing three Rate Sensor Units (RSUs), each containing two new gyroscopes, one Battery Module-1 installation into Bay 2 and an Advanced Camera for Surveys Repair (ACS-R) 'get-a-head' task (installation of the PIE Harness). The aliveness and functional tests of the RSUs and the battery were successfully completed. The crew did have trouble during the installation of one of the RSUs and needed to swap it out with a spare unit to complete the task. A flight software patch was uplinked to HST to update the gyroscope configuration post-release.

Airlock ingress occurred at 135/20:23 GMT (04/02:21 MET). The RMS support of EVA activities was concluded with the maneuver to the extended-park position at 135/22:03 GMT (04/04:01 MET).

The forward-port PLB floodlight was reported as failed (IFA STS-125-V-04). As a result of this second PLB floodlight failure, no floodlights were operating in the forward area of the payload bay. This was not considered a mission impact.

After all ascent data was retrieved from sensor 1092, a diagnostic command was sent to the unit in preparation of on-orbit monitoring. The diagnostic results showed good health; however, later in the mission many consecutive local timeouts were experienced with the sensor while trying to program for On-Orbit Monitoring (IFA STS-125-V-05). Following this anomaly, the sensor continuously provided local timeout messages. As a result of multiple timeouts, sensor 1094 (from Group 2) was substituted for this sensor since it monitors the same locations.

The forward port fuselage tile survey using the RMS end-effector camera started at 135/11:10 GMT (03/17:08 MET) and was completed at 135/11:36 GMT (03/17:34 MET). The survey had to be repeated because these tiles were missed during the previous survey. This area of tile was subsequently cleared by the DAT. All of the TPS and RCC were cleared for entry at the MMT meeting.

A Flash Evaporator System (FES) Prime B water dump was initiated at 135/11:43 GMT (03/17:41 MET). This dump continued until 135/12:47 GMT (03/18:45 MET) when an unexpected FES shutdown occurred. A restart was performed, but the FES shutdown again. A core flush of FES Prime B was initiated at approximately 135/21:37 GMT (04/03:35 MET) with termination at approximately 135/22:12 GMT (04/04:10 MET). The FES Prime B core was successfully flushed of ice. FES Prime A was used to complete the water dump and was used until after the HST was deployed.

Flight Day 6

The main activity for FD 6 was the third EVA for the repair of the HST. The duration of the third EVA was 6 hr 36 min. The EV crewmember assigned as the 'free floater' was John Grunsfeld, and the RMS EV crewmember was Drew Feustel during the EVA.

The RMS was maneuvered to the Airlock MFR ingress position at 136/13:24 GMT (04/19:22 MET). The third EVA started at 136/13:55 GMT (04/19:33 MET) with both EMU's switching power to the battery. The airlock egress was initiated at 136/13:45 GMT (04/19:43 MET). MFR ingress occurred at 136/13:55 GMT (04/19:53 MET).

The Corrective Optics Space Telescope Axial Replacement (COSTAR) which had been installed on SM1/STS-61 to repair the optical aberration of the primary mirror, was removed from the HST and replaced with the Cosmic Origins Spectrograph (COS). The second major task of this EVA was the repair of the Advanced Camera for Surveys (ACS), and as a result of timeline efficiencies, both parts 1 and 2 of the repair were completed. Part 2 of the repair was originally scheduled to be performed on the fifth EVA , however, since it was completed during the third EVA, the fifth EVA tasks was revised to incorporate the change out of the Fine Guidance Sensor - 2 instrument.

The ACS was originally installed during the SM3B/STS-109 in 2002 and prior to its failure in 2007, had been the most heavily used science instrument. An electronics failure in January 2007 rendered inoperable the two most-used science channels, the Wide Field Camera (WFC) and the High Resolution Channel (HRC), and it had been operating on one remaining channel, the 'Solar-Blind' Channel. In general, the HST systems and science instruments were designed to be replaced by an EVA crewmember. The repair of the ACS was unique in that it was the first time during an EVA that a card or board level repair was made on an electronics box in zero gravity. The electronics board for the WFC and a new power supply was installed. Many specialized tools were designed and fabricated by the Goddard Space Flight Center (GSFC) to accomplish this task.

During the third EVA, the crew noted that the window in the center of the IMAX Cargo Bay Camera (ICBC) had fogging/condensation on it. It was believed that this was due to extended exposure with the cover open and camera in the armed configuration.

Airlock ingress occurred at 136/19:59 GMT (05/01:57 MET). RMS support of EVA activities concluded with the maneuver to the extended-park position at 136/20:41 GMT (05/02:39 MET).

A FES water dump was initiated on the FES Primary A Controller at approximately 136/10:46 GMT (04/16:44 MET) for 10 hr. It was successfully completed at approximately 136/23:38 GMT (05/05:36 MET).

The crew reported seeing water on the humidity separator B area in the Environmental Control and Life Support System (ECLSS) bay under the middeck floor during the standard inspections (IFA STS-125-V-09). Water was wiped off and Humidity Separator A was powered up to increase the separation rate. The leading possible cause for this condition was that the FES core flush performed earlier had created a condition of slugging the humidity separators. The humidity levels increased by 26% by the time the core flush was completed, thus creating high condensate collection rates on the condensing heat exchanger, which the humidity separators have to process. A factor that could have contributed to this problem was the accumulation of hydrophilic materials on the pitot collection tube of the humidity separators; the result was degraded water uptake by the pitot tube which leads to carryover. Carryover on humidity separators is the amount of condensate beyond the current capability of the humidity separators to process. The hydrophilic coating on the condensing heat exchanger tends to degrade with time and sloughs off the heat exchanger and is "washed" down to the humidity separators. The FES core flush may have aggravated the accumulation of this hydrophilic coating material in the humidity separators such that the water uptake of the pitot tube is impacted.

An increasing trend in the fuel cell 1 substack 1 differential voltage (ΔV) had been seen since the crew initiated the first manual purge at 132/20:37 GMT (01/02:36 MET); at that time, the differential voltage reading increased by 12 millivolts (mV). During the fuel cell auto purge on FD 4 at 134/21:53:55 GMT (03/03:52 MET), the reading increased by 20 mV. During the last fuel cell auto purge on FD 6, at 136/22:14:55 GMT (05/04:13 MET), the reading increased again by 26 mV. After each increase, the reading decreased slightly, but not back to where it was before the purge. The total substack 1 differential reading was at 32 mV, a total increase of 26 mV from its prelaunch baseline value of 6 mV. Flight rules required a bus tie when the differential voltage reading was above 50 mV from the prelaunch baseline.

Flight Day 7

The main activity for FD 7 was the fourth EVA for the repair of the HST. The duration of the fourth EVA was 8 hr and 2 min. The EV crewmember assigned as the ‘free floater’ was Mike Massimino, and the RMS EV crewmember was Mike Good during EVA4.

The fourth EVA started at 137/13:44 GMT (05/19:42 MET) when the EMU power was placed to battery.

The STIS repair was completed and it passed both the aliveness and functional tests. The repair consisted of replacing the failed low voltage power supply no.2 circuit card in the main electronics box no.1. The repair required the removal of a handrail. This proved to be time consuming due to the inability to remove the lower right bolt of the hand rail. After many attempts to use tooling to remove the bolt, it was decided to pull on the top of the handrail and break the bolt. This method successfully removed the hand rail. Most EVA goals were accomplished, although the EVA was terminated prematurely. The premature termination of the EVA was in accordance with an established Flight Rule because of a tear that was observed during the glove inspection of the left palm of the EV 3 crewmember. The crew photographed the glove and downlinked the images for review and to make a recommendation as to where and when the damage occurred. Because the EVA was long (8 hr 2 min), the bay 8 New Outer Blanket Layer (NOBL) installation was not attempted and it was deferred to the fifth EVA.

The RMS support of the EVA activities was concluded with the maneuver to the extended-park position at 137/21:08 GMT (06/03:06 MET). The EVA was completed at the start of repressurization at 137/21:46 GMT (06/03:44 MET).

For a majority of FD 7, both humidity separators were operating. During the pre-sleep activities, the crew inspected both humidity separators and found no accumulated water. For the crew sleep, humidity separator B was deactivated.

Flight Day 8

The main activity for FD 8 was the fifth and final EVA to repair and upgrade the HST. The duration of the fifth EVA was 7 hr and 2 min The EV crewmember assigned, as the ‘free floater’ was Drew Feustel, and the RMS EV crewmember was John Grunsfeld during the EVA.

The RMS was maneuvered to the Airlock MFR ingress position at 138/12:18 GMT (06/18:16 MET). The fifth EVA started at 138/12:20 GMT (06/18:18 MET) with both EMU’s switching power to the battery. The airlock egress was initiated at 138/12:20 GMT (06/18:18 MET), and MFR ingress occurred at 138/12:30 GMT (06/18:28 MET).

The EV crew began the fifth EVA approximately one hour early. During the EVA, the crew performed Bay 3 Battery removal and replacement, Fine Guidance System 2 removal and replacement, and replaced degraded Multi Layer Insulation (MLI) with New Outer Blanket Layers (NOBL) on Support System Module (SSM) Bays 5, 7, and 8. At the end of EVA, during the final closeout operations in the payload bay, EV1 inadvertently hit the HST low gain antenna located on the bottom of the telescope with his EMU, knocking off the foam tip of the antenna. This required the crew to retrieve the

Low Gain Antenna Protective (LGAP) cover and install it over the low gain antenna to help provide thermal protection for the exposed antenna wiring. This configuration did not interfere with functionality of the antenna.

Airlock ingress occurred at 138/19:07 GMT (07/01:05 MET). The RMS support of EVA activities was concluded with the maneuver to the extended-park position at 138/19:31 GMT (07/01:29 MET).

With the completion of the fifth EVA, there was a total of 36 hr 56 min of EVA activity, with all tasks completed successfully. The fifth EVA was also the 150th EVA for US Shuttle/ISS programs and the 23rd EVA for the HST.

The S-Band Phase Modulation (PM) forward link dropouts via the Lower Right Quad Forward and Aft antenna path occurred intermittently starting at 138/12:49:00 GMT (06:18:47:04 MET) (IFA STS-125-V-11). The forward link dropouts occurred with both S-Band communications strings 1 and 2 as well as through the TDRSs 171 and 46. When the dropouts occurred, forward link lock was intermittent for up to 12 min.

During the EVA, a white piece of Foreign Object Debris (FOD) was observed on the port aft payload bay door seal below Bulkhead Latch Roller 2. An imagery review showed that the FOD was present as early as 131/21:10 GMT (00/03:03 MET). The debris did not impede the port payload bay door closing or latching.

The crew was unable to remove the supply-dump-line purge line after a supply water dump. The crew attempted to push the purge device towards the wall and turn the Quick-disconnect (QD) to remove purge line. The crew reported that the devise could not be removed, and the purge device QD housing remained attached to the flight QD (IFA STS-125-V-06). A nozzle dump could still be performed, but the broken QD eliminates the purging capability. To eliminate the concern for water remaining and freezing in the lines, a FES dump was used for future dumps.

A review of the data associated with the fuel cell 1 substack 1 differential voltage increases during purges showed a signature consistent with fuel cell port plugging, which was seen and accepted during the pre-launch activities. Fuel cell 1 was already planned for removal post-flight based on its operating hours.

Simulations of the RCS R5R thruster performance using attitude control/chamber pressure response data determined that the thruster has reduced performance. The data confirmed that instrumentation was not causing the lower-than-nominal chamber-pressure indications. The R5R thruster remained available for nominal use.

Prior to crew sleep on Flight Night (FN) 8, the crew completed an additional inspection of the humidity separators and found some water. The crew activated system B and ran both systems over-night.

Flight Day 9

The main activities for FD 9 were the release of the HST and the RCC survey.

The Integrated Display Processor (IDP) 4 annunciated a single IDP 4 BITE fail message during unit power up on FD 9 followed immediately by a Mass Storage Unit (MSU) Input/Output (I/O) error message (IFA STS-125-V-10). The IDP continued to perform nominally thereafter, although the BITE indication recurred on all subsequent unit power activations.

The RMS maneuvered to the HST pre-grapple position at 139/10:40 GMT (07/16:38 MET) and grappled the HST at 139/10:45 GMT (07/16:43 MET). The HST was maneuvered to the Hover position at 139/11:28 GMT (07/17:26 MET). The maneuver to the HST Deployment attitude started at 139/12:00:23 GMT (07/17:58 MET) and was completed at 139/12:31 GMT (07/18:29 MET). The RMS released the HST 139/12:58 GMT (07/18:56 MET) and the RMS was moved to pre-cradle at 139/13:33 GMT (07/19:31 MET).

The Ku-Band was switched to the RADAR mode at 139/13:05 GMT (07/19:03 MET) and locked on the HST at approximately 400 ft. The Ku-Band was taken back to the COMM mode at a range of 5200 ft at 139/13:41 GMT (07/19:39 MET).

The Separation 1 maneuver was performed with the RCS -X thrusters F1F and F2F and consisted of ten 0.48-sec pulses, Ignition for the maneuver was at 139/12:59:07 GMT (07/18:57:12 MET). The ΔV was 1.1 ft/sec. The Separation maneuver 2 was performed with the RCS –X thrusters F1F and F2F, which were fired for approximately 25 sec. The maneuver was performed at 139/13:27:52 GMT (07/19:25 MET) with a ΔV of 5.9 ft/sec.

The Orbit Adjust (OA) OMS-6 maneuver was a dual-engine firing that was 143.6 sec in duration. The ignition occurred at 139/14:59 GMT (07/20:57 MET) and no trim was required. The ΔV delivered was 234.8 ft/sec and the Orbiter was placed into a 305.3 by 160.4 nmi orbit. The Orbit Adjust was performed to lower the risk of an Micrometeoroid Orbital Debris (MM/OD) strike. This was done by placing the Orbiter in a lower orbit, thus lowing MM/OD exposure time.

The RMS was maneuvered to the OBSS pre-grapple position at 139/15:22 GMT (07/21:20 MET), and the OBSS was unberthed at 139/15:56 GMT (07/21:54 MET) to begin the RCC inspection for MM/OD damage. The starboard RCC survey started at 139/16:44 GMT (07/22:42 MET) and ended at 139/18:11 GMT (08/00:09 MET). The nose RCC survey occurred from 139/18:33 GMT (08/00:31MET) to 139/19:05 GMT (08/01:03 MET). The port survey started at 139/19:22 GMT (08/01:20 MET) and the port survey was concluded at 139/20:28 GMT (08/02:26 MET). The additional OBSS Integrated Sensor Inspection System (ISIS) Digital Camera (IDC) scanned the port RCC panels 7 through 11, and was designed for this mission due to increased MM/OD risk. The scan was executed from 139/20:38 GMT (08/02:36 MET) to 139/20:55 GMT

(08/02:53 MET). The OBSS was berthed and latched on the starboard sill at 139/21:32 GMT (08/03:30 MET).

The FES was switched from prime A to prime B at 139/19:16 GMT (08/01:14 MET) to verify nominal operations after the unexpected shutdown due to icing on FD 5. Prime B FES performed nominally.

The fourth on-orbit fuel cell purge was performed, beginning at 139/20:16 GMT (08/02:14 MET). During the 46-hour purge interval, the approximate performance decay was 0.16 Vdc for fuel cell 1, 0.15 Vdc for fuel cell 2, and 0.26 Vdc for fuel cell 3. The fuel cell 1 sub stack 1 ΔV rate-of-change was consistent with the previous purges, indicating that port plugging was the cause for the step increase in sub stack 1.

The left OMS pod lower-fuel-tank temperature increased to near the SM limit of 95 ºF. The SM upper limit was increased from 95 to 100 ºF. The temperature subsequently reached approximately 97.0 ºF while operating on the B heater string. This condition is explained because the switch to the B heater string was performed shortly after the A heater string had peaked with a nominal thermostat shut off at approximately 72 ºF. The B heater string continued to heat peaking with a nominal thermostat shut off at approximately 85.4 ºF. While operating on the B heater string, the higher peak temperatures have been observed and documented on previous flights of this OMS pod.

The crew reported that during the latest inspection, the humidity separators were dry indicating that with dual operation over the crew sleep period, no water carryover occurred.

All RCC inspection imagery was successfully downlinked, and the review is in progress with no significant anomalies identified.

Flight Day 10

The main activities for FD 10 were RMS cradle and latch, crew day off, Public Affairs Office (PAO) events and an Orbiter-to-ISS call.

The results of the OBSS coverage of the nose cap and the port and starboard upper wing RCC were presented to the Orbiter Project Office (OPO) meeting.

Oxygen tank 4 was depleted to residual quantity at 140/12:35:58 GMT (08/18:34:02 MET). Oxygen tank 5 was depleted to residual quantity at 140/16:05:22 GMT (08/22:03:26 MET).

The RMS was powered down at 140/14:14 GMT (08/17:02 (MET). A waste dump and a dual Lithium Hydroxide (LiOH) canister change-out were completed. Additionally, the humidity separator was inspected, and the crew reported both separators were dry.

Fuel cell 1 performance continues to be monitored. The differential voltage measurement, 28mV, is consistent with previous fuel cell purges.

Flight Day 11

The main activities for FD 11 were Flight Control System (FCS) checkout, RCS hot-fire, stowing the cabin, and the last planned PAO events.

The fifth on-orbit fuel cell purge was performed, beginning at 140:18:55 GMT (09/00:53 MET). During the 47-hour purge interval, the approximate performance decay was 0.16 Vdc for fuel cell 1, 0.10 Vdc for fuel cell 2, and 0.22 Vdc for fuel cell 3. There was no step increase in the fuel cell substack 1 differential voltage.

The FCS checkout was performed satisfactorily. Auxiliary Power Unit (APU) 3 was started at 141/10:17:56 GMT (09/16:16:00 MET). The APU 3 ran for 4 min 22 sec, with shutdown at 141/10:22:18 GMT (09/16:20:22 MET). Due to the short APU run-time, the APU lubrication oil spray cooling was not required. The maximum lubrication oil return-temperature after APU shutdown was 211ºF. Following the completion of the FCS checkout, the elevons were parked to reduce propellant usage during extended operations.

Following the FCS checkout, the Water Spray Boiler (WSB) 3 Gaseous Nitrogen (GN_2) tank pressure increased. The WSB GN_2 shutoff valve was closed approximately 6 min later; however, the regulator pressure continued to increase. Over the course of the following 23 hr, the regulator pressure went from 25.5 psia to 27.3 psia. The leakage was within the allowable limits for the regulator, and this condition did not impact the mission.

The RCS hot-fire was initiated at 141/11:06:03 GMT (09/17:04:07 MET) and terminated at 141/11:15:28 GMT (09/17:13:32 MET). All 38 RCS thrusters were fired at least once for at least 0.240 sec per pulse. All thrusters have now been fired, and the performance was nominal.

At approximately 141/18:20:56 GMT (010:00:19:00 MET) during the entry preparations, a crew member reported that the cap on the Airlock Negative Pressure Relief Valve (NPRV) on the starboard-side was stuck and could not be pulled to equalize the pressure to cabin pressure. The crew member was able to pull the cap on the port-side NPRV and equalize the pressure inside the cap to cabin pressure. It is believed that this is the first time this procedure has been performed in-flight on the NPRV's. There was no risk for entry.

Flight Day 12

The main activity for FD 12 was to land at Kennedy Space Center (KSC). However, the two landing opportunities for FD 12 were scrubbed because of inclement weather at the planned KSC landing site.

During the landing checkout, the ground initially could not see any Heads-Up Display (HUD) video being downlinked. During a subsequent pass, the crew moved the downlink Y-cable at the Audio Visual Interface Unit (AVIU) J2 connector and intermittent downlink was observed. No spare J2 AVIU cable was onboard. On a later pass, downlink was solid.

The Inertial Measurement Unit (IMU) fan Differential Pressure (ΔP) increased while operating on IMU fan B (IFA STS-125-V-13). IMU fan A was activated and IMU Fan B was deactivated; however, the ΔP did not return to the acceptable level. Following that activity, IMU fan A and IMU fan C were both powered for simultaneous operation. Again no improvement was observed. IMU Fan A was then powered down leaving IMU Fan C operating and the IMU ΔP dropped to an acceptable level.

Flight Day 13

The main activity for FD 13 was to land at KSC. However, the two landing opportunities for FD 13 were scrubbed because of inclement weather at the planned KSC landing site. The landing opportunity for Edwards Air Force Base (EAFB) was not used based on possible weather improvement at KSC on FD 14.

The Freon Coolant Loop (FCL) 1 Radiator Flow Control Assembly (RFCA) failed to operate in Auto A radiator flow when the crew was performing the de-orbit back-out procedures (IFA STS-125-V-12). FCL 1 radiators are on the port side. Shortly after the de-orbit wave-off was declared, the crew started radiator flow procedures in preparation for payload bay door opening. At 143/12:37 GMT (11/18:35 MET), the crew switched FCL 1 radiator control to Auto A. The FCL 1 RFCA again tripped to bypass1 min later, thus the RFCA failed to achieve radiator flow. A restart attempt initiated at 143/12:40 GMT (11/18:38 MET) on Auto A again resulted in a trip to bypass 1 min later. At 143/12:43 GMT (11/18:41 MET), the FCL 1 RFCA was switched from Auto A to Auto B control. Subsequently, successful flow through the FCL 1 radiators was achieved with radiator mixed outlet temperatures set to a high set-point to prevent any other possible issues.

Flight Day 14

The main activity for FD 14 was a planned landing at KSC.

