

# **STS-117 SPACE SHUTTLE MISSION REPORT**

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January 2008



**National Aeronautics and  
Space Administration**

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

## NOTE

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**STS-117**  
**SPACE SHUTTLE MISSION REPORT**

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# STS-117 SPACE SHUTTLE MISSION REPORT

## INTRODUCTION

The Space Transportation System (STS) -117 Space Shuttle Mission Report presents a discussion of the Orbiter activities on the mission, as well as a summary of the External Tank (ET), the Solid Rocket Booster (SRB), the Reusable Solid Rocket Motor (RSRM) and the Space Shuttle Main Engine (SSME) performance during the 118th mission of the Space Shuttle Program. The purpose of this mission, designated as Flight 13A, was to deliver and install International Space Station (ISS) assembly hardware, and deliver critical supplies and cargo to the ISS.

STS-117 was the 5th mission since the return to flight following the STS-107 mission, and the 21st to the ISS. STS-117 was also the 28th flight of the *Atlantis* vehicle.

The flight vehicle consisted of the OV-104 Orbiter; the ET, a super lightweight tank (SLWT) designated ET-124; three Block II SSMEs that were designated as serial numbers (S/Ns) 2059, 2052, and 2057 in positions 1,2, and 3, respectively; and two SRBs that were designated BI-129. The two RSRMs were designated flight set RSRM-96. The individual RSRMs were S/N 360W096A (left) and S/N 360W096B (right). Launch pad 39A and Mobile Launch Platform (MLP) -2 were used as the platform for launch of the STS-117 mission.

The primary objectives of the STS-117 mission were as follows:

1. Perform a crew rotation, replacing Expedition 14 Flight Engineer 2 with Expedition 15 Flight Engineer 2 and transfer mandatory crew rotation cargo.
2. Deliver and install the Integrated Truss Segment (ITS) Starboard 3/Starboard 4 (S3/S4) onto ITS S1.
3. Activate the ITS S3/S4 systems.
4. Perform three Extravehicular Activities (EVA's) to permanently attach and activate the S3/S4 ITS, reconfigure P6 for survival power and retract the P6 Starboard Solar Array Wing (SAW), to configure/activate the Starboard SARJ, and to enable the Mobile Transporter (MT) to be moved to workstation 1.
5. Transfer mandatory quantities of water as well as other critical items to the ISS.

During the mission, difficulties in retracting and stowing the P6 SAW resulted in the addition of a fourth EVA.

All times during the flight are given in Greenwich Mean Time (GMT) and The STS-117 mission was planned to be a 12-day plus 2-contingency-day flight. Two

additional docked days were approved during the flight by the Mission Management Team (MMT) to allow for the additional EVA to repair the port OMS pod blanket, and ensure that the six Russian computers were back on line and operating satisfactorily.

mission elapsed time (MET). Appendix A contains the sequence of events. Appendix B provides a table containing all Orbiter, SRB, ET, and Integration in-flight anomalies (IFAs) and their status at the time of the publication of this report. Appendix C provides a list of sources of data, both formal and informal, that were used in the preparation of this report. Appendix D provides a list of acronyms, abbreviations and definitions as used throughout this report.

The eight crewmembers (seven up, seven down) that were on the STS-117 flight were Frederick W. "Rick" Sturckow, Colonel, U. S. Marine Corps, Commander; Lee Joseph Archambault, Colonel, U. S. Air Force, Pilot; Patrick G. Forrester, Colonel, U. S. Army , etired, Mission Specialist 1; Steven R. Swanson, Ph. D, Civilian, Mission Specialist 2; John D. Olivas, Ph. D., P. E., Civilian, Mission Specialist 3; James F. Reilly, Ph. D. Civilian, Mission Specialist 4; Clayton C. Anderson, Civilian, ISS Flight Engineer (up to ISS); and Sunita Williams, CDR, U. S. Navy, ISS Flight Engineer (down from ISS).

STS-117 was the third Shuttle flight for Commander and Mission Specialist 4, second flight for the Mission Specialist 1 and ISS Flight Engineer 2 (down), and the first flight for the Pilot, Mission Specialist 2, Mission Specialist 3, and ISS Flight Engineer 2 (up).

## **MISSION SUMMARY**

### **Prelaunch**

The Space Shuttle vehicle (SSV) was damaged by hail during a severe thunderstorm on February 26, 2007, at Pad A. The assessment performed at the launch pad on the External Tank (ET) identified Thermal Protection System (TPS) damage from the liquid oxygen tank ogive to the aft interface hardware. The damage was in all quadrants of the ET. The payload was removed from the payload bay and stored in the Payload Changeout Room (PCR) and the vehicle was returned to the Vehicle Assembly Building (VAB) to adequately assess the damage and make repairs on the SSV.

The damage assessment to the Orbiter TPS was 27 tile indications on the left wing, based on a macro inspection at the pad. Although there were no visual indications of Reinforced Carbon-Carbon (RCC) panel damage, additional inspections were completed with no damage found.

To manage the large number of damage sites, a database was created to track the progress based on an ET grid system, and a sampling plan was implemented to characterize and guide the disposition development. Repairs began on March 8. Three repair methods were employed based on the severity of the damage; sand and blend, Polymer Development Laboratories (PDL) consisting of pouring small foam amounts into voids and (BX) foam spray covering large damaged areas. Test panels were developed and used in support of the repair validation testing conducted in support of the flight rationale. The flight rationale was presented and accepted by the Space Shuttle Program prior to roll out to Pad A.

### **Ascent and Flight Day 1**

The STS-117 mission was launched at 159/23:38:04.012 GMT on June 8, 2007. All Orbiter subsystems performed nominally during ascent and post-insertion with the exception of the Multiplexer/Demultiplexer (MDM) item discussed in a following paragraph.

Solid Rocket Booster (SRB) and External Tank (ET) separation were clearly visible from the ET camera. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 159/23:40:17.517 GMT [00/00:02:13.505 Mission Elapsed Time (MET)], and the maneuver was 170.40 sec in duration.

Main engine cutoff (MECO) occurred at 159/23:46:29.145 GMT (00/00:08:25.133 MET). The ET separated from the Orbiter at 159/23:46:50.147 GMT (00/00:08:46.135 MET).

A nominal OMS-2 maneuver was performed at 160/00:16:34. GMT (00/00:38:30.488 MET). The maneuver was 63.6 sec in duration with a differential velocity ( $\Delta V$ ) of 96.7 ft/sec. The achieved orbit was 85.1 by 124.7 nmi.

The payload bay doors were opened at 160/01:18:14 GMT (00/01:40:10 GMT) and radiator flow was established satisfactorily.

Multiplexer/Demultiplexer (MDM) Flight Aft (FA) 4 experienced an analog/digital Built-In Test Equipment (BITE) on card 14 during ascent (IFA STS-117-V-01). Only one measurement [Main Propulsion System (MPS) Engine 3 Liquid Hydrogen (LH<sub>2</sub>) Inlet Pressure] was affected, and this condition did not impact the ascent nor did it impact the remainder of the mission. During post-flight troubleshooting, a failed engine 3 transducer was discovered and replaced.

The forward bulkhead floodlight failed to illuminate when activated. This problem was noted during pre-flight activities and flown without repair due the ground processing impact for special access needs to reach the area. There was no effect on any mission objectives.

During the post-ascent survey on FD 1, the crew reported that a blanket on the port Orbiter Maneuvering System (OMS) pod was turned-up and extended upward about 4 to 5 in (IFA STS-117-V-02). The crew photographed the area of damage and the downlinked the images were provided to the Damage Assessment Team (DAT) for assessment.

## **Flight Day 2**

During Flight Day (FD) 2 the Flight Control Team reported that the Ku-Band was experiencing periods of data dropouts. An investigation of this condition was initiated.

The OMS-3 (NC-2) maneuver was a dual-engine OMS firing with an ignition time of 160/16:40:44 GMT (00/17:02:40 MET), a firing time was 26.10 sec, a  $\Delta V$  of 39.5 ft/sec, and resulting orbit was 99.1 by 130.0 nmi. Engine performance was nominal.

The crew performed the TPS wing leading edge (WLE) (port and starboard) and nose-cap survey to check for ascent-debris damage. The Shuttle Remote Manipulator System (SRMS) unberthed the Orbiter Boom Sensor System (OBSS) for the FD 2 vehicle-inspection surveys. The nose-cap survey was completed at 160/21:29 GMT (00/21:51 MET) and the port-wing survey was completed at 160/23:19 GMT (00/23:41 MET). An operator-commanded auto sequence (OCAS) was performed to view the damaged OMS pod blanket and the viewing was completed at 161/00:17 GMT (01/00:39 MET). SRMS/OBSS performance was nominal throughout the surveys. The OBSS was berthed, and the SRMS was parked in the Pre-Cradle position with the brakes on.

The OMS-4 (NC-3) maneuver was a dual-engine OMS firing with an ignition time of 161/01:09:49 GMT (01/01:31:45 MET) with a firing time of 93.08 sec with a  $\Delta V$  of 143.8 ft/sec. The resulting orbit was 129.0 by 180.2 nmi. Thruster performance was nominal.

The Orbiter Docking System (ODS) was activated at 161/01:46:37 GMT (001/02:08:33 MET) and the ODS was deactivated after the avionics power-on time was 8 min, 36 sec. Ring extension to the initial position was nominal, beginning at 161/01:50:41 GMT (001/02:12:37 MET) and ended after 3 min, 39 sec (dual motor time). The ODS ring extension activity was nominal. The ODS checkout and preparations for docking were completed satisfactorily.

The performance of the Trajectory Control Sensor (TCS) in support of the Rendezvous Tools Checkout was nominal. The TCS was powered on at 161/02:15 GMT (01/02:37 MET) and passed its self test. The TCS was powered off 20 min later and the Rendezvous Tools Checkout was completed satisfactorily.

### **Flight Day 3**

At the start of FD 3, a dual-engine OMS-5 NC-4 maneuver was performed with an ignition time of 161/15:27:28.117 GMT (01/15:49:24.105 MET). The firing duration was 51.6 sec with a  $\Delta V$  of 80.3 ft/sec. The resulting orbit was 174.0 by 179.7 nmi. Engine performance was nominal.

The NCC maneuver was a multi-axis Reaction Control System (RCS) firing with an ignition time of 161/16:02:58 GMT (01/16:24:54 MET). The firing duration was 6.8 sec with a  $\Delta V$  of 1.0 ft/sec. The resulting orbit was 174.0 by 179.7 nmi.

The Transfer Initiation (TI) maneuver was a straight-feed, left OMS engine firing with an ignition time of 161/17:00:37.317 GMT (01/17:22:33.305 MET). The firing duration was 12.2 sec with a  $\Delta V$  of 9.8 ft/sec. The resulting orbit was 178.5 by 182.1 nmi. Engine performance was nominal.

No mid-course correction (MC) 1 or Out-of-Plane Null maneuvers were required. MC-2 was a -X RCS maneuver with an ignition time of 161/17:50:41 GMT (01/18:12:37 MET). The firing duration was 7.5 sec with a  $\Delta V$  of 9.82 ft/sec. MC-3 was a multi-axis RCS maneuver. The ignition was at 161/18:07:39 GMT (01/18:29:35 MET), and the  $\Delta V$  delivered was 0.47 ft/sec. The maneuver duration was 1.9 sec and the Orbiter was in a 178.3 by 181.6 nmi orbit. MC-4 was a 9.3-sec +X RCS maneuver, and the ignition was at 161/18:17:54 GMT (01/18:39:49 MET). The  $\Delta V$  delivered was 2.1 ft/sec, and the Orbiter was in a 178.3 by 181.7 nmi orbit.

The R-Bar Pitch Maneuver (RPM) started at 161/18:34:52 GMT (01/18:56:48 MET) and ended 9 min 11 sec later. The peak pitch rate was approximately 0.69 deg/sec during the maneuver. The maximum roll error reached approximately 7.0 deg. Performance was nominal.

The ODS was activated at 161/19:01:26 GMT (01/20:23:22 MET) and was deactivated after the avionics had operated for 54 min, 22 sec. Shuttle's capture of the ISS occurred at 161/19:36:11 GMT (01/19:58:07 MET). Ring-drive-in began at 161/19:40:13 GMT (01/20:02:09 MET), and ran for approximately 6 sec. The system was stopped and allowed to dampen out for approximately 118 sec. In accordance with the normal procedure, a ring-drive-out command was given beginning 1 min 56 sec later, and operated for 7 sec during which time any stuck dampers were cleared. No stuck dampers were observed prior to ring retraction. The final ring-drive-in command was issued at 161/19:42:17 GMT (01/20:04:13 MET). Ring retraction, using dual motors, proceeded nominally for approximately 3 min, 18 sec with good ring alignment. The hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the ring final-position being acquired at approximately 161/19:49:34 GMT (01/20:11:30 MET), at which time docking operations were complete.

The SRMS unberthed the S3/S4 Truss Segment at 161/22:12 GMT (01/22:34 MET) and handed it off to the Space Station Remote Manipulator System (SSRMS) for overnight parking. The SRMS was then maneuvered to the 1A/3A Solar Array Wing (SAW) viewing position.

The Leading Edge Structure System (LESS) Problem Resolution Team (PRT) cleared the RCC for the mission. The TPS PRT was still analyzing the port OMS upturned blanket and a tadpole-gap-filler protruding at the arrowhead to clear those conditions for the mission. The Focused Inspection requirements meeting was held and it was determined that no requirement existed for a FD5 focused inspection. However, the possibility of a focused inspection on FD7 remained open to allow for completion of all data review and analysis.

A normal fuel cell purge was performed earlier than planned because of performance degradation. Fuel cell 1 showed slightly more degradation than the other two fuel cells and as a result, the purge was performed.

#### **Flight Day 4**

All planned EVA tasks were completed on 6 hr 15 min first EVA. The main task of this EVA was installing and preparing the S3/S4 Solar Array Wing (SAW) for deployment. In addition, an EVA 2 get-ahead task was completed. This task removed the SVS Target on S3 to aid in clearing the path for the Mobile Transporter (MT) translation.

The RPM data review was completed by the Damage Assessment Team (DAT) and all TPS tile and RCC were cleared for the mission except for two protruding gap fillers and one tile area near the outboard edge of the port ET door. One of these gap fillers was near the arrowhead tile directly aft of the nose landing gear door and the other was on an aft tile forward of the body flap. Aerothermal analysis including the possible tripped flow downstream of these gap fillers was a continuing effort. Based on the data analysis, the team did not believe that any gap filler removal was required. Additionally, there was one area where adequate data were not obtained on the aft portion of the right-inboard elevon. The area had shadows that obscured areas of interest, and an additional imagery request was being considered. Parametric analysis was also being conducted for this area.

The aero-thermal analysis for the port OMS pod was discussed by the Mission Management Team (MMT) and indications were that the entry thermal environment inside the exposed cavity would result in localized temperatures that exceeded the OMS pod graphite-epoxy structure-certification limits. The heating was predicted to be slightly higher in this area than on past flights with similar damage because the blanket extended up into the flow, and thus resulting in increased heat transfer into this cavity. The flow in this area was very difficult to model, thus certain best estimate engineering assumptions were applied to accurately model the heating in addition to using a lower surface model not designed for this area. Based on the thermal analysis and the limited test data available for this type of graphite composite structure, the MMT decided to consider the TPS suspect for this area, and that the blanket would require a repair performed during an EVA. To accommodate the EVA, the docked mission period was extended two additional days.

During crew sleep, a Operational Aft (OA) 2 MDM BITE failure was annunciated at 163/07:54:44 GMT (03/08:16:40 MET) (IFA STS-117-V-03). The crew was awakened by the alarm. The failure resulted in a loss of discrete instrumentation parameters on Card 5. There were no mission duration impacts for this failure nor did it adversely affect any operations. A power cycle of this MDM was not performed because it did not affect critical instrumentation and would have resulted in a power cycle of the two remaining OA MDM's. The team began assessing the instrumentation loss impacts for FCS checkout and the entry phase.

## **Flight Day 5**

The TPS tiles around window 5/6 and the Port ET Door were cleared. The final analysis for the protruding gap fillers continued during FD 5. Additionally, assessments of the right inboard elevon tile that was obscured by shadows as well as the aft fuselage gap filler continued.

The DAT continued its effort regarding thermal analysis and material testing for the torn blanket and underlying graphite epoxy structure on the port OMS pod. A detailed test plan was submitted for the Arc Jet Facility and the Radiant Heat Facility testing with graphite epoxy panels, and also for a blanket pull-test to assist in development of the Extravehicular Activity (EVA) repair technique.

The MMT was briefed on the different blanket repair options which included using the Nichrome pins from the TPS overlay repair kit, staples from the medical kit stapler, or the EVA servicing kit needle with 22-gauge wire to secure the blanket. A decision on whether the repair would be performed during the third or fourth EVA was delayed until the next MMT meeting.

## **Flight Day 6**

The second EVA was completed satisfactorily in 7 hr and 16 min. EVA 2 began with both crewmembers translating to the P6 SAW to assist in retracting the 2B Solar Array. The original time planned for the retraction activity was 1 hr 15 min. However, the task was extended to 2 hr 15 min because of successful corrections being made to the back-folded Flat Connector Circuits (FCC) and grommet hang-ups. All remaining launch locks on the S3 SARJ were removed, and then the torque was broken on three of the SARJ launch restraints. The removal of all of the launch restraints was not completed because of the extended length of the 2B Solar Array retraction assistance task as well as the loads constraints levied by the inability to engage DLA 2 that was installed on EVA 1.

All TPS tiles, blankets and gap fillers were cleared for entry with the exception of a section of the right inboard elevon tile. Because the imagery of the elevon was partially obscured by shadows during the RPM when photography of the vehicle was taken, the DAT could not conclusively clear this section of tile.

A major activity was the planning and developing of procedures for the repair of the port OMS blanket. The MMT decided that the Port OMS pod blanket repair would be performed during the third EVA on Flight Day 8. The repair option selected used the Nichrome pins from the TPS overlay repair kit and staples from the medical kit stapler to secure the blanket.