The eighth on-orbit fuel cell purge was performed, beginning at 144/08:31 GMT (12/14:38 MET). During the 25-hr purge interval, the approximate performance decay was 0.05 Vdc for fuel cell 1, 0.11 Vdc for fuel cell 2, and 0.08 Vdc for fuel cell 3. The step increase in the fuel cell substack 1 Cell Performance Monitor (CPM) delta voltage was from 16 to 18 mV.

Entry and Landing

Both Payload Bay Doors (PLBD's) were closed and latched nominally by 144/10:18:26 GMT (12/16:17:11 MET) in preparation for landing.

The first opportunity to KSC on orbit 196 was waved off due to inclement weather. For orbit 197 both the KSC and EAFB opportunities were worked until 15 min prior to the deorbit maneuver at which time the decision was made to go to EAFB. The weather was still to uncertain at KSC for landing.

The deorbit maneuver for the first landing opportunity at EAFB was an OMS dual-engine straight-feed firing, performed on orbit 197 at 144/14:24:41.2 GMT (12/20:22:45.2 MET). The maneuver was 157.8 sec in duration with a ΔV of 267.6 ft/sec. The orbital parameters after the deorbit maneuver were 26.3 by 294.5 nmi.

During entry the APU 2 drain-line pressure 1 reading had many annunciations of the 25-psia Backup Flight System (BFS) Fault Detection and Annunciation (FDA) class 3 alarm. These annunciations occurred when the pressure exceeded 25 psia due to heater cycling. The APU 2 drain system was noted to have in-specification static and dynamic fuel pump shaft seal leakage into the drain system during the ascent operation and heat soak back after the shutdown. This leakage resulted in the higher drain system pressures that caused alarm annunciation during entry. There is no Primary Avionics Software System (PASS) FDA limit for drain system pressure, so no alarm annunciated during the on-orbit phase of the mission.

During the entry, the ground radars at Vandenberg Air Force Base (VAFB) experienced late acquisition of the Orbiter. The problem was determined to be caused by the fact that the radars VDBC and VDHC are very high power and have a small beam width of 0.38 deg. The entry set provided to the radars were compared to the Global Positioning System (GPS) and showed an azimuth difference at horizon break of 0.49 deg. The Orbiter was well outside of the beam. The radars initiated a search to locate the vehicle and acquired the Orbiter 133 sec after expected horizon break.

Entry interface occurred at 144/15:08:03 GMT (12/21:06:07 MET).

The main landing gear touchdown occurred on EAFB runway 22 at 144/15:39:04 GMT (12/21:37:08 MET) on May 24, 2009. The drag chute was deployed at 144/15:39:06.9 GMT (12/21:37:10.9 MET). The nose gear touchdown occurred at 144/15:39:15 GMT (12/21:37:19 MET). Drag chute jettison occurred at 144/15:39.40.5 GMT (12/21:37:44.5 MET). Wheels stop occurred at 144/15:40:41 GMT (12/21:38:45 MET). The rollout was normal in all respects.

A Multifunction Electronic Display System (MEDS) Input/Output (I/O) error for Cathode Ray Tube (CRT) 4 was annunciated at nose wheel landing gear touchdown. The error appears to be a single transient drop-out error, which cleared 1 sec later. No errors

were seen and no Flight Software (FSW) message was annunciated. (IFA STS-125-V-16)

During roll-out, there were observations of what appeared to be small puffs of “smoke” coming from the right hand main landing gear tires. It was not obvious if this was smoke. After review of the data, the smoke clouds were correlated with abrupt brake pressure rises during rollout.

The flight duration through wheels stop was 12 days 21 hr 38 min 45 sec. The last APU was shutdown18 min 49 sec after landing.

Post-Flight

Post-flight testing of one 112G battery indicated much lower-than-expected Open Circuit Voltage (OCV) (approximately 2 volts) (IFA STS-125-V-15). The failure was initially suspected to be caused by inadvertent triggering of the bleed-down circuit (i.e., inadvertent short of battery leads). However, a radio associated with this suspect battery was tested and observed to have a problem with the GPS operation and the Liquid Crystal Display (LCD).

During post-flight vehicle inspection, Foreign Object Debris (FOD) was observed in Window 5. A Government Furnished Equipment (GFE) Quick Shoe mount know from a crew work lamp was found wedged between pressure pane no. 5 and the console dashboard close-out panel. (IFA STS-125-V-17).

PAYLOADS AND EXPERIMENTS

The primary purpose of the mission was to capture and repair the Hubble Space Telescope (HST), and the release of the HST for future scientific operations. The STS-125 mission was the fifth servicing mission to the HST. A successful rendezvous occurred on Flight Day (FD) 3 with capture of the HST by the Remote Manipulator System (RMS). After the successful completion of five Extravehicular Activities (EVAs) during which all of the mission objectives were accomplished, the HST was released on FD 9.

LAUNCH PACKAGE OVERVIEW

The Payload Bay (PLB) of Atlantis included the following major elements which supported the fifth HST servicing mission:

1. Flight Support System (FSS)
2. Multi-Use Logistics Carrier (MULE)
3. Orbital Replacement Unit Carrier (ORUC)
4. Super Lightweight Interchangeable Carrier (SLIC)

CREW ACTIVITY SUMMARY

On FD 1 during the Payload Bay survey of the Space Support Equipment (SSE), a thermal cover was noted to be protruding. After a thermal analysis of the Axial Scientific Instrument Protective Enclosure (ASIPE), no impact was identified to the equipment in the ASIPE. During the first EVA, the cover was tapped into place by the Extravehicular (EV) 1 crewmember. Also, the initial checkout of the Large Format Motion Picture Camera (IMAX) Cargo Bay Camera – 3D (ICBC3D) was nominal.

On FD 2, the HST completed all preparations for rendezvous on FD 2. The third Rate Sensor Gyro was activated and added to the control loop, the aperture door was closed, the high-gain antennas were stowed, and HST was transitioned to the capture attitude.

The SSE activation was completed. The Flight Support System (FSS) carrier completed its checkout and the Berthing and Positioning System (BAPS) ring was pivoted up to the berthing position.

The Relative Navigational System (RNS), located in the payload bay, is an imaging system consisting of optical and navigation sensors and supporting avionics. The RNS collected imagery data during the capture and deployment of the HST. The data will enable NASA to pursue rendezvous options in the future to support the safe de-orbit of the HST.

The ICBC3D checkout was completed. The camera housing window was opened and the film was advanced in the camera through 20 frames of film (equivalent to about 1 sec of footage) in preparation for Scene 1 (HST berthing).

On FD 3, grapple of the HST by the RMS was completed at 133/17:13 GMT (01/23: 04 MET). During the rendezvous, an issue arose concerning establishing communications between the Orbiter and the HST. Commanding of the HST was lost during the transition from the Tracking and Data Relay Satellite (TDRS) to the Shuttle communication systems. The rendezvous was temporarily stopped while the HST systems were reconfigured to establish the new communication path to the HST ground system at the Goddard Space Flight Center (GSFC). The fault was isolated to the HST Data Management Unit Communications Module that had not been reconfigured from the 1 Mbps science format to the 32 Kbps rate, which is required for downlink through the Shuttle Payload Integrator (PI). The rendezvous was completed without incident once the Shuttle communication path was established. As a result of the delay in commanding, the HST, the final roll maneuver was not performed and the Orbiter performed a manual flyaround to achieve the capture orientation and the grapple of the HST. The HST was berthed to the FSS and the external power was activated. The ICBC successfully captured Scene 1 (HST Berthing).

On FD4, the first EVA was successfully completed in 7 hr and 20 min. The Wide Field and Planetary Camera 2 (WF/PC2), one of the Radial Scientific Instruments that was installed on the previous SM1/STS-61, was replaced by the Wide Field Camera (WFC 3).

The Science Instrument Command and Data Handling unit (SI C&DH-2) was also successfully installed during the first EVA. The A-Side of the SIC&DH had failed in September of 2008, and that was the cause of the delay of the this SM4 mission from Oct 11, 2008, to allow time to develop the hardware and a plan to replace the equipment located inside of the Bay 10 door of the HST. This unit provides the electronics to command the science instruments from the ground and to flow science and engineering data back to the ground.

The EVA crew also completed the transfer of the Soft Capture Mechanism (SCM) from the FSS to the HST. The SCM will enable the future rendezvous, capture, and safe disposal of HST by either a manned or robotic mission.

The post-EVA electrical testing showed both SI C&DH and WFC3 were operating nominally. There were a few problems that were resolved by the EVA and ground teams. One of the issues was a high breakaway torque on the WF/PC2 A-latch. The crew was required to use contingency tools to release the A-latch on this instrument to release it from HST. Also, during the execution of the WFC3 Functional Test the instrument entered suspend mode. Troubleshooting isolated the problem to a voltage limit within one of the instrument's two detectors. The issue was resolved and the test was successfully completed. The post-test data review confirmed the functional test was successful.

During the first EVA, the crew installed 2 of 3 Latch Over Centerline Kits (LOCK) onto the –V2 door. Because of a concern that installing the third LOCK might bend the doors in such a way as to allow light to enter the telescope, (not acceptable to HST), the crew installed one Aft Shroud Door Latch Repair (ASLR) kit on the lower middle latch of the –V2 door.

The two Bay 5 New Outer Blanket Layers (NOBL) vent plugs were removed and lubrication was applied to several door latch bolts as 'Get Ahead' tasks during this EVA.

After the first EVA, the crew reported a faint burning odor from the middeck after initiating charging of the EVA battery. The atmospheric measurements were taken and all readings were nominal. The crew checked the chargers and narrowed the issue down to the EVA Helmet Interchangeable Portable Light (EHIP) charger. The crew switched to the spare charger, and the failed charger was not used during the rest of the mission.

The majority of the Wide Field Camera III installation during the first EVA was during the night period of the orbit, and as a result the lighting conditions did not support the planned 3D IMAX filming.

On FD 5, the second EVA was successfully completed in 7 hr and 56 min. During the second EVA, the planned installation activities were completed and these were three Rate Sensor Units (RSU) , which each contained two new gyroscopes, one Battery Module-1 in Bay 2 and an Advanced Camera for Surveys Repair (ACS-R) 'get-ahead' task, which involved the installation of the Payload Interface Equipment (PIE) harness. The aliveness and functional tests of the RSU's and the battery were successfully completed. The crew did have trouble during the installation of one of the RSU's and as a result, a spare unit used to complete the task.

All six of the HST gyroscopes were replaced during the second EVA. The six gyroscopes that were replaced had been installed during the SM3A/STS-103 mission and were nearing their end-of-lifetime operation. Three of the six gyros had failed prior to SM4. Two gyroscopes are required to control the pointing of the HST.

Each battery module contains three nickel-hydrogen batteries, which supply the electrical power to support the HST operations during the night portion of the orbit.

The IMAX Cargo Bay Camera (ICBC) was operated four times during the FD 5 EVA, capturing 128 sec of footage that included two scenes during the RSU 2 replacement, one scene of the ingress for RSU 3, and one scene during the Bay 2 Battery Module replacement.

On FD 6, the third EVA was successfully completed in 6 hr and 35 min. The Corrective Optics Space Telescope Axial Replacement (COSTAR) which had been installed on SM1/STS-61 to repair the optical aberration of the primary mirror was removed from the

HST and replaced with the Cosmic Origins Spectrograph (COS). The second major task of this EVA was the repair of the Advanced Camera for Surveys (ACS), and as a result of time-line efficiencies, both part 1 and 2 of the repair were completed. Part 2 of the repair was originally scheduled to be performed on the fifth EVA. As a result of completion of both parts, the fifth EVA tasks were revised to incorporate the change out of the Fine Guidance Sensor 2 instrument.

The ACS was originally installed during the SM3B/STS-109 in 2002 and prior to its failure in 2007, had been the most heavily used science instrument. An electronics failure in January 2007 rendered inoperable the two most-used science channels, the Wide Field Camera (WFC) and the High Resolution Channel (HRC), and it had been operating on one remaining channel, the 'Solar-Blind' Channel. In general, the HST systems and science instruments were designed to be replaced by an EVA crewmember. The repair of the ACS was unique in that it was the first time during an EVA that a card or board level repair was made on an electronics box in zero gravity. The electronics board for the WFC and a new power supply was installed. Many specialized tools were designed and fabricated by the GSFC to accomplish this task.

During the third EVA, the ICBC3D recorded 24 sec (instead of over a minute) of the COSTAR/COS and ACS scenes, however, condensation was observed on the camera housing window which put a halt to the filming. It was believed that this was due to extended exposure with the cover open and camera in the 'armed' configuration. Guidelines to prevent and/or mitigate fogging of the window were uplinked to the crew, and included minimizing the time that the door was open and setting the camera to the 'DISARM' condition so that heaters kept the camera warmed until prior to the shot. At the conclusion of the third EVA, a total of 4 min (of 8 min total) of film was remaining for use.

On FD 7, the fourth EVA was successfully completed in 8 hr and 2 min. The Space Telescope Imaging Spectrograph (STIS) repair was completed and the unit passed both the aliveness and functional tests. The STIS had been installed on the SM2/STS-82 mission in 1997. It stopped functioning in August 2004 due to a power-supply failure and was placed in a 'safe mode' until a repair could be performed. The repair consisted of replacing the failed low voltage power supply 2 circuit card in main electronics box 1. The repair required the removal of a handrail. This proved to be time consuming due to the inability to remove the lower right bolt of the hand rail. After many attempts to use tooling to remove the bolt, it was decided to pull on the top of the handrail and break the bolt. This method successfully removed the hand rail. At the end of the EVA, crewmember Mike Massimino reported a hole in his left glove, but no leak in the suit. However, per flight rule 125-A-11 this was a 'terminate' condition. The crew was already in clean-up portion of the STIS task when this report was made. Because the EVA ran long, the bay 8 New Outer Blanket Layer (NOBL) installation was not attempted and it was deferred to the fifth EVA.

The two IMAX planned photographic opportunities of opening the HST door and repair of the Space Telescope Imaging Spectrograph (STIS) were successfully completed.

On FD 8, the fifth EVA was successfully completed in 7 hr and 2 min. The EV crew began the fifth EVA approximately one hour early. During the fifth EVA, the crew performed Bay 3 Battery removal and replacement, Fine Guidance System (FGS) 2 removal and replacement, and replaced degraded Multi Layer Insulation (MLI) with New Outer Blanket Layers (NOBL) on Support System Module (SSM) Bays 5, 7 and 8. At the end of fifth EVA, during the final closeout operations in the payload bay, the EV1 crewmember inadvertently hit the HST low-gain antenna located on the bottom of the telescope with his EMU, knocking off the foam tip of the antenna. This required the crew to retrieve the Low Gain Antenna Protective (LGAP) Cover and install it over the low gain antenna to help provide thermal protection for the exposed antenna wiring. This configuration did not interfere with functionality of the antenna.

The Fine Guidance Sensor (FGS) that was returned on SM3A/STS-103 in 1999 was refurbished and upgraded for re-use on this repair mission. The FGS now has an enhanced on-orbit alignment capability over the original FGS design. There are three FGS's onboard the HST and they are used in conjunction with the gyroscopes for fine tuning the pointing of the HST by acquiring and locking onto pre-selected guide stars, feeding the position signals to the main computer where small but inevitable drifts in the gyroscopic signals can be corrected. Two of the three FGS's are used at a time, with each one locked onto the one guide star. The third FGS can be used as a scientific instrument for astrometry, providing an extremely precise measurement of stellar positions and motions. The new FGS 2 will likely be designated as the astrometry FGS, due to its enhanced design and expected performance.

The NOBL protect the HST external Multi-Layer Insulation (MLI) covering equipment bays. The NOBL have become embrittled by the space environment and fatigued by thermal cycling. Previously, the NOBLS had been installed on SSM Bays 1, 9, and 10 during the SM3A/STS-103, and also onto Bay 6 during SM3B/STS-109.

The Battery Module and the FGS 2 both successfully passed their aliveness and functional testing subsequent to the EVA.

The IMAX Cargo Bay Camera (ICBC) successfully captured two scenes during the fifth EVA, and there was approximately 30 seconds of film remaining to record the HST release on FD 9.

With the completion of the fifth EVA, a total of 36 hr 56 min of EVA activity were completed with all tasks completed successfully. The fifth EVA was also the 150th EVA for US Shuttle/ISS programs and the 23rd EVA for the HST.

The HST was successfully deployed by the RMS at 139/12:59 GMT (07/18:57 MET) and the FSS was configured for the landing configuration. All of the HST pre-flight mission objectives were successfully completed. The HST deployment was filmed by the ICBC3D system as planned.

SIGNIFICANT FIRSTS

The significant firsts for the STS-125 mission are listed as follows:

1. First flight of a fully composite structure, Super Lightweight Interchangeable Carrier (SLIC) in the payload bay.
2. Rescue STS-400 Launch-On-Need Shuttle ready to launch from Pad B within 10 Days of STS-125 launch.
3. Unique middeck stowage accommodations in support of Contingency Shuttle Crew Support (CSCS) to stow additional Lithium Hydroxide (LiOH) canisters for a total of 78 onboard, food bars and Apollo bags.
4. Orbit Adjust maneuver to lower perigee (305 by 160 nmi orbit) to support Mitigation of MM/OD risks on FD 9.
5. High definition video downlink of a Public Affairs Office (PAO) event from orbit.

HST SERVICING MISSION PRIORITIES

The HST priorities and the EVA when the priority was met are as follows:

1. Three Rate-Sensor Unit (gyroscope) removal and replacement (EVA2, FD 5).
2. Wide Field Camera 3 installed in place of Wide Field Planetary Camera 2 (EVA 1, FD 1).
3. Science Instrument Command & Data Handling System change-out (EVA 1, FD 1).
4. Cosmic Origins Spectrograph installed in place of the Corrective Optics Space Telescope Axial Replacement (EVA 3, FD 6).
5. Battery Module replacement installation (Bays 2 and 3) (Bay 2-EVA 2, FD 5; Bay 3, EVA 5, FD 8).
6. Space Telescope Imaging Spectrograph –or- Advanced Camera For Surveys Repair (ACS part 1 and 2 (EVA 3, FD 6).
7. Fine Guidance Sensor 2 removal and replacement (EVA 5, FD 8).
8. Remaining instrument repair (Space Telescope Imaging Spectrograph power Supply system repair or restore power supply for the Advance Camera for Surveys) (STIS-EVA 4, FD 7).
9. New Outer Blanket Layer installation (Bays 8, 5, and 7) (EVA 5, FD 8).
10. Soft Capture Mechanism installation (EVA 1, FD 4).
11. Reboost Hubble Space Telescope altitude (not performed).

SECONDARY PAYLOADS

IMAX Cargo Bay Camera 3D (ICBC 3D) was flown in the payload bay mounted to the ORUC.

PAYLOADS OF OPPORTUNITY

The Maui Analysis of Upper-Atmospheric Injections (MAUI) was an observational payload of opportunity. This payload observes Orbital Maneuvering System (OMS)

engine exhaust plumes utilizing optical telescope sensors and all-sky imagers at the Air Force Maui Optical and Supercomputing Site (AMOS) at Maui, Hawaii.

The Shuttle Exhaust on Turbulence Experiments (SEITE) was an observational payload of opportunity. The SEITE uses the Space Shuttle to investigate plasma turbulence caused by the OMS-engine exhaust. Data are collected by flying satellites through the plasma turbulence during a conjunction with the Space Shuttle.

DEVELOPMENT TEST OBJECTIVES (DTO)

DTO 695 – Thrust Oscillation Seat

Three crew seats (3, 5, and 6) were instrumented with three tri-axial accelerometers and three sensor boxes to measure seat vibration during ascent. Data were collected and results will be reported in other documentation after post-flight analysis is complete.

DTO 805 – Crosswind Landing Performance

Crosswind conditions did not meet the criteria, so this DTO was not performed.

DTO 900 – Shuttle RSRM Chamber Pressure, Strain Gauge, and Acceleration Rates Data Collection

DTO 900 flew on STS-125 to collect higher frequency and resolution thrust data during SRB operations. The Intelligent Pressure Transducers (IPT) [one per Solid Rocket Booster (SRB)] operated nominally and the data were analyzed. One of the three Operational Pressure Transducers (OPT) was monitored by Enhanced Data Acquisition System (EDAS) units.

One EDAS unit 102 on the left-hand SRB did not record pressure oscillation data due to filter wiring short. The other left-hand SRB pressure measurement which was on the other EDAS box 101 had a drop in reading amplitudes due to the same fault, but analytical corrections were successfully applied to recover the data. The accelerometers and strain gages on the EDAS boxes recorded successfully.

DETAILED SUPPLEMENTARY OBJECTIVE (DSO)

DSO 500 – Space Flight-Induced Reactivation of Latent Epstein-Barr Virus

Samples from the crew were collected during the pre-flight and post-flight and the objectives of the investigation were met for five of the five subjects (one post-flight session at 120 days after landing remains for each subject).

SDBI 1634 Sleep/Wake Actigraphy and Light Exposure During Space Flight

Objectives were met by 4 out of 5 subjects participating in the SDBI 1634 (SLEEP SHORT)) investigation and all of the post-flight data collection are complete including debriefing with the Principal Investigator.

National Laboratory Pathfinder (NLP)

The NLP-Vaccine-1C is a commercial payload in support of the NLP initiative. It was a follow-on to the STS-126 and STS-119 NLP-Vaccine 2 and 3 payloads and contained pathogenetic organisms, which are being examined to develop potential vaccines for the prevention of infections on Earth. Post mission data analysis of the samples was process as this report was being written.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected during the launch-countdown and ascent of the STS-125 mission. No Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred. No in-flight anomalies were identified during the review and analysis of the data.

Both SRBs were successfully separated from the ET and reports from the recovery area indicate that the deceleration subsystem performed as designed. The recovery ships returned both boosters to the port for transportation to Kennedy Space Center (KSC) for inspection and preparation for the next flight.

REUSABLE SOLID ROCKET MOTORS

The STS-125 Reusable Solid Rocket Motor (RSRM) set performed within established and predicted limits (nominal). No LCC or OMRSD violations occurred during the pre-launch and launch countdown. One in-flight anomaly was identified during the mission.

During disassembly of the Reusable Solid Rocket Motor (RSRM) -105B motor, several areas of missing stiffener ring foam were observed (IFA STS-125-M-001). In some locations, the discoloration was present on the remaining foam and in areas where the foam was missing. The darkened areas indicate that the foam liberated prior to splash down. This is a first-time observation since return to flight. Based upon the following additional information gathered by the investigation team, it has been determined that no suspect anomalous condition exists. The investigation data indicates that the foam loss at the darkened (sooted) areas was a post-separation occurrence

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

There was no indication of hold-down post stud hang-up based on the analysis performed.

EXTERNAL TANK

All External Tank (ET) systems performed as expected during launch countdown and ascent. The ET pre-launch countdown was nominal. No LCC or OMRSD violations occurred during the pre-launch and launch countdown. No in-flight anomalies were identified during the mission.

All ET objectives and requirements associated with propellant loading and flight operations were met. No significant oxygen or hydrogen concentrations were detected in the Intertank. All electrical equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly, and the Liquid level and Engine Cut-Off (ECO) sensors performed as designed.

ET separation was nominal. The Main Engine Cut Off (MECO) occurred as expected, and the ET impact was at latitude 16.699 deg North and Longitude 147.375 deg West, which was within the predicted footprint.

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle Main Engine (SSME) systems performed as expected during the launch countdown and ascent, and performance was typical of previous flights. The SSME pre-launch countdown was nominal, and no potential SSME in-flight anomalies were identified from the review and analysis of the data.

Engine “Ready” was achieved at the proper time, and no LCC or OMRSD violations were identified. The thrust build- up was nominal. The flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown.

The High Pressure Oxidizer Turbo Pump (HPOTP) and High Pressure Oxidizer Fuel Turbo Pump (HPFTP) temperatures were well within specifications throughout engine operation.

The commanded Maximum Dynamic Pressure (Max Q) throttle-down was a one step throttle to 72%, as predicted. The preliminary average SSME specific impulse tag value was 452.01 sec at 104.5% power level.

Propellant dump operations data were normal and the Main Engine Cutoff (MECO) time was Engine Start + 511 sec.

The review of the 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 dumping on all engines. All accelerometer measurements were healthy.

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 nominally during launch countdown and ascent, and one instrumentation in-flight anomaly was identified from the review and analysis of the data. There were no Launch Commit Criteria (LCC) violations nor were there any Operational Maintenance Requirement and Specification Document (OMRSD) violations.

The GH_2 system in-flight performance was nominal with the exception of an instrumentation anomaly on the SSME 2 Gaseous Hydrogen (GH_2) outlet pressure (IFA STS-125-V-01). Failure of the GH_2 outlet pressure violates the File IX requirement, but is related to instrumentation only, and the failure did not impact the flight. See the Operational Instrumentation section for further discussion.

The Flow Control Valves (FCV'S) performed nominally with 18 cycles for FCV no. 1, 24 cycles for FCV no. 2, and 29 cycles for FCV no. 3. The GH_2 FCV's will be removed and inspected during the next flow due to the FCV cracked poppet issue.

Hazardous Gas Concentrations

The aft hazardous gas concentrations during loading were nominal. The overall GH_2 system in-flight performance was nominal.

The Gaseous Oxygen (GO_2) fixed-orifice pressurization system performed as predicted. Reconstructed data from engine and MPS parameters closely matched the actual ET ullage pressure measurements.

The following table summarizes the results.

HAZARDOUS GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	12900	7500
Hydrogen	168	15
Oxygen	17	10
LD54/55	0	0

Gas Sample Analysis

The measured sample bottle pressures indicate the redesigned Orbiter aft fuselage gas sampler system. The redesigned gas sampler system performed nominally with the exception of one bottle. The right-hand number 1 had a slightly lower than expected pressure. The remaining five measured pressures were within the range of acceptable pressures established by the Propulsion Systems Integration Group (PSIG).

A summary of bottle pressure and gas concentration for STS-125 is given in the following table.

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	3.08	0.67	4.22	0.02
2	LH 1	1.63	0.31	3.36	0.02
3	RH 2	1.31	0.69	3.53	0.03
4	LH 2	0.81	0.57	3.16	0.04
5	LH 3	0.18	0.91	1.71	0.13
6	RH 3	0.06	2.95	0.95	0.27

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rates in the following table.

HYDROGEN FIRING LEAK RATE SUMMARY

Bottle no.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	920
2	LH 1	560
3	RH 2	725
4	LH 2	680
5	LH 3	600
6	RH 3	480

The measured sample bottle pressures indicate the redesigned Orbiter aft-fuselage gas-sampler system successfully collected five samples. Bottle right hand no. 1 had a pressure that was 3 torr below the expected range of 162 to 250 torr. The composition of the bottle appears valid so the KSC laboratory results for the bottle were included in the analysis. STS-125 was the 13th flight using the new gas chromatograph/mass spectrometer at the KSC Materials Science Laboratory.

The hydrogen concentrations were well below the flammability limit in each bottle. The highest estimated leak rate was 920 scim from the right hand no. 1 bottle. The oxygen concentration of the first bottle, right hand no. 1, was right at the flammability limit with a value of 4.22%. Argon indicates air as the major source of the oxygen and not an Orbiter system leak. The remaining oxygen concentrations were in family with the next highest concentration being 3.53% in right-hand bottle no. 2.

The highest Helium concentration was 2.95% in the right hand no. 3 bottle. Due to the low pressure at the time the last bottle acquired its sample and the lack of diluting atmosphere, the last bottle has shown to have the most variation.

The complete results of the gas chemical analysis, provided by KSC, 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, %
1122 FLT-1	RH1	159.0	0.18	19.16	0.67	0.03	0.01	0.01	4.02	4.22	0.04	0.02
1105 FLT-2	LH1	84.2	0.13	14.35	0.31	0.01	0.03	0.01	3.01	3.36	0.02	0.02
1124 FLT-1	RH2	67.8	0.14	15.10	0.69	<0.01	0.04	0.01	3.17	3.53	0.03	0.03
1110 FLT-2	LH2	41.7	0.13	13.49	0.57	<0.01	0.04	0.01	2.83	3.16	0.04	0.04
1121 FLT-1	LH3	9.18	0.08	8.67	0.91	0.25	<0.01	0.02	1.82	1.71	0.27	0.13
1127 FLT-1	RH3	3.27	0.07	7.07	2.95	0.13	<0.01	0.04	1.48	0.95	0.34	0.27

Purge, Vent, and Drain System

The Purge, Vent and Drain (PV&D) system performed nominally throughout the mission. The purge readings and hazardous gas detection system readings were nominal. No in-flight anomalies were identified during the analysis of the flight data.

Reaction Control System

The Reaction Control System (RCS) performed all functions required for successful completion of the mission. One in-flight anomaly was identified in the review and analysis of the flight data.

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, % Target, lb	94.44 1502	94.71 944	100.48 1523.	100.76 962	100.48 1523	100.76 962
Calculated, % Advertised, lb	94.68 1505.2	94.82 945	100.01 1530.1	100.76 962	100.94 1529.2	100.69 961.4
PASS WHI[a]	4.3389	4.2639	4.3446	4.2627	4.3652	4.2486
BFS WHI[b]	4.3503	4.2757	4.3522	4.2815	4.3804	4.2649

Notes: [a] PASS WHI – Primary Avionics Software System Initial Weight of Helium Load
[b] BFS WHI – Backup Flight System Initial Weight of Helium Load

The Tyvek cover release data 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	4.8	59	-6	9
F2D	6.0	76	-3	6
F3D	7.9	104	1	1
F4D	8.4	111	3	0
F3L	8.6	114	4	0
F1L	8.6	114	4	0
F1F	8.9	119	5	-1
F4R	9.0	121	6	-1
F2R	9.7	132	7	-2
F2U	10.2	140	8	-3
F3F	10.4	143	8	-3
F3U	10.5	144	9	-2
F1U	10.6	146	9	-2
F2F	10.7	147	9	-2
REMNANT RELEASE DATA				
F3D	19.2	293	3	0
F4D	19.8	304	3	0

The RCS window-protect firing of F1U, F2U and F3U was initiated at 131/18:03:59 GMT (00/00:02:03 MET) for total duration of 2.08 sec. The Forward RCS performance was nominal. The window-protect firing is intended to deflect exhaust from the SRB separation motors away from windows during SRB separation.

The ET Separation maneuver was performed at 131/18:10:41 GMT (00/00:08:45 MET) and was a 6.0-second, 10-thruster translation. The ET Photographic +X maneuver was performed. The RCS maneuvers performed during the mission are shown 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	131/18:01:56	N/A	2.08
ET Separation	RCS	131/18:10:41	N/A	6.0
ET Photo +X	RCS	131/18:10:51	N/A	10.7
ET Photo Pitch	RCS	131/18:14:21	N/A	0.800
NC 1	RCS	131/21:49:54.65	19.5	90.88
NCC	RCS	133/13:41:50	1.6	7.0

RCS MANEUVERS AND FIRING DATA (Concluded)

Maneuver/Firing	Engine/ System	Time of Ignition, GMT	ΔV, ft/sec	Duration, sec
MC 1	RCS	Not required		
Out of Plane Null	RCS	133/15:27:27.9	N/A	N/A
MC 2	RCS	Not required		
MC 3	RCS	133/15:53:26.3	0.9	0.2
MC 4	RCS	133/16:03:26.5	2.1	8.9
HST Grapple	RCS	133/17:13:45	N/A	N/A
HST Release	RCS	139/12:58:16	N/A	N/A
Separation 1	RCS	139/12:59:07	1.1	0.48
Separation 2	RCS	139/13:27:52	5.9	24.96
RCS Hotfire	RCS	141/11:15:28	N/A	N/A
Forward Reaction Control System Dump	RCS	144/14:50:03	N/A	16.8

The HST was grappled and the Driver and Logic for the primary thrusters were turned off at 133/17:30:52 GMT (01/23:28:56 MET), and the HST was released at approximately 139/12:58:16 GMT (17/18:56:45 MET).

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]	
	%	lbs	%	lbs
Forward Oxidizer	3.6	49	2.0	27.0
Forward Fuel	0	0	-0.6	-5.1
Left Oxidizer	35.6	480	35.6	480.6
Left Fuel	38.0	323	37.9	322.2
Right Oxidizer	35.6	480	34.1	460.4
Right Fuel	32.2	274	32.0	272.0

Note: [a] The official JSC Engineering RCS propellant residuals are those listed under the PASS model

The RCS propellant usage is shown in the following table.

RCS PROPELLANT CONSUMPTION

Parameter	Oxidizer, lb	Fuel, lb	Mixture ratio, Oxidizer/Fuel
Forward RCS	1251.2	811.1	1.54
Left RCS	883	534.3	1.65
Right RCS	902.3	583.9	1.55

The RCS hot-fire was initiated at 141/11:06:03 GMT (09/17:04:07 MET) and terminated at 141/11:15:28 GMT (09/17:13:32). All 38 RCS thrusters were fired for at least 0.240 sec per pulse. All four sequences were performed once. No fail-off or fail-leak problems were detected during the hot-fire.

From RCS vernier-thruster activation on FD 1, the R5R thruster chamber pressure was lower than nominal (IFA STS-125-V-07). Nominal peak chamber pressures exceeded 100 psia while for short pulses or high propellant-temperatures, the pressures were reduced to as low as 75 psia. STS-125 peak chamber pressure was 96 psia and as low as 48 psia. The thruster was never declared failed by Redundancy Management (RM) as deselection occurs if the thruster fails to reach 36 psia on startup or drops below 26 psia afterwards. The crew was asked to deselect the R5R thruster and operate with 5 of 6 vernier thrusters during crew sleep periods to prevent nuisance alarms. The Guidance, Navigation and Control (GN&C) simulations confirmed that the thruster performance was degraded, and the low chamber pressure readings were not an indication issue.

The primary thrusters were fired 3792 times, for a total firing time of 1084.56 sec. The vernier thrusters were fired 16903 times, with a firing time of 17740.56 sec.

Orbital Maneuvering System

The Orbital Maneuvering System (OMS) performed nominally and no in-flight anomalies were identified during the review and analysis of the data. The following table provides the OMS configuration data.

OMS CONFIGURATION

Vehicle/ Equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 04	30th	L-OME S/N 108	4th rebuilt flight – 28th flight
Right Pod (RP) 01	37th	R-OME S/N 109	9th rebuilt flight - 26th flight

The following table lists the OMS maneuvers performed during the STS-125 mission.

OMS MANEUVERS

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV, ft/sec
Assist	Dual Engine	Not required	N/A	N/A
OMS-2	Dual Engine	131/18:45:41.2	92.6	139.6
OMS-3 (NC3)	Right Engine	132/22:27:19.3	9.6	7.3
OMS-4 (NH)	Dual Engine	133/12:17:16.1	197.4	308.2
OMS-5 (TI)	Left Engine	133/14:41:56.3	12.0	9.4

OMS MANEUVERS (Concluded)

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV, ft/sec
OMS-6 (Orbit Adjust)	Dual Engine	139/14:59:36.3	143.6	234.8
Deorbit	Dual Engine	144/14:24:41.1	157.8	267.6

There was no OMS/RCS interconnect usage during the STS-125 mission.

The propellant usage and residuals are shown in the following table. The official propellant residuals are those listed in the aft gage results.

PROPELLANT USAGE DATA

Parameters	Left OMS pod		Right OMS pod	
	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, lbm	7756	4686	7704	4685
Residual, lbm (aft gage)	478	364	575	406
Residual, lbm (burn time integration)	577	435	576	329
Residual, lbm (SODB flow rate)	515	341	510	322

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-125 mission. The STS-115 signature [APU 1 Gas Generator (GG) Bed Heater lower set point shift] repeated as expected on STS-125. No in-flight anomalies were recorded for the APU system this flight. The APU run times and fuel consumption are shown in the following tables.

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 (409)	00:19:37	00:00:00	01:03:43	01:23:20
2 (410)	00:19:59	00:00:00	01:39:26	01:59:25
3 (204)	00:20:16	00:04:24	01:04:24	01:28:57

APU FUEL CONSUMPTION

APU (S/N)	Ascent, lb	FCS Checkout, lb	Entry, lb	Total, lb
1 (409)	48	0	114	162
2 (410)	49	0	174	223
3 (204)	51	14	130	195

At 131/18:11:00 GMT (00/00:09:04 MET), the APU 2 drain-line temperature 2 reading exhibited an increase from 82 ºF to 108 ºF. The APU 2 drain system was also noted to

have an in-specification dynamic fuel pump shaft seal leakage into the drain system during the ascent run. This temperature rise and other similar drain system temperature rises (STS-99 and STS-97) have been attributed to a slug of warm fuel in the drain system moving to the temperature sensor location.

At 133/20:40:01 GMT (02/02:38:05 MET) a Table Maintenance Block Update (TMBU) was uplinked to change the lower Fault Detection and Annunciation (FDA) limit on the APU 3 fuel pump drain line temperature (sensor 1) from 43 ºF to 40 ºF. This action was taken as a precaution to avoid a nuisance alarm during the crew-sleep period, since the lowest temperature the heater cycled on at was approximately 44 ºF.

Hydraulics/Water Spray Boiler System

The Hydraulic/Water Spray Boiler (HYD/WSB) system performance for STS-125 was nominal during the flight, and no IFA's were identified.

The HYD System 3 Right Outboard Elevon (ROE) return-line temperature sensor, exhibited an erratic thermal response over a period of approximately 3 hr, 23 min from 132/13:39:00 GMT to 132/17:02:00 GMT (00/19:37:04 MET to 00/23:00:04 MET). The temperature increased from 90 ºF to 112 ºF. There were three subsequent temperature spikes to 103 ºF, 106 ºF, and 103 ºF. The sensor data returned to normal trending in-line with the other ROE temperature sensors at 132/17:02:00 GMT (00/23:00:04 MET). The HYD System 1 and 2 ROE return line temperatures, which are located in the same general area, did not respond similarly during the period of deviation. This condition did not recur during the remainder of the flight.

ASCENT WATER SPRAY BOILER TEMPERATURES AND PGME/WATER USAGE

WSB	Spray Start Temperature	Steady State Temperature	PGME/H_2O Usage
System 1	253 ºF	253 ºF	3.4 lb
System 2	271 ºF	253 ºF	2.2 lb
System 3	261 ºF	255 ºF	2.8 lb

ENTRY WATER SPARE BOILER TEMPERATURES AND PGME/WATER USAGE

WSB	Spray Start Temperature	Steady State Temperature	PGME/H_2O Usage
System 1	259 ºF	253 ºF	21.4 lb
System 2	269 ºF	249 ºF	47.4 lb
System 3	263 ºF	253 ºF	28.6 lb

Power Reactant Storage and Distribution System

The OV-104 Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-125. No in-flight anomalies were identified from the review and analysis of the data.

The PRSD system supplied the fuel cells with 3198 lb_m of oxygen and 403 lb_m of hydrogen for the production of electrical energy. The tank quantities at the end of loading, launch, and landing are listed in the following table.

PRSD TANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb_m
Loaded	101.8	101.4	100.9	101.8	101.8	3965
Launch	100.5	100.1	99.6	100.5	100.5	3914
Landing	26.9	20.8	11.2	5.5	5.0	542
Hydrogen	**Tank 1, %**	**Tank 2, %**	**Tank 3, %**	**Tank 4, %**	**Tank 5, %**	**Total Mass, lb_m**
Loaded	102.3	101.5	102.8	103.7	102.8	472.1
Launch	99.3	97.9	99.3	100.6	99.3	456.7
Landing	19.7	16.1	21.0	1.1	0.7	53.9

The total oxygen supplied to Shuttle Environmental Control and Life Support System (ECLSS) was 174 lb_m.

A 28-hour mission extension capability existed at landing, based upon the PRSD O_2 (the limiting reactant) tank landing quantities at the average fuel cell flight power level of 15.0 kW. At the mission extension day power level of 12.88 kW, a 32-hour mission extension was available.

Fuel Cell System

The overall performance of the OV-104 fuel cell system was nominal for STS-125. The overall thermal performance of the fuel cell water relief, water line, and reactant purge heater systems was nominal. No in-flight anomalies were identified during the mission and the post-flight review and analysis of the data.

The average electrical power level and load was 15.0 kW and 490 A. During the 309.65-hr mission, the fuel cells produced 4630 kWh of electrical energy and 3601 lb_m of potable water. The fuel cells consumed 3198 lb_m of oxygen and 403 lb_m of hydrogen. Eight fuel cell purges were performed, occurring at approximately 27, 76, 125, 170, 217, 253, 277, and 303 hours MET.

The past two fuel cell 1 diagnostic tests have indicated “Port Plugging” on numerous cells. During the purges, the fuel cell 1, sub-stack 1, Cell Performance Monitor (CPM) was increasing progressively.

After the EVAs were completed and the Hubble Space Telescope was released, the vehicle power load significantly decreased and the subsequent fuel cell purges had much smaller substack 1 Cell Performance Monitor (CPM) changes during purges, which is additional verification of port-plugging on cell 15 or 32. Fuel Cell 1 will be

removed from the vehicle based on the number of operating hours and the fuel cell will returned to the manufacturer for testing and storage.

The actual fuel cell voltages (200-A load) at the end of the mission were 0.10 V above predicted for fuel cell 1, as predicted for fuel cell 2, and 0.15 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 0.58 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 Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages within each fuel cell during prelaunch, on-orbit, and postlanding operations. Full-rate on-orbit data was recorded for 12 min, and no outliers were identified; however, pin sharing was observed on cells 54/55 of fuel cell 2.

Electrical Power Distribution and Control System

The Electrical Power Distribution and Control (EPDC) system performed nominally during all mission phases of STS-125. No abnormal conditions were identified during the data review and analysis of all available EPDC.

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

1. Fuel Cell voltages and currents
2. Essential bus voltages
3. Control bus voltages
4. Forward Power Control Assemblies (FPCA's) voltages and currents
5. Mid Power Control Assemblies (MPCA's) voltages and currents
6. Aft Power Control Assemblies (APCA's) voltages and currents
7. AC bus voltages and currents
8. AC bus Monitor/auto switch status and overload/over-voltage alarm
9. Main bus to Control bus Remote Power Controller (RPC) status
10. Forward, Mid and Aft Motor Control Assemblies operations status
11. Fuel Cell to Essential bus switch status
12. Main bus to Essential Bus RPC and switch status
13. Drag chute Pyrotechnic Controller Functions.

EPDC aided in the ASA-1 investigation and observed a 400 Hz signal on Main Bus A. The first occurrence of the 400 Hz signal lasted 0.02 sec and recovered. The second occurrence lasted 0.85 sec. The current on Main Bus A and B increased to 12.5 Amperes (A) (RPC-10, APCA-4) and 7.5 A (RPC-12, APCA-5) respectively, for 2.5 sec before tripping, which is indicative of a hard-short event.

Orbiter Docking System

The Orbiter Docking System (ODS) was removed from the vehicle for the STS-125 mission. The removal was a weight-saving measure for the HST mission.

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 from the review and analysis of the flight data.