In parallel with the OMS pod blanket repair procedure development, the ISS had problems providing attitude control other than from the Control Moment Gyroscopes (CMGs) due to problems with the computers in the Russian Segment that control the ISS thrusters. Should the ISS CMGs become saturated, attitude control would have been transferred to the Orbiter RCS thrusters. Without the Russian computers to control ISS thrusters, transferring back to the ISS for attitude control would be compromised. To minimize attitude transients, Orbiter water dumps were delayed to at least FD 9. In addition,

methods to increase the cryogenic consumables margin to allow for an extra docked day that may be required were evaluated.

### **Flight Day 7**

The procedure to secure the port OMS pod blanket using the Nichrome pins from the TPS overlay repair kit and staples from the medical kit stapler were sent to the crew for their review.

The blanket pull-test was completed which provided high confidence that the pins and staples would secure the blanket throughout the entry environment. Also, Wind Tunnel testing at Texas A&M University and Arc Jet and Radiant Heat tests using the repaired configuration were being performed.

ISS troubleshooting of Russian computer problems continued. Non-essential systems on the Orbiter were being powered down to increase the cryogenic consumables margin to allow for an extra docked day should it be required. The ISS CMG's continued to maintain the ISS attitude without the use of the Orbiter RCS.

### **Flight Day 8**

The crew's main task was the third EVA during which all modified objectives for that EVA were completed. The duration of the EVA was 7 hr 58 min. The procedure to secure the port OMS pod blanket using the Nichrome pins and medical kit staples was completed successfully during the EVA.

Troubleshooting of Russian computers continued. Four of the six computers had been operating for over 16 hr, but thruster control of the ISS attitude with the Russian thrusters was still inhibited. The ISS CMG's continued to maintain the ISS attitude. To minimize attitude transients, Orbiter water dumps were delayed until after the Orbiter hatches were closed. In addition, equipment on the Orbiter was powered down to increase the cryogenic consumables margin.

### **Flight Day 9**

The crew's main task was preparations for the fourth EVA, which consisted primarily of the tasks originally scheduled for the third EVA. The fourth EVA, which was added during the mission, and the duration of the EVA was 6 hr 29 min. All of the various planned tasks for this EVA were completed.

The Damage Assessment Team completed their analysis and cleared all Thermal TPS tiles, blankets, and gap fillers, including the repair of the left OMS pod blanket.

ISS Troubleshooting of Russian computers continued, and thruster control of the ISS attitude with the Russian thrusters was available, if needed. The ISS CMG's continued to maintain the ISS attitude without the use of the Russian thrusters or the RCS. Additional equipment on the Orbiter was powered down to increase the cryogenic consumables margin.

### **Flight Day 10**

Two new problems were identified, neither of which impacted the mission. The crew reported a minor leak at the Mineral/Silver Biocide injection port on the water transfer hose while filling Contingency Water Container (CWC) (IFA STS-117-V-05). The crew also reported a buzzing interference noise coming from the Annunciator Control Assembly (ACA) that was believed coupled into a speaker circuit on the flight deck behind panel A6 (IFA STS-117-V-10).

ISS Troubleshooting of the Russian computers continued.

### **Flight Day 11**

All planned transfers were completed and the hatches between the ISS and the Orbiter were closed at 170/00:00:07 GMT (10/00:22:53 MET).

The RCS was used to control attitude during an Orbiter water dump. After the water dump was completed, Russian control of the ISS attitude was successfully tested. Attitude control was then returned to the ISS CMG's. The Orbiter continued in the partial power-down mode to maintain the additional weather day.

During ET digital camera image review, evaluations showed that six of the twenty-nine digital umbilical camera images downlinked on FD 1 had varying degrees of horizontal "tearing" or bands of corruption (IFA STS-117-V-07). The multiple available overlapping images of the ET still allowed adequate image analysis of ET TPS.

### **Flight Day 12**

Undocking occurred at 170/14:42 GMT (10/15:04 MET). The Orbiter Docking System (ODS) performed satisfactorily.

After undocking, a fly-around (1-lap) was initiated with +X pulse at 170/15:12:25 GMT (10/15:37:21 MET) and was completed in approximately 48 min. The Separation 1 maneuver was an RCS firing and was a 5.2-sec +X pulse at 170/16:00:19 GMT (10/16:22:15 MET). The Separation 2 maneuver was performed at 170/16:28:27 GMT (10/16:50:23 MET). This firing was a 3.9-sec -X RCS maneuver. The Nominal Correction (NC) 5 maneuver was performed at 171/00:23:05 GMT (11/00:55:01 MET). The firing was a 2.6-sec multi-axis RCS

firing. The  $\Delta V$  was 0.7 ft/sec and the Orbiter was in a 184.9 nmi by 178 nmi orbit following the maneuver.

The Micrometeoroid Orbital Debris (MMOD) late inspection of the port, starboard, and nose-cap RCC was successfully completed. The OBSS was berthed and latched at 170/23:22 GMT (10/23:44 MET). The RMS was cradled and latched at 170/23:52 GMT (11/00:14 MET). All of the inspection data were downlinked for review by the DAT. An additional tadpole protruding gap filler was identified in the RCC panel 21L area and it was later cleared by the Damage Assessment Team.

During the late inspection operations, the crew reported a loss of camera data displayed on monitor 2 (IFA STS-117-V-08). The crew also reported flickering and loud buzzing on monitor 1, but the monitor later recovered with no crew action (IFA STS-117-V-09).

### **Flight Day 13**

The Flight Control System (FCS) checkout was performed with no anomalies. Auxiliary Power Unit (APU) 1 was used for the checkout and the APU ran for 6 min 52 sec. All Navigation Aids including the Microwave Scanning Beam Landing System (MSBLS) 3, performed satisfactorily during the FCS checkout. As a result of the OA2 Card 5 failure, the Primary Avionics Software System (PASS) System Management (SM) affected systems including the OMS, RCS, APU, Hydraulics (HYD) and the Thermal Control System (TCS) with a loss of insight, but no loss of function. The Backup Flight System (BFS) bypassed all of OA2 MDM parameters because of the Card 5 failure, and as a result, the system-monitoring functions for Orbiter systems including Fault Detection and Annunciation were impacted. The panel F7 Caution and Warning (C&W) was used to provide additional insight into the affected Orbiter systems.

The RCS hot-fire was initiated at 171/15:04:03 GMT (11/15:25:59 MET) and completed 8 min later. All 38 RCS thrusters were fired at least twice for at least 0.24 sec on each pulse.

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

### **Flight Day 14**

The Payload Bay Doors (PLBDs) were closed nominally at 172/14:38:00 GMT (12/14:59:56 MET) in preparation for landing. Both landing opportunities at Kennedy Space Center (KSC) on the planned landing day were waived because of unacceptable weather conditions. The PLBD's were reopened at 172/17:44 GMT (12/18:06 MET).

An orbit adjust maneuver was performed to enable an earlier Edwards Air Force Base (EAFB) landing on subsequent landing days. The firing was a 54.3-sec +X RCS firing with ignition occurring at 172/20:46:05 GMT (13/03:08:01 MET). The  $\Delta V$  was 14.8 ft/sec and the Orbiter was placed in a 178.8 by 192.7 nmi orbit following the maneuver.

During cabin deorbit preparation activities, the crew reported that the middeck floodlight no. 6 switch (S6) was stuck in the OFF position. The switch had no impact to the mission and entry activities.

## **Flight Day 15**

The PLBDs were closed again nominally at 173/14:38:00 GMT (13/14:57:12 MET) in preparation for landing on the second landing day. Both landing opportunities at KSC on the second landing day were waived because of unacceptable weather conditions, and the decision was made to land at EAFB on the first opportunity at that site.

The deorbit maneuver was performed on orbit 219 for the first landing opportunity at EAFB, a dual-engine straight-feed firing, was performed at 173/18:43:46.557 GMT (13/19:05:42.545 MET). The duration of the deorbit firing was 153.6 sec and the  $\Delta V$  was 295.6 ft/sec. The orbit following the deorbit firing was 193.8 by 23.4 nmi.

Entry interface occurred at 173/19:18:13 GMT (13/19:40:09 MET), and entry was completed satisfactorily. The main landing gear touchdown occurred on EAFB concrete runway 22 at 173/19:49:38 GMT (13/22:09:34 MET) on June 22, 2007. The drag chute was deployed at 173/19:49:40 GMT. Nose-gear touchdown occurred at 173/19:49:49 GMT. Drag chute release occurred at 173/19:50:18 GMT. Wheels stop occurred at 173/19:50:51 GMT. The rollout was normal in all respects. The last APU was shutdown at 173/20:07:57 GMT (18 min 19 sec after landing). All post landing operations were nominal.

The STS-117 flight duration was 13 days 22 hr 9 min 34 sec.

## **PAYLOADS AND EXPERIMENTS**

### **SUMMARY AND ACCOMPLISHMENTS**

All of the ISS 13A mission objectives were successfully accomplished during this mission.

The ISS 13A launch package consisted of the S3/S4 Integrated Truss Segment (ITS) with the S4 Photovoltaic (PV) module containing the Photovoltaic Radiator (PVR), two Beta-Gimbal/PV array assemblies, two Beta Gimbal Transition Structures (BGTS) and one Integrated Equipment Assembly (IEA), and associated cabling. This cargo element also included six battery sets, four Payload Attachment Systems (PAS), the Alpha Joint Interface Structure (AJIS), and the Solar Array Rotating Joint (SARJ).

Two Department of Defense payloads of opportunity were manifested and these were the Ram Burn Observation (RAMBO), and the Maui Analysis of Upper-Atmospheric Injections (MAUI).

The Development Test Objectives (DTO's) and Development Secondary Objectives (DSO's) assigned to STS-117 were:

1. DTO 805 – Crosswind Landing Performance.
2. DTO 1200-U – Shuttle Booster Fan Bypass.
3. DTO 13005-U – Structural Life Verification and Extension for Dedicated Thruster Firing.
4. DTO 13005-U – Structural Life Validation and Extension for S3/S4 Installation.
5. DTO 15003-U – Microgravity Environment Definition for Orbiter Ergometer Exercise.
6. DTO 15003-U – Microgravity Environment Definition for SARJ Checkout.
7. DSO 498 – Space Flight and Immune Function (Pre-flight and Post-flight only).
8. Short Duration Bioastronautics Investigation (SDBI) 1503-S – Midodrine.

The Orbiter Project Office's assessment of the OMS Pod Thermal Protection System (TPS) blanket led the Space Shuttle Program (SSP) Mission Management Team (MMT) to declare the Orbiter TPS suspect for contingency de-orbit situations in accordance with the Flight Rules. Subsequently, the MMT added two mission-extension days and a fourth Extravehicular Activity (EVA) to accomplish the TPS blanket repair and remaining mission objectives. The MMT also decided to perform the repair to the blanket on the third EVA.

As a result of the loss of attitude control discussed in following paragraphs, the Orbiter powered down many of the systems, which provided two additional days, thus making it possible to change the nominal mission duration from 11+2+2 days to 13+0+2 days without impacting the cryogenic margin.

## **CREW ACTIVITIES**

After docking on FD 3, the Shuttle Remote Manipulator System (SRMS) unberthed the S3/S4 Truss Segment and handed the segment off to the Space Station Remote Manipulator System (SSRMS). The S3/S4 truss was placed in an overnight parked position in preparation for the first EVA on FD 4.

During the FD 4 robotic S3/S4 installation, the ISS Momentum Manager (MM) reached 100-percent saturation while handing-over attitude control from the US Thruster Only (USTO) to the MM, and this resulted in loss of attitude control. This delayed the completion of the S3/S4 installation for over an hour. The Orbiter took over attitude control of the International Space Station (ISS)/Orbiter stack and handed it back over to USTO and finally back to MM. The Intravehicular (IVA) crew, using the SSRMS, maneuvered the S3/S4 truss into the position for latching and bolting into place. As soon as 3 of the 4 truss bolts were tightened, the SSRMS released the S3/S4 truss. After releasing the truss, the SSRMS was maneuvered into the pre-deploy survey position, where it provided video of the S3/S4 Solar Array Wing (SAW) deployment operations, after which the fourth bolt was successfully torqued down.

During FD 5 IVA operations, a Russian Service Module Terminal Computer (SMTC) failed, leaving the Orbiter in attitude control for the ISS/Shuttle stack. As a result of this configuration, the ISS solar arrays were no longer allowed to autotrack, resulting in Caution and Warning alarms for low US battery-charge levels. Ground controllers were able to manage the arrays and the power loads until the SMTC was re-enabled (Russian SMTC anomaly resolution is under the Significant ISS Anomalies section). Subsequently, during the handover of attitude control from the Orbiter back to ISS Control Moment Gyroscope (CMG) momentum management, the CMG momentum levels quickly saturated and the mated stack experienced a loss of attitude control. Attitude control was immediately handed back to the Orbiter. A second loss of attitude control of the mated stack occurred when the ISS CMG's saturated because of high momentum levels. Mated-stack attitude-control was handed back to the Orbiter. The ISS CMG MM was successfully regained later in the mission.

Atlantis was undocked from the ISS on FD 12, June 19 at 9:42 a.m. Central Standard Time (CST) [10/15:04 Mission Elapsed Time (MET)].

## **TRANSFER WEIGHT SUMMARY**

Orbiter consumables transferred to the ISS during the mission were satisfactory. The transfers included:

1. **Water** – A total of 16 Contingency Water Containers (CWC's) and 5 Portable Water Reservoirs (PWR's) were transferred during the mission. (1656 lb<sub>m</sub>)
2. **Oxygen** – A total of 107 lb<sub>m</sub> was transferred to ISS airlock high pressure gas tanks; however, 18 lb<sub>m</sub> was used during the third EVA, leaving a total of 89 lb<sub>m</sub> for ISS use.
3. **Nitrogen** – A total of 17.3 lb<sub>m</sub> of nitrogen were transferred to the ISS Airlock tanks for a total usable amount of 16 lb<sub>m</sub> for ISS stack repressurization.
4. **LiOH** – a total of 6 Lithium Hydroxide (LiOH) canisters were transferred to the ISS.

### **SIGNIFICANT FIRSTS**

The significant firsts for the STS-117 mission were as follows:

1. The first flight of the redesigned Low Pressure Fuel Turbopump (LPFTP) duct no. 8 flow-meter that was flown on Space Shuttle Main Engine (SSME) 2059.
2. The first flight of three Advanced Health Management System (AHMS) controllers (two controllers were operating in the monitor-only mode, and one controller was operating in the redline-active mode).
3. The first flight of SSME 2059.
4. The first flight of Engine Cut-off (ECO) Sensor System Instrumentation for measuring SSME voltage.
5. The first flight on Pad A since modifications/refurbishments following STS-107.

### **SIGNIFICANT ISS ANOMALIES**

In accordance with the Mission Control Center-Moscow (MCC-M) direction, the ISS crew performed a cable bypass of a power-supply switch in two Service Module Central Computers (SMCC's) and two Service Module Terminal Computers (SMTC's). Several restart attempts of the Russian Service Module computers were then performed, successfully recovering two SMCC's and two SMTC's. The ground controllers configured the computers to remain powered and in a test/diagnostic mode. The Russians had already requested the return of two computers that are not online for assessment (SMCC lane 1 and SMTC lane 2), and therefore, those computers were not part of the bypass/ restart activities.

After the Russian crew and specialists completed the computer troubleshooting, one lane (1) of the Service Module (SM) Central Computer remained up and available. All lanes of the SM Terminal Computer had power applied, but none of the lanes were available for normal operations. To return to a stable

configuration, the lane 1 computer was deactivated, and two SM were activated. Although the SM computers were only operational for a short time, ground teams were able to cycle power to the FGB Multiplexer/ Demultiplexer (MDM) to connect it to the SM, which allowed them to activate one American-to-Russian Converter Unit (ARCU 51) to feed power to the Functional Energy Block (FGB) systems. As a result, the United States On-orbit Segment (USOS) power to the FGB and Soyuz was restored. The Soyuz was able to go on FGB power, and the Soyuz prime battery was recharged.

To verify the satisfactory recovery and operation of the SM computers, the following paragraphs discuss the activities that were successfully performed. Based on these activities, the ISS MMT made the decision that the ISS was ready for the Space Shuttle undocking:

1. The starboard SARJ checkout: was successfully performed in two phases. The first phase of the checkout included moving the SARJ 5 degrees and holding, then moving back 5 degrees to the original position. This test verified the US CMG MM attitude management capacity during minor SARJ rotation. The second phase of the SARJ checkout included transitioning the SARJ to auto-track while in US CMG attitude control.
2. Mated-stack attitude-control was transitioned to the Orbiter for the planned water dump. After the water dump, attitude control was transitioned back to the Russian Segment (RS) for a 54-min attitude-hold test using Russian thrusters. Attitude control was then transitioned from the RS to the USTO for approximately 45 min prior to switching back to US CMG control. US CMG control remained stable.
3. The SSRMS was maneuvered into a double-grappled configuration on the Mobile Base System (MBS) and was subsequently powered down with the arm's logical base changed to MBS Power and Data Grapple Fixture (PDGF)
- 4.

## MAJOR ISS MISSION PRIORITIES

The following table provides a listing of all the ISS Mission priorities that were completed.

### MAJOR ISS MISSION PRIORITIES COMPLETED

| Mission priority        | Mission Task                                                                                                               | Method(s)         | Completed |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------|-------------------|-----------|
| <b>Category 1 Tasks</b> |                                                                                                                            |                   |           |
| 1                       | Inspect Orbiter TPS including focused inspections                                                                          | IVA/SRMS/<br>OBSS | FD 2      |
| 2                       | Rendezvous, perform Orbiter tile inspection using ISS imagery during the R-bar Pitch Maneuver (RPM) and dock with the ISS. | IVA               | FD 3      |

## MAJOR ISS MISSION PRIORITIES COMPLETED (Continued)

| Mission priority        | Mission Task                                                                                                                                                                                                                                                                                                                                                             | Method(s)  | Completed      |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------------|
| 3                       | Rotate Expedition 14/15 Flight Engineer 2 with Expedition 15/16 Flight Engineer 2, transfer mandatory crew rotation cargo per flight 12A.1 Transfer Priority List (TPL) (in the Flight Rules annex), and perform mandatory tasks consisting of Individual Equipment Liner Kit (IELK) install, Sokol suit checkout and the safety briefing, and the crew safety handover. | IVA        | FD 4           |
| 4A                      | Install S3 to S1 and all four bolts fully tight. Connect all cables and umbilicals, and activate S3/S4 for minimum survival.                                                                                                                                                                                                                                             | EVA<br>IVA | FD 4           |
| 5                       | Complete S3/S4 installation.                                                                                                                                                                                                                                                                                                                                             | EVA        | FD 4 – FD 11   |
| 6                       | Transfer maximum amount of Shuttle O <sub>2</sub> , as available, to ISS to replenish ISS airlock tanks (16 CWC's and 5 PWR's)                                                                                                                                                                                                                                           | IVA        | FD 11          |
| 7                       | Transfer and stow critical items                                                                                                                                                                                                                                                                                                                                         | IVA        | Completed      |
| <b>Category 2 Tasks</b> |                                                                                                                                                                                                                                                                                                                                                                          |            |                |
| 8                       | Configure and deploy S4 Photovoltaic Radiator and activate S4 active thermal system                                                                                                                                                                                                                                                                                      | IVA<br>EVA | FD 4           |
| 9                       | Charge Channel 1A and 3A batteries within 8 days of launch                                                                                                                                                                                                                                                                                                               | Ground     | Completed      |
| 10A                     | Position and lock S4 Beta Gimbals for S4 SAW deployment                                                                                                                                                                                                                                                                                                                  | ISS-IVA    | FD 5           |
| 10B                     | Maneuver to required attitude and thermal condition S4 SAW                                                                                                                                                                                                                                                                                                               | ISS-IVA    | FD 5           |
| 10C                     | Deploy S4 1A and 3A SAW's                                                                                                                                                                                                                                                                                                                                                | ISS-IVA    | FD 5           |
| 11                      | Re-configure P6 for survival power and retract P6 starboard SAW                                                                                                                                                                                                                                                                                                          | IVA-EVA    | FD 8           |
| 12                      | Configure/activate starboard SARJ                                                                                                                                                                                                                                                                                                                                        | EVA        | FD 11          |
| 12A and B               | Install 4 of 4 Alpha Joint Interface Structure Struts and Install 4 SARJ Brace Beams                                                                                                                                                                                                                                                                                     | EVA        | FD 4           |
| 12C                     | Engage pinion gears for both starboard drive lock assemblies                                                                                                                                                                                                                                                                                                             | EVA        | FD 4 and FD 6  |
| 12D and 12E             | Remove Launch Locks and Launch Restraints                                                                                                                                                                                                                                                                                                                                | EVA        | FD 4 and FD 10 |
| 13                      | Verify 1A and 3A SAW positioning capability for docking and undocking activities                                                                                                                                                                                                                                                                                         | IVA        | FD 4           |
| 14                      | Perform full rotation checkout of SARJ                                                                                                                                                                                                                                                                                                                                   | IVA        | FD 11          |
| 15                      | Configure ISS for post S3/S4 installation; begin S4 Beta Gimbal tracking and nominal starboard SARJ tracking. Configure nominal power distribution and accept S4 power                                                                                                                                                                                                   | IVA        | FD 11          |
| 16                      | Replace Synchronization and Control Unit                                                                                                                                                                                                                                                                                                                                 | IVA        | FD 3           |
| 17                      | Perform crew handover of 12 hr including crew safety handover                                                                                                                                                                                                                                                                                                            | IVA        | FD9            |

## MAJOR ISS MISSION PRIORITIES COMPLETED (Concluded)

| Mission priority        | Mission Task                                                                                                                                                                                                              | Method(s) | Completed          |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------|
| 18                      | Transfer remaining items                                                                                                                                                                                                  | IVA       | FD I9 and FD 11    |
| 19                      | Perform EVA tasks to enable Mobile Transporter (MT) translation to MSS Worksite 1. These include removing S3 Keel and Drag Link, S3 Space Vision System Target, Install S3 MT temporary stop and stow S1 MT stop.         | EVA       | FD 10              |
| <b>Category 3 Tasks</b> |                                                                                                                                                                                                                           |           |                    |
| 20                      | Perform EVA task to modify existing Laboratory condensate water vent to hydrogen vent. Remove water vent nozzle and install hydrogen vent nozzle, and perform hydrogen vent line leak check and open hydrogen vent valve. | EVA       | FD 8               |
| 21                      | Perform USOS/RS daily ISS payload status checks                                                                                                                                                                           | IVA       | FD 11              |
| 22                      | Perform full functional checkout of S3/Bay 2 MT Worksite 1                                                                                                                                                                | IVA       | FD 11              |
| 23                      | Perform EVA Get-Ahead tasks as designated by Ground established priorities (List of activities will be provided by Mission Manager).                                                                                      | EVA       | FD 4 through FD 11 |

## **VEHICLE PERFORMANCE**

### **LAUNCH DELAY**

On February 26, 2007, a hail storm passed over the launch pad as the vehicle was being prepared for launch. The storm left the External Tank (ET) with more than 4,000 damage sites and the Orbiter with minor damage to approximately 26 heat shield tiles on the left wing. The launch was delayed from March 15 to June 8. Repairs to Atlantis and ET were completed May 11 in the NASA Kennedy Space Center (KSC) Vehicle Assembly Building.

### **SOLID ROCKET BOOSTERS**

All Solid Rocket Booster (SRB) systems performed as expected during launch countdown and ascent of STS-117. The SRB pre-launch countdown was nominal and no SRB IFAs were identified. No SRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) waivers or exceptions were written during the countdown. No SRB LCC or OMRSD violations occurred.

Both SRBs were successfully separated from the ET and reports from the recovery area indicate that the deceleration subsystem performed as designed. Recovery ships report the boosters in the water at 6.7 nmi and 6.4 nmi away. Recovery operations were successful in returning the SRB's to KSC for disassembly and inspection.

There was no indication of stud hang-ups from the Orbiter accelerometers.

### **REUSABLE SOLID ROCKET MOTORS**

The Reusable Solid Rocket Motors (RSRM's) performed nominally with no violations of the RSRM LCC or OMRSD during the STS-117 mission. Data indicate that the flight performance of both RSRMs was well within the allowable performance envelopes and typical of the performance observed on previous flights. One in-flight anomaly was identified during the disassembly of the RSRM.

All Ground Environmental Instrumentation (GEI) and Operational Flight Instrumentation (OFI) performed within established requirements. The power plant that provides electricity to KSC experienced a wide area power failure the evening of June 7, 2007. The net result of this condition was that some of the recorded data was not transmitted in real time due to the interruption in the NASA router connection to the T1 internet line locally. Communications were not re-established until after the joint heater activation time, but previous to the start of ET tanking.

All available data was recorded, transmitted (total dataset after the launch), and analyzed without incident. Some of the Field Effect Transistor (FET) flash report inputs had to be evaluated manually as opposed to using the automated programs since heater activation times were not recorded. It was determined that all sensors operated as expected. No significant hardware problems or weather concerns occurred during the successful countdown.

The ambient temperatures recorded during the 78 hr prior to launch of STS-117 varied from 77 to 82 °F. The data recorded during this time frame was at the  $\pm 1.0\sigma$  range from historical June average hourly temperatures. At the time of launch, the ambient temperature was 78 °F. The average historical ambient temperature for the time of launch for the month of June is 79 °F.

Igniter joint heaters operated for 14 hr 22 min during the launch countdown. Power was applied to the heating elements 40-percent (average) of the time during the LCC time frame of the countdown to keep the igniter joints in their normal operating range.

Field joint heaters operated for 14 hr 31 min during the launch countdown. Power was applied to the heating elements 26-percent (average) of the time during the LCC time frame of the countdown.

The aft skirt purge was activated twice during the countdown for a total of 7 hr 47 min. It was necessary to thermally condition the aft skirt region prior to launch to achieve the nozzle/case joint seals minimum LCC temperature of 75 °F. It was not necessary to thermally condition the flex bearings to meet the 60 °F mean bulk temperature requirement.

During the LCC time frame, the left- and right-hand motor nozzle/case joint sensor temperatures ranged from 77 to 86 °F and 77 to 87 °F, respectively. The Flex Bearing Mean Bulk Temperature (FBMBT) was calculated to be 81 °F.

The motor performance parameters for motor set 360W096 were within Contract End Item (CEI) specification limits. Reconstructed performance parameters were adjusted to a 60 °F.

#### RSRM PERFORMANCE PARAMETERS AT 60 °F PMBT

| Parameter                       | CEI specification limit, 60 °F | Left motor delivered | Right motor delivered |
|---------------------------------|--------------------------------|----------------------|-----------------------|
| Web time, sec                   | 105.4 – 116.7                  | 110.5                | 110.4                 |
| Action time, sec                | 115.2 – 131.2                  | 122.6                | 122.9                 |
| Head end pressure, psia         | 847.9 – 965.7                  | 907.8                | 910.8                 |
| Maximum Sea Level Thrust, Mlbf  | 2.88 – 3.26                    | 305                  | 306                   |
| Web Time Average Pressure, psia | 629.9 – 700.5                  | 665.7                | 667.3                 |

|                                    |               |         |         |
|------------------------------------|---------------|---------|---------|
| Web Time Average Thrust, Mlbf      | 2.46 – 2.74   | 2.61    | 2.61    |
| Web time total impulse, Mlbf sec   | 285.8 – 291.6 | 288.1   | 288.3   |
| Action time impulse, Mlbf sec      | 293.7 – 299.7 | 296.4   | 296.6   |
| ISP average delivered, lbf sec/lbm | 266.5 – 270.3 | 268.4   | 268.5   |
| Loaded propellant weight, lbm      | >1103750      | 1105161 | 1105133 |

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

Propellant Mean Bulk Temperature (PMBT) standard are listed in the following table. Propulsion performance is listed in the subsequent table. The calculated PMBT was 79 °F at time of launch. The maximum trace shape variation of pressure vs. time during the 62-80 sec time frame was calculated to be 1.3 percent at 72.0 sec (left motor) and 0.64 percent at 68.0 sec (right motor). These values were within the 3.2-percent allowable limits.

### RSRM PROPULSION PERFORMANCE

| Parameter                                           | Left motor, 79 °F |        | Right motor, 79 °F |        |
|-----------------------------------------------------|-------------------|--------|--------------------|--------|
|                                                     | Predicted         | Actual | Predicted          | Actual |
| Impulse gates                                       |                   |        |                    |        |
| I-20, 10 <sup>6</sup> lbf-sec                       | 66.02             | 65.57  | 66.11              | 65.86  |
| I-60, 10 <sup>6</sup> lbf-sec                       | 176.48            | 175.47 | 176.67             | 175.93 |
| I-AT, 10 <sup>6</sup> lbf-sec                       | 296.86            | 296.81 | 296.86             | 296.98 |
| Vacuum Isp, lbf-sec/lbm                             | 268.6             | 268.6  | 268.6              | 268.7  |
| Burn rate, in./sec @ 60 °F at 625 psia              | 0.3692            | 0.3685 | 0.3695             | 0.3689 |
| Event times, sec <sup>a</sup>                       |                   |        |                    |        |
| Ignition interval                                   | 0.232             | N/A    | 0.232              | N/A    |
| Web time <sup>b</sup>                               | 108.1             | 108.4  | 108.0              | 108.2  |
| 50 psia cue time                                    | 118.1             | 118.7  | 118.0              | 118.2  |
| Action time <sup>b</sup>                            | 120.3             | 121.2  | 120.1              | 120.5  |
| Separation command                                  | 122.5             |        | 122.5              |        |
| PMBT, °F                                            | 79                | 79     | 79                 | 79     |
| Maximum ignition rise rate, psia/10 ms              | 90.8              | N/A    | 90.8               | N/A    |
| Decay time, sec (59.4 psia to 85 K)                 | 3.1               | 3.3    | 3.1                | 3.1    |
| Tailoff impulse imbalance differential <sup>c</sup> | Predicted<br>N/A  |        | Actual<br>355.1    |        |

<sup>a</sup>All times are referenced to ignition command time except where noted by footnote b.

<sup>b</sup>Referenced to liftoff time (ignition interval).

<sup>c</sup>Impulse imbalance = integral of the absolute value of the left motor thrust minus right motor thrust from web time to action time.

Distinct and non-distinct gas penetrations in the Room Temperature Vulcanizing (RTV) material were found around the full circumference of Joint 2 on both RSRM nozzles (IFA STS-117-M-001). This recurring observation for most flight

and static test motors has now been identified as an anomaly. Gas penetration through Joint 2 RTV is not consistent with the original design intent, but is not unexpected based on the accumulated flight experience. This phenomenon and each occurrence are carefully evaluated for any challenge to flight rationale and level of risk assessment.

## EXTERNAL TANK

All ET objectives and requirements associated with propellant loading and flight operations were met during the STS-117 ascent. No significant oxygen or hydrogen concentrations were detected in the intertank. All ET electrical equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly. No ET LCC or OMRSD violations occurred. Two in-flight anomalies were identified from the post-launch camera and film review, and the anomalies are discussed in a following paragraph.

This was the first flight of the following design changes:

1. New ET LO<sub>2</sub> feedline camera system electronics package due to vendor change
2. BX-265 on LH<sub>2</sub> tank cover plate (internal to Intertank).

Less than typical ice/frost was observed for most of the vehicle during the Final Inspection Team (FIT) Survey. ET surface temperatures ranged from 66 to 85 ° F. ET acreage showed no anomalies and no bondline ice/frost was observed in the hail damage repair areas. All ice/frost formations were within NSTS 08303, "Ice/Debris Inspection Criteria." No LCC or OMRSD violations conditions were reported.

ET separation was nominal. Main Engine Cutoff (MECO) occurred within expected tolerances and as a result, entry and breakup was within the predicted footprint at 36.383 deg South latitude and 158.478 deg West longitude.

The ET Camera footage revealed one area of TPS loss at 134.5 sec Mission Elapsed Time (MET) from the LH<sub>2</sub> acreage at Station 1160, directly aft of the +Y bipod fitting (IFA STS-117-T-001). It appears that the piece of liberated LH<sub>2</sub> acreage foam may have impacted the LO<sub>2</sub> feedline breaking into one large piece and another smaller piece. There does not appear to be any collateral damage observed on the LO<sub>2</sub> feedline from this event in the Orbiter umbilical photographs. The total volume of the debris loss was estimated to be approximately 13.98 in<sup>3</sup>. Additional discussion of this anomaly is presented in Appendix B under External Tank Anomalies.

Post-launch review and analysis of ascent photography also showed a loss of LH<sub>2</sub> acreage foam at stations 1623 and 1871 adjacent to the inboard LO<sub>2</sub> feedline support brackets (IFA STS-117-T-002). The dimensions of the foam loss at station 1623 were 8.1 in length by 4.05 in width by 0.5 in diameter. The mass of the loss was 0.012 lb, and the event occurred at 369 sec MET. The dimensions of the foam loss at station 1871 were 6.6 in length by 6.02 in width by 0.5 in depth. The mass of the foam loss was 0.011 lb, and the event occurred at 403 sec MET. Both of these losses were within NSTS 60559 requirements for LH<sub>2</sub> acreage foam loss for MET's later than 135 sec. Additional discussion of this anomaly is presented in Appendix B under External Tank Anomalies.

## **SPACE SHUTTLE MAIN ENGINES**

All Space Shuttle Main Engine (SSME) parameters were nominal throughout the pre-launch countdown and were typical of previous flights. There were no LCC or OMRSD violations. Engine "Ready" was achieved at the proper time, all LCC's were met, and thrust build-up was nominal. Flight data indicate nominal SSME performance during startup, mainstage, throttling, and shutdown for the STS-117 mission. The High Pressure Oxidizer Turbo Pump (HPOTP) and High Pressure Fuel Turbo Pump (HPFTP) temperatures were well within specifications throughout engine operation. Commanded Max Q throttle-down was a one-step throttle to 72 percent. No SSME-related Failure Identifiers (FIDs) occurred during the countdown and launch.

First flight design changes are as follows:

1. Low Pressure Oxidizer Turbo Pump (LPOTP) Inducer, Leading Edge Cutback  
Design (SSME-2052 only).
2. Fuel Flowmeter Redesign (SSME-2059 only).

In addition, STS -117 is the first flight with the Advanced Health Monitoring System (AHMS) controller in redline-active mode on SSME 3 with SSME 1 and SSME 2 in monitor mode. Initial review of STS-117 AHMS vibration measurements indicates nominal performance. All accelerometer measurements appear healthy.

The average SSME specific impulse tag value was 452.3 seconds at 104.5-percent power level.

## **SHUTTLE RANGE SAFETY SYSTEM**

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the STS-117 launch countdown. There were no OMRSD or LCC violations.

All SRSS Safe and Arm (S&A) devices were armed and system inhibits turned off at the appropriate times. As planned, the SRB safe and arm devices were safed and SRB system power was turned off prior to SRB separation.

## **MAIN LAUNCH PLATFORM**

A potential lift-off debris source was identified in the imagery provided by camera 35. The imagery showed that the down-spout on the side-1 relief line, below the porch on the Mobile Launch Platform (MLP), had a spider-guide out of configuration. The concern was that the spider guide would be a potential debris source. The STS-117 Final Inspection Team pictures of the spider guide showed the guide was secured by one bolt that was mounted flush. After reviewing the STS-115 photography, this spider guide was also out of configuration during that launch. The Liftoff Debris Team provided an engineering assessment concluding this condition was not a constraint to flight.

# ORBITER SYSTEMS

## Main Propulsion System

The Main Propulsion System (MPS) performed satisfactorily and there were no LCC or OMRSD violations during the STS-117 launch and ascent. Data from the prelaunch, operations, MECO, post-MECO and entry/landing events revealed no anomalous valve movements. All timings were within the required specifications and within the current historical database.

The overall  $\text{GH}_2$  system in-flight performance was nominal. All three flow control valves performed nominally. The cycle count for SSME 1 was 30 cycles; SSME 2 - 26 cycles; and SSME 3 - 33 cycles.

The  $\text{GO}_2$  fixed orifice pressurization system performed as predicted. Reconstructed data from engine and MPS parameters closely matched the actual ET ullage pressure measurements.

Helium system performance for the SSME and pneumatic Helium (He) systems was nominal. Entry helium usage was 56.6 lbm which is within the requirements. All other parameters were nominal.

During the pre-flight checkout, the  $\text{LO}_2$  Engine Cutoff (ECO) sensor no. 2 indicated DRY for one data period (0.2 sec) before changing to the expected WET indication. This is an explained condition. When the simulated commands are sent, the resistance changes from infinite to 66.5 ohms over a small but finite period of time. If the data are sampled when the resistance is between approximately 74 and 350 ohms, the dry indication will be reported.