The Nitrogen (N_2) system 2 flow sensor was erratic and reading off-scale high several times during the mission. The N_2 flow sensor system 1 read off-scale high during various stages of the STS-125 mission. There were a total of 13 occurrences. The first occurrence was early in the mission at 133/11:27:02 GMT (01/17:25:06 MET), which lasted 2 sec, and, lastly at 144/15:46 GMT (12/21:44 MET) there were three more 2 to 3 sec spikes. Since this was a known issue for this flight, the Master alarm and Backup Caution and Warning (C&W) for N_2 system 1 and 2 was inhibited for the entire mission.

The crew compartment was successfully depressed from approximately 14.7 psia to 10.2 psia one day into the flight. The Pressure Control System (PCS) 1 was configured and used for the entire mission up to GMT 139/17:14:43 when the 14.7 repressurization from 10.2 was performed. PCS was configured to system 2 following the 14.7-psia and the checkout of system 2 was performed. There were several 10.2-psia maintenance activities performed using PCS Sys 1. There were 5 Orbiter-based EVAs out of the External Airlock.

Airlock System

The Airlock Systems performed nominally throughout the STS-125 mission. Five Extravehicular Activities (EVA's) were performed using the Airlock.

During the Airlock depressurization activities supporting the second EVA, a slower-than-expected rate was observed from the Airlock-to-Cabin ΔP sensor. The expected depressurization rate for an Airlock EVA is 2.8 psia/min from 10.2 psia to 5 psia. For the second EVA, the observed depressurization-rate from 10.2-psia to 7-psia was 0.44 psia/min. The event occurred at 135:12:31:48 GMT (03/18:29:53 MET). Other than the slightly longer time to depress the Airlock, this event had no impact to the second EVA.

The crew reported that the Airlock depressurization cap was left on by mistake prior to the venting of the Airlock. Once the EVA crew member noticed the cap was still installed on the valve, the crewmember removed the cap and the Airlock depressurization was performed nominally. In addition, the airlock depressurizations for the following three EVA's were all performed nominally.

Supply and Waste Water System

The performance of the Supply Water and Waste Management Systems (SWWMS) was nominal throughout the mission and all of the scheduled in-flight checkout requirements were satisfied. One in-flight anomaly was identified. Supply water was managed through the use of the Flash Evaporator System (FES) and the dump nozzle.

The line heater maintained the supply water dump line temperature between 75 °F and 115 °F. Three waste water simultaneous-nozzle dumps at a nominal average rate of 1.81 %/min (2.99 lb/min) were performed. Two additional waste water dumps were performed at a nominal average rate of 1.90 %/min (3.13 lb/min). The waste water dump line temperature was maintained between 57 °F and 97.5 °F throughout the mission.

The crew was unable to remove the purge device following the third simultaneous dump supply-water dump-nozzle purge (IFA STS-125-V-06). The crew was able to remove the purge device, however part of the purge device Quick Disconnect (QD) remained attached to the vehicle cross-tie QD. The QD on the purge device fell apart. To prevent further damage, crew was instructed not to try to remove the remaining piece. No supply water nozzle dump was performed during the remainder of the mission, and the FES dumps were used instead.

The supply water tanks A and C quantity sensor exhibited a quantity dropout many times throughout the mission. Such dropouts have been experienced in previous flights and the problem was caused by either contamination on the collector bar and/or surface defect on the collector bar of the potentiometer, which causes an intermittent break in continuity. These dropouts are understood problems and are deferred for a quantity sensor replacement during the next Orbiter Maintenance Down Period (OMDP) or during the normal flow as approved by the Problem Resolution Team (PRT).

Vacuum vent line temperature was maintained between 75 °F and 58 °F.

Smoke Detection and Fire Suppression System

Smoke Detection and Fire Suppression (SDFS) operated nominally with no issues. The smoke detector checkout was completed, and all smoke detection A and B sensor circuits passed the checkout requirements.

Use of the Fire Suppression system was not required.

Active Thermal Control System

The Active Thermal Control System (ATCS) Orbiter operations were nominal throughout the STS-125 mission. Three in-flight anomalies were identified during the review and analysis of the flight data.

The crew compartment Partial Pressure Carbon Dioxide ($PPCO_2$) was managed to levels below 5.0 mmHg for the entire mission except FD 1 where it reached 5.64 mmHg. The $PPCO_2$ peaked to 4.48 mmHg at 139/23:14 GMT (08/05:12 MET) during the 14.7-psi cabin operations at the latter part of the mission.

After landing, the Ammonia Boiler System (ABS) A secondary controller was powered at 144/15:52 GMT. Continued ABS operation on system A was for 44 min, until termination at 144/16:36 GMT with the start of ground-cooling. System B activation was not required because Ground Support Equipment (GSE) cooling was initiated.

During the FD 6 post-sleep period, the crew discovered unprocessed condensate, also known as carryover, during the visual check in the immediate area of the humidity separators in the lower equipment bay (IFA STS-125-V-09). The humidity separator that was operating at that time was B. The crew dried up a ball of water about 2 in. in diameter. The crew was asked to power humidity separator A for dual separator operation. On the morning of FD 7, the crew reported a quarter-size bubble of water on humidity separator B, and again the crew dried the area. Later that afternoon, the crew inspection showed humidity separator A to be dry but water had to be wiped up from humidity separator B. Because of additional findings of water in the humidity separator area, both humidity separators were powered for dual separator operation for the remainder of the flight.

A possible explanation for the humidity separator carryover condition is a combination of the FES core flush operation and the accumulation of hydrophilic materials within the humidity separator flow path restricting water uptake capability which lead to carryover. It is known that the hydrophilic coating on the condensing heat exchanger tends to degrade with time and sloughs off into the condensate being transported to the humidity separators. The FES core flush performed around 04/04:12 MET did cause cabin humidity levels to increase by 26% resulting in higher condensate collection rates at the condensing Heat Exchanger (HX) section thus aggravating the amount of hydrophilic-coating that may slough off the HX. Thus, the increased accumulation of hydrophilic-coating material in the humidity separators blocks separator-passages and the pitot-tube resulting in carryover.

On FD 12 the Inertial Measurement Unit (IMU) fan Differential Pressure (ΔP) was observed to slowly increase, with the first incidence of toggling above the Flight Rule limit of 4.71-psi ΔP occurring at 142/18:22 GMT (011/00:20 MET) (IFA STS-125-V-13). In response to the increase, the crew was asked to check the IMU filters. The crew reported that all three filters were about the same and cleaned them. When there was no notable decrease in the rising ΔP following the filter cleaning, the crew was asked to switch from IMU fan B (powered for the majority of the flight) to IMU fan A. After no notable improvement was observed on IMU fan A for approximately 65 min, the crew was instructed to power IMU fan C, and fan A remained powered in parallel with fan C for approximately 3 min after which fan A power was removed. Shortly after the fan A powerdown, the IMU fan ΔP was observed to be lower in expected values. IMU fan C remained selected for crew sleep and the remainder of the flight. Regardless which fan

operated, there were no significant transients observed for the cabin temperature and pressure, or the coolant water temperature that could account for the ΔP increase.

The Freon Coolant Loop (FCL) 1 Radiator Flow Control Assembly (RFCA) failed to get into radiator flow after the crew initiated deorbit back-out procedures for the ATCS shortly after the deorbit waveoff was declared (IFA STS-125-V-12). The crew started radiator-flow procedures in preparation for payload bay door opening by switching FCL 1 radiator control to Auto A. The FCL 1 RFCA tripped to bypass one min later, thus the RFCA failed to achieve radiator flow. A restart attempt on Auto A resulted in a trip to bypass one min later. The FCL 1 RFCA was switched from Auto A to Auto B control. The Auto A controller was not used for the remainder of the mission.

Flight Software

The Primary Avionics Software System (PASS) and Backup Flight System (BFS) Flight Software (FSW) performed satisfactorily, and no in-flight anomalies were identified from the review and analysis of the data.

The following items are noteworthy for the flight:

1. When Display Spec 211 was initialized, the initialization resulted in an MDM BITE Test 4 I/O error that was read on each discrete output location. These BITEs were caused by the FLEX MDM being powered off.
2. The Backup Flight System (BFS) logged 19 General Purpose Computer (GPC) "B1" errors starting at wheel stop and ending with the OPS 000 transition 10 min later. These GPC errors are explained by a User Note concerning potential GPC errors during braking and after rollout on the runway.

Data Processing System Hardware

The data review and analysis of the Integrated Data Processing System (DPS) parameters show that the DPS performed nominally, and no in-flight anomalies were identified for the analysis.

Multifunction Electronic Display System

At 131/18:11:29 GMT, shortly after MECO, Multifunction Display Unit (MDU) Cathode Ray Tube (CRT) 1 reported a BITE failure of Power Supply/Lamp Fail - Luminance Control Loop Fail. The failure cleared 16:16 later (131/18:27:45 GMT). This was determined to be a manifestation of a Multifunction Electronic Display System (MEDS) Hardware User Note. Bright ambient light conditions may cause luminance control loop failure errors to be detected due to MDU BITE limits being exceeded. This does not affect the performance of the MDU or the quality of the display image. The error condition will exist for as long as the bright ambient light is present.

On FD2, the MDU CRT2 had no display at unit power up. A power cycle of the MDU at the bezel power switch recovered the display. The failure and recovery scenario are consistent with a MEDS Hardware User Note.

On FD 9, the integrated Display Processor (IDP) 4 annunciated a single "message during unit power up followed immediately by a Mass Storage Unit I/O error" message (IFA STS-125-V-10). The errors did not repeat while the unit remained powered on, but the error messages were reported on each subsequent unit power-up through Entry. There was no loss of IDP/system functionality. The MSU failure had no impact on IDP performance and nominal End-Of-Mission objectives.

Displays and Controls System

The Display and Controls (D&C) system performed nominally except for the two in-flight anomalies that are discussed in the following paragraphs. The failures of the floodlights did not impact the successful completion of the mission.

On FD 2 at 132/20:55 GMT (01/02:53 MET), current signatures on all three Main Bus Mid-Power Control Assemblies (MPCA's) indicated four Payload Bay Floodlights were activated by the crew (each floodlight draws approximately 6.6 A). When all four floodlights were deactivated at 132/23:08 GMT (01/05:06 MET), the current signature on Main Bus B (MNB) MPCA 2 showed only a 2 A decrease instead of the expected approximately 6.6 A indicating a floodlight had failed. On FD 3 at 133/16:39 GMT (01/22:37 MET), current signatures showed only a 2 A increase on MNB MPCA 2 indicating a floodlight did not illuminate. The next time the Payload Bay Floodlights were activated, the crew was asked to deactivate the Forward Starboard Payload Bay Floodlight. Current signatures on MNB MPC 2 confirmed that this light had failed (IFA STS-125-V-03). The crew marked the switch as a reminder that the floodlight had failed.

On FD 5 at 136/00:18 GMT (04/06:17 MET), the crew was asked to cycle the switch for the Forward Port Payload Bay (FWD PORT PLB) floodlight and the current signature showed only a 2 A increase/decrease on Main Bus A (MNA) MPCA 1, which is an indication that only the electronics assembly was energized and the floodlight had failed to illuminate (IFA STS-125-V-04). The crew marked the switch as a reminder that the floodlight had failed.

Flight Control System

The Flight Controls System (FCS) performed nominally throughout the STS-125 mission. One in-flight anomaly was identified in-flight and it is discussed in a later paragraph in this section.

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. Reaction jet driver (RJD) operation was also normal with no thruster failures or other anomalies noted. Device driver unit (DDU) and controller operations were nominal as well. Both the rotational hand controller (RHC) and the transitional hand controller (THC) were used and exhibited normal channel tracking.

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

During the SSME ignition sequence, an electrical anomaly occurred that caused Aerosurface Servo Amplifier (ASA) 1 to be lost (IFA STS-125-V-02). Additionally, while the suspected short was occurring, a significant number of measurements became erratic. This anomaly caused Remote Power Controllers (RPC's) A and B, which supply dc power to ASA 1 to trip and after that, all measurements returned to nominal. Extensive review of past history revealed a similar occurrence happened during ground processing for STS-37. The root cause for the STS-37 event was traced to a wiring short in one of the wings. The effect of the short was not only to the ASA excitation line but, due to a floating grounding scheme, placed a 400Hz noise signal onto the two Multiplexer/Demultiplexers (MDM's) until the short was removed.

Entry performance was nominal from the deorbit maneuver through vehicle touchdown with FCS 1 channel not powered. The pre-deorbit maneuver OMS gimbal profile was as expected with the OMS actuator active and standby channels reaching nominal drive rates. All aerosurface actuators performed nominally except channel 1. Secondary Differential Pressures (ΔP) for all actuators were well within the equalization threshold, and all actuator positions closely tracked GPC commands. Entry hydraulic system temperatures were comparable to previous flights with aerosurface actuator temperatures being within the normal limits. The MPS TVC actuator performance was normal, with secondary Δ's within threshold and TVC actuator positions and GPC commands following each other closely.

Air Data Transducer Assembly

The STS-125 Air Data Transducer Assemblies (ADTA's) performed nominally during preflight, countdown, orbit, FCS checkout, deorbit preparation, entry, landing and post landing operations.

All four ADTAs functioned nominally from power-on until nominal data loss that occurred at the T-minus-20-min transition on launch day. The ADTA self-test performed shortly after power-on was 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.

During the FCS checkout, the performance of the ADTA's was nominal. Power-on and self-tests were performed with no anomalies. All 16 transducer outputs showed nominal responses.

Entry performance was nominal from deorbit through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.6, 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 2.4. No ADTA dilemmas or 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 performance was nominal throughout the mission. During the on-orbit operations, one adjustment was made to the onboard IMU's accelerometer compensation values, and one adjustment of the IMU drift compensation values.

The –Y and –Z Star Tracker (ST) performance performed nominally with respect to acquiring navigation-stars throughout the STS-125 mission. However, one annunciation was noted on the –Y ST and it is discussed in a following paragraph.

The –Y ST acquired a navigation-star 380 times during the mission, and also missed a navigation-star 101 times, which was nominal performance.

The –Z ST acquired a navigation-star 84 times during the mission, and missed the navigation-star 56 times, which is nominal for the mission.

The –Y ST annunciated a pressure-fail Built-In Test Equipment (BITE) at 131/19:48 GMT (00/01:46 MET) during the power-up sequence on FD 1. The internal Charge Coupled Device (CCD) temperature binary code was set to the wrong value, which set a tracker-good flag. The ST requires a warm-up period and when the CCD reached the normal operation temperature threshold about 1 min after the power-up sequence began. At that time, the BITE cleared and the ST functioned normally throughout the mission.

Global Positioning System Navigation

Overall, the one-string Global Positioning System (GPS) performed nominally and no in-flight anomalies were identified from the analysis of the data.

The GPS string 2 was powered up the day prior to the first deorbit attempt. Although GPS 2 was powered, there were no visible data until after the Flight Forward (FF) 2 Multiplexer/Demultiplexer (MDM) was brought up. Once FF2 was brought up, the Miniature Air-to-Ground Receiver (MAGR) indicated that it had a valid key immediately and a Figure of Merit (FOM) of less than 6 was achieved approximately 8 min after aiding was restored. The GPS receiver remained powered for the remainder of the mission; however the FF2 MDM was taken down after the final wave-off of each landing day. The downlist data indicated that a potential MAGR tilt occurred during the first period of operation where the MAGR was up and running without the FF2 MDM active. A tilt during this mode of operation is a known condition attributed to powering up the MAGR during dynamic operations after being off for more than 30 min (last valid solution is too old) without valid GPC aiding. Under this condition, the MAGR will zero its velocity and perform ballistic propagation of its last valid solution, resulting in the potential for an overflow condition when it calculates the line-of-sight distance to the satellites. Subsequent powering down of FF2 had no impact on the MAGR since the MAGR was already powered with a good solution and good tracking of satellites.

The GPS state vector was incorporated into both the Primary Avionics Software System (PASS) and Backup Flight System (BFS) in Major Mode (MM) 304 after the performance confirmation was completed with the high-speed C-band tracking. This occurred at approximately 138,000-ft altitude, and simultaneously with the instruction to incorporate Tactical Air Command and Navigation System (TACAN's). The effect was that the PASS and BFS navigation-state-vector residuals were reduced significantly, as expected. The PASS navigation state vector residuals remained consistently low from GPS incorporation down to the Microwave Landing System (MLS) incorporation (approximately 16,000 ft) where the PASS automatically stops taking GPS updates per design. Likewise, the BFS navigation state-vector residuals remained consistently low from GPS incorporation all the way through rollout as designed.

During Entry, the GPS high-FOM period usually encountered in the Plasma region cleared well before the GPS was incorporated into the PASS Navigation. The FOM varied between 1 and 2 after GPS incorporation. 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.

Communications and Tracking System and Navigation Aids

The Communications and Tracking systems performed nominally during the STS-125 mission. Likewise, the Navigation Aids (NAV AIDS) performed nominally. One In-flight anomaly was identified from the review and analysis of the data.

S-Band forward-link dropouts through both the forward and aft lower right quadrant antenna path occurred intermittently starting at 138/12:49 GMT (06/18:47 MET) (IFA STS-125-V-11). The anomaly occurred with both S-Band Strings 1 and 2 and via all scheduled TDRS operations. When these dropouts occurred, the forward-link lock was intermittent for up to 12 min. The dropouts appear to have no correlation to a particular area of either antenna pattern. The dropouts were observed to start and stop on a

single lower-right antenna beam and continued after a switch to the alternate lower-right antenna beam. The intermittent condition resulted in the occasional loss of forward link through which the S-Band Air-to-Ground (AG) 1 and 2 audio and commanding are conducted. The entry/landing impact was minimal because the upper quad antennas were selected for communication through TDRS during that time period. Testing will be conducted during the turnaround activities in an attempt to resolve this anomaly.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) system, including the Pulse Code Modulation Master Unit (PCMMU), Payload Data Interleaver (PDI), Master Timing Unit (MTU), sensors, signal conditioners and fuel cell monitoring subsystems performed nominally during the STS-125 mission with one IFA identified from the data and analysis.

During ascent, the Space Shuttle Main Engine (SSME) 2 Gaseous Hydrogen (GH_2) outlet-pressure transducer became erratic after engine ignition as the pressure passed through 840 psia. The erratic reading varied between 3120 psia and 1520 psia prior to the thrust bucket (typically steady at approximately 3000 psia and only varies approximately 200 psia at FCV cycling (IFA STS-125-V-01). The erratic reading continued throughout ascent and slowly shifted lower during the steady engine-run. The GH_2 outlet pressure transducers on the other two engines functioned as expected. The downstream GH_2 2-in. disconnect pressure reading responded nominally to flow control valve openings and closings and indicated nominal operation of the flow control valves. This failure did not impact the operation of the SSMEs.

The Modular Auxiliary Data System (MADS) sensors and signal conditioners performed nominally with no IFA's identified from the analysis. The MADS PCM ascent and entry data was reviewed and no issues or concerns were noted. The MADS PCM data, recorded on the Solid State Recorder, was reviewed after the flight and no issues related to the MADS PCM unit were identified.

Mechanical and Hatches System

All mechanical and hatch systems performed nominally during the STS-125 mission. No in-flight anomalies were identified from the review and analysis of the data.

Vent door operations prior to liftoff were nominal. No mechanical systems were active during ascent. Post-insertion, the ET door closing and star tracker door opening were satisfactory.

In preparation for entry, the star tracker closure and vent door repositioning was satisfactory. The payload bay doors were closed and reopened nominally because of a weather wave-off.

During entry, the vent doors repositioning for Entry Interface (EI) and post-EI was normal. The Air Data probe deployment was normal.

Post-landing, the ET door opening and vent door repositioning on the runway was nominal.

Landing and Deceleration System

The Landing and Deceleration System performance during STS-125 was nominal. Landing was at Edwards Air Force Base (EAFB) on concrete runway 22. It was the first flight of the nose landing gear tires used on this mission. They were in good condition and performance was nominal. The main landing gear tires also appeared nominal. The inspection showed the normal appearance of tread cord materials on areas of the tire's surface, and this condition is a known and expected characteristic of the new tire design. After nose-gear touchdown during roll out and after chute disreef, there were observations of puffs of smoke coming from the Main Landing Gear (MLG) tires. Further analysis of the landing data determined that the puffs of smoke were a result of inadvertent brake petals inputs from the crew as they were responding to lateral accelerations experienced during roll out.

The parachute performance was nominal.

The following table presents the landing parameters for the STS-125 mission.

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	3980.3	144/15:39:03.796	200.1	192.0	-1.60	N/A
Drag Chute Deployment	4952.8	144/15:39:06.907	186.4	180.4	-	-
Drag Chute Disreef	5278.5	144/15:39:11.565	166.6	159.2	-	-
Nose Landing Gear Touchdown	7167.0	144/15:39:15.154	140.6	137.6	-	--5.45
Brakes On	9116.4	144/15:39:25.318	102.8	95.3	-	-
Drag Chute Jettison	10991.9	144/15:39:40.505	OSL[b]	54.5	-	-
Wheels Stop	12484.5	144/15:40:17.372	0.0	0.0	-	-

Parameter	Data
Brake Initiation Speed, keas	102.8
Brake On Time, sec	62.22
Rollout Distance, ft	8504.2
Rollout Time, sec	73.58
Runway Location, Surface and Degrees	EAFB 22/Concrete
Orbiter Weight at Landing, lb	232591.4

LANDING PARAMETERS (Concluded)

Parameter	Maximum Brake Pressure, psia	Total Brake Energy, Mft/lb
Left inboard	1236	9.54
Left outboard	1236	6.52
Right inboard	1404	10.34
Right outboard	1152	7.83

[a]Knots equivalent air speed
[b]Off-scale-low

Aerothermodynamics, Integrated Heating and Interfaces

Inspection of the overall Orbiter Thermal Protection System (TPS) indicated normal heating during the STS-125 mission. The lower structural temperature data indicated normal entry heating. The recorded structure temperatures are within the flight experience of OV-104. However, the sensor at location P1 (T_{max} = 140.4 °F) experienced the most temperature rise for the OV-104 vehicle. The sensors at locations RW and S2 experienced the minimum temperature ever recorded for this vehicle at that location. Based on the MADS surface thermocouples data, the Boundary Layer Transition (BLT) was symmetric and occurred at BP 1600 (X/L = 0.6) around Mach 7.1 or 1240 sec after Entry Interface (EI) based on a pre-flight EOM trajectory

The runway report and post-flight inspection pictures indicated that there were no protruding Ames gap fillers. The tile damage on the right chine area appeared unchanged relative to the on-orbit photographs and the maximum damage depth was 0.1-in. The chin panel gap filler Outer Mold Line (OML) fabric was breached on the left hand side and was approximately 3-in. long.