At approximately 3.5 min MET, the SSME 3  $\text{LH}_2$  inlet pressure went off-scale-high (IFA STS-117-V-01), which caused an analog/digital (A/D) Built-In Test Equipment (BITE) on Flight Aft 3 (FA3) Multiplexer/Demultiplexer (MDM) card 14. A BITE-status read was performed and all other parameters associated with card 14 appeared to be correct. During post-flight ground tests, the anomaly was reproduced.

At 163/07:54:43.73 GMT (03/08:16:39 MET), a MDM OA2 fault message was annunciated and the failure caused MPS to lose insight to three indications during entry (IFA STS-117-V-03). Card 5 of the MDM with 3 MPS channels were found to be affected; however, the loss of these parameters did not affect or impact entry operations. As a result, MDM OA2 card 5 was declared failed since the data were invalid.

## Hazardous Gas Concentrations

The aft hazardous gas concentrations during the STS-117 loading for launch were nominal and are shown in the following table.

### HAZARD GAS CONCENTRATIONS

| Launch    |           |                   |
|-----------|-----------|-------------------|
| Parameter | Peak, ppm | Steady State, ppm |
| Helium    | 10759     | 8724              |
| Hydrogen  | 136       | 22                |
| Oxygen    | 17        | 11                |
| LD54/55   | 2200/2200 | 16/0              |

## Gas Sample Analysis

All six redesigned gas sampler system bottles functioned as expected. All measured pressures were within the range of acceptable pressures established by the Propulsion Systems Integration Group (PSIG) Subcommittee in March 1995. A summary of the Right Hand (RH) and Left Hand (LH) bottle pressure and gas concentration for STS-117 is given in following table.

### SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

| Bottle no. | Position | Pressure, psia | Helium, % | Measured Oxygen, % | Hydrogen, % |
|------------|----------|----------------|-----------|--------------------|-------------|
| 1          | RH 1     | 2.60           | 1.56      | 1.86               | <0.01       |
| 2          | LH 1     | 1.39           | 0.51      | 2.07               | 0.05        |
| 3          | RH 2     | 1.25           | 1.13      | 1.94               | 0.07        |
| 4          | LH 2     | 0.78           | 0.56      | 3.34               | 0.12        |
| 5          | LH 3     | 0.18           | 0.67      | 2.41               | 0.16        |
| 6          | RH 3     | 0.07           | 3.96      | 3.40               | 0.27        |

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rate for STS-117 was 1960 scim. The estimated firing leak rates for all sample bottle data from this flight are summarized in the following table.

### HYDROGEN FIRING LEAK RATES

| Bottle no. | Position | Hydrogen Firing Leak Rate, scim |
|------------|----------|---------------------------------|
| 1          | RH 1     | 405                             |
| 2          | LH 1     | 1225                            |

## HYDROGEN FIRING LEAK RATES (Concluded)

| Bottle no. | Position | Hydrogen Firing Leak Rate, scim |
|------------|----------|---------------------------------|
| 3          | RH 2     | 1600                            |
| 4          | LH 2     | 1960                            |
| 5          | LH 3     | 750                             |
| 6          | RH 3     | 500                             |

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

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

### AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS

|            | Position | Actual pressure torr | Ar % | Air from Ar % | He % | CO %  | CH <sub>4</sub> % | CO <sub>2</sub> % | O <sub>2</sub> from air % | O <sub>2</sub> found % | H <sub>2</sub> % | H <sub>2</sub> pyro-corrected, % |
|------------|----------|----------------------|------|---------------|------|-------|-------------------|-------------------|---------------------------|------------------------|------------------|----------------------------------|
| 1104 FLT-2 | RH1      | 139.0                | 0.07 | 7.51          | 1.56 | <0.01 | <0.01             | 0.01              | 1.57                      | 1.86                   | <0.01            | <0.01                            |
| 1100 FLT-2 | LH1      | 71.7                 | 0.08 | 8.99          | 0.51 | <0.01 | <0.01             | 0.01              | 1.89                      | 2.07                   | 0.05             | 0.05                             |
| 1105 FLT-1 | RH2      | 64.8                 | 0.08 | 8.03          | 1.13 | <0.01 | <0.01             | 0.01              | 1.69                      | 1.94                   | 0.07             | 0.07                             |
| 1102 FLT-2 | LH2      | 40.3                 | 0.10 | 10.71         | 0.56 | <0.01 | <0.01             | 0.02              | 2.25                      | 3.34                   | 0.12             | 0.12                             |
| 1103 FLT-2 | LH3      | 9.33                 | 0.07 | 6.75          | 0.67 | <0.01 | <0.01             | 0.01              | 1.57                      | 2.41                   | 0.16             | 0.16                             |
| 1117 FLT-1 | RH3      | 3.38                 | 0.13 | 13.90         | 3.96 | <0.01 | <0.01             | 0.03              | 2.92                      | 3.40                   | 0.27             | 0.27                             |

### Purge, Vent and Drain System

The Purge, Vent and Drain (PV&D) system performed nominally during the STS-117 launch countdown. The purge and hazardous gas readings were nominal. The white room oxygen concentration display as observed via Orbiter Television (OTV) was indicating low oxygen readings. The display was confirmed to be in error because the telemetry coming from the same sensor indicated normal oxygen levels.

The PV&D system is not active on orbit, but performed nominally during entry and landing. Purge was not initiated within 45 min of wheel stop and a Data Trend Notice (DTN) was generated by USA ground operations. No problems were noted as a result of the delay.

### Reaction Control System

The Reaction Control System (RCS) performed nominally during the STS-117 mission. The data review and analysis did not identify any hardware in-flight anomalies.

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

#### **TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES**

| Cover | MET (sec) | Velocity (mph) | Alpha (deg) | Beta (deg) |
|-------|-----------|----------------|-------------|------------|
| F1D   | 4.32      | 52             | -2          | 10         |
| F3D   | 4.92      | 60             | -1          | 9          |
| F2D   | 5.43      | 67             | 0           | 8          |
| F4D   | 5.66      | 70             | 0           | 8          |
| F1L   | 6.90      | 88             | 1           | 7          |
| F3L   | 7.10      | 91             | 1           | 7          |
| F1U   | 8.08      | 105            | 1           | 6          |
| F2R   | 8.23      | 108            | 1           | 6          |
| F2F   | 8.31      | 109            | 1           | 6          |
| F2U   | 8.33      | 109            | 1           | 6          |
| F3U   | 8.76      | 116            | 1           | 6          |
| F4R   | 9.18      | 122            | 1           | 6          |
| F1F   | 9.91      | 133            | 1           | 4          |
| F3F   | 11.08     | 152            | 1           | 2          |

The RCS window-protect firing, using thrusters F1U, F2U and F3U, was a 2.08 sec firing. The Forward Reaction Control System (FRCS) thruster performance was nominal. The window-protect firing was performed to deflect exhaust from the SRB separation motors away from the Orbiter windows during SRB separation.

The ET separation maneuver was a 6.0-sec, 10-thruster translation and thruster performance was nominal. The ET Photographic +X maneuver was not performed.

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

## RCS MANEUVERS AND FIRING DATA

| Maneuver/Firing                      | Time of Ignition, GMT | $\Delta V$ , ft/sec | Duration, sec |
|--------------------------------------|-----------------------|---------------------|---------------|
| RCS Window Protect                   | 159/23:40:06          | N/A                 | 2.08          |
| ET Separation                        | 159/23:46:50          | N/A                 | 6.0           |
| NC1                                  | Not Required          |                     |               |
| NCC                                  | 161/16:02:58          | 1.0                 | 6.8           |
| MC1                                  | Not Required          |                     |               |
| Out of Plane Null                    | Cancelled             |                     |               |
| MC2                                  | 161/17:50:41          | 9.82                | 7.5           |
| MC3                                  | 161/18:07:39          | 0.47                | 1.9           |
| MC4                                  | 161/18:17:54          | 2.1                 | 9.3           |
| ISS Docking                          | 161/19:36:10          |                     |               |
| ISS Undock                           | 170/14:42:03          |                     |               |
| ISS Fly Around                       | 170/15:12:25          |                     |               |
| Separation 1                         | 170/16:00:19          |                     | 5.2           |
| Separation 2                         | 170/16:28:27          |                     | 3.9           |
| NC5                                  | 171/00:23:05          | 0.7                 | 2.6           |
| RCS Hotfire                          | 171/15:04:02.67       |                     |               |
| NC6                                  | Cancelled             |                     |               |
| Orbit Adjust                         | 172/20:46:05          | 14.8                | 54.3          |
| Forward Reaction Control System Dump | 173/19:00:13.8        |                     | 23.0          |

The RCS preflight propellant load was 4188 lb of oxidizer and 2660600.2 lb of fuel, for a total of 6848 lb of propellant loaded for the mission. The residual propellants, as calculated by the Primary Avionics Software System (PASS), were 2021 lb. The propellant used was 4157.1, which included 613.8 lb used from the OMS during RCS interconnect operations.

Prior to docking, FRCS thrusters F1F and F2F were deselected. Docking with the ISS was completed when the Digital Autopilot (DAP) was moded to Free Drift. Undocking was initiated with a +Z pulse and the ISS undocking was nominal. The Fly Around (full maneuver) was performed nominally. The Separation 1 maneuver was a 5.2-sec +X firing, and the Separation 2 maneuver was a 3.9-sec -X maneuver. Thruster performance during the undocking and separation operations was nominal.

During the 7-hr period while Shuttle maintained Vernier RCS (VRCS) attitude control at the Solar Array Wing (SAW) Torque Equilibrium Attitude (TEA), the Shuttle consumed three times more propellant than pre-flight predictions (IFA STS-117-N-01). Flight data reflects a yaw disturbance at the TEA that is not manifested in the simulations. The commanded flight attitude during this hold period was not the true TEA as confirmed by the ISS Momentum Manager. The stabilized attitude had a 1.28-deg. offset from the Shuttle-commanded TEA.

Actual propellant use on subsequent flights has agreed with predicted values for attitude-hold operations and attitude maneuvers.

The RCS hotfire was completed satisfactorily, and all RCS thrusters were fired at least twice for at least 0.240 sec on each pulse. No problems were detected during the hotfire.

Attitude control responsibilities between the ISS and Shuttle are summarized in the following table.

### CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

| Control Responsibility | Control Start, GMT | Control End, GMT | Comments                                 |
|------------------------|--------------------|------------------|------------------------------------------|
| Docked                 | 161/19:36:10       | 161/19:54:20     |                                          |
| Orbiter                | 161/10:54:20       | 161/20:00:34     | DAP AUTO - TEA Maneuver                  |
| Station                | 161/20:00:34       | 161/20:00:40     | DAP FREE DRIFT                           |
| Orbiter                | 161/20:00:40       | 161/20:10:35     | DAP AUTO                                 |
| Station                | 161/20:10:35       | 161/20:10:42     | DAP FREE DRIFT                           |
| Orbiter                | 161/20:10:42       | 161/20:20:34     | DAP AUTO                                 |
| Station                | 161/20:20:34       | 161/20:20:40     | DAP FREE DRIFT                           |
| Orbiter                | 161/20:20:40       | 161/20:31:08     | DAP AUTO                                 |
| Station                | 161/20:31:08       | 162/16:35:08     | DAP FREE DRIFT                           |
| Orbiter                | 162/16:35:08       | 162/17:03:14     | DAP LVLH – ISS MG De-saturation          |
| Station                | 162/17:03:14       | 163/17:22:53     | DAP FREE DRIFT                           |
| Orbiter                | 163/17:22:53       | 163/17:52:21     | DAP AUTO – Post solar array deployment   |
| Station                | 163/17:52:21       | 163/18:00:00     | DAP FREE DRIFT                           |
| Orbiter                | 163/18:00:00       | 163/23:38:49     | DAP AUTO                                 |
| Station                | 163/23:38:49       | 163/23:43:00     | DAP FREE DRIFT                           |
| Orbiter                | 163/23:43:00       | 164/00:50:57     | DAP AUTO                                 |
| Station                | 164/00:50:57       | 164/03:27:48     | DAP FREE DRIFT                           |
| Orbiter                | 164/03:27:48       | 164/03:30:26     | DAP LVLH                                 |
| Orbiter                | 164/03:30:26       | 164/03:51:24     | DAP AUTO                                 |
| Station                | 164/03:51:24       | 164/03:51:27     | DAP FREE DRIFT                           |
| Orbiter                | 164/03:51:27       | 164/04:07:19     | DAP AUTO                                 |
| Station                | 164/04:07:19       | 169/12:43:27     | DAPFREE DRIFT                            |
| Orbiter                | 169/12:43:27       | 169/14:33:30     | DAP AUTO – Simo water dump               |
| Station                | 169/14:33:30       | 169/23:16:43     | DAP FREE DRIFT                           |
| Orbiter                | 169/23:16:43       | 170/00:04:52     | DAP AUTO                                 |
| Station                | 170/00:04:52       | 170/11:55:44     | DAP FREE DRIFT                           |
| Orbiter                | 170/11:55:44       | 170/14:20:23     | DAP AUTO                                 |
| Station                | 170/14:20:23       | 170/14:22:00     | DAP FREE DRIFT                           |
| Orbiter                | 170/14:22:00       | 170/14:39:07     | DAP AUTO                                 |
| Station                | 170/14:39:07       | 170/14:42:01     | DAP FREE DRIFT – ISS Physical Separation |
| Station                | 170/14:42:01       | 170/14:43:12     | DAP FREE DRIFT                           |
| Orbiter                | 170/14:43:12       | 170/15:12:14     | DAP AUTO – Undocking (+Z)                |
| Orbiter                | 170/15:12:14       | 170/16:00:19     | Fly Around (+X)                          |
| Orbiter                | 170/16:00:19       | 170/16:28:27     | ISS Separation 1 Maneuver                |
| Orbiter                | 170/16:28:27       |                  | ISS Separation 2 Maneuver                |

The RCS pressurization and propellant isolation valves were configured for entry. The FRCS dump (four thrusters) was satisfactory and lasted 23 sec. The dump consumed 288.2 lb<sub>m</sub> of forward RCS propellant.

The primary thrusters were fired 5986 times, for a total firing time of 1160.84 sec. The vernier thrusters were fired 10,451 times, with a firing time of 15962.16 sec.

### **Orbital Maneuvering System**

The OMS functioned satisfactorily throughout the STS-117 mission, with no in-flight anomalies identified during the review and evaluation of the data. No LCC or OMRSD violations were documented during either the launch attempt or the subsequent launch. The standard OMS configuration and OMS maneuvers are provided in the following tables.

The engine inlet pressure, chamber pressure, and regeneration jacket temperatures for both engines were as expected. OMS firing times and propellant consumption were consistent with predictions and verified proper performance.

#### **OMS CONFIGURATION**

| Vehicle/equipment | Flight           | Orbital Maneuvering Engine (OME) | Ancillary data                                          |
|-------------------|------------------|----------------------------------|---------------------------------------------------------|
| Left Pod (LP) 04  | 28 <sup>th</sup> | L-OME S/N 108                    | 2 <sup>nd</sup> rebuilt flight, 26 <sup>th</sup> flight |
| Right Pod (RP) 01 | 35 <sup>th</sup> | R-OME S/N 109                    | 7 <sup>th</sup> rebuilt flight, 24 <sup>th</sup> flight |

#### **OMS MANEUVERS**

| Maneuver designation | Configuration | Time of ignition, GMT | Firing time, sec | $\Delta V$ , ft/sec/<br>interconnect usage, percent |
|----------------------|---------------|-----------------------|------------------|-----------------------------------------------------|
| Assist               | Dual OME      | 159/23:40:17.5        | 170.4            | N/A                                                 |
| OMS-2                | Dual OME      | 160/00:16:34.1        | 63.6             | 96.7                                                |
| OMS-3 (NC2)          | Dual OME      | 160/16:40:44          | 26.1             | 39.5                                                |
| OMS-4 (NC3)          | Dual OME      | 161/01:09:49          | 93.08            | 143.8                                               |
| OMS-5 (NC4)          | Dual OME      | 161/15:27:28.1        | 51.6             | 80.3                                                |
| OMS-6 (TI)           | Left OME      | 161/17:00:37.3        | 12.2             | 9.8                                                 |
| DOB (D/O)            | Dual OME      | 173/18:43:46.5        | 153.6            | 295.6                                               |

## INTERCONNECT USAGE, PERCENT/POUNDS

| Parameter          | Interconnect usage, percent | Interconnect usage, lb <sub>m</sub> |
|--------------------|-----------------------------|-------------------------------------|
| Left interconnect  | 1.369                       | 177.29                              |
| Right interconnect | 3366                        | 435.930                             |

Helium usage during OMS firings and repressurizations was as predicted, verifying no detectable external leakage. Tank ullage pressures during the firings were nominal.

During the deorbit firing, both the left and right OMS fuel Propellant Quantity Gaging Systems (PQGS) exhibited anomalous behavior. For the left OMS fuel system, the total quantity (Totalizer) update from the probes 14 sec into the firing showed an increase in propellant remaining rather than a decrease as expected (due to interconnect usage); additionally, the aft probe output did not show as large of increase at the 14-sec update as expected. Instead, the probe output continued down at a nominal slope and ended at approximately 4.6-percent remaining at the completion of the deorbit firing. Since this quantity was below the 5-percent low-level alert, a Left OMS Quantity Alert was generated. This probe and the totalizer behavior is similar to performance observed during the last flight (STS-115) of this vehicle, except that the off-nominal performance was less pronounced this flight. The lower-than-expected final left OMS fuel quantity is likely due to an undetected error in the forward probe quantity output during loading that made the tank quantity appear to be 1.26-percent higher than indicated by the Ground Support Equipment (GSE) flowmeters. Thus the “advertised” quantity was higher than the actual quantity by approximately 1 percent. For the left OMS fuel system, the official residual was an engineering estimate that was calculated by subtracting the quantity consumed as calculated with the Engineering firing-time integration program from the total loaded quantity as indicated by GSE flowmeters.

During the deorbit firing, the right OMS fuel quantity gaging system’s aft probe continued to exhibit a fuel consumption rate that was slower than the corresponding oxidizer usage rate as has been seen on previous flights of this pod; however, the consumption rate this flight was almost nominal rather than unrealistically slow. Based on the past unreliable performance of the PQGS for at least 7 flights of this vehicle, the firing-time Integration result was used for the official residual determination.

Totalizer readings all agree closely with the expected values and with both the left and right oxidizer aft probe readings. The official propellant loading and residuals are shown in the following table.

## PROPELLANT DATA

| Parameters                                           | Left OMS pod |      | Right OMS pod |      |
|------------------------------------------------------|--------------|------|---------------|------|
|                                                      | Oxidizer     | Fuel | Oxidizer      | Fuel |
| Loaded, lb <sub>m</sub>                              | 7538         | 4531 | 7538          | 4537 |
| Residual, lb <sub>m</sub> (aft gage)                 | 478          | 226  | 503           | 421  |
| Residual, lb <sub>m</sub><br>(burn time integration) | 627          | 341  | 575           | 257  |
| Residual, lb <sub>m</sub><br>(SODB flow rate)        | 572          | 349  | 583           | 313  |

## Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-117 mission. No in-flight anomalies were recorded on the APU system. The one issue from the previous flight of this vehicle (APU 1 Gas Generator Bed Heater lower set-point shift) repeated as expected. The run times and fuel consumption for the APUs, including the S/N of each, during STS-117 are summarized in the following tables.

### APU RUN TIMES

| APU<br>(S/N)   | Ascent,<br>hr:min:sec | FCS Checkout,<br>hr:min:sec | Entry,<br>hr:min:sec | Total time,<br>hr:min:sec |
|----------------|-----------------------|-----------------------------|----------------------|---------------------------|
| <b>1 (409)</b> | <b>00:19:42</b>       | <b>00:06:52</b>             | <b>01:02:14</b>      | <b>01:28:48</b>           |
| <b>2 (410)</b> | <b>00:20:00</b>       | <b>00:00:00</b>             | <b>01:02:18</b>      | <b>01:22:18</b>           |
| <b>3 (204)</b> | <b>00:20:07</b>       | <b>00:00:00</b>             | <b>01:29:05</b>      | <b>01:49:12</b>           |

### APU FUEL CONSUMPTION

| APU<br>(S/N)   | Ascent,<br>Lb <sub>m</sub> | FCS Checkout,<br>Lb <sub>m</sub> | Entry,<br>Lb <sub>m</sub> | Total,<br>Lb <sub>m</sub> |
|----------------|----------------------------|----------------------------------|---------------------------|---------------------------|
| <b>1 (409)</b> | <b>51</b>                  | <b>20</b>                        | <b>114</b>                | <b>185</b>                |
| <b>2 (410)</b> | <b>53</b>                  | <b>0</b>                         | <b>127</b>                | <b>180</b>                |
| <b>3 (204)</b> | <b>51</b>                  | <b>0</b>                         | <b>166</b>                | <b>217</b>                |

During the launch countdown, the APU 3 Fuel Pump Drain Line Temperature 2 exceeded its LCC limit of 90 °F. This occurred as a result of the aft purge temperature being increased to 105 °F for loading the cryogenics. The occurrence was closed as an explained condition, thus, no LCC violation was recorded.

At 163/07:54:41.517 GMT (03/08:16:37.505 MET) MDM OA2 card 5 failed and a BITE word was sent indicating this failure (IFA STS-117-V-03). Data were lost from 14 parameters, and 2 were APU parameters which could violate limits and

generate APU Fault Detection Annunciation (FDA) messages (APU 2 Gearbox Pressure and APU 2 Lubrication Oil Outlet Pressure). A review of these parameters at the time of alarm annunciation showed that both parameters were reading nominally and had not violated on-orbit FDA limits. The MDM was declared failed, and although the limits were later violated because of the MDM failure, no impact to the mission or the operation of the APU's occurred.

APU 1 was selected for the Flight Control System (FCS) checkout. In accordance with the updated Flight Data File (FDF) procedure, prior to FCS checkout, the APU 1 Gas Generator (GG) /Fuel Pump A heaters were turned off to ensure that the GG bed temperatures were at acceptable start levels.

### **Hydraulics/Water Spray Boiler System**

Overall Hydraulic (HYD) and Water Spray Boiler (WSB) system performance was nominal. STS-117 was the second flight (1<sup>st</sup> flight on OV-104) to use the water additive Propylene Glycol Monomethyl Ether (PGME) in all three WSB water tanks to preclude post-ascent freeze-ups in the boiler Heat Exchanger (Core).

Of the 14 measurements affected by the failure MDM OA2 card 5 on Flight Day (FD) 5, five HYD system sensors were identified on this card and were checked for accuracy. None of the lost measurements impacted the mission. Cards 4 and 6 contained four and five HYD sensors, respectively, but these were not affected by the card 5 failure.

On FD 7, the Body Flap (BF) Power Drive Unit (PDU) body temperature began a steady increase from approximately 16 °F to 37 °F over a period of approximately 27 hr while the BF hydraulic return lines and seal cavity drain line temperatures remained fairly constant in the range of 17 to 20 °F. Review of the data indicated that this was caused by activating Aerosurface Actuator (ASA) 3 for elevon parking (switched from ASA 4 to ASA 3 for Orbiter power down scenario for mission extension) and the BF Enable 3 solenoid valve was commanded ON by ASA 3. It was determined that selecting ASA 3 powers the BF Enable solenoid valve whereas ASA 4 does not power the BF Enable 3 solenoid valve. Nominal operations use ASA 4 throughout the flight. The powered BF solenoid valve provided the energy (approximately 9.3 W) for the BF PDU body temperature sensor response.

This finding also explains the STS-115 case of the BF PDU temperature being approximately 15 °F higher than the BF hydraulic return lines and BF seal cavity drain line during the entire time on-orbit. This was the result of ASA 3 being powered on to troubleshoot the Rudder Speed Brake (RSB) issue on that flight.

Additionally, this explains the non-responsive RSB PDU body temperature that occurred during the STS-115 mission in the end-of-mission Orbiter attitude of (Minus Z-Axis Local Vertical (-ZLV), Minus -X axis on the Velocity Vector (-

XVV), Beta angle - 43 deg, following the Flight Control System (FCS) checkout. In an almost identical attitude on STS-112 (OV-104), -ZLV -XVV, Beta -41 deg attitude, the RSB PDU body temperature exhibited a definite cooling trend following FCS checkout. Because of an intermittent fault in the Channel 3 Speedbrake command signal, channel 3 was deselected after the secondary actuator check. Since ASA 3 was left on for further troubleshooting, the isolation valve remained energized until after APU shutdown at landing. The energy dissipating in the valve has been confirmed to be sufficient to cause the temperature changes noted.

The HYD circulation pump 1 initially ran for 1 min 54 sec to perform the elevon-park operations, however, the park operation was not accomplished because an onboard switch position. The crew performed the checklist again and the circulation pump ran for 16 min 27 sec to perform the elevon-park operation, and elevon parking was successfully completed. These two runs of the circulation pump were the only pump runs during the mission. No circulation pump runs were required for either hydraulics fluid/component thermal conditioning or accumulator recharges during the mission.

FCS checkout was performed with APU/HYD system 1. The HYD/WSB systems performed nominally for FCS checkout and all parameters were within their expected ranges. Nominal heater cycling (144 °F to 186 °F) was observed on all three WSB System "B" vent heaters throughout the FCS checkout. Because of the short APU runtime (6 min 52 sec), the APU lubrication oil spray cooling was not required. The maximum APU lubrication oil return temperature after APU shutdown was approximately 241 °F.

The PGME/H<sub>2</sub>O usage during ascent for spray cooling was as follows (specification is no-greater-than 8 lb/sys):

1. System 1 = 3.9 lb PGME/Water.
2. System 2 = 3.4 lb PGME/Water.
3. System 3 = 4.2 lb PGME/Water.

HYD/WSB performance during entry was nominal. The WSB Vent Heater performance on all three systems was also nominal. The brake line heaters likewise functioned nominally.

WSB usage during entry for spray cooling was as follows (specification is no-greater-than 45 lb/sys):

1. System 1 = 8.1 lb (PGME/Water).
2. System 2 = unknown due to MDM OA2 failure.
3. System 3 = unknown due to MDM OA2 failure.

## Power Reactant Storage and Distribution System

The Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-117. The PRSD system supplied the fuel cells with 2901 lb of oxygen and 365 lb of hydrogen for the production of 4269 kWh of electrical energy. The total oxygen supplied to the Orbiter and ISS Environmental Control and Life Support System (ECLSS) was 277 lb<sub>m</sub> from PRSD. Shuttle ECLSS used 170 lb<sub>m</sub> and 107 lb<sub>m</sub> was transferred to ISS.

The O<sub>2</sub>/H<sub>2</sub> manifold isolation valves were cycled for the crew-sleep periods, which satisfied the OMRSD File IX In-flight Checkout requirement. There were no in-flight anomalies identified in the PRSD system as a result of data analysis and evaluation.

The initial loading of the five PRSD tank sets was performed on June 6, 2007. The prelaunch reactant boiloff rate averaged 0.073 lb/hr/tank for hydrogen and 0.19 lb/hr/tank for oxygen.

### **PRSD TANK QUANTITIES**

| <b>Oxygen</b>   | <b>Tank 1,<br/>%</b> | <b>Tank 2,<br/>%</b> | <b>Tank 3,<br/>%</b> | <b>Tank 4,<br/>%</b> | <b>Tank 5,<br/>%</b> | <b>Total<br/>Mass, lb<sub>m</sub></b> |
|-----------------|----------------------|----------------------|----------------------|----------------------|----------------------|---------------------------------------|
| Loaded          | 100.9                | 100.9                | 101.4                | 101.8                | 101.4                | 3955                                  |
| Launch          | 100.1                | 100.1                | 100.1                | 100.5                | 100.5                | 3869                                  |
| Landing         | 31.3                 | 25.2                 | 26.9                 | 5.9                  | 5.0                  | 736                                   |
| <b>Hydrogen</b> | <b>Tank 1,<br/>%</b> | <b>Tank 2,<br/>%</b> | <b>Tank 3,<br/>%</b> | <b>Tank 4,<br/>%</b> | <b>Tank 5,<br/>%</b> | <b>Total<br/>Mass, lb<sub>m</sub></b> |
| Loaded          | 102.3                | 101.5                | 102.8                | 103.7                | 103.2                | 472.4                                 |
| Launch          | 99.7                 | 98.4                 | 99.7                 | 100.6                | 103.2                | 458.3                                 |
| Landing         | 30.7                 | 28.5                 | 39.1                 | 1.1                  | 1.5                  | 92.8                                  |

The Orbiter landed with 736 lb<sub>m</sub> of oxygen and 92.8 lb<sub>m</sub> of hydrogen remaining in the PRSD system. A 52-hour mission extension capability existed at landing, based upon the PRSD O<sub>2</sub> (the limiting reactant) tank quantities and an average flight power level of 12.8 kW. At an extension day power level of 12.501 kW, a 53-hour mission extension was available.

## Fuel Cell System

The overall performance of the fuel cell system was nominal for STS-117. The fuel cells produced 3267 lb of potable water and 4269 kWh of electrical energy from 2901 lb<sub>m</sub> of oxygen and 365 lb<sub>m</sub> of hydrogen during the 332 hr 11 min mission.

The fuel cells installed in OV-103 for STS-117 were serial numbers 123, 104, and 119 in positions 1 through 3, respectively. Fuel-cell startup was initiated June 8,

2007. Startup and prelaunch operations were nominal. Fuel cell operating times, which are the times accumulated on the fuel cells during the prelaunch, on-orbit, and postlanding operations were 363:50:31 (hr:min:sec) for fuel cell 1, 363:50:31 for fuel cell 2, and 362:14:07 for fuel cell 3. The end-of-mission accumulated operating times for these fuel cells 1, 2 and 3 are 1605,756, and 1093 hr, respectively.

The Orbiter electrical power level averaged 12.8 kW and the total Orbiter load averaged 461 amperes (A). For the 332 hr 11 min mission, the fuel cells produced 4269 kWh of electrical energy and 3267 lb of potable water. The fuel cells consumed 2901 lb<sub>m</sub> of oxygen and 365 lb<sub>m</sub> of hydrogen. Seven fuel cell reactant purges were performed, and these occurred at approximately 17, 50, 114, 185, 258, 301 and 325 hours MET. The actual fuel-cell voltages at the end of the mission were 0.00 Vdc (predicted) for fuel cell 1, 0.10 Vdc above predicted for fuel cell 2, and 0.05 Vdc above predicted for fuel cell 3. The voltage margins above the minimum performance curves at 200 A at the end of the mission were 0.85 Vdc above minimum for fuel cell 1, 1.10 Vdc above minimum for fuel cell 2, and 0.90 Vdc above minimum for fuel cell 3.

The overall thermal performance of the fuel cell water relief, water line, and reactant purge heater systems was nominal. Water relief and water line system A was used during prelaunch, ascent, and up to 170/17:22 GMT (10/17:44 MET) and then system B was selected for the remainder of the flight. All of the water system heaters cycled to satisfy the in-flight checkout requirements, except for the fuel cell 1, 2, and 3 water relief valve heaters. The loss of this File IX requirement was caused by the thermal environment not being cold enough for the thermostats to activate the heaters.

The prelaunch primary and secondary oxygen samples taken after cryogenics loading exceeded the specified impurity level. A waiver was taken to accept total impurities of 285 ppm (247 ppm He) where the limit is a total impurity level of 110 ppm. Post-flight sampling of oxygen tanks 1, 2, and 3 indicated He levels of less than 10 ppm. Higher contaminant levels would cause fuel cell performance to degrade faster than nominal.

All 3 alternate water line temperatures indicated leakage through the alternate water check valves during FD 1. This condition resulted from the potable water tanks C and D being depleted from FES operation. The FES was in use for longer compared to usage on previous missions. Throughout the mission, the fuel cell 2 alternate water lines temperatures were erratic when Potable Water Tank A was full or isolated. This causes the pressure upstream of the check valve to increase above the downstream pressure enough to crack the check valve and leakage of the 140 °F product water affects the nominal heater cycles of the line heaters.

The Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages prelaunch, on-orbit, and postlanding. Full-rate on-orbit data were recorded for 12 min beginning at 162/03:00:42 GMT (2/03:22:38 MET), and there were no issues. The fuel cell 2, cell 54/55, were biased 10 mV with cell 54 biased higher and cell 55 biased lower. This is due to an OV-104 specific FCMS instrumentation bias.

## **Electrical Power Distribution and Control System**

The Electrical Power Distribution and Control System (EPDC) performed nominally during all mission phases of STS-117. The data review and analysis of all available EPDC parameters was completed. All File IX requirements were met. No problems or in-flight anomalies were identified from the review and analysis of the mission data.

No abnormal conditions were identified other than Mid Motor Controller Assembly (MMCA)

No. 2 status and this was the result of the failure of card 5 of MDM OA2.

As a minimum, the following EPDC parameters were analyzed

1. Fuel cell voltages and currents;
2. Essential bus voltages;
3. Control bus voltages;
4. Forward Power Control Assemblies voltages and currents;
5. Mid Power Control Assemblies voltages and currents;
6. Aft Power Control Assemblies 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 RPC status;
10. Forward, Mid and Aft Motor Control Assemblies ops status;
11. Fuel cell to Essential bus switches status;
12. Main bus to Essential Bus RPC and switch status: and
13. Drag chute Pyrotechnic Controller Functions.

## **Orbiter Docking System**

The Orbiter Docking System (ODS) performed satisfactorily during the STS-117 mission with no in-flight anomalies identified in the data.

The ODS Docking Control Panel (DCP) circuit breakers were activated on FD 1 at 161/01:46:37 GMT (01/02:08:33 MET) for a total time of 5 min 37 sec. All parameters were nominal during the activation and the ODS was ready for rendezvous and docking.

The ODS was activated for docking operations at 161/19:01:25 GMT (01/19:23:21: MET), and the docking system was active for 54 min 20 sec. The Shuttle captured the ISS at 161/19:36:10 GMT (01/19:58:06 MET, and the ODS operated satisfactorily throughout the docking activities.

On FD 10, the Orbiter undocking from the ISS began with powerup at 170/14:16:37 GMT (10/14:38:33 MET). The Orbiter completed the undocking sequence from the ISS at 170/14:41:59 GMT (10/15:03:55 MET).

### **Atmospheric Revitalization and Active Thermal Control System**

The Atmospheric Revitalization System (ARS) and the Active Thermal Control System (ATCS) performed satisfactorily during the STS-117 mission and no problems or in-flight anomalies were identified in the review and analysis of the data.

The highest cabin temperature during launch was 76.3 °F and it occurred 1 min 38 sec after launch. The cabin humidity reached 38.4-percent and the Partial Pressure Carbon Dioxide (ppCO<sub>2</sub>) was 1.25 mmHg. During on-orbit operations, the highest cabin temperature was 78.0 °F, the cabin humidity reached 58.4-percent and the ppCO<sub>2</sub> reached 5.5 mmHg. During the landing operations, the highest cabin temperature was 71.6 °F, the cabin humidity reached 65 percent and the pp CO<sub>2</sub> reached 2.15 mmHg.

A total of 29 Lithium Hydroxide (LiOH) canisters were taken on the mission. Three ISS canisters that were nearing their certification life expiration were transferred to the Orbiter from the ISS stockpile and used during the docked portion of the mission. Three Orbiter canisters were transferred to the ISS to replace those transferred to the Orbiter.

After landing, the Ammonia Boiler System (ABS) continued satisfactory operation on system B until activation of the ground cooling. The ABS system A was not required for ground cooling.

### **Atmospheric Revitalization Pressure Control and Airlock Systems**

The Pressure Control System (PCS) and Airlock systems performed nominally throughout the STS-117 mission. No in-flight anomalies were identified during the review and analysis of the mission data.

The Orbiter 14.7-psia regulator inlet valves are nominally closed for ascent and remained closed during the ISS docked operation except during the manual maintenance of the cabin Nitrogen (N<sub>2</sub>) pressure. Upon docking, the Orbiter pressure was equalized with the ISS at 13.79 psia. The Orbiter/ISS stack was then pressurized via an N<sub>2</sub> repressurization to

14.26 psia. Prior to hatch closure and in preparation for undocking, the ISS was repressurized to 14.26 psia.

Since all Extravehicular activities (EVAs) were performed from the ISS, the PCS was not required to support these EVAs.