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, ºF	Maximum Temperature Rise, ºF
Lower fuselage forward center (B1)	140.4	121.6
Lower fuselage forward left-hand (B2)	190.4	169.1
Lower fuselage forward mid left-hand (B3)	179.8	176.4
Lower fuselage mid center (B4)	150.8	150
Lower fuselage mid aft center (B5)	166.6	158.1
Lower fuselage aft center (B6)	185.1	153.6
Left-wing center (LW)	119.4	133.8
Right wing center (RW)	111.6[b]	138.6
Port side FRCS forward (P1)	140.4	113.9[c]
Port side fuselage forward center (P2)	109	95.4

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA (Concluded)

Thermal Sensor Location	Maximum Temperature, ºF	Maximum Temperature Rise, ºF
Port side fuselage forward mid center (P3)	96	84.9
Port side fuselage mid aft center (P4)	75.3[a]	76.9[a]
Port side fuselage aft center (P5)	98.6	77.3
Starboard side FRCS Forward (S1)	124.7	105.9
Starboard side fuselage forward center (S2)	101.2[b]	130.7
Starboard side fuselage forward mid center (S3)	90.8	92.5
Starboard side fuselage mid-aft center (S4)	57.2[a]	81.7[a]
Starboard side fuselage aft center (S5)	83	84.7
Left-hand OMS pod side forward (LP)	70.1[a]	53.9[a]
Right-hand OMS pod side forward (RP)	54.6[a]	66.5[a]
Lower body flap center	106.4[a]	77.4
Right-hand PLBD forward	59.8[a]	142.1[a]
Left-hand PLBD forward	64.9[a]	122.2[a]
Right-hand PLBD aft	70.1[a]	134.9[a]
Left-hand PLBD aft	72.7[a]	124.9[a]
Right wing upper center	80.5[a]	120.1[a]
Left wing upper center	96.0[a]	125.5[a]
Forward RCS center	85.6[a]	74.5[a]
Forward Fuselage Upper Center	70.1	97.1

Notes

[a] Maximum temperature occurred 30 min after wheel stop.

[b] Minimum temperature ever experienced on the OV-104 vehicle.

[c] Maximum temperature ever experienced on the OV-104 vehicle.

Thermal Control System

The passive Thermal Control System (TCS) performed nominally during the STS-125 mission. A number of minor issues were noted and none of the issues impacted the mission. No in-flight anomalies were identified from the review and analysis of the data. The external airlock water line Fault Detection and Annunciation upper value was exceeded during EVA due to a crew delay in turning off the higher set-point “C” heaters. There was no impact to the EVA and no hardware issues resulted.

The Right Outboard Elevon return-line sensor had an erratic signature for several hours early in the mission. Similar behavior for this sensor occurred on STS-122. The sensor is not used for circulation pump control and will be accepted “as is” for the STS-129 mission.

The APU 3 system A fuel-pump drain-line sensor near the thermostats cycled about 10 to 12 ºF lower on system A than on previous missions of this vehicle, thus requiring an

adjustment of the lower Fault Detection and Annunciation (FDA) from 43 ºF to 40 ºF. The range of the sensor was also increased. STS-125 was the first flight of this thermostat.

Two bondline sensors responded unrealistically during the ASA 1 electrical short anomaly just before lift-off.

The port OMS pod fuel tank sensor reached a peak temperature slightly higher than its previous peak on STS-115 due to the higher B-heater set-point being enabled during the general heater reconfiguration just after a system A cycle was completed. This sensor has had a history of being biased high and an inspection after a previous flight showed no issues with the sensor.

Thermal Protection System and Post-Landing Assessment

Post-Landing Assessment

The STS-125 vehicle looked very good and there was minimum debris damage. The following table itemizes the debris damage to the Orbiter.

SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE

Orbiter Surface	Impacts greater than 1 in.	Total impacts
Lower surface	14	109
Upper Surface/Window	1	9
Right OMS pod	3	21
Left OMS pod	0	17
Totals	**18**	**156**

All components of the drag chute were recovered. The drag chute hardware and components appeared to have functioned nominally. Both reefing-line-cutter pyrotechnic devices were expended.

Tire material loss on the Main Landing Gear (MLG) and nose landing gear door tires was nominal. The Right Hand (RH) MLG tires appeared to have more wear than the Left-Hand (LH) side.

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

The Space Shuttle Main Engine (SSME) Dome-Mounted Heat Shield (DMHS) blankets all appeared to be in excellent condition with a low amount of fraying.

The LH_2 and LO_2 umbilicals both appeared to be nominal. The External Tank/Orbiter (EO) 2 and EO 3 both had two missing clips around the perimeter of the salad bowl.

The starboard-side chine damage that was reported on-orbit did not appear to have propagated further and did experience high heat. There were 11 distinct damage points ranging in size from 0.25 in. to 3.75 in. Depths were no deeper than 0.10 in. and damage was primarily loss of black coating on the tile.

The right side of the fuselage lower surface just in front of the body flap has 2 grooves measuring 1-in. by ¼-in. and 1 ½-in. by ¼ in.

The right side inboard elevon on the inner vertical edge has damage measuring 1 in. by ¼ -in.

There was damage on the right wing tip just behind the RCC measuring 1in. by ½”-in.

There was 2-in. by 2-in. damage to a tile (293446-033) on the base of the vertical tail just above the speedbrake.

Damage to tile 391034-523 measuring 1–in. by ¾-in. was observed.

Numerous small damage sites greater-than (<) 1 in. were observed aft of the LH ET umbilical. There were two sets of these impacts that appeared to be from the same impactor. The impacts on two of the tiles (395007-074 and 395007-082) were in line and appear to be from the same impactor. Another tile (395009-063) had two small impacts (0.7 in. by 0.4 in. and 0.2 in. by 0.2 in.) that appear to be from the same impactor.

On the LH OMS pod, there was discoloration at the interface between the tiles and the blankets were noted. However, the visual inspection did not show any protruding gap fillers

The starboard forward window had white marks that were not commented on during orbit.

A left side chin-panel gap-filler in front of a tile that is immediately inboard of RCC panel 3, an OML fabric 3 in. long is protruding approximately 0.20-in. at its deepest point.

The Orbiter nose cap appeared to be in nominal condition. The LH and RH RCC panels both appeared to have no debris damage. However, one panel on the RH side had a red/orange streak about 4 in. by ¾-in. that appears to be residue from a Ames gap-filler.

Tile and Blanket Flight Assessment

The overall performance of the Thermal Protection System (TPS) was satisfactory and only one in-flight anomaly was identified during the review and analysis of the data (IFA STS-125-V-14). All tile and blanket anomalous conditions were assigned to this anomaly.

The Tile and Blanket Damage Assessment Team (DAT) assessment of imagery from the FD 2 inspections determined that no focused inspection was required.

RCC Flight Assessment

The Reinforced Carbon-Carbon (RCC) performed satisfactorily with no in-flight anomalies identified in the review and analysis of the data.

Windows

The evaluation of the nine windows has been completed and seven of the nine have been declared as acceptable for flight. Two windows, W1 and W7, have been declared as unusable for flight because of hypervelocity impact and as a result, will be scrapped.

Window 2 has hazing on the upper edge with a small streak in the center of the window. Window 3 has hazing on the upper inboard corner.

During post-flight vehicle inspection, Foreign Object Debris (FOD) was observed in Window 5. A Government Furnished Equipment (GFE) Quick Shoe mount know from a crew work lamp was found wedged between pressure pane no. 5 and the console dashboard close-out panel. (IFA STS-125-V-17)

Waste Collection System

The Waste Collection System operated nominally.

EXTRAVEHICULAR ACTIVITY

During the STS-125 Hubble Space Telescope (HST) Servicing Mission (SM)-4, five Extravehicular Activities (EVA's) were performed to service the HST. The total duration of the five EVAs was 36 hr 56 min. All of the scheduled tasks as well as get-ahead tasks were completed during the five EVA's.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was performed on Flight Day (FD) 4 (May 14, 2009) by the Extravehicular (EV) 1 and EV 2 crewmembers, and the total time of the first EVA was 7 hr and 20 min. The EVA started at 7:52 a.m. Central Daylight Time (CDT). The following tasks were completed:

1. The Wide Field Planetary Camera (WFPC) II was replaced with the Wide Field Camera (WFC) III.
2. The Science Instrument Control and Data Handler (SIC & DH) was replaced.
3. Three Latch Over-Center Kits (LOCK's) were to be Installed in the three locations on the -V2 aft shroud doors. However, the LOCKS could only be installed on the upper and lower positions. An Aft Shroud Lock Repair (ASLR) kit was installed on the middle latch.
4. The Soft Capture Mechanism (SCM) was installed on the aft bulkhead of the HST.
5. The HST doors were lubricated.

SECOND EXTRAVEHICULAR ACTIVITY

The second EVA was successfully completed on FD 5 (May 15, 2009) by the EV 3 and EV 4 crewmembers. The duration of the second was 7 hr and 56 min. The EVA started at 7:49 am CDT. The following tasks were completed:

1. All three Rate Sensor Units (RSU's) were replaced.
2. The Bay 2 Battery was replaced.
3. Advanced Camera for Surveys Repair (ACS-R) 'get-a-head' task - installation of the PIE Harness.

THIRD EXTRAVEHICULAR ACTIVITY

The third EVA was performed on FD 6 (May 16, 2009) by the EV 1 and EV 2 crewmembers. The EVA started at 8:35 am CDT. The duration of the third EVA was 6 hr and 36 min.

1. The original Corrective Optics Space Telescope Axial Replacement (COSTAR) was replaced with the Cosmic Origins Spectrograph (COS).

2. The Advanced Camera for Surveys (ACS) was repaired.

FOURTH EXTRAVEHICULAR ACTIVITY

The fourth EVA was successfully completed on FD 7 (May 17, 2009) by the EV 3 and EV 4 crewmembers. The duration of the fourth was 8 hr and 2 min. The EVA started at 8:43 am CDT. The following task was completed:

1. The Space Telescope Imaging Spectrograph (STIS) was repaired.

Installation of the New Outer Blanket Layer (NOBL) onto the Bay 8 door was deferred due to difficulty removing the STIS handrail. One fastener on the handrail could not be removed and EV 1crewmember pried the handle off, breaking the stuck bolt.

FIFTH EXTRAVEHICULAR ACTIVITY

The fifth EVA was performed on FD 8 (May 18, 2009) by the EV 1 and EV 2 crewmembers. The EVA started at 7:21 am CDT. The duration of the fifth EVA was 7 hr and 2 min.

1. The Bay 3 Battery was replaced.
2. The Fine Guidance Sensor (FGS) 2 was removed and replaced.
3. New Outer Blanket Layers (NOBL) were installed on Bays 5, 7 and 8.

At the end of the fifth EVA, during payload bay cleanup, the EV 1 crewmember accidentally bumped the end cone of the Low Gain Antenna (LGA) on the aft bulkhead of the telescope, knocking the tip off. The LGA protective cover was reinstalled for thermal protection. All reports are that the antenna is operating nominally.

REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Remote Manipulator System (RMS) performed nominally, and no in-flight anomalies were identified from the review and analysis of the data.

The RMS on-orbit Initialization began at 131/20:53 GMT (00/02:51 MET) on Flight Day (FD) 1. The port and starboard Manipulator Positioning Mechanisms (MPMs) were deployed and the RMS shoulder brace was released. The RMS checkout began at 131/21:33 GMT (00/03:31 MET) and was completed 43 min later.

On FD 2, the RMS grappled the Inspection Boom Assembly (IBA) at 132/11:30 GMT (00/17:28 MET) and maneuvered the IBA to the Orbiter Boom Sensor System (OBSS) hover position 23 min later. The Starboard (STBD) Reinforced Carbon-Carbon (RCC) Survey was completed at 132/15:08 GMT (00/21:06 MET). This survey included the new STBD Belly-Tile Survey, which was required because no R-Bar Pitch Maneuver (RPM) could be performed as there was no International Space Station (ISS) to photograph the underside of the Orbiter. The Nose RCC Survey was completed at 132/16:05 GMT (00/22:03 MET). The Port RCC Survey, which also included a belly survey, was completed at 132/19:29 GMT (01/01:27 MET). The Port Wing Glove and Crew Cabin Survey was completed at 132/19:53. GMT 01/01:51 MET). The port T-0 umbilical and Orbital Maneuvering System (OMS) Pod Survey was completed at 132/20:52 GMT (01/02:50 MET). The OBSS was berthed and the RMS was moved to the pre-cradle position at 132/21:49 GMT (01/03:47 MET).

On FD 3, The Orbiter rendezvous with the Hubble Space Telescope (HST) was completed and the RMS captured the HST at 133/17:13 GMT (01/23:17 MET). The HST was berthed in the payload bay at 133/18:12 GMT (02/00:10 MET). The RMS was used to perform an exterior survey of the HST before maneuvering the RMS to the extended-park position at 133/19:41 GMT (02/01:39 MET).

On FD 4, the Manipulator Foot Restraint (MFR) was installed and following MFR ingress by an Extravehicular (EV) crewmember, the RMS supported the first Extravehicular Activity (EVA). The RMS supported the Wide Field Planetary Camera (WFPC) 2 removal from the HST at 134/14:58 GMT (02/20:56 MET) and the installation of Wide Field Camera 3 (WFC) 3 one hr later. The RMS also provided support for the Science Instrument Command and Data Handling (SI C&DH) replacement at 134/17:14 GMT (02/23:12 MET) and Latch Over-Center Kits (LOCK's installation. At the end of the EVA, the crew reconfigured the MFR to clear the view of the arm's wrist camera to enable a TPS inspection of an area missed during the FD 2 surveys. The RMS was then maneuvered to the extended-park position at 134/19:59 GMT (03/01:57 MET).

On FD 5, prior to the second EVA, the End Effector (EE)/Wrist Roll Camera survey of the port chine tile was completed at 135/11:35 GMT (03/17:33 MET). The RMS was maneuvered to the Airlock MFR ingress position and RMS support of Rate Sensor Unit

(RSU) Removal and Replacement (R&R) started at 135/13:17 GMT (03/19:15 MET) and finished at 135/18:45 GMT (04/00:43 MET). The RMS completed support of the Bay 2 battery installation at 135/20:15 GMT (04/02:13 MET). The RMS was then placed in the extended-park position after completion of the EVA support activities.

On FD 6, the RMS was maneuvered to the Airlock MFR ingress position at 136/13:24 GMT (04/19:22 MET), and after the EV crewmember ingressed the MFR, the RMS was maneuvered to the -V2 Shroud Door Position at 136/13:57 GMT (04/19:55 MET) to support the Corrective Optics Space Telescope Axial Replacement (COSTAR) removal. The RMS was then used to support retrieval and installation of the Cosmic Origins Spectrograph (COS) for a 46-min period beginning at 136/15:02 GMT (04/21:00 MET). After repair of the Advanced Camera for Surveys (ACS), the HST doors were closed and the RMS was moved to the extended-park position at 136/20:40 GMT (05/02:38 MET).

On FD 7, the RMS maneuvered to the Airlock MFR ingress position at 137/13:39 GMT (05/19:37 MET), and the EV crewmember ingressed the MFR ingress at 137/14:01 GMT (05/19:59 MET). Four min later, the RMS moved to the Fastener Capture Plate (FCP) retrieve position, and then continued on to the +V2 Shroud Doors position 11 min later. The RMS supported the Space Telescope Imaging Spectrograph (STIS) repair from 137/14:29 GMT (05/20:27 MET) to 137/21:08 GMT (06/03:06 MET). The 8 hr and 2 min EVA was concluded with the RMS positioned in the extended-park position at 137/21:37 GMT (06/03:35 MET).

On FD 8, the RMS maneuvered to the Airlock MFR ingress position at 138/12:15 GMT (06/18:13 MET). Support for the battery R&R was completed at 138/12:42 GMT (06/18:40 MET). After the battery installation, the RMS Fine Guidance Sensor (FGS) support was completed at 138/15:24 GMT (06/21:22 MET). The RMS then supported the installation of three New Outer Blanket Layer (NOBL) thermal covers which were completed at 138/17:45 GMT (06/23:43 MET). The RMS released the MFR 1 and then maneuvered to the extended-park position at 138/19:30 GMT (07/01:28 MET).

On FD 9, the RMS maneuvered to grapple the HST at 139/10:45 GMT (07/16:43 MET). The HST was unberthed and maneuvered to the Hover position at 139/11:28 GMT (07/17:26 MET). While maneuvering to the final release position, the arm paused at the Relative Navigation System (RNS) intermediate position at 139/11:36 GMT (07/17:34 MET). The RMS released the HST at 139/12:58 GMT (07/18:56 MET) and moved to Pre-Cradle position.

The RMS maneuvered to the OBSS pre-Grapple position at 139/15:22 GMT (07/21:20 MET) and unberthed the OBSS to begin the late inspection. The RMS completed the STBD Laser Dynamic Range Imager (LDRI) Automatic Commanded Auto Sequence (ACAS) Inspection at 139/18:10 GMT (08/00:08 MET). The nose cap LDRI ACAS Inspection was completed at 139/19:05.GMT (08/01:03 MET). The Port inspection was completed, and the OBSS was berthed at 139/21:32 GMT (08/03:30 MET) after which the RMS was maneuvered to pre-cradle position 19 min later.

On FD 10, the RMS began maneuvering to the cradle position and was latched down at 140/10:58 GMT (08/16:56 MET)). Stowing the Port and Starboard MPMs was completed at 140/11:01 GMT (08/16:59 MET). At that time, the RMS activities for the mission were completed.

WING LEADING EDGE IMPACT DETECTION SYSTEM

ASCENT MONITORING

Ascent summary data downloads were available 8 hr 11 min [Mission Elapsed Time (MET)] at which time the ascent data downlinks, conversion, and analysis began. All ascent summary files were downlinked in approximately 3 hr. A total of 11 half-second windows of ascent raw data were requested and received. The Imagery Analysis Team (IAT) reported a possible impact on the starboard chine at approximately 11 hr 30 min MET. Two half-second windows from the starboard chine area were received for analysis, and the ascent analysis and findings were completed and issued. Two impact indications over 1.0 Grms occurred in the chine area with unknown damage likelihoods because of the location on the impacts.

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
104.3	113.5	Stbd	Chine	1097-J1	2.9	11.0	+	+	+	+	P	P
120.7	129.9	Stbd	Chine	1097-J1	1.8	5.6	+	+	+	+	P	P

[a]Adjusted to correct for known differences between the onboard laptop and actual GMT times.
[b]P = Probable

Automated scanning of post-flight data acquired from 10-500 sec MET revealed a total of 49 ascent debris impact indications on the wing leading edge (20 on the port and 29 on the starboard wing) ranging from 0.1 to 2.9 Grms.

ORBIT MONITORING

One Micrometeoroid/Orbital Debris (MM/OD) impact indication was reported during this mission. For this mission, the Wing Leading Edge Impact Detection System (WLE IDS) system triggered five times although, triggers 4 and 5 belonged to the same event. Only the third trigger passed both the multi-sensor and trapped wave criteria. Automatic scanning of post-flight data revealed no additional on-orbit indications.

SUMMARY OF MM/OD IMPACT

Times[a]		Location			Magnitude		Criteria				Impact[b]	
GMT		Wing	RCC	Unit-Channel	Max. Grms	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post-Flt
132/20:00:18		Stbd	10/11 L	1235-J2	0.47	0.49	+	o	+	+	P	P

[a]Adjusted to correct for known differences between the onboard laptop and actual GMT times.
[b]P = Probable

ANOMALIES

No ascent data spike anomalies were found during the mission. Automatic scanning of post-flight ascent data revealed no additional data spike anomalies. Automatic scanning did reveal an extended duration area of noise on unit 1092.

ASCENT DATA ANOMALIES

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
504.3	513.5	Port	10/11 U	1092-J2	0.17	0.389	+	+	-	-	U	P

[a]Adjusted to correct for known differences between the onboard laptop and actual GMT times.
[b]P = Probable

CONCLUSIONS

The WLE IDS system performed well for ascent impact monitoring. An initial ascent report was published at Launch +14 hr. During the mission, two ascent impact indications above the 1.0 Grms reporting threshold with unknown damage likelihood were reported. Post-flight review of the data found no additional ascent indications over 1 Grms.

One MM/OD impact indication was detected during on-orbit monitoring using the latest MM/OD Impact Criteria.

Based on the ascent findings from all systems, including WLE IDS, the Orbiter Project Office (OPO) recommended that a focused Wing Leading Edge (WLE) Reinforced Carbon-Carbon (RCC) inspection was not required.

The late-mission Orbiter Boom Sensor System (OBSS) survey visually inspected the WLE after Orbiter undocking and prior to entry and no damage was found.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government Furnished Equipment (GFE) and Flight Crew Equipment (FCE) performed nominally. Four GFE anomalies were identified, none of which impacted the successful completion of the mission.

After all of the Wing Leading Edge Impact Detection System (WLEIDS) ascent data were retrieved from sensor 1092, a diagnostic command was sent to the unit in preparation of on-orbit monitoring. The diagnostic results showed good health; however, later in the mission many consecutive local timeouts were experienced while trying to program the sensor for On-Orbit Monitoring (IFA STS-125-V-05). Following this anomaly, the sensor continuously provided local timeout messages. As a result of multiple timeouts, sensor 1094 (from Group 2) was substituted for this sensor since it monitors the same location.

The crew was unable to remove the supply-dump-line purge line after a supply water dump. The crew attempted to push the purge device towards the wall and turn the Quick-disconnect (QD) to remove purge line. The crew reported that the devise could not be removed, and the purge device QD housing remained attached to the flight QD (IFA STS-125-V-06). A nozzle dump could still be performed, but the broken QD eliminated the purging capability. To eliminate the concern for water remaining and freezing in the lines, a FES dump was used for future dumps.

During ascent, the crew-cabin video downlink attempts were made, and the crew reported that there was no video available for downlink (IFA STS-125-V-08). Initial indications pointed to a failed cable between the Audio Video Interface Unit (AVIU) and the video recorder. Since a report of intermittent Mini camera video was reported in the pre-launch timeframe, the request to downlink any available video was made. On FD 10, the crew reported that V10 video looked good with a replacement cable. The old cable was used with another V10 and the crew verified no video. This confirmed the problem was due to a bad cable.

STS-125 post-flight testing of one 112G battery used in the crew escape radio, indicated much lower-than-expected Open Circuit Voltage (OCV) (approximately 2 volts) (IFA STS-125-V-15). The failure was initially suspected to be related to pre-flight operator-error which may have caused inadvertent triggering of the bleed-down circuit (i.e., inadvertent short of battery leads).

POST-LAUNCH PAD INSPECTION

The post launch inspection of the Main Launch Platform (MLP) -2, Pad A Fixed Service Structure (FSS), and Pad A apron was conducted on May 11, 2009, from 3:20 P.M. to 6:20 P.M. Eastern Daylight Time (EDT). The inspection proceeded relatively quickly while Safing Teams secured the Pad. The entire PAD, FSS and MLP were inspected. The infield and perimeter were inspected and no flight hardware was found other than minimal SRB nozzle throat plug foam.

The most substantial non-flight hardware issue noted is the Fondue Fyre liberation and the resulting collateral damage to the MLP and Pad Structure.

Inspections of the SRB Holddown Posts (HDP) were performed and are as follows:

1. **HDP no.1** – The EA934 poured sidewalls were nominal (acceptable) with some pitting in the South sidewalls that measured ¾ in. by ¼ in. and ¼ in. by ¼ in. (acceptable). The Phenolic shim was nominal and 1 of the 2 firing lines were present [Left-Hand (LH) 3 in.]. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down
2. **HDP no. 2** – The EA934 poured sidewalls are nominal with minor pitting on the South, North and SW sidewall (acceptable). The Phenolic shim was nominal and both firing lines were missing. Approximately 1-ft of the Range Safety System (RSS) cable remained. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.
1. **HDP no. 3** – This HDP showed nominal indications of erosion on the Room Temperature Vulcanizing (RTV) -coated blast shield with proper closure.
2. **HDP no. 4** – showed nominal indications of erosion on the RTV coated blast shield with proper closure.
3. **HDP no. 5** - EA934 poured sidewalls are nominal with minor pitting on the SW wall (acceptable*). Phenolic shim is nominal with typical erosion and 1 of 2 firing lines were present (LH 4 in. below flush). No galling or chatter marks were noted in the chamfer of the thru hole and the stud was set down.
4. **HDP no 6** - EA934 poured sidewalls have multiple voids larger than recently seen, but were acceptable. Phenolic shim is nominal. Both firing lines were removed. No galling or chatter marks were noted in the chamfer of the thru hole and stud was set down.
5. **HDP no. 7** - showed nominal indications of erosion on the RTV coated blast shield with proper closure.
6. **HDP no. 8** - showed nominal indications of erosion on the RTV coated blast shield with proper closure and RSS cable was missing.

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

1. The Left-Hand (LH) probe was erect and straight with about 85% of the protective tape layering remaining with no exposed braiding. The O-ring was present.
2. The Right-Hand (RH) probe was erect and slightly bent to the East with about 85% of the protective-tape layering remaining with no exposed braiding. The O-ring was present.

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

1. The LH SRB Lift-off (T-0) GCAs appeared to be in nominal condition with proper demate.
2. The RH SRB T-0 GCAs appeared to be in nominal condition with proper demate.

Additional inspection results from the Launch Pad are as follows.

1. The LO_2 and LH_2 Tail Service Masts (TSM's) appeared to be undamaged and both bonnets appeared to have closed properly.
2. The MLP deck was in nominal condition. Typical blast erosion was observed in and around the SRB flame holes with some indication of a Northeast (NE) ascent. All sound- suppression pipe support shims appeared to be in place.
3. The Orbiter Access Arm (OAA) at the 195-ft level was retracted and secured. All slidewire baskets were still secured at the 195-ft level with no evidence of damage. All of the Basket signs were present and all PIP pins were engaged.
4. The GH_2 vent line on the Ground Umbilical Carrier Plate (GUCP) as the 215-ft level was latched on the seventh tooth (of eight) on the latching mechanism. The vent line was in between the gimbal struts and slightly South of center in the latching mechanism as seen from the Fixed Service Structure (FSS). The External Tank (ET) GUCP 7-in GH_2 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 and liquid runs on the poppet probe. The ET GUCP exhibited typical blast damage and the pyrotechnic bolt fired nominally.
5. Special attention was focused on both Left and Right leg pivot assemblies, which exhibited nominal undamaged separation and deceleration cycle.
6. The Gaseous Oxygen (GOX) vent hood, windows and structure on the Vent Arm (at the 255-ft level) appeared to be in nominal condition, and the latch mechanism locked properly. The seals were able to be inspected and showed no signs of topcoat or foam.

Numerous items were found but overall, the PAD facility was found to be in very good condition while the SRB flame trench experienced nominal erosion and the previous repair areas were intact. On the Southwest (SW) slope near the midpoint of arc of the

SRB flame trench, three areas had some damage. The most notable debris items using the debris collection criteria are included below:

1. Minor pieces of SRB throat plug material were found on the PAD surface.
2. West PAD surface – Two bolts were found 100-ft South of the elevators.
   West PAD surface – One bolt was found 30-ft S of the elevators.
3. West PAD surface – A toolbox lock was found West of the flame deflector.
4. West PAD surface – A small piece of nut was found 130-ft S of the elevator.
5. West PAD surface – A broken stud with attached nut was found West of the flame deflector.
6. West PAD surface – A washer was found near the stairs of the FSS.
7. South PAD surface – Small pieces of fondue fyre were found.
8. South PAD surface – Large pieces of rust scale were found.
9. South PAD surface – Black plastic bagging with orange tape was found that was acceptable appeared to come from PAD pedestals.
10. North East PAD surface – An acceptable waterbag rope and became collection data for the Debris Transport Analysis (DTA).
11. East PAD surface – A pen was found under the East (E) flame deflector.
12. East PAD surface – A braided tie cable was found under the E flame deflector.
13. East PAD surface – Large rust scale was noted.
14. MLP deck level – A missing bolt of the camera flame deflector was found one the NE side).
15. 107-ft level – Large rust scale was identified on the RSS side 4.
16. 135-ft level – An 8-in bolt with washer was found in the crossover area, and two large rust scales were identified on the West side. Also facility insulation foam and a tie wrap were found near the RSS.
17. 175-ft level – A small piece of black asphalt type material was found on the NE side. A larger piece of the same material was found on top of the cable tray on the NE side, and it was not accessible to be retrieved.
18. 195-ft level – Two loose clamps, which secure grating, were found directly in front of stairs on the E side of the FSS. Also, a sheared bolt was found on the E side of the FSS. A washer was found near the bathroom, and a nut was found on the SW side of the FSS.
19. 200-ft level – Temperature transducer was unplugged and hanging loose on the NE side of the FSS, and rust scale was also noted on the E side of the FSS.
20. 275-ft level – A bolt was found on the E side of the FSS.

LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

VEHICLE OBSERVATIONS

From - 3.482 to -3.032 sec, tile chips were noted on the Orbiter stingers during Space Shuttle Main Engine (SSME) ignition. Three tile chips were noted on the Orbiter's port stinger pod and one tile chip was noted on the Orbiter's starboard stinger.

From -2.911 to -2.898 sec, debris Impacts were noted on the 7th and 8th hatband of SSME no. 3 nozzle bell at Ignition.

At -3.013 sec, a piece of ice/frost debris was seen liberating from the LO_2 T-0 umbilical lines during SSME ignition and it was noted to impact SSME no. 3 on the +Y side near the top of the eighth hatband, and no damage was identified. SSME has reviewed both the debris impact imagery and the engine flight data and reported there were no indications of any operational or performance issues with the engine or nozzle operations and any anomalies will be documented.

At 0.425 sec Mission Elapsed Time (MET) some ice/frost particles fell from Orbiter/LH_2 T-0 umbilical interface.

At 0.446 sec MET, Ice/Frost was observed falling from the Orbiter/LO_2 T-0 umbilical interface.

At 0.753 sec MET, off-gassing was observed from the starboard aft skirt Debris Containment System (DCS) stud hole, which is located on the Holddown Post (HDP) no.3 skirt stud hole.

At 0.760 sec MET, possible ice/frost was seen remaining on the Orbiter after the LH_2 T-0 Umbilical had retracted.

At 14.023 sec MET, a single piece of debris was seen falling aft under the Orbiter's port wing.

From approximately 24 to 49 sec MET, multiple dark marks, suspected to be grease or liquid splatter, appear on the right Solid Rocket Booster (SRB) near the forward (aft pointing) SRB camera. This is only the second flight for the repointed SRB camera view.

At approximately 57 sec MET, dark tape-like material was observed on the forward section of the port Orbital Maneuvering System (OMS) pod moving and subsequently falling aft of vehicle during ascent.

Thermal Protection System (TPS) loss was noted on Liquid Oxygen (LO_2) Ice Frost Ramp (IFR) 593. The time of this event was not provided.

TPS loss was noted at approximately Xt 2000, outboard of LO_2 feedline. Also, a divot was noted in the Liquid Hydrogen (LH_2) acreage TPS, inboard of pressure lines and between IFR 1980 and IFR 2013. The time of this event was not provided.

TPS loss was noted at approximately Xt 2000, Inboard of LO_2 feedline. Also, a divot was noted in the LH_2 acreage TPS at approximately Xt 2000 and inboard of LO_2 feedline.

TPS loss was noted at approximately Xt 2002 and inboard of LO_2 feedline. Also, a divot in the LH_2 acreage TPS was found at approximately Xt 2002 and inboard of LO_2 feedline.

At 104.2 sec MET, debris appears to originate forward of the LO_2 feedline camera, and the debris falls aft along the starboard fuselage and travels under the starboard wing. From the LO_2 feedline imagery, an Orbiter impact could not be conclusively determined. However, from a different camera view, a single piece of debris appears to impact the Orbiter and continue aft passing under the starboard wing. There is evidence of tile damage on the starboard chine with a location consistent with the damage observed on orbit. This debris, observed in ascent imagery, has a possible correlation to the Wing Leading Edge Impact Detection System (WLEIDS) indication at the starboard chine reported at 104.3 sec MET. The radar has also identified a debris event during this timeframe from the X3 and X4 sensors.

Additional information on the 104 sec MET debris first seen near the starboard SRB/ET intertank region, travelled aft toward the starboard wing and then appears to travel outboard over the wing. No impact to the Orbiter was observed. The Image Assessment Team (IAT) believes this debris event is not related to the chine tile damage seen on orbit. This debris is believed to be a possible large popcorn foam release.

At 153.700 sec MET, a debris event, identified from radar data, showed a shower consisting of four events over an estimated release duration of 1.15 sec. The velocity profiles and geometry of the objects are consistent with foam possibly that may be embedded with frost or ice. All of the objects are visible with track lengths greater than the length of the stack but with low initial velocities (between 100-380 ft/sec) indicating that the debris was visible shortly after release, and with unobstructed track durations. This indicates that they were released from the forward third of the vehicle and moved over the top of the Orbiter while remaining in view until moving behind the stack. All of the objects have similar radar cross-section. Ballistic numbers appear to be affected by turbulence effects, and vary widely, which was a confirming cue that the objects were visible within the stack. Size estimates are not available for these objects.

A radar-detected debris event consisted of a single object that was first observed with a Shuttle relative velocity of 700 ft/sec. The object had low reflectivity and the ballistic performance was indicative of an irregularly shaped foam of approximately 4 in. in size. The material type is based on a comparison with ground-based static laboratory measurements.

At approximately 270.5 sec MET, multiple pieces of External Tank (ET) TPS debris were seen moving up from the ET with several possible impacts to the belly of the Orbiter. There was no damage noted in this area from the on-orbit inspection.

LAUNCH PAD OBSERVATIONS

At 9.115 sec MET, facility debris was observed falling West of the Fixed Service Structure (FSS). The debris, which was possibly facility hardware, was found near the slide wire baskets on the 195-ft level during the post-launch walk down. The debris was identified as the cap to a 4-in. Hydrogen line.

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APPENDIX A
STS-125 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-1 Gas Generator Chamber Pressure	131/17:57:08.743
	APU-2 Gas Generator Chamber Pressure	131/17:57:10.377
	APU-3 Gas Generator Chamber Pressure	131/17:57:11.490
SRB HPU Activation	LH HPU System A Start Command	131/18:01:28.092
	LH HPU System B Start Command	131/18:01:28.252
	RH HPU System A Start Command	131/18:01:28.412
	RH HPU System B Start Command	131/18:01:28.612
Main Engine Start	SSME-3 Start Command Accepted	131/18:01:49.437
	SSME-2 Start Command Accepted	131/18:01:49.552
	SSME-1 Start Command Accepted	131/18:01:49.682
SRB Ignition	SRB Ignition Command	131/18:01:55.992
Throttle Up 104.5 %	SSME-2 Command Accepted	131/18:01:59.828
	SSME-1 Command Accepted	131/18:01:59.839
	SSME-3 Command Accepted	131/18:01:59.853
Throttle Down to 94%	SSME-2 Command Accepted	131/18:02:13.748
	SSME-1 Command Accepted	131/18:02:13.759
	SSME-3 Command Accepted	131/18:02:13.773
Throttle Down to 72%	SSME-2 Command Accepted	131/18:02:25.908
	SSME-1 Command Accepted	131/18:02:25.919
	SSME-3 Command Accepted	131/18:02:25.933
Throttle Up 104.5%	SSME-2 Command Accepted	131/18:02:43.029
	SSME-1 Command Accepted	131/18:02:43.040
	SSME-3 Command Accepted	131/18:02:43.054
Maximum Dynamic Pressure (MAX Q)	Derived Ascent Dynamic Pressure	131/18:03:00
Both SRMs to less than 50 psi	RH SRM Chamber Pressure	131/18:03:55.032
	LH SRM Chamber Pressure	131/18:03:55.632
End SRM Action	RH SRM Chamber Pressure	131/18:03:57.592
	LH SRM Chamber Pressure	131/18:03:57.792
SRB Separation Command	SRB Separation Command Flag	131/18:04:00
SRB Physical Separation	LH APU B Turbine Loss of Signal	131/18:04:00.392
	RH APU A Turbine Loss of Signal	131/18:04:00.392
	LH APU A Turbine Loss of Signal	131/18:04:00.432
	RH APU B Turbine Loss of Signal	131/18:04:00.432
Throttle Down for 3g	SSME-2 Command Accepted	131/18:09:19.355
	SSME-1 Command Accepted	131/18:09:19.371
	SSME-3 Command Accepted	131/18:09:19.378
3G Acceleration	Total Load Factor (g)	131/18:09:42.4
Throttle down to 67 percent for Cutoff	SSME-2 Command Accepted	131/18:10:13.436
	SSME-1 Command Accepted	131/18:10:13.453
	SSME-3 Command Accepted	131/18:10:13.459
SSME Shutdown	SSME-2 Command Accepted	131/18:10:19.956
	SSME-1 Command Accepted	131/18:10:19.973
	SSME-3 Command Accepted	131/18:10:19.979
Main Engine Cutoff (MECO)	MECO Command Flag	131/18:10:20
	MECO Confirmed Flag	131/18:10:21
ET Separation	ET Separation Command Flag	131/18:10:42

APPENDIX A
STS-125 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Deactivation	APU-1 Gas Generator chamber Pressure APU-2 Gas Generator chamber Pressure APU-3 Gas Generator chamber Pressure	131/18:16:41.993 131/18:17:07.677 131/18:17:25.060
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	131/18:45:41.2 131/18:45:41.3
OMS 2 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	131/18:47:14.1 131/18:47:14.2
Payload Bay Doors Open	Right Payload Bay Door Open 1 Left Payload Bay Door Open 1	131/19:38:43 131/19:40:01
OMS 3 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	 132/22:27:19.3
OMS 3 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	 132/22:27:29.1
OMS 4 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	133/12:17:16.1 133/12:17:16.1
OMS 4 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	133/12:20:33.7 133/12:20:33.7
OMS 5 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	133/14:41:56.3
OMS 5 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	133/14:42:08.5
OMS 6 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	139/14:59:36.3 139/14:59:36.3
OMS 6 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	139/15:02:00.3 139/15:02:00.3
Flight Control System Checkout – APU 1 Start	APU-1 Gas Generator Chamber Pressure	141/10:17:56.330
APU 1 Stop	APU-1 Gas Generator Chamber Pressure	141/10:22:20.490
Payload Bay Door Close	Left Payload Bay Door Close Right Payload Bay Door Close	144/10:14:42 144/10:18:27
APU Activation	APU-2 Gas Generator Chamber Pressure APU-1 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	144/14:19:46.937 144/14:55:10.193 144/14:55:12.640
Deorbit Maneuver	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	144/14:24:41.2 144/14:24:41.2
Deorbit Maneuver Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	144/14:27:19.2 144/14:27:19.4
Entry Interface	Orbital Altitude Referenced to Ellipsoid	144/15:8:03
Blackout End	Data Locked (High Sample Rate)	NO BLACKOUT
Terminal Area Energy Management (TEAM)	Major Mode Code (305)	144/15:32:51
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure Main Landing Gear Right Hand Tire Pressure	144/15:39:04 144/15:39:04

APPENDIX A
STS-125 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
Main Landing Gear Weight on Wheels	Main Landing Gear Right Hand Weight on Wheels Main Landing Gear Left Hand Weight on Wheels	144/15:39:09 144/15:39:10
Drag Chute Deployment	Drag Chute Deployment 1 CP Volts	144/15:39:06.9
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	144/15:39:15
Nose Landing Gear Weight on Wheels	Nose Landing Gear Weight on Wheels	144/15:39:16
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	144/15:39:40.5
Wheels Stop	Velocity with respect to Runway	144/15:40:41
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	144/15:58:51.353 144/15:59:11.767 144/15:59:27.650

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

INTRODUCTION

INTRODUCTION

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-125 mission.