The Airlock Vestibule passed all leak-check verifications for docked and undocking operations. Use of the airlock depressurization valves was not required because all EVAs were performed from the ISS airlock.

## **Supply and Waste Water System**

The Supply Water and Waste Management System (SWWS) performed nominally throughout the STS-117 mission and all of the scheduled in-flight checkout requirements were satisfied.

Early in the flight, the supply dump line A heater system cycled up to 114 °F. The A thermostat was replaced during the turnaround flow because of dithering and an increasing trend to the upper range. The A control thermostat tests were nominal during preflight operations and the over-temperature set-points were 72.5 °F to 85.1 °F and 92.4 °F to 107.1 °F, respectively. The data sensor is located between the bracket and the thermostat. This locates the thermostat near a significant heater concentration compared to other heater systems.

The A control thermostat performed nominally as a result of the newly installed thermostat being tested before the flight at KSC. However, the cycling was at a higher range than expected during the flight. The subsystem model analysis indicates that the hotspot reaches 110 °F and the hotspot was near the thermostat. Based on these known conditions, it is possible that the temperature sensor is located near the hotspot. The high- temperature cycling seen on heater A will be monitored on future flights for trending purposes only. To achieve File IX requirements, the heater B was reconfigured to control the supply dump line temperature and heater B performed nominal.

Supply water was managed through the use of the FES, water transfer to the ISS and the overboard nozzle dump system. One supply water dump (as a simultaneous waste and supply water dump) was performed at a nominal dump rate of 1.7 percent (2.8 lb/min). The line heater A maintained the supply water dump line temperature at an average between 85 °F and 109 °F while heater B maintained the line between 74.5 °F and 90 °F.

Three wastewater (from waste tank) dumps were performed at an average rate of 1.97 percent/min (3.25 lb/min). During this mission, two Contingency Water Containers (CWCs) containing Shuttle condensate were dumped through the waste water dump nozzle. The waste water dump line temperature was maintained between 60 °F and 74 °F throughout the mission.

Vacuum vent line temperature was maintained between 58.4 °F and 74.6 °F. Sixteen

CWC's were filled with supply water and transferred to the ISS, for a total of 1562.9 lb. In addition, 5 Portable Water Reservoirs (PWRs) of iodinated water for a total 93.6 lb were filled and transferred to the ISS.

## **Smoke Detection and Fire Suppression System**

The Smoke Detection and Fire Suppression (SDFS) operated nominally during the STS-117 mission. The SDFS in-flight checkout was performed during FD 1. All smoke detection A and B sensors circuits passed after the retest on Smoke Detection Circuit Test B. Use of the Fire Suppression system was not required.

## **Flight Software**

Performance of all flight software Primary Avionics Software System (PASS) and Backup Flight System (BFS) was nominal throughout the STS-117 mission.

At T-20 min, the PASS Operations (OPS) 9 to OPS 1 transition occurred and was nominal. Subsequently, the BFS was moded from OPS 0 to OPS 1 and was observed to be tracking all four PASS strings. The PASS flight software successfully moded from Major Mode (MM) 101 to MM106 and the BFS maintained satisfactory tracking during the ascent profile.

The PASS was transitioned from OPS 2 to OPS 8 to support FCS checkout and then transitioned back to OPS 2 after completion of on-orbit activities. Both OPS transitions were nominal and no unexpected errors were observed.

During deorbit preparation, the BFS was transitioned to OPS 3 and tracked all PASS strings to support entry operations. All OPS transitions were nominal and no unexpected errors were observed.

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

The MDM OA2 Card 05 failure resulted in two fault messages and internal BITE indications (IFA STS-117-V-03). All parameters on card 05 were invalid both onboard and in the downlink. Additional impacts resulted due to the Systems Management (SM) GPC and the BFS GPC attempts to fetch this data from the Pulse Code Modulation Master Unit (PCMMU). When the PCMMU read that contains Card 05 data was performed, the invalid indication caused all data included in this read to be communication-faulted. In addition to Card 05, the PASS SM data read includes parameters from Cards 02, 04, and 06. While

these additional parameters are communication-faulted by the PASS flight software, the downlink remained unaffected. The BFS obtained the data in one transaction, which resulted in the BFS software bypassing the entire OA2. The flight software monitoring required an analysis to identify the impacts of the bypassed data to crew displays, the down-list, and Fault Detection Annunciation (FDA) for PASS SM.

## **Data Processing System Hardware**

Data Processing System (DPS) hardware performed nominally throughout the STS-117 mission. This hardware includes the General Purpose Computers (GPC), Multiplexer Interface Adapters (MIA), Data Bus Couplers (DBC), Data Bus Isolation Amplifiers (DBIA), Keyboard units (KBU), Engine Interface Units (EIU), and Master Events Controllers (MEC)/ Backup Flight Controllers (BFC). The data review and analysis of DPS hardware parameters have been completed and two in-flight anomalies were identified and are discussed in later paragraphs.

Several DPS hardware items were affected by a Group B Powerdown configuration. Later in the mission, a modified Group C Powerdown was performed. This affected Flight Critical and Payload MDM's and GPC 2. These units were later powered back up to support mission operations with no problems observed. Because of the powered-off condition of GPC 2, the Error Detection and Correction (EDAC) process was not running. This required an Initial Program Load (IPL) of GPC 2 upon recovery to obtain a clean copy of OPS 2 software.

During ascent, the SSME 3 LH<sub>2</sub> inlet pressure indication went off-scale high resulting in Flight Aft (FA) 3 MDM logging an analog/digital (A/D) Built In Test Equipment (BITE) against MDM Card 14 (IFA STS-117-V-01). As part of troubleshooting during the mission, a BITE Status Register read and BITE Test 4 read were performed. Results indicated the actual input voltage of the LH<sub>2</sub> inlet pressure Indication was +6.06V, which is higher than the +5.11 maximum input voltage for proper A/D conversion. This off-scale high condition correctly resulted in an MDM BITE annunciation, and had no impact on the remainder of the mission.

The MDM OA2 Card 05 failure resulted in fault messages and internal BITE indications (IFA STS-117-V-03). All parameters on MDM card 05 were invalid both onboard and in the downlink. Additional impacts resulted because the SM GPC and the BFS GPC attempted to fetch these data from the PCMMU. When the PCMMU read that contains Card 05 data was performed, the invalid indication causes all data included in this read to be in error. In addition to card 05, the PASS SM data read included parameters from cards 02, 04, and 06. While these additional parameters were communication-faulted by the PASS flight software, the downlink remained unaffected. The BFS obtained the data in

one transaction, which resulted in the BFS software bypassing the entire OA2 MDM, although the downlink remained unaffected for all parameters except those on card 05.

## **Multifunction Electronics Display System**

The Multifunction Electronics Display System (MEDS) performed satisfactorily during the STS-117 mission.

## **Displays and Controls System**

The Displays and Control (D&C) system performance was satisfactory during the STS-117 mission. One in-flight anomaly was identified, but did not impact the flight.

At 168/14:35 GMT, the crew reported that a high-pitched interference noise was coming from the panels in the aft flight deck when the Annunciator Bus Select switch was taken to the Main Bus B (MNB) position. The crew was asked to take the Annunciator Bus Select switch to Main Bus C (MNC), and the noise continued. The noise stopped when the Annunciator Bus Select switch was taken to the off position (IFA STS-117-V-10). This switch provides main bus power to the Annunciator Control Assemblies (ACA's) 4 and 5. There is a known condition associated with all ACA's. The printed circuit board guides have card extractors (dog ears) at the top. When snapped into place after the boards are installed, they have (by design) a built-in slack. The slack causes them rattle when the box is shook or in the operating mode (power vibrations within the card). It is not considered a failure, but rather a "live with" situation. There was no mission Impact from this noise.

During the deorbit preparation activities, the crew reported that the mid-deck floodlight no. 6 switch was stuck in the off position. There were no impacts to mission success or safety. There is a separate switch for each Mid-deck Interior Floodlight. There were 9 other mid-deck floodlights that the crew can utilize. This mid deck floodlight no. 6 is one of three mid-deck floodlights powered by emergency power. A review of data from previous flights shows that this is the first occurrence of a switch being reported as stuck in the off position. Post-flight checkout at EAFB found that both the switch and mid-deck floodlight 6 are working normally.

## **Flight Control System**

Flight Control System (FCS) hardware/ effector systems performed nominally throughout the STS-117 mission. No in-flight anomalies were identified in the review and analysis of the data. No anomalies were found in aerosurface drive data, individual channel test data, Orbiter Rate Gyro Assemblies (ORGA) and

accelerometer assemblies (AAs) test data, nose-wheel steering test data, and Data Display Unit (DDU)/controller data.

The FCS hardware/effector systems performed nominally during ascent through APU shutdown. At all times, the SRB Thrust Vector Controller (TVC), MPS TVC, and aerosurface actuators were positioned exactly as commanded with normal driver currents, secondary differential pressures, and elevon primary differential pressures. The rate outputs of the four (ORGAs) and four Station Rate Gyro Assemblies (SRGAs) tracked one another normally, and there were no spin motor rotation detector (SMRD) dropouts. The outputs of the four (AAs) also tracked one another normally. The Reaction Jet Driver (RJD) operation was also normal with no thruster failures or other anomalies noted. Display Driver Unit (DDU) and controller operations were also nominal. Both the Rotational Hand Controller (RHC) and the Transitional Hand Controller (THC) were used and exhibited normal channel tracking.

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

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

### **Air Data Transducer Assembly**

All four Air Data Transducer Assemblies (ADTAs) functioned nominally during the pre-launch tests, FCS checkout and entry operations for the STS-117 mission and no in-flight anomalies were noted in the data. ADTA transducer entry performance was nominal from deorbit through wheel-stop. No LCC or OMRSD violations occurred during the prelaunch operations, and no in-flight anomalies were identified during the data analysis and evaluation.

All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.7, and deployment timing was within specification at less than 15 sec. ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at an altitude that is equivalent to about Mach 2.6. No ADTA dilemmas or Redundancy Management (RM) failures occurred during deployment through wheels-stop.

## **Inertial Measurement Unit and Star Tracker System**

The Inertial Measurement Unit (IMU) and Star Tracker (ST) systems performed satisfactorily throughout the STS-117 mission. No in-flight anomalies or problems were identified during the analysis of the data. The IMU's required only one adjustment of the onboard IMU accelerometer compensations during the mission. Also, only one adjustment was performed for the IMU drift compensation values.

The ST performed nominally during the STS-117 mission in acquiring navigation-stars. The -Y ST acquired navigation-stars 1220 times, but also missed a navigation-star 1195 times (49.4 percent) during the mission. Data showed that 82.5 percent of the missed stars occurred with three stars. This condition did not impact the mission.

The -Z ST acquired a star 56 times and missed a star 39 times (41 percent). Data showed that these stars were missed during docking and undocking activities. This condition also did not impact the mission.

## **Global Positioning System Navigation**

The Global Positioning System (GPS) operation during STS-117 was nominal. The hardware configuration on this flight consisted of the Miniaturized Airborne GPS Receiver (MAGR) and two preamplifiers, which make up a single-string GPS system. The MAGR was loaded with firmware -007, which was being flown for the third time.

As planned, the GPS state vector was incorporated into PASS navigation after performance confirmation with high-speed C-band tracking. This occurred at Entry Interface plus 22 min (137,500 ft altitude). The effect was that the PASS navigation state vector residuals were reduced significantly. The PASS navigation state vector residuals remained consistently low from GPS incorporation until data from the Microwave Landing System (MLS) was incorporated.

Power was applied to the GPS approximately 4¼ hr prior to launch and remained on for the entire mission until 16 min after touchdown. The high Figure of Merit (FOM) period of plasma cleared well before GPS incorporation into the PASS navigation system. No "Data Invalid" or FOM chimneys occurred during the critical phase of Entry (below 140,000 ft altitude).

## **Communications and Tracking System and Navigation Aids**

During STS-117, the Communications and Tracking systems and Navigation Aids performed nominally and all File IX requirements were satisfied.

Performance during landing was nominal based on data analysis. Microwave Scanning Beam Landing System (MSBLS) no. 3 failed self-test during prelaunch operations and a decision was made to launch with only two units operational. This unit will be removed and replaced during turnaround operations.

Two occurrences of the intermittent angle tracking anomaly were noted during STS-117 and were a repeat of the same anomaly that occurred on STS-115 (IFA STS-115-V-26). During the two angle-track events, the Ku-Band forward link was recovered by selecting GPC Designate mode, which does not use the angle-track circuitry. Both events occurred during operations in the communications mode. The problem has not occurred during radar operations. Flight Control confirmed that no Orbiter blockage was contributing to the behavior. Orbiter Processing Facility (OPF) testing prior to STS-117 failed to repeat the STS-115 angle-track behavior, and as a result, the condition was upgraded to a Deferred Unexplained Anomaly (UA) with on-orbit monitoring planned during STS-117. Additional in-flight testing is also planned for the next flight of this vehicle.

### **Operational Instrumentation/Modular Auxiliary Data System**

The Operational Instrumentation (OI) hardware PCMMU, Payload Data Interleaver (PDI) and Master Timing Unit (MTU) performed nominally throughout the STS-117 mission. Two anomalies were identified during the mission or after the post-flight review of the mission data.

During the STS-117 mission, a BITE signature of 1080 was noted from the Multiplexer/Demultiplexer (MDM) Operational Aft (OA) 2, along with System Management (SM) software alert annunciating the bypass of the OA 2 (IFA STS-117-V-03). The PCMMU Bite Status Register (BSR) bit 10 (Input Data Invalid) was indicating failed. After transition to Major Mode 3, the SM software was not reading the PCMMU BSR, and the PCMMU BSR bit 10 was getting reset (high) every other second and then back low (observed to be toggling). Toggling of PCMMU BITE status bits are indicative of a failure as continuously set BITE bits. The toggling is only a function where the BITE Status Register is reset.

At wheel stop, the Modular Auxiliary Data System (MADS) recorder "Percent tape used" changed speed from 15 in/sec to 60 in/sec and continued at this rate until End of Tape (EOT) (IFA STS-117-V-11). Normally, the recorder would continue recording data on the runway (at 15 in/sec) until EOT. All indications are the flight data were recorded successfully, but the data on the runway were not recorded. Tests were performed on the vehicle to determine whether the MADS Control Module (MCM) did send the 60 in/sec command erroneously. The recorder did not respond to playback commands during postflight testing and the recorder was removed from the vehicle for further troubleshooting and testing.

At approximately 3.5 min after lift-off, the SSME 3 LH<sub>2</sub> pressure transducer went off-scale-high instantaneously. The associated MDM-OA 3 performed an in-flight test that was successful. It was noted the subject measurement remained at off-scale-high prior to ferry flight. Testing will be performed during the turnaround activities to determine the cause of the failure.

The MADS PCM ascent data were recorded on the Solid State Recorder and dumped to the ground during the flight. The MADS PCM performed nominally with no problems identified during the review of the data. MADS PCM entry data was also reviewed after the flight and no problems related to the MADS PCM unit were identified.

### **Mechanical and Hatches System**

The mechanical and hatches system performance was nominal and within specification during the STS-117 mission. No in-flight anomalies were identified in the data during the STS-117 mission. The system consists of the ET doors, Star Tracker doors, vent doors, and air data probes as well as the Payload Bay Doors Drive and Latch Systems, Ku-Band Deployment System, Radiator Drive and Latch System.

During the final side-hatch closure for flight, a resistance check showed one of two latch over-center limit switches indicated infinite resistance and should have been less than 2.0 ohms. Using the established troubleshooting procedure, the latches were partially unlatched and again latched, after which both limit switches indicated nominal. Post-flight, the rigging for the limit switch was verified to be within the allowable spec, although it was at the low end of the spec.

During the SRMS MPM Stow, both forward pedestal stow switches did not indicate the MPM was stowed (IFA STS-117-V-14). The system 1 stow indication did come on approximately 3 min after the SRMS MPM stow occurred. However, the system 2 stow indication did not come on until approximately 4 min before landing.

### **Landing and Deceleration System**

The landing system performance at Edwards Air Force Base (EAFB) was nominal during the STS-117 mission. This assessment included all events from landing gear deployment through wheels stop. The nose landing gear tires were in good condition and performed nominally. The main landing gear tires also appeared to be nominal. There was the appearance of tread cord materials on areas of the tire's surface and this a known and expected condition based on the characteristics of the new tire design.

The main landing gear touchdown occurred on concrete runway 22 at EAFB at 173/19:49:37 GMT (13/20:11:33 MET) on June 22, 2007. The drag chute was

deployed at 173/19:49:40.2 GMT (13/20:11:36.2 MET). Nose-gear touchdown occurred at 173/19:49:49 GMT (13/20:11:45 MET). Wheels stop occurred at 173/19:50.51 GMT (13/20:02:47 MET). The rollout was normal in all respects.

The following table presents the pertinent data on the landing of the STS-117 Orbiter.

### LANDING PARAMETERS

| Parameter                          | From threshold, ft | Speed, keas <sup>a</sup> | Sink rate, ft/sec | Pitch rate, deg/sec |
|------------------------------------|--------------------|--------------------------|-------------------|---------------------|
| <b>Main landing gear touchdown</b> | <b>1483.7</b>      | <b>204.8</b>             | <b>3.48</b>       | <b>N/A</b>          |
| <b>Nose landing gear touchdown</b> | <b>5364.5</b>      | <b>139.7</b>             | <b>N/A</b>        | <b>-5.30</b>        |

| Parameter                 | Data                      |
|---------------------------|---------------------------|
| Brake Initiation Speed    | 83.9 keas                 |
| Brake On Time             | 46.6 sec                  |
| Rollout Distance          | 10013.1 ft                |
| Rollout Time              | 75.22 sec                 |
| Runway                    | Edwards AFB 22 (concrete) |
| Orbiter Weight at Landing | 199,305 lb                |

### LANDING PARAMETERS (Concluded)

| Parameter      | Maximum Brake Pressure, psia | Total Brake Energy, M ft-lb |
|----------------|------------------------------|-----------------------------|
| Left inboard   | 722.7                        | 8.99                        |
| Left outboard  | 593.2                        | 6.24                        |
| Right inboard  | 875.7                        | 14.51                       |
| Right outboard | 842.7                        | 13.37                       |

<sup>a</sup>Knots equivalent air speed

### Aerothermodynamics, Integrated Heating and Interfaces

Post-flight reports indicated that overall, the Orbiter TPS appeared normal following the STS-117 mission. The lower structural temperature data indicated normal entry heating. The recorded temperatures are within the flight experience of OV-104. From the thermo-couple data, Boundary Layer Transition (BLT) occurred at Mach 7.2 based on the centerline location of X/L = 0.6. The surface

thermal sensors as well as the aileron deflection and yaw thruster firing data all indicated that the vehicle had symmetrical BLT. The frayed arrowhead tadpole gap filler did not affect the BLT earlier than planned. The post-flight inspection indicated that the repaired left-hand OMS pod blanket adequately protected the OMS pod structure.

The lower structural temperature data indicated normal entry heating and the temperatures were within the range expected for this vehicle weight and inclination. The recorded temperatures were within the flight experience of the OV-104 vehicle except at the port-side aft fuselage (P4) and right-hand side OMS pod forward side (RP), which experienced the largest temperature rise recorded for the OV-104 flights. However, their maximum temperatures were only 80.5 °F and 64.9 °F respectively, and occurred at 30 minutes after wheel stop.

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

**ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA**

| Thermal Sensor Location                   | Maximum Temperature, °F | Maximum Temperature Rise, °F |
|-------------------------------------------|-------------------------|------------------------------|
| Lower fuselage forward center (B1)        | 127.3                   | 116.2                        |
| Lower fuselage forward left-hand (B2)     | 169.3                   | 160.7                        |
| Lower fuselage forward mid left-hand (B3) | 158.7                   | 165.5                        |
| Lower fuselage mid center (B4)            | 135.1                   | 144.4                        |

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

| Thermal Sensor Location                    | Maximum Temperature, °F | Maximum Temperature Rise, °F |
|--------------------------------------------|-------------------------|------------------------------|
| Lower fuselage mid aft center (B5)         | 153.5                   | 152.6                        |
| Lower fuselage aft center (B6)             | 177.2                   | 153.3                        |
| Left-wing center (LW)                      | 111.6                   | 136.1                        |
| Right wing center (RW)                     | 114.2                   | 133.6                        |
| Port side FRCS forward (P1)                | 129.9                   | 103.5                        |
| Port side fuselage forward center (P2)     | 88.2 <sup>a</sup>       | 92.4 <sup>a</sup>            |
| Port side fuselage forward mid center (P3) | 80.5                    | 84.6                         |
| Port side fuselage mid aft center (P4)     | 80.5 <sup>a</sup>       | 99.9 <sup>a</sup>            |
| Port side fuselage aft center (P5)         | 83                      | 72                           |

| Thermal Sensor Location                         | Maximum Temperature, °F | Maximum Temperature Rise, °F |
|-------------------------------------------------|-------------------------|------------------------------|
| Starboard side FRCS Forward (S1)                | 132.5                   | 106.1                        |
| Starboard side fuselage forward center (S2)     | 114.2                   | 123.5                        |
| Starboard side fuselage forward mid center (S3) | 93.4                    | 82.3                         |
| Starboard side fuselage mid-aft center (S4)     | 77.9 <sup>a</sup>       | 82.1 <sup>a</sup>            |
| Starboard side fuselage aft center (S5)         | 90.8                    | 74.6                         |
| Left-hand OMS pod side forward (LP)             | 70.1 <sup>a</sup>       | 59.0 <sup>a</sup>            |
| Right-hand OMS pod side forward (RP)            | 64.9 <sup>a</sup>       | 74.2 <sup>a</sup>            |
| Lower body flap center                          | 111.6 <sup>a</sup>      | 82.6 <sup>a</sup>            |
| Right-hand OMS-pod side forward                 | 64.9 <sup>a</sup>       | 74.2 <sup>a</sup>            |
| Left-hand OMS-pod side forward                  | 70.1 <sup>a</sup>       | 59.0 <sup>a</sup>            |
| Right-hand PLBD forward                         | 83.0 <sup>a</sup>       | 135.3a                       |
| Left-hand PLBD forward                          | 85.6 <sup>a</sup>       | 132.8 <sup>a</sup>           |
| Right-hand PLBD aft                             | 88.2 <sup>a</sup>       | 127.9 <sup>a</sup>           |
| Left-hand PLBD aft                              | 90.8 <sup>a</sup>       | 133.0 <sup>a</sup>           |
| Right wing upper center                         | 111.6 <sup>a</sup>      | 136.1 <sup>a</sup>           |
| Left wing upper center                          | 122.0 <sup>a</sup>      | 151.6 <sup>a</sup>           |
| Forward RCS center                              | 111.6 <sup>a</sup>      | 90.3 <sup>a</sup>            |
| Forward fuselage upper center                   | 77.9                    | 97.3                         |

<sup>a</sup> Maximum temperature occurred at 30 minutes after wheel stop.

### **Thermal Control System**

The Thermal Control System (TCS) performed nominally during the STS-117 mission. Minor problems were noted, but none had any impact on the mission.

The crew reported that a 4- to 5-in piece of the TPS thermal blanket on the port OMS pod was sticking up on one corner adjacent to the Low Temperature Reusable Surface Insulation (LRSI) tiles. The temperatures of the interior of the OMS pod near the location of the TPS damage were assessed. The OMS atmospheric model was used with the TPS bondline structure drivers for the damaged area for the two hottest cases. The results of the model assessment were presented to the DAT. It was concluded that internal insulation, if intact, is very effective despite degradation of the structural properties as pressures increases.

The APU 3 Fuel Pump Drain-Line temperature no. 2 violated the LCC of 90 °F for a short period during prelaunch operations. This condition resulted from the daytime heating on the starboard sidewall (reached 88 °F at that time due to Eastern Sun) and the simultaneous increase in the aft purge temperature to 105 °F just prior to tanking. The intent of the LCC is to detect heater failed-on

conditions. Formal documentation was prepared to document this LCC violation as an explained condition.

## **Thermal Protection System**

### **Tile and Blanket Flight Assessment**

The TPS tiles and blankets performed satisfactorily, and a consolidated in-flight anomaly (IFA STS-117-V-02) was assigned for all identified on-orbit issues.

The R-Bar Pitch Maneuver (RPM) data review was completed by the Damage Assessment Team (DAT) and all TPS tile was cleared for the mission except for two protruding gap fillers and one tile area near the outboard edge of the port ET door. One of these gap fillers was near the arrow head tile directly aft of the nose landing gear door and the other was on an aft tile forward of the body flap. Based on the data analysis, the DAT did not recommend removal of either gap filler.

The TPS tiles around window 5/6 and the Port ET Door were cleared on FD 5. Additionally, one area on the right-inboard elevon was identified where adequate data were not obtained. The area had shadows that obscured any areas of interest, and additional imagery was requested.

The major activity of the flight for the DAT was the assessment of the lifted blanket on the port OMS pod. The aerothermal analysis indicated that the entry thermal environment would result in localized temperatures inside the exposed cavity that would exceed the OMS pod graphite-epoxy structure-certification limits. The heating was predicted to be slightly higher in this area than on past flights with similar damage because the blanket extended up into the flow, and thus resulted in increased heat transfer into this cavity. Based on the thermal analysis and the limited test data available for this type of graphite composite structure, the MMT decided to consider the TPS suspect for this area, and directed repair of the blanket on EVA 3. To accommodate the EVA, the docked mission period was extended two additional days.

The DAT also evaluated material testing for the torn blanket and underlying graphite epoxy structure on the port OMS pod. A detailed test plan was submitted to the MMT for the Arc Jet Facility and the Radiant Heat Facility testing of graphite epoxy panels, and also for a blanket pull-test to assist in development of the EVA repair technique.

Team 4 was invoked to plan and develop the procedures to repair the OMS blanket. The MMT was briefed on the different blanket repair options, and the option selected used the Nichrome pins from the TPS overlay repair kit and staples from the medical kit stapler to secure the blanket. The repair was completed successfully during the third EVA.

As a result, all TPS tiles, blankets, and gap fillers were cleared for entry including the repair of the left OMS pod blanket.

### **Reinforced Carbon-Carbon Flight Assessment**

The RPM data review was completed by the DAT and the Reinforced Carbon-Carbon (RCC) was cleared for the mission.

On FD 13, the Micrometeoroid Orbital debris (MMOD) late inspection of the port, starboard, and nose-cap RCC was successfully completed. All of the inspection data were down-linked for review by the DAT. The review of the imagery from the FD 13 OBSS late inspection was completed, and no issues were identified. The vehicle was cleared for entry, and the Wing Leading Edge Impact Detection System (WLEIDS) was powered down.

The post-flight inspection revealed that the RCC panels did have some pinhole locations from outgas on entry. The left-hand RCC panel 9 had pinholes that were the most prominent. There was a chip on the expansion seal of the nose cap at the -Y edge. There were two hypervelocity impacts at the 12 o'clock position of the nose cap just below the expansion seal.

### **Post-landing Assessment**

The Orbiter TPS performed satisfactorily throughout the mission. Overall, the Orbiter post-landing inspection showed the vehicle to be in very good condition with some minor items that are discussed in later paragraphs of this section.

#### **SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE**

| Orbiter Surface             | Impacts > 1in. | Total impacts |
|-----------------------------|----------------|---------------|
| <b>Lower surface</b>        | <b>15</b>      | <b>247</b>    |
| <b>Upper Surface/Window</b> | <b>0</b>       | <b>12</b>     |
| <b>Right side</b>           | <b>1</b>       | <b>3</b>      |
| <b>Left side</b>            | <b>1</b>       | <b>11</b>     |
| <b>Right OMS pod</b>        | <b>0</b>       | <b>13</b>     |
| <b>Left OMS pod</b>         | <b>0</b>       | <b>6</b>      |
| Totals                      | 17             | 292           |

Based on the postlanding runway inspection, the Orbiter lower surface sustained a total of 247 hits, of which 15 had a major dimension of 1 in or larger. The upper surface/windows sustained 12 hits, and none had a major dimension greater than 1 in. The overall condition of the lower surface was within the previous flight experience.

There was a large concentration of debris hits between the main landing gear and the ET doors. The cause of this concentration is not known but is believed to have occurred during landing.

Samples were taken from two debris locations forward of the body flap and just inboard of the left-hand elevon that match up with the debris strike seen from the left-hand SRB camera looking aft.

The leading edge of repaired left-hand OMS blanket had lifted approximately 1 in. There was a small gap visible between the inboard adjacent blanket and the tile. Prior to the ferry flight to KSC, the blanket was removed for failure analysis. A photograph showing the post-flight condition of the left OMS pod blanket is provided on the following page.

A rivet from the drag chute door area was found beneath SSME 2 on the base heat shield to aft stub transition. There was Koropon primer on the rivet. There was also some RTV from the same area.

SSME 1 blanket was frayed at the 6 o'clock position, and the blankets around SSME 2 and 3 were nominal.

There was a fuselage stub tile at the body-flap interface that had lost the entire corner, and the missing piece was approximately 4 in by 2 in.

There appears to be higher amount of base heat shield hits and coating damage in the area between the 3 main engines.

## **Windows**

The windshield windows have been removed and sent to the NASA Shuttle Logistics Depot (NSLD) for detailed inspection. At the time that this report was written, the complete results of the windshield windows were not available. However, windows W7, W8, and W11 have been inspected and no reportable defects were documented.

## **Waste Collection System**

The Waste Collection System (WCS) performed nominally throughout the STS-117 mission. A nominal compaction of the WCS unit was performed. The Shuttle Urine Pre-Treat Assembly (SUPA) was used for the entire mission. There are no in-flight anomalies reported for the WCS.



Post-flight view of port OMS blanket repair.

## **EXTRAVEHICULAR ACTIVITY**

The crew performed three scheduled Extravehicular Activities (EVAs) and one unscheduled EVA. The Mission Management Team (MMT) decided to add a fourth EVA to complete all of the planned tasks. To accommodate the fourth EVA, the docked mission duration was extended one day. The Airlock campout protocol was utilized on this mission in preparation for all of the EVAs.

### **FIRST EXTRAVEHICULAR ACTIVITY**

All planned EVA tasks were completed in 6 hr 15 min during the first EVA. All electrical, data and video umbilical interface connections between the S1 and the S3 Upper and Lower Avionic Trays were completed. Following the connections, the S4 Keel Pin Rotation to enable Solar Array Blanket Box (SABB) deployment was performed. Both crewmembers removed and jettisoned the thermal shrouds on one Multiplexer/De-Multiplexer (MDM) unit, two Electrical Switching Units (ESU) and two Sequential Shunt Units (SSU) following ground confirmation that the hardware was active and operational.

All SABB Launch Restraints were removed to enable SABB deployment and the actuations of the Photovoltaic Radiator (PVR) Cinches and Winches to enable radiator deployment on S4 were completed. The Forward and Aft Mast Canisters launch locks were released and the 4-Bar Mechanism was deployed. This deployment was necessary to position the Solar Array mast canisters to the final fixed position.

The SABB was un-stowed so that the Solar Array Wing deployment could be completed. The initial Solar Array Rotary Joint (SARJ) tasks were performed; and these included installing the Drive Lock Assembly (DLA) no. 2 and removing six Launch Locks. The installation of four Alpha Joint Interface Struts (AJIS) that provide structural support between the SARJ and S4 was completed.

The last task completed was an EVA 2 get-ahead task. The SVS Target on S3 was removed to aid in clearing the path for Mobile Transporter (MT) translation.

### **SECOND EXTRAVEHICULAR ACTIVITY**

The second EVA was completed satisfactorily in 7 hr and 16 min. EVA 2 began with both crewmembers translating to the P6 SAW to begin to assist in retracting the 2B Solar Array. The original time planned for the retraction activity was 1 hr 15 min. However, the task was extended to 2 hr 15 min because of successful corrections being made to the back-folded Flat Connector Circuits (FCC) and grommet hang-ups.

Four SARJ Brace Beams were then installed to provide structural rigidity to the S3 truss. The crewmembers experienced difficulty in aligning the Face 6 Brace Beam because of the extra force required to complete the activity. All Brace Beams were seated and bolted. After completing the Brace Beam task, the DLA no. 1 installation task began, but installation problems were encountered. The Engage-Disengage Motor was in a Drive position and should have been in the Neutral position. Because of this motor position, the DLA experienced pinion gear interference with the race ring and would not align until the motor was returned to Neutral. During troubleshooting of the DLA, the ground controllers confirmed by testing that the DLAs were mislabeled, and therefore, commands sent to DLA 2 were actually going to DLA 1 and vice a versa. This is why the DLA 1 was in the engage configuration because DLA 2 was sent an engage command on Flight Day (FD) 4.

All remaining launch locks on the S3 SARJ were removed, and then the torque was broken on three of the SARJ launch restraints. The removal of all of the launch restraints was not completed because of the extended length of the 2B Solar Array retraction assistance task as well as the loads constraints levied by the inability to engage DLA 2 that was installed on EVA 1.

### **THIRD EXTRAVEHICULAR ACTIVITY**

The third EVA was completed satisfactorily in 7 hr and 58 min. The EVA began with both crewmembers preparing the Shuttle Remote Manipulator System (SRMS) configuration for Orbital Maneuvering System (OMS) pod blanket-repair. The EV2 crewmember translated on the SRMS to the OMS pod and successfully repaired the blanket using techniques developed by ground personnel. The blanket was repaired by inserting pins between the thermal blankets and the Shuttle tiles. The pins were originally developed for Shuttle overlay tile-repair. A surgical stapler was also used to secure the two blankets together.

During the OMS pod blanket repair, the EV1 crewmember successfully performed the water-to hydrogen vent change out on the U.S. Laboratory that will enable oxygen production by the Oxygen Generation System (OGS) in the U. S. Laboratory. Some difficulty was experienced in reinstalling the Micrometeoroid Orbital Debris (MMOD) shield on the U. S. Laboratory forward end cone because of panel misalignment with the Dzus fasteners. To secure the one of the MMOD Shields, adjustable EVA equipment tethers were used to tie down the shield to the adjacent EVA handrails.

The next EVA task performed was the 2B solar array retract task with EV1 on the Space Station Remote Manipulator System (SSRMS) and EV2 on the Mast Canister. After multiple grommet manipulations, guide wire adjustments and single-bay retractions, the SAW was successfully retracted.

## **FOURTH EXTRAVEHICULAR ACTIVITY**

The fourth EVA, which was added during the mission, was 6 hr 29 min in duration. The purpose was to complete tasks previously planned for the earlier EVAs and these were successfully completed.

EVA 4 began with both crewmembers performing a visual inspection of External Stowage Platform (ESP) 2 for structural integrity. No visual gaps were detected during the inspection, as reported by the EV3 crewmember. The intravehicular crewmember reported that good video was received of ESP 2 inspection from the Wireless Video System (WVS). Both crewmembers then removed the Video Stanchion Support Assembly (VSSA) from the Flight Support Equipment (FSE) on ESP-2 and translated to S3 and installed the VSSA.

The DLA no. 2 re-installation and verification was successfully completed by EV3 while EV4 removed six SARJ launch restraints. All EVA SARJ tasks were now completed and ready for the SARJ check out by the ground control team. An EVA Temporary Rail Stop (ETRS) was installed to prevent Crew and Equipment Translation Aid (CETA) Cart, located outboard of the Mobile Transporter (MT), from traveling beyond the rail end points.

Both crewmembers then performed tasks that were deferred from the third EVA 3. Both crewmembers removed and stowed the Drag Link and the Keel Pin that were used for support interfaces between the S3 truss and the Shuttle Cargo Bay, and then they configured the S1 and S3 MT stops as part of the MT clearance tasks.

The crewmembers then completed the Node Local Area Network (LAN) connection between Node 1 and the Russian Functional Energy Block (FGB) segment to provide computer networking connectivity between the two segments. The Micrometeoroid Orbital Debris (MMOD) shield Dzus fastener re-attachment could not be achieved because of MMOD Shield C2-02 panel alignment problems similar to problems encountered on EVA 3. The MMOD shield was tethered using the backup plan for this operation. The final tasks of removing handrail no. 120 and re-tethering the MMOD Shield C2-03 on the U. S. Laboratory were completed using instructions from the ground controllers.