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

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-125-V-01	MPS Main Engine 2 GH_2 Outlet Pressure Transducer Erratic	During ascent, the Space Shuttle Main Engine (SSME) 2 GH_2 outlet pressure transducer became erratic after engine ignition as the pressure passed through 840 psia. The erratic reading varied between 3120 psia and 1520 psia prior to the thrust bucket (typically steady at approximately 3000 psia and only varies at Flow Control Valve (FCV) cycling by approximately 200 psia. The erratic reading continued throughout ascent and slowly shifted lower during steady-state engine operation. The GH_2 outlet pressure transducers on the other two engines functioned as expected. The downstream GH_2 2-in. disconnect pressure reading responded nominally to FCV openings and closings, indicating nominal operation of the FCV's. This failure did not impact the operation of the SSMEs. This sensor annunciated Backup Flight System (BFS) Caution and Warning (set at 1050 psi) four times. The messages were annunciated at 0:35, 0:46, 7:10 and 7:36 Mission Elapsed Time (MET). The crew was informed, and no actions were required. Prior to throttle down for Main Engine Cutoff (MECO), the SSME 2 transducer was erratic between 1840 psia and 700 psia while the SSME 1 and SSME 3 transducers were at 2980 psia and 3180 psia. At MECO, SSME 1 was 1920 psia, SSME 2 was 380 psia and SSME 3 was 1920 psia. Loss of the measurement during ascent had no impact on the mission. The ground controller declared this measurement unreliable for engine cues and the indication was to be ignored for the remainder of ascent – no crew action was required. **Post-Flight:** The preliminary post-flight troubleshooting/inspection at Dryden Flight Research Center (DFRC) wire wiggle test showed a change in pressure reading that was toggling from 20-40 psi to 0-40 psi (data bit is 20 psi). The pressure applied at DFRC was not sufficient to properly characterize the function of the transducer during the wire wiggle Checks. Inspection and testing at Kennedy Space Center (KSC) noted that two wires (-1 and -3) were broken at the backshell tang. The two remaining wires (-2 and -4) had damage at the same location. The connector was replaced.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-02	Aerosurface Actuator (ASA) 1 Power Supply Failure	During SSME ignition, an electrical anomaly occurred that caused ASA 1 to be lost. Additionally, while the suspected short was occurring, a significant number of measurements on Operational Aft (OA) 01 and Flight Aft (FA) 01 Multiplexer/Demultiplexers (MDM's) became erratic. This anomaly caused Remote Power Controllers (RPC's) A and B to ASA 1 to trip and after that, all OA01 and FA01 measurements returned to nominal. Extensive review of the past MDM history revealed a similar occurrence had occurred during ground processing for STS-37. The root cause for the STS-37 event was traced to a wiring short in one of the wings. The effect of the short was not only to the ASA excitation line but, due to a floating grounding scheme, put a 400-Hz noise signal on the 2 MDM's until the short was removed. This explains the signature seen on STS-125. No other measurements were affected, which clears the remaining wiring for Entry. Hi-pot test of the Right Hand (RH) inboard elevon primary differential pressure transducer excitation circuit failed, indicating a short to ground. Further isolation revealed hard contact between a wire harness and an adjacent Hi-Lok® fastener in the actuator cavity region. The wire harness was removed and sent for failure analysis where it was determined that the cause of the IFA was an exposed conductor (due to chafing) within the wire harness shorting to the Hi-Lok® fastener.
STS-125-V-03	Forward Starboard Floodlight Failed	On Flight Day (FD) 2, at 132/20:55 GMT (01/02:53 MET), current signatures on Main Bus A (MNA) Mid-Power Controller (MPC) 1, Main Bus B (MNB) MPC2, and Main Bus C (MNC) MPC3 showed four Payload Bay (PLB) floodlights were activated by the crew (each floodlight draws approximately 6.6 Ampere (A). When all four floodlights were deactivated at 132/23:08 GMT (01/05:06 MET), the current signature on MNB MPC2 showed only a 2 A decrease instead of the expected approximately 6.6 A; indicating a floodlight had failed. On FD 3, at 133:16:39 GMT (01/22:37 MET), current signatures showed only a 2 A increase on MNB MPC 2 indicating a floodlight did not illuminate. The next time the PLB floodlights were activated, Mission Control Center (MCC) controllers asked the crew to deactivate the Forward Starboard Payload Bay Floodlight. Current signatures on MNB MPC 2 confirmed that this light had failed. The crew marked the switch as a reminder to not use it for the duration of the mission. Post-flight inspection indicated that the bulb was cracked, it was Removed and Replaced (R&R'd).
STS-125-V-04	Forward Port PLB Floodlight Failed	On FD 5 at 136/00:18 GMT (04/06:17 MET), the crew was asked to cycle the switch for the Forward Port PLB floodlight, and the current signature showed only a 2 A increase/decrease on MNA MPC1, which is an indication that only the electronics assembly was energized and the floodlight failed to illuminate. The crew marked the switch as a reminder to not use this light for the remainder of the mission. The post-flight inspection indicated that the bulb was cracked and it was R&R'd.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-05	Wing Leading Edge Impact Detection System (WLEIDS) Sensor S/N 1092 Local Timeouts	After all ascent data was retrieved from sensor 1092, a diagnostic command was sent to the unit in preparation of on-orbit monitoring. The diagnostic results showed good health; however, later in the mission many consecutive local timeouts were experienced with the sensor while trying to program for On-Orbit Monitoring, Group 2, Start 1. From that time, the sensor continuously provided local timeout messages displaying a low likelihood of being able to communicate with it for the remainder of the mission. As a result of multiple timeouts, sensor 1094 (from Group 2) was substituted for this sensor and monitored the same location. Later in the mission, the team unsuccessfully attempted to reestablish communication with sensor unit 1092; however, communication was established with sensor unit 1092, Group 2 sensor 1094, which is a redundant sensor that will cover the missing panels that sensor 1092 would normally cover. One disadvantage is that the alternated sensor would have 7 hr less monitoring capability due to previous usage as well as the battery power constraints. For the last Micrometeoroid/Orbital Debris (MM/OD) monitoring period for Group 2 sensors on the port wing monitoring with S/N 1094 could not be performed because of battery limitations, and as a result, the diagonal monitoring capability was lost for Reinforced Carbon-Carbon (RCC) Panels 8 through 13. However, lateral adjacent sensors will provide data to meet the multi-sensor indication assessment criteria. During post-flight troubleshooting, the problem could not be duplicated.
STS-125-V-06	Supply Water Dump Line Purge Device Failed	At approximately 138/12:17 GMT (06/18:16 MET), following the termination of a supply-water nozzle dump, the crew reported that they could not remove the Supply Water Dump-line Purge Device from the Contingency Water Cross Tie Potable Quick Disconnect (QD) that is located on the outboard wall of the Waste Collection System (WCS). During the crew's next attempt to remove the purge device, the QD on the purge device failed, leaving a portion of the QD still attached to the fitting on the wall. Without the Supply Water Dump-line Purge Device, the crew was not able to perform the dump-line purge that is nominally done following a dump. The purpose of the purge is to clear the dump-line of any residual water to prevent "burping" of the supply water dump valve. Burping occurs when water trapped in the dump valve freezes and expands, momentarily forcing the dump valve open and allowing water to flow. The flowing water melts the ice, causing the valve to reseat. Without the capability to perform a purge, the potential for burping to occur existed. The following actions were recommended to the crew in the FD 9 Execute Package to secure the Contingency Water Cross-Tie Potable QD with a Ziploc bag and gray tape to cover the Contingency Water Cross-Tie Potable QD. The QD cap was taped to the wall and the crew were instructed to check the Ziploc bag daily for signs of moisture. To prevent any possibility of dump valve burping, the supply water dump plan was adjusted to replace the last planned supply water nozzle dump with a Flash Evaporator System (FES) dump. In a follow-up discussion with the ground personnel, they were not aware of this requirement (not to rotate it when disconnecting) so the crew was not cautioned of this requirement.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-07	Vernier Reaction Control System (VRCS) Thruster R5R Chamber Pressure Indications Low	Since VRCS activation on FD 1, thruster R5R's Chamber Pressure (Pc) has been consistently lower than nominal. Nominal peak Pc should be greater than 100 psia. For short pulses or elevated propellant temperatures, a Pc as low as approximately 75 psia is not unusual. For STS-125, the R5R peak Pc was as low as 48 psia on FD 2. The R5R thruster Pc status improved over FD 2 but still averaged less than 92 psia. To determine whether the R5R thruster low Pc was due to thruster performance or indication problem, simulations were performed of 2 R5R firings. The analysis confirmed vehicle rates consistent with indicated R5R thruster performance, thus confirming that indication was not an issue. The de-selection of the thruster for crew-sleep periods was used to avoid any nuisance alarms. If the thruster fails, vernier control is still possible with the remaining five thrusters. The plan was to use the thruster unless it fails off. No dedicated R5R hot-fire was required. Post-flight testing could not identify an exact cause. The most likely cause was an obstruction of the oxidizer flow path from nitrate contamination that does not have a practical corrective action beyond those operational changes already performed to reduce primary thruster oxidizer valve leakage.
STS-125-V-08	Intermittent Ascent Mini-Camera Video	Following ascent, when attempting to downlink the crew-cabin video, the crew reported that there was no video available for downlink. Since a report of intermittent Mini-Camera video was reported in the prelaunch timeframe, the ground had requested the crew to downlink any available video. Instead of down-linking the video, the crew reviewed the tape and reported the Mini-Camera tape was blank with just a few prelaunch blips. Initial indications point to a failed cable, and adapter cable connected to a Sony V10 Video Tape Recorder (VTR) on the flight deck between the Audio Video Interface Unit (AVIU) and the video recorder. On FD 10, the crew reported that V10 video looked good with a replacement cable. The old cable was used with another V10 and the crew verified no video. This confirms the problem was due to a bad cable. Post-flight testing confirmed a bad cable.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-09	Humidity Separator Water Carryover	During the FD 6 post sleep period, the crew discovered carryover or unprocessed condensate in the immediate area of the humidity separators in the lower equipment bay. The crew nominally performs visual checks of the humidity separators at least once a day. The humidity separator that was operating at that time was B. The crew towel dried a ball of water having a diameter of about 2 in. The crew was directed to power ON humidity separator A for dual separator operation. On the morning of FD 7, the crew reported about a quarter-size bubble of water on humidity separator B, and towel dried it. Later that afternoon, the crew inspection showed humidity separator A to be dry but the crew had to wipe up a wash-cloth's amount of water from humidity separator B. The humidity separator B was deactivated about 4 hr 28 min later, thereby having humidity separator A perform condensate processing operations. A FD 7 pre-sleep inspection showed dry humidity separators. Subsequent inspections showed dry humidity separators until the pre-sleep inspection on the evening of FD 8, which showed water (about 1 wash cloth) on humidity separator A. The crew activated humidity separator B for dual separator operation after they dried the water. Carryover on humidity separators is the amount of condensate beyond the current capability of the humidity separators to process, which is to send the condensate to the waste tank. However, humidity control is still preserved. The crew performed inspections every pre-sleep and post-sleep period. For the remainder of the flight, the workaround was for the crew to towel dry any carryover discovered during their visual inspections of the humidity separators. The Flash Evaporator System (FES) core flush performed had created a condition of slugging the humidity separators. The humidity levels increased by 26% by the time the core flush was completed thus creating high condensate collection rates on the condensing heat exchanger, which the humidity separator had to process. A second factor that may have contributed to this problem is the accumulation of hydrophilic materials on the pitot collection tube of the humidity separators; with a result of degraded water uptake by the pitot tube which leads to carryover. The hydrophilic coating on the condensing heat exchanger tends to degrade with time and sloughs off the heat exchanger and is washed down to the humidity separators. The FES core flush may have aggravated the accumulation of this hydrophilic coating material in the humidity separator such that the water uptake of the pitot tube is impacted. As a part of the OMRSD, the humidity separator assembly is flushed every flight.
STS-125-V-10	MEDS IDP4 MSU BITE FAIL	Integrated Display Processor (IDP) 4 (S/N 510) annunciated a single "IDP4 BITE FAIL" / "(P)OST SCSI/MSU FAIL IDP4" message during unit power-up on FD 9 and was followed immediately by an "MSU I/O Error" message. The IDP continued to perform nominally thereafter, although the BITE indication recurred on all subsequent unit powerup actions. The Mass Storage Unit (MSU) errors do not affect IDP performance (the MSU is the hard- drive portion of the IDP). This failure signature may indicate either a hard failure of the IDP's MSU or a communication issue between the IDP and MSU on their internal Small Computer System Interface (SCSI) interface. This failure was isolated to the MSU only. Loss of the MSU function has no mission effects. During post-flight power-up at KSC, the BITE indication recurred. The failed IDP as R&R'd.

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STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-11	S-Band Lower Right Quadrant Antenna Intermittent Forward Link Drop-Outs	S-Band Phase Modulation (PM) forward-link dropouts via the Lower Right Quadrant (Forward and Aft) antenna paths occurred intermittently starting at 138/12:49:00 GMT (06/18:46:04 MET). The forward link dropouts occurred with S-Band Communication Strings 1 and 2 and via Tracking and Data Relay Satellites (TDRS's) 171 and 46. When the dropouts occurred, forward-link lock was intermittent for up to 12 min. There appeared to be no correlation to a particular area of either antenna pattern. The dropouts were observed to start and stop on a single lower-right antenna beam and were observed to continue after a switch to the alternate lower-right antenna beam. The intermittent condition resulted in occasional loss of forward link (Air-to-Ground (AG) 1 and 2 audio and commanding). The entry/landing impact was minimal because the Upper Quad Antennas were selected for communication through TDRS during that entry time-period. The most probable cause of the drop outs is an intermittent connection in the coaxial cable path from the Antenna Switch Assembly to the Lower Right Antenna. The Lower Right Quad Antenna path functioned with occasional forward link dropouts that interrupted command and voice to the Orbiter. Post-flight testing found the S-band preamplifier was the cause of the problem. The preamplifier was R&R'd.
STS-125-V-12	Radiator Freon Coolant Loop 1 Trip to Bypass on Auto A	The Freon coolant loop (FCL) 1 Radiator Flow Control Assembly (RFCA) failed to begin radiator flow after the crew initiated deorbit back-out procedures for the Active Thermal Control System (ATCS). The FCL 1 radiators are on the portside of the vehicle. Shortly after the deorbit waveoff was declared, the crew started radiator flow procedures in preparation for payload bay door opening. At 143/12:37 GMT (11/18:35 MET), the crew switched FCL 1 radiator control to Auto A. The FCL 1 RFCA tripped to bypass one min later, thus the RFCA failed to achieve radiator flow. A restart attempt was initiated 3 min later on Auto A and it resulted in a trip to bypass one min later. At 143/12:43 GMT, the FCL 1 RFCA was switched from Auto A to Auto B control. Subsequently, successful flow through the FCL 1 radiators was achieved with radiator mixed outlet temperatures set to high set-point to prevent any cold slug. The FCL 2 radiators (starboard) did not have any problems starting on Auto A controller. The item was closed as a Unexplained Anomaly (UA) with the most probable cause having been an intermittent failure in th controller which was R&R'd.

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IFA Number	Title	Comments
STS-125-V-13	Inertial Measurement Unit (IMU) Fan Differential Pressure Unexplained Increase	The IMU fan Differential Pressure (ΔP) was observed to slowly increase on FD 12, with the first incidence of toggling above the Flight Rule limit of 4.71 psi. In response to the increase, the ground controller requested that the crew check the IMU filters. The crew said all 3 filters were about the same and cleaned them. When no notable improvement (decrease) was noted in the rising ΔP following the filter cleaning, the crew was asked to switch from IMU fan B (powered for the majority of the flight) to IMU fan A. After no notable improvement was observed on IMU A for approximately 65 min, the crew was instructed to power on IMU fan C; and fan A remained powered in parallel with fan C for approximately 3 min, then fan A was powered down. Shortly after the fan A powerdown, the IMU fan ΔP was observed to drop within expected values. IMU fan C remained selected for crew sleep and the remainder of the flight. This item was closed as an explained condition. The measurement is offset high by O.224 in. H_2O (within allowable lime of 3.4%, which caused the flight rule to be exceeded.
STS-125-V-14	TPS Tile Anomalies	A complete listing of the Thermal Protection System (TPS) Tile, Blanket, and RCC Regions of Interest (ROI) evaluated by the Tile and RCC Damage Assessment Teams (DAT's) are documented in the TPS Imagery Inspection Management System (TIIMS) Database located at: http://isal-web1.jsc.nasa.gov/tiims/TIIMS.htm. One TPS item was identified which exceeded pre-defined screening criteria and was entered into the TIIMS Database. This one item that required additional analysis was D-125-ITVC-612-001 - Starboard Chine Damaged Tile. No focused inspection was required based on the imagery data available from the FD 1 and FD 2 surveys/inspections. An additional survey was performed on FD 5 to obtain imagery of approximately 40 tiles on the port forward fuselage, which were not obtained during the FD 2 surveys. This imagery was reviewed and no issues were identified. One additional item was evaluated and presented to the FD 9 OPO. An 18" pad-type gap filler was observed to liberate from the Left OMS Pod at 57 sec MET. The DAT assessed the exposed gap between the rows of tile just forward of the blankets. Based on a bounding gap heating assessment performed for STS-117, the missing gap filler was cleared. **Post-Flight**: Standard post-flight repair. Gap filler was determined to be missing during the post-flight inspection. Assessment of the open gap showed no evidence of over-temperature on the filler bar. Inspection of the cavity revealed only a limited part of the gap filler had indications of bond to the filler bar and only minor tack bonds to the tiles sidewall. A review of the environments that would cause the gap filler to protrude was performed with the result that the primary conductor was acoustic loading. Although this gap filler failed in flight, mitigations to a repeat anomaly were already implemented. Some limited risk still exists on parts that were installed prior to implementation of the 10 pl pull tests.

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STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-V-15	Crew Escape Radio Battery Found with Low Voltage	STS-125 post-flight testing of one 112G battery indicated much lower-than-expected Open Circuit Voltage (OCV) (approximately 2 volts). The failure was initially suspected to be related to pre-flight operator-error which may have caused inadvertent triggering of the bleed-down circuit (i.e., inadvertent short of battery leads). . **Post-Flight:** Bench-top tests successfully recreated the shorted battery failure condition. However, a radio associated with this suspect battery was tested and observed to have a problem with the Global Positioning System (GPS) operation and the Liquid Crystal Display (LCD).
STS-125-V-16	Multifunction Electronic Display System (MEDS) Cathode Ray Tube (CRT) 4 Transient Communications Failure	The MEDS Multifunction Display Unit (MDU) 4 reported “MSG COM 1553B Error”, “MESSAGE 1553B FAIL” and “MEDS I/O Error” in downlist just after main landing gear touchdown. The errors cleared within 3 sec. Prior to crew egress, the crew verified nominal display performance on MDU 4 and annunciation of the message “I/O ERROR CRT4” on the display. After further review of the data, this event actually occurred at Nose Landing Gear (NLG) touchdown. These messages are reported when an MDU is powered off or loses communication with its commanding Integrated Display Processor (IDP). Extensive testing has exonerated the OV-104 vehicle and isolated the failure to the MDU itself. The Problem Resolution Team (PRT) suspects a faulty power bezel switch, but the unit needs to be sent to the vendor for Test, Teardown and Evaluation (TT&E).
STS-125-V-17	FOD Found in Window 5	A Government Furnished Equipment (GFE) Quick Shoe mount knob from a crew work lamp was found wedged between pressure pane no. 5 and console dashboard close-out-panel. The knob was successfully removed without further damage to the pressure pane by chilling the knob while employing mechanical motion and pressurizing the crew compartment. After removal, the pressure pane was inspected per window inspection spec MT0501-514 and 2 damage sites were detected. Mold impressions were taken and the larger of the defects measured 0.00035” deep. After inspecting the pane and the damaged sites, the Micro Inspection Team (MIT) reported that there were no bruises on this pane. To take mold impression of the damaged sites in the most accurate way, a small portion of the Infrared (IR) coating was removed. The area of removed IR coating was accepted as is, and the pressure pane retained its 100-mission life for unrestricted use.

APPENDIX B
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SOLID ROCKET BOOSTER ANOMALIES

No Solid Rocket Booster (SRB) anomalies were identified from the data and analysis of the STS-125 operations.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

REUSABLE SOLID ROCKET MOTOR ANOMALIES

IFA Number	Title	Comments
STS-125-M-001	Missing Stiffener Ring Foam With Discoloration, Stiffener Rings (RSRM- 105B)	During disassembly of the Reusable Solid Rocket Motor (RSRM) -105B motor, several areas of missing stiffener ring foam were observed. In some locations, the discoloration was present on the remaining foam and in areas where the foam was missing. The darkened areas indicate that the foam liberated prior to splash down. This is a first-time observation since return to flight (foam loss was not reportable prior to return to flight). Also observed were areas of what appeared to be separations between the foam and motor case surface in various locations. Initial assessment indicates possibility of ascent material loss. **Post-Flight Activities:** Based upon the following additional information gathered by the investigation team, it has been determined that no suspect anomalous condition exists. The investigation data indicates that the foam loss at the darkened (sooted) areas was a post-separation occurrence based on the following: 1. Ground-based imagery verifies missing foam was intact at mid-ascent burn (approximately 60 sec into ascent). 2. Photos/video show no evidence of foam liberation prior to booster separation. 3. Paint/foam residuals analysis indicates evidence of minor thermal exposure indicative of partial entry heating only. 4. Areas of missing foam do not show heavy foam decomposition deposits. Heavy foam decomposition deposits are indicative of ascent heating. For RSRM-106 and subsequent, the bounding case thermo-structural analysis predicts positive margins through ascent and booster separation. 5. Ascent loads are well defined per azimuth location and motor orientation. 6. Conservative assumptions bound RSRM-105 observations and all future flights a. Assumed full circumference non-bond, 8-in. axial length. b. Successful porta-pull sampling assures assumptions are conservative and bounding. c. Assumed worst-case ascent design loads with superimposed peak loads applied simultaneously. d. Assumed 1/8 in. crack into the foam at both ends of non-bonded area (crack not predicted) 7. Foam loss during entry is a recognized potential (Material and processing on the RSRM-106 and subsequent stiffener ring foam applications have or will have on-motor process verifications. As a result, it has been determined that the foam loss and paint discoloration on RSRM-105 was a post-separation event and future foam loss during ascent is not predicted.

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STS-125 IN-FLIGHT ANOMALIES

SPACE SHUTTLE MAIN ENGINE ANOMALIES

No Space Shuttle Main Engine (SSME) anomalies were identified from the data and analysis of the STS-125 operations.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

EXTERNAL TANK ANOMALIES

No External Tank (ET) anomalies were identified from the data and analysis of the STS-125 operations.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-125-I-001	Unexpected Debris /Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Lift-off Debris)	The Risk Assessment indicates that given the proposed mitigations, observed debris poses no appreciable increase in risk. The lift-off debris risk is currently characterized as infrequent catastrophic due to significant limitations in controls and significant uncertainties in analysis. The expected lift-off debris risk is classified as infrequent catastrophic. Unexpected lift-off debris from KSC Facilities/GSE is transferred and is classified as infrequent catastrophic. Debris release mitigations are identified for potential sources by adding inspections for system-level components (e.g. cable tray covers, grating clips, and unistrut fasteners). Ongoing mitigations include Foreign Object Damage (FOD) awareness, attrition-based removal of hardware, and routine inspections and monitoring for facility corrosion along with applied-corrosion controls. IIFA closure recommends updating NSTS 60559 with revised Risk Assessment Masses for Umbilical Ice at the LH_2 and LO_2 Tail Service Masts (TSM's).
STS-125-I-002	Ice Internal and External to the LH_2 T-0 Umbilical	Prior to launch of STS-125 on 5/11/09, the Final Inspection Team photographs indicated ice/frost build-up at several locations along the outside edge of the peripheral seal on the Z side of the LH_2 T-0 umbilical. The ice formations were estimated to be: 1. A ¼-in. by 5 in. on vehicle only. 2. A ¼ in. by 1.5 in. on vehicle only 3. A 3/8 in. by 3 in. on LH_2 T-0 umbilical seal and vehicle. The size of the ice that crosses onto the vehicle is 1/16 in. by 2 in. A Launch Commit Criteria (LCC) Waiver to ICE documentation was approved by the Mission Management Team (MMT) prior to launch and the LCC violation was cleared. Prior to T-0, the ice/frost formations were noted to be decreasing in size and were not considered a threat to the vehicle. In the event ice/frost is observed external to the peripheral seal on STS-127, the size and mass estimates will be assessed by Element and SE&I personnel and if decided it is not a threat to the vehicle, a LCC ICE-01 Waiver will be written and submitted to the MMT for approval. Post-launch review of the LH_2 T-0 umbilical retraction from camera E-022 revealed ice/frost formations in three locations inside the umbilical cavity. The size of the ice/frost observed both external and internal to the peripheral seal on STS-125 were assessed as being within the worst case size identified on STS-126 interior to the peripheral seal. As a result of external ice being observed at the LH_2 T-0 umbilical during the STS-125 Launch Countdown, the STS-126 Integrated IFA, STS-126-I-002, which addressed ice internal to the peripheral seal at the LH_2 T-0 umbilical, was closed. Integrated IFA STS-125-I-002 was opened to address both external and internal ice.

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IFA Number	Title	Comments
STS-125-I-003	Aerosurface Servo Amplifier-1 (ASA-1) Power Supply Failed	During STS-125, after SSME start and approximately 3.5 sec prior to SRB ignition, numerous analog measurements originating in Multiplexer/Demultiplexers (MDM's) Flight Aft (FA) 1 and Operational Aft (OA) 1 exhibited noise. The Main Bus A (MNA) and Main Bus B (MNB) 28V DC bus currents increased to 14 Amperes (A) and 7 A, respectively. Additionally, current fluctuations and noise continued through T-0 and stopped after 3.7 sec when the data indicates the 26V ac 400 Hertz power supply in ASA 1 failed off, and Aft Power Control Assembly (APCA) -4 MNA Remote Power Controller (RPC) and APCA-5 MNB RPC tripped. The ASA-1 was then in a powered-off state, the ASA-1 Flight Control Channel Fail was annunciated to the crew, and the MDM FA1 and OA1 single-ended analog data values for Orbiter, Main Propulsion System (MPS), SSME, ET, and RSRM returned to nominal readings. The ASA system has four units designed for fail operational, fail safe redundancy, and the system can return safely with two units operating. This is the first failure of an ASA unit in the Space Shuttle Program. All four ASA units in OV-105 have completed tin whisker remediation and passed subsequent Acceptance Test Procedure (ATP) testing. LCC's exist to monitor ASA power to T-31sec and Flight Control System Channel failures are monitored fromT-5 min to T-10 sec. The Wiring Flight Rationale for STS-127 (OV-105) completed a baseline wiring inspection in 2007. Critical functions are generally redundantly wired and powered through physically separated wire bundles. The ASA wire routing has been reviewed and redundant wire runs in the umbilical area will be rerouted through separate clamps. This will comply with the Orbiter critical wire separation effort. The MPS, SSME, ET, RSRM, and Ground Processing Elements have reviewed the affected data channels and evaluated the entire countdown for possible launch scrub and pad abort situations due to Launch Commit Criteria violations. These Elements also considered the effects of similar failures of ASA units 2, 3 or 4, and found similar or reduced effects, primarily loss of redundancy, on the systems. Finally these Elements considered the effects of ASA failures occurring during powered ascent, and concluded the consequences of a single failure would result in loss of redundancy. Generally, the consequence of a second ASA failure would be a next Primary Landing Site (PLS) or launch abort. If multiple ASA's fail and their short-duration noisy data periods overlap, limited circumstances exist that could cause loss of crew and vehicle. Integrated Hazard reports IEPD-01, IFSW-02, IGNC-01, and IEMO-02 were assessed and the appropriate causes, controls, and verifications were reviewed at Shuttle Integration Control Board (SICB). Verification Tracking Log (VTL) entries were made and the Hazard Reports will be assessed for a potential new cause relative to system susceptibility to noise on signal grounds. Recommend single flight Interim Disposition of IIFA STS-125-I-003,Aero-Surface Actuator Servo Amplifier (ASA) 1 Power Loss, for STS-127.This interim disposition is predicated on the continuing investigation on OV-104 to determine the root cause of this anomaly

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STS-125 IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-125-I-004	Missing Stiffener Ring Foam	During the RSRM Post-Flight Assessment (PFA), several crescent-shaped pieces of stiffener ring foam were observed missing from the Right-Hand (RH) forward, center, and aft stiffener rings. These crescent-shaped areas of foam loss occurred at various locations all the way around the forward and center stiffener rings. Several areas of missing foam also showed signs of being heat-affected, indicating that the loss of foam was prior to splash down. The areas of foam loss revealing the highest degree of discoloration were on the side closest to the wing, toward the Orbiter, and forward of the triple Booster Separation Motors (BSMs). The integration concern is for a potential ascent debris liberation and impact to the Space Shuttle Vehicle (SSV). The combined evidence from STS-125 imagery, aerodynamic and thermal loads during different time phases of the trajectory, structural analysis of a bounding case of foam debonding, and thermal analysis of foam and case paint at different heat-flux rates support the conclusion that foam that is debonded at the tack coat for the entire 360-deg circumference of any of the stiffener rings will not liberate on ascent. Foam of these larger masses may possibly liberate starting when the boosters are re-entering the atmosphere on descent (from around T+280 sec), and continuing to possibly be liberated through splashdown. There is no expected increase in risk of debris liberation on ascent due to debonded tack coat of RSRM stiffener ring foam. This Integrated IFA STS-125-I-004 can be closed based on evidence that the loss of foam is not likely to occur on ascent and low likelihood of impact to Orbiter if a piece could be liberated.

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IFA Number	Title	Comments
STS-125-I-005	Debris Event at 104 Sec MET	ET foam debris was seen at approximately 104.3 sec MET (imagery camera-view SRA 110) impacting the Orbiter starboard Chine area and continued aft passing under the starboard wing with no additional contact with the vehicle. In addition, both Wing Leading Edge Impact Detection System (WLEIDS) and NDR observations confirm the impact. Orbiter Debris Assessment Team (DAT) reviewed the damage and cleared the Orbiter TPS for entry. Initial analysis indicates that the foam was released from the ET Infrared (IFA) Xt718 with an imagery and ET mass assessment of 0.007 lbm. Other IFR locations were considered, however, Imagery reveals that the foam debris originates forward of the Intertank. To confirm the release location a Debris Transport Analysis (DTA) was performed for STS-125 IFRs for Xt 404, 439, 594 and 718 at 105 sec MET. This analysis exonerates the IFR 404, 439 and 594 locations. In addition, Orbiter performed a reconstruction analysis with the FOAM Rapid Response Damage Model (mass, velocity and incident angle). These results complement the DTA by confirming the mass being with in 0.004 to 0.007 lbm, velocity approxi8mately 1500 ft/sec and an incident angle of approximately 7deg. The STS-125 event changes the currently accepted debris risk by increasing the likelihood for a larger release based on recent flight experience. The risk annotated in IDBR-01 is based on the ET foam debris cloud which is dominated by smaller releases at the beginning of the Void/DP failure mechanism with the potential of large masses being released later. However, a foam release of up to 0.020 lbm mass could be liberated any time during Void/DP. Therefore, a higher program risk and a suggestion to a heightened awareness is warranted. Debris Integration Group plans to revisit this risk after STS-127. A Safety Issue Briefing was presented at the PRCB and is no constraint to flight (The conditional PRA supports a Remote/Catastrophic risk acceptance). Recommend Interim closure for one flight.
STS-125-I-006	Gap Filler Releases From Port OMS Pod	At approximately 57.0 MET, a pillow gap-filler on the forward section of the port OMS POD was observed moving and finally liberated. The Pillow gap-filler debris was seen falling aft of vehicle during ascent with no observation of any contact to the vehicle. Pillow gap-filler liberation is considered unexpected debris. Therefore, no pillow gap-filler allowable is annotated in NSTS 60559. On STS-126, 3 gap fillers protruded on the Left OMS Pod and remained intact to wheels stop. An Orbiter IFA (STS-126-V-01) investigation revealed minimal Room Temperature Vulcanizing (RTV) application/contact to the bonding surface. The PRT identified process improvements to ensure full-length bonding and evaluated an increase to the pull-test requirements from 4 to 10 lb. However, the liberated gap filler was installed prior to the new process. Inspections performed on OV-105 in support of STS-127 resulted in protruding gap fillers noted in the same area as the one liberated on STS-125. Consequently, all gap fillers in the area have been inspected, and, if required, removed and re-installed in accordance with the improved process, including the more robust pull test of 10 lb. In addition, documentation has been written to address the liberated gap filler, which is tracked under Orbiter IFA STS-125-V-14.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

No Flight Operations and Integration anomalies were identified from the STS-125 data.

APPENDIX B
STS-125 IN-FLIGHT ANOMALIES

MISSION OPERATIONS ANOMALIES

No anomalies were identified in this area for STS-125.

APPENDIX C

STS-125 DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-125 MER Daily Reports by Malise Fletcher, Lead MER Manager:

Launch and First Daily Report, dated May 11, 2009
Second Daily Report, dated May 12, 2009
Third Daily Report, dated May 13, 2009
Fourth Daily Report, dated May 14, 2009
Fifth Daily Report, dated May 15, 2009
Sixth Daily Report, dated May 16, 2009
Seventh Daily Report, dated May 17, 2009
Eighth Daily Report, dated May 18, 2009
Ninth Daily Report, dated May 19, 2009
Tenth Daily Report, dated May 20, 2009
Eleventh Daily Report, dated May 21, 2009
Twelfth Daily Report, dated May 22, 2009
Thirteenth Daily Report, dated May 23, 2009
Fourteenth Daily Report, dated May 24, 2009
Landing Plus 2 Hour Report, dated May 24, 2009
Mission Summary Report, dated May 31, 2009

ET/SRB/RSRM/SSME REPORTS

STS-125 Anomalies, David W. Morr, USA-Huntsville, June 8, 2009
STS-125 MSFC Console Flash Report, Dino Diluigi, USA-Huntsville, May 11, 2009
STS-125 RSRM Flash Report, Larry Manuel, ATK, May 11, 2009
STS-125 ET Impact Point, David W. Morr, USA-Huntsville, June 5, 2009

ORBITER REPORTS

STS-125 Consolidated Landing Report, Lonnie W. Jenkins, Boeing-Houston, May 24, 2009
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STS-125 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
A	Ampere
AA	Accelerometer Assembly
ABS	Ammonia Boiler System
ACAS	Automatic Command Auto Sequence
ACS	Advanced Camera for Surveys
ACS-R	Advanced Camera for Surveys-Repair
AG	Air-to-Ground
ADTA	Air Data Transducer Assembly
AGT	Adaptive Guidance Throttling
AHMS	Advanced Health Monitoring System
AMOS	Air Force Maui Optical Supercomputing Site
APCA	Aft Power Control Assembly
APU	Auxiliary Power Unit
ARPCS	Atmospheric Revitalization Pressure Control System
ASA	Aerosurface Servo Actuator
ASIPE	Axial Science Instrument Protective Cover
ASLR	Aft Shroud Door Latch Repair
ATCS	Active Thermal Control System
AVIU	Audio Visual Interface Unit
BAPS	Berthing and Positioning System
BFS	Backup Flight System
BITE	Built-In Test Equipment
BLT	Boundary Layer Transition
CBC	Cargo Bay Camera
CCD	Charged Coupled Device
CDT	Central Daylight Time
C&W	Caution and Warning
COMM	Communications
COS	Cosmic Origins Spectrograph
COSTAR	Corrective Optics Space Telescope Axial Replacement
CPM	Cell Performance Monitor
CRT	Cathode Ray Tube
CSCS	Contingency Shuttle Crew Support
CWC	Contingency Water Container
D & C	Display and Control
DAT	Debris Assessment Team
DCS	Debris Containment System
DDU	Data Display Unit

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Acronym/ Abbreviation	Explanation
DMHS	Dome Mounted Heat Shield
DOLILU	Day of Launch I-Load Update
DPS	Data Processing System
DTA	Debris Transport Analysis
DTO	Development Test Objective
∆P	Differential Pressure
∆V	Differential Velocity/Differential Voltage
EAFB	Edwards Air Force Base
ECLSS	Environmental Control and Life Support System
ECO	Engine Cut-off
E	East
EDAS	Enhanced Data Acquisition System
EDT	Eastern Daylight Time
EE	End Effector
EHIP	EVA Helmet Interchangeable Portable Light
EI	Entry Interface
ELOG	
EMU	Extravehicular Mobility Unit
EO	External Tank/Orbiter
EPDC	Electrical Power Distribution and Control
ET	External Tank
EV	Extravehicular (Crewmember)
EVA	Extravehicular Activity
FCE	Flight Crew Equipment
FCL	Freon Coolant Loop
FCMS	Fuel Cell Monitoring System
FCP	Fastener Capture Plate
FCS	Flight Control System
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection and Annunciation
FES	Flash Evaporator System
FF	Flight Forward
FGS	Fine Guidance Sensor
FID	Failure Identifier
FN	Flight Night
FOD	Foreign Object Damage
FOM	Figure of Merit

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STS-125 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
FPCA	Forward Power Control Assembly
FSS	Fixed Service Structure/Flight Support System
FSW	Flight Software
GCA	Ground Carrier Assembly
GFE	Government Furnished Equipment
GH_2	Gaseous Hydrogen
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GN_2	Gaseous Nitrogen
GO_2/GOX	Gaseous Oxygen
GPC	General Purpose Computer
GPS	Global Positioning System
Grms	Gravity root mean square
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GUCP	Ground Umbilical Carrier Plate
HDP	Holddown Post
HPFTP	High Pressure Fuel Turbopump
HPOTP	High Pressure Oxidizer Turbopump
HRC	High Resolution Camera
HST	Hubble Space Telescope
HUD	Heads-up Display
HX	Heat Exchanger
HYD	Hydraulic
IAT	Image Analysis Team
IBA	Inspection Boom Assembly
ICBC/ICBC-3D	IMAX Cargo Bay Camera-3 Dimension
IDC	ISIS Digital Camera
IDP	Integrated Display Processor
IDS	Impact Detection System
IFA	In-Flight Anomaly
IFR	Ice Frost Ramp
IMU	Inertial Measurement Unit
I/O	Input/Output
IPT	Intelligent Pressure Transducer
ISIS	Integrated Sensor Inspection System
ISS	International Space Station
keas	knots estimated air speed

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Acronym/ Abbreviation	Explanation
KSC	Kennedy Space Center
L	Launch
LCC	Launch Commit Criteria
LCD	Liquid Crystal Display
LDRI	Laser Dynamic Range Imager
LGA	Low Gain Antenna
LGAP	Low Gain Antenna Protective (Cover)
LH	Left Hand
LH_2	Liquid Hydrogen
LO_2	Liquid Oxygen
LOB	Left Outboard
LOCK	Latch Over-Center Kit
LiOH	Lithium Hydroxide
LP	Left Pod/Launch Package
MAGR	Miniature Air-to-Ground Receiver
MAUI	Maui Analysis of Upper Atmospheric Modification
MADS	Modular Auxiliary Data System
Max Q	Maximum Dynamic Pressure
MC	Midcourse Correction
MCC	Mission Control Center
MDM	Multiplexer/Demultiplexer
MDU	Multifunction Display Unit
MEB	Main Electronics Box
MECO	Main Engine Cutoff
MEDS	Multifunction Electronics Display System
MET	Mission Elapsed Time
MFR	Manipulator Foot Restraint
MLG	Main Landing Gear
MLI	Multi-Layer Insulation
MLP	Main Launch Platform
MLS	Microwave Landing System
MM	Momentum Manager/Major Mode
MM/OD	MicroMeteoroid/Orbital Debris
MMT	Mission Management Team
MNB	Main Bus B
MPC	Mid Power Controller
MPCA	Mid Power Control Assembly

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Acronym/ Abbreviation	Explanation
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MRL	Manipulator Retention Latch
MSU	Mass Storage Unit
MTU	Master Timing Unit
MULE	Multi-Use Lightweight Equipment
N_2	Nitrogen
NASA	National Aeronautics and Space Administration
NAVAID	Navigation Aids
NC	Nominal Correction
NCC	Nominal Correction Combination
NE	Northeast
NH	Nominal Height
NLP	National Laboratory Pathfinder
NOBL	New Outer Blanket Layer
NPRV	Negative Pressure Relief Valve
NSTS	National Space Transportation System
O_2	Oxygen
OA	Orbit Adjust (Maneuver)
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
OCV	Open Circuit Voltage
ODRC	Orbiter Data Reduction Center
ODS	Orbiter Docking System
OE	Operations Exception
OFS	Onboard Fault Summary (Message)
OI	Operational Instrumentation
OMDP	Orbiter Maintenance Down Period
OME	Orbiter Maneuvering Engine
OML	Outer Mold Line
OMRSD	Operational Maintenance and Requirements Specification Document
OMS	Orbital Maneuvering System
OPO	Orbiter Project Office
OPT	Operation Pressure Transducer
ORUC	Orbital Replacement Unit Carrier
ORGA	Orbiter Rate Gyro Assembly

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STS-125 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
OV	Orbiter Vehicle
PAO	Public Affairs Office
PASS	Primary Avionics Software System
PCM	Pulse Code Modulation
PCMMU	PCM Master Unit
PCS	Pressure Control System
PDI	Payload Data Interleaver
PDU	Power Drive Unit
PGME	Propylene Glycol Monomethyl Ether
PI	Payload Interrogator
PIE	Payload Interface Equipment
PLB	Payload Bay
PLBD	Payload Bay Door
PM	Phase Modulation
PMBT	Propellant Mean Bulk Temperature
$PPCO_2$	Partial Pressure Carbon Dioxide
PRSD	Power Reactant Storage and Distribution System
PRT	Problem Resolution Team
PSIG	Propellant Systems Integration Group
PV&D	Purge, Vent and Drain
QD	Quick Disconnect
R&R	Remove and Replace
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RFCA	Radiator Flow Control Assembly
RH	Right Hand
RHC	Rotational Hand Controller
RJD	Reaction Jet Driver
RM	Redundancy Management
RMS	Remote Manipulator System
RNS	Relative Navigation System
ROE	Right Outboard Elevon
RP	Right Pod
RPC	Remote Power Controller
RPM	R-Bar Pitch Maneuver
RSB	Rudder Speed Brake
RSRM	Reusable Solid Rocket Motor

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STS-125 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
RSS	Range Safety System
RSU	Rate Sensor Unit
RTV	Room Temperature Vulcanizing (material)
S	South
S&A	Safe and Arm
SDBI	Short Duration Bioastronautics Investigation
SCM	Soft Capture Mechanism
SDFS	Smoke Detection and Fire Suppression
SE	Southeast
SE&I	Systems Engineering and Integration
SEITE	Shuttle Engine Ion Turbulence Experiment
SIC&DH	Science Instrument Command and Data Handling (Unit)
SLIC	Super Lightweight Interchangeable Carrier
SLWT	Super Lightweight Tank
SM	Servicing Mission
SMRD	Spin Motor Rotation Detector
S/N	Serial Number
SRB	Solid Rocket Booster
SRGA	SRB Rate Gryo Assembly
SRSS	Shuttle Range Safety System
SSE	Space Support Equipment/Solar System Exploration
SSM	Space Support System
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSV	Space Shuttle Vehicle
ST	Star Tracker
STBD	Starboard
STIS	Space Telescope Imaging Spectrograph
STS	Space Transportation System
SW	Southwest
SWMMS	Supply Water and Waste Management System
TACAN	Tactical Air Navigation System
TCS	Thermal Control System/Trajectory Control Sensor
TDRSS	Tracking and Data Relay Satellite System
THC	Translation Hand Controller
TI	Terminal Phase Initiation/Transfer Initiation
TMBU	Table Maintenance Block Update

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Acronym Abbreviation	Explanation
T-0	Time of Lift-off
TPS	Thermal Protection System
TSM	Tail Service Mast
TVC	Thrust Vector Controller
V	Volt/Voltage
VAFB	Vandenberg Air Force Base
VDT	Vehicle Data Table
W	West
WFC	Wide Field Camera
WFPC	Wide Field Planetary Camera
WLE	Wing Leading Edge
WLEIDS	Wing Leading Edge Impact Detection System
WSB	Water Spray Boiler
WSIPC	Wide Field Camera Scientific Instrument Protective Cover

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STS-125 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Unit of Measure	Explanation
^{o}F	degree Fahrenheit
deg	degree
deg/sec	degree per second
ft	feet
ft/sec	feet per second
Grms	gravity root mean square
Hz	Hertz
hr	hour
In.	inch
Kbps	kilobits per second
keas	knots estimated air speed
kgs	knots ground speed
kW	Kilowatt
kWh	Kilowatt hour
lb_m/lbm	pound mass
lb/min	pound per minute
min	minute
mmHg	Millimeters of Mercury
mph	miles per hour
mV	milliVolt
nmi	nautical mile
%	percent
%/min	percent per minute
psi	pound per square inch
psia	pound per square inch absolute
scim	standard cubic inch per minute
sec	second
Vdc	Volt direct current