## **REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM**

The Shuttle Remote Manipulator system (SRMS) performed nominally during the mission. STS-117 was the 74th flight of the Shuttle Remote Manipulator System (SRMS), the 25th flight of serial number 301 SRMS, the 5th flight of the Orbiter Boom Sensor System (OBSS), and the 3rd flight of Inspection Boom Assembly (IBA). One problem was identified and it is discussed in a later paragraph.

SRMS initialization and power-up began at 160/02:29 GMT (00/02:51 MET) on FD 1. The port and starboard Manipulator Positioning Mechanisms (MPMs) were deployed and the SRMS shoulder brace was released. The SRMS checkout began 29 min later and was completed in 30 min. SRMS performance during the checkout was nominal. A payload bay survey was then performed, and the SRMS wrist camera was used to inspect the damaged blanket on the port OMS pod. The SRMS was then cradled, powered down and latched.

On FD 2, the SRMS unberthed the OBSS to perform the port and starboard wing leading edge (WLE) Reinforced Carbon-Carbon (RCC) and nose cap surveys. The surveys started at 160/18:49 GMT (0/19:11 MET) and were completed at 160/23:20 GMT (0/23:41 MET). The SRMS berthed the OBSS, and the SRMS wrist camera was then used to inspect the damaged port OMS pod blanket again.

On FD 3, The Orbiter docked with the ISS with the SRMS in the pre-cradle position. The SRMS then grappled the Flight Releasable Grapple Fixture (FRGF) on the starboard side of the S3/S4 truss, unberthed the truss from the payload bay, and handed it off to the Space Station Remote Manipulator System (SSRMS). The SRMS ungrappled the truss at and was maneuvered to the Solar Array Wing (SAW) viewing position.

On FD 4, the SRMS provided viewing support as the SSRMS was used to install the S3/S4 truss. On FD 5, the SRMS provided viewing support during the P6 SAW retraction. On FD 6, the SRMS remained in the SAW-retraction viewing-position during the second EVA. There were no SRMS activities on FD 7.

On FD 8, the SRMS was used as a work platform for the repair of the Port OMS Pod Blanket during the third EVA. A Portable Foot Restraint Attachment Device (PAD), Articulating Portable Foot Restraint (APFR) and Worksite Interface Fixture (WIF) extender were installed on the SRMS. EV2 ingress the APFR and was moved to the OMS Pod Blanket Repair position. During the repair, the SRMS was used to move EV2 slightly around the worksite as the crewmember requested. Following the blanket repair, EV2 egressed the APFR and removed the EVA hardware from the SRMS. After the EVA was completed, the SRMS was cradled, latched and powered down at 167/02:29 GMT (07/02:51 MET).

On FD 9, 10, and 11, the SRMS remained cradled and latched, with no SRMS activities except for a brief power-up twice a day to check SRMS and OBSS temperatures.

On FD 12, the SRMS unberthed the OBSS and completed the port, starboard, and nose cap planned late-inspection surveys. The surveys were completed in 3 hr 5 min. The OBSS and the SRMS were then berthed and powered down, and the port and starboard MPMs were stowed.

During the stowing of the Port Manipulator Positioning Mechanism (MPM), the Forward MPM Stow System 1 and 2 indications did not come on as expected at the end of the stowing motion (IFA STS-117-V-14). The Port MPM stowed in nominal dual motor run since the stow motors are controlled by the shoulder-stow indications. Loss of the forward stow indications does not affect the stow drive time. At 2 min 44 sec after motion stopped, the Forward Stow System 1 indication came on. The Stow System 2 indication occurred approximately 4 minutes prior to touchdown.

# WING LEADING EDGE IMPACT DETECTION SYSTEM

## ASCENT MONITORING

The analysis of the Wing Leading Edge Impact Detection System (WLEIDS) ascent data, downloads, and downlinks identified six impact probable cases above the 1.0 Grms reporting threshold.

All units triggered on Main Engine Ignition and began recording data at launch within 0.1 sec of each other except for unit 1099 which triggered approximately 0.6 sec early. The small errors between units allowed analysis to proceed without additional synchronization, except for unit 1099, which was manually time-shifted to match the other units. The summary of all probable and questionable impacts above 1.0 Grms for this flight is shown in the following table.

A total of six impact probable cases above 1.0 Grms (1 on the port and 5 on the starboard wing) were found and reported during the flight. Post-flight analysis concluded that all cases were analyzed correctly, and did not identify any additional WLEIDS probable impacts above 1.0 Grms.

### SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1 Grms

| Time (s) |       | Location  |     |              | Magnitude    |           | Criteria  |       |          |       | Impact <sup>†</sup> |                 |
|----------|-------|-----------|-----|--------------|--------------|-----------|-----------|-------|----------|-------|---------------------|-----------------|
| MET      | DET   | Wing      | RCC | Unit-Channel | Maximum Grms | Maximum G | Transient | Local | Spectral | Shock | In-flight           | Post-flight     |
| 13.8     | 23.0  | Port      | 6-7 | 1085-J3      | 1.9          | 10.0      | +         | +     | +        | +     | P                   | P <sup>††</sup> |
| 76.0     | 85.2  | Starboard | 5-6 | 1088-J3      | 1.8          | 7.3       | +         | +     | +        | +     | P                   | P               |
| 94.2     | 103.4 | Starboard | 3-4 | 1209-J2      | 1.6          | 12.0      | +         | +     | +        | +     | P                   | P               |
| 99.2     | 108.4 | Starboard | 8-9 | 1110-J1      | 1.1          | 5.6       | +         | +     | +        | +     | P                   | P               |
| 108.2    | 117.4 | Starboard | 5-6 | 1088-J3      | 1.0          | 3.2       | +         | +     | +        | +     | P                   | P               |
| 109.9    | 119.1 | Starboard | 10  | 1114-J2      | 2.4          | 8.8       | +         | +     | +        | +     | P                   | P               |

<sup>†</sup> P=probable, Q=questionable, N=no, U=unfound

<sup>††</sup>For STS-115, 1085-J3 indicated a 3.9 Grms response at MET 14.2 sec with nearly identical frequency response characteristics. These responses may not be ascent debris impact related.

Automatic scanning of the post-flight data acquired from liftoff to 500 sec revealed a total of 87 probable ascent debris impacts on the wing leading edge (27 on the port and 60 on the starboard wing) ranging from 0.1 Grms to 2.4 Grms.

## ORBIT MONITORING

The Micrometeoroid Orbital Debris (MMOD) monitoring on the port wing was performed on Flight Day (FD) 2 and 3, and then again during the latter half of the mission on FD 12 and 13 for a total monitoring time of 40.19 hrs. The MMOD monitoring of the starboard wing was performed during the middle of the flight on FD's 3 through 9, for a total monitoring time of approximately 127.76 hrs. Each WLE was monitored with groups of 3 units covering 9 Reinforced Carbon-Carbon (RCC) panel interfaces. The sensor unit battery life limitations are highly dependent upon the thermal environment, and as a result, continuous on-orbit monitoring of each RCC panel was not possible.

On Flight Night 3, the WLE IDS recorded data from two valid triggers. The first of these was evaluated by the WLE Valid Trigger Team and found to meet all impact criteria. The second trigger was also found to meet all impact criteria. Multiple subsystems within the MER were polled for each case to determine if other activities may have been responsible for this structural transient, but no other likely sources were identified.

The summary of all WLEIDS MMOD probable impacts for this flight is shown in the following table.

### SUSPECTED MMOD IMPACTS

| Time         | Location  |       |         | Magnitude    |              | Criteria  |           |       |          | Impact <sup>†</sup> |           |
|--------------|-----------|-------|---------|--------------|--------------|-----------|-----------|-------|----------|---------------------|-----------|
|              | GMT       | Wing  | RCC     | Unit-Channel | Maximum Grms | Maximum G | Transient | Local | Spectral | Shock               | In-flight |
| 162/07:41:23 | Port      | 7-8   | 1089-J1 | 0.1          | 0.5          | +         | +         | +     | +        | P                   | P         |
| 162/10:50:57 | Starboard | 11-12 | 1098-J3 | 0.2          | 1.3          | +         | +         | +     | +        | P                   | P         |

Post-flight automatic scanning found no additional MMOD impacts.

## ANOMALIES

No ascent data anomalies were found during the mission. Automatic scanning of post-flight ascent data revealed the single anomaly listed in the following table.

## ASCENT DATA ANOMALIES

| Time (s) |       | Location  |       |              | Magnitude    |           | Criteria  |       |          |       | Anomaly <sup>†</sup> |             |
|----------|-------|-----------|-------|--------------|--------------|-----------|-----------|-------|----------|-------|----------------------|-------------|
| MET      | DET   | Wing      | RCC   | Unit-Channel | Maximum Grms | Maximum G | Transient | Local | Spectral | Shock | In-flight            | Post-flight |
| 490.6    | 499.8 | Starboard | 11-12 | 1098-J3      | 0.2          | 0.7       | +         | +     | -        | -     | U                    | P           |

While reviewing MMOD monitoring data in-flight, some units were found to have large, quick, random, bias shifts as well as fluctuating magnitude. These units are listed in the following table.

### OTHER ANOMALOUS BEHAVIOR

| Anomaly Description | OV-103 Units     |
|---------------------|------------------|
| Sharp Bias Shifts   | 1092, 1100, 1101 |

### SUPPLEMENTAL DATA COLLECTED

During the Flight Control System (FCS) checkout, on-orbit groups 4-7 of the Port wing captured the checkout. Twenty-four triggers were captured across all groups. Post-flight analysis confirmed that WLES and FCS checkout event elapsed times were highly correlated.

### CONCLUSIONS

The WLEIDS performed well for ascent impact monitoring, and most of the reported impacts were close to the 1.0 Grms reporting threshold.

The MMOD monitoring capability was limited by the lack of:

1. The continuous wing coverage associated with battery/thermal considerations.
2. The gaps in coverage due to lack of Ku-band antenna communications.
3. The time required to request units be brought out of and placed into the MMOD-monitoring mode
4. The excessive invalid triggering of the units.

Even though these conditions existed, the MMOD monitoring detected two probable impacts on flight night 3.

A recommendation to not perform a focused WLE inspection of the RCC was made based on the ascent findings from all systems including WLEIDS. A focused inspection for the MMOD impact cases was likewise not recommended. The analysis of the late inspection data was able to clear the vehicle for entry.

## **GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT**

The overall performance of the Government Furnished Equipment/Flight Crew Equipment was satisfactory; however, five In-flight Anomalies (IFA's) were identified and none impacted the successful completion of the mission. The anomalies are described in the following paragraphs and a more detailed description is contained in Appendix B of this report.

The crew reported that camera A was stuck in near focus (IFA STS-117-V-04). Troubleshooting was performed later and the response was reported to be sluggish. However, approximately 24 hr later, the focus was recovered and the camera operated properly for the remainder of the flight.

At 168/14:19 GMT (008/14:41 MET), the crew reported that minor leakage was observed at the Mineral/Silver Biocide Injection Port on the Water Transfer Hose when filling a Contingency Water Container (CWC) (IFA STS-117-V-05). The crew reported that the leakage was very small and had no impact to the flight when filling CWC's. Upon further investigation, the leakage was believed to be around the injection port of the Shuttle Supply Water Hose Assembly, and started when filling CWC 6 or 7.

The Space-to-Space Orbiter Radio (SSOR) primary string was lost (IFA STS-117-V-06). Telemetry indicated abnormal frame synchronization. The problem was first observed at 164/14:26 GMT for about 3 min, and then unit recovered without intervention. The second occurrence was at 164/15:27 GMT for about 5 min, after which the crew switched to string 2. The Extravehicular Activities (EVAs) were performed using SSOR string 2. On Flight Day (FD) 11, the SSOR 1 was powered for approximately 1 min, and it worked nominally.

During Late Inspection activities on FD 12 the crew reported CCTV monitor 2 had static pan and tilt values on the screen (IFA STS-117-V-08). The monitor was removed and shipped to the vendor for troubleshooting. Also, the crew discovered and reported image flickering on CCTV monitor 1 causing the top half of the image to distort and shift (IFA STS-117-V-09). The image remained usable for clearance views. The monitor will be removed and shipped to the vendor for troubleshooting.

Six of the twenty-nine digital umbilical camera images downlinked on FD 1 had varying degrees of horizontal "tearing" (bands of corruption) (IFA STS-117-V-07). JSC Engineering believes this corruption is introduced during image downloading from the camera to the crew-cabin laptop when the images pass through a firewire conversion board (i.e. not in the Kodak DCS760 camera). This may result from a cold (unheated) camera-firewire-board.

During the post-flight review of the STS-117 MSGU flight data, it was discovered that the three MSGU units (S/Ns 1057, 1058, and 1070) did not take data during the flight (IFA STS-117-V-13). These units had originally passed pre-flight functional testing and programming, but failed to take data during ascent. Four units (S/N 1006, 1030, 1048, 1050 and 1065) failed prior to flight during pre-flight functional testing. Formal documentation declared these units non-functional before flight.

## **DEVELOPMENT TEST OBJECTIVES**

### **Development Test Objective 805 Crosswind Landing Performance**

Development Test Objective (DTO) 805 Crosswind Landing Performance, a DTO of opportunity, was not performed during landing because the 2 knot crosswind component did not meet the minimum requirements. The minimum acceptable crosswind is a 10 knot crosswind at landing.

## **POSTLAUNCH PAD INSPECTION**

The STS-117 post launch inspection of the Mobile Launch Platform (MLP) 2, Launch Pad A Flight Service Structure (FSS), and Launch Pad A apron was conducted from Launch +2.5 hr to 6.5 hr. The inspection proceeded relatively quickly after the Safing Teams secured the launch pad. Overall, the launch pad area was in very good condition with no anomalous conditions identified.

No flight hardware was found other than typical SRB nozzle throat plug foam and RTV.

Orbiter liftoff lateral acceleration data indicated a maximum of 0.12g. Hold-down stud hang-ups are typically noted with lateral accelerations above 0.19g.

The inspection of the SRB holddown posts (HDP) was performed and the items identified are as follows:

1. HDP no.1 – The poured sidewalls were nominal without any delamination from the shoe, the Phenolic shim was nominal without visual blistering and the firing lines were not present;
2. HDP no. 2 – The poured sidewalls were nominal without any delamination from the shoe, the Phenolic shim was nominal without visual blistering, approximately 2 ½ ft of Range Safety System (RSS) cable was present, and the firing lines were not present;
3. HDP no. 3 – The HDP showed nominal indications of erosion on the Room Temperature Vulcanizing (RTV) -coated blast shield with proper closure;
4. HDP no. 4 – The HDP showed more than typical indications of erosion on the RTV-coated blast shield with proper closure;
5. HDP no. 5 – The poured sidewalls had visible voids on the South wall without any delamination from the shoe, the Phenolic shim was nominal without visual blistering and the firing lines were not present;
6. HDP no. 6 – The poured sidewalls were nominal without any delamination from the shoe, the Phenolic shim was nominal without visual blistering and the firing lines were partially present (approximately 1 ft for both lines);
7. HDP no. 7 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure; and
8. HDP no. 8 – This HDP showed more than typical indications of erosion on the RTV-coated blast shield with proper closure. The RSS cable was also missing.

Both SRB aft-skirt Gaseous Nitrogen (GN<sub>2</sub>) purge lines were intact. The left-hand probe was standing straight, but the protective tape layering was missing, and the braiding was exposed with no erosion damage. The right-hand probe

was standing straight, but the protective tape layering was missing and the braiding was exposed with no erosion damage.

The LO<sub>2</sub> and LH<sub>2</sub> Tail Service Masts (TSM's) appeared undamaged and both bonnets appeared to have closed properly. The MLP deck was in excellent condition with no debris detected under the raised deck and no debris was found in the gutters. Typical blast erosion was observed in and around the SRB flame holes. All sound suppression shims appeared to be in place.

The GH<sub>2</sub> vent line Ground Umbilical Carrier Plate (GUCP) latched on the eighth tooth (of eight) on the latching mechanism. The vent line was in between the gimbal struts and slightly south of center in the latching mechanism as seen from the FSS. The External Tank (ET) GUCP 7-inch GH<sub>2</sub> Quick-Disconnect (QD) probe was accessible for inspection and appeared to be undamaged. Both the QD probe sealing surface and the poppet valve assembly were in good condition with minor SRB plume speckles on the poppet probe. The deceleration cable was in the nominal configuration. The GH<sub>2</sub> vent line blanket was mostly torn away by plume impingement. The ET GUCP exhibited minimal blast damage and the pyrotechnic bolt fired nominally.

The Orbiter Access Arm (OAA) was not accessible for a walkdown, but it appeared to be intact with no evidence of plume damage. All slidewire baskets were still secured at the 195-ft level with no evidence of damage.

The Gaseous Oxygen (GOX) vent arm, vent hood, ducts and structure appeared to be in nominal condition. The GOX vent seals were inspected and showed no signs damage nor ET topcoat or Thermal Protection System (TPS) transfer. The East (port side) GOX vent flexible duct aluminized blanket showed blast damage. The upper and lower shock- absorbers had visible corrosion and the latch mechanism locked properly.

Although numerous debris items were found, the launch pad facility was found to be in very good condition. The most notable debris items using the new debris collection criteria are as follows.

1. Some pieces of Solid Rocket Booster (SRB) throat plug material were found on the launch pad apron;
2. Six small pieces of concrete/fondue fire material were found on the west and east side of the Pad surface;
3. One piece of wood approximately 1-in by 1-in by 6-in was found near the east side of the launch pad apron;
4. Six pieces of rust/scale larger than 1-in in diameter were found between 135-ft level and 255-ft level;
5. The 235-ft level southeast Firex suppression line was leaking excessively;
6. The 295-ft level fiberglass panel roof showed evidence of major damage, with most panels scattered and loosely stacked atop the support structure,

and this condition created potential hazards during high-wind conditions. The remnant roofing material debris was found on preceding levels;

7. Several bundles of SRB flame trench water baggie rope were found and will be weighed and cataloged;
8. A Security Seal Tag was found on East portion of the launch pad surface near the flame deflector; and
9. The 135-ft level southeast Firex box was excessively corroded and liberated large scaling into the grating. The loudspeakers above the Firex box were warped due to heat effects. Two bolts were also found in the grating and Orbiter Work Platform beams.

## LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

The ground cameras, both film-type and television, provided very good coverage of the launch and ascent of the STS-117 vehicle. In general, less than typical facility debris entered the field of view of the Main Launch Platform (MLP) and Flight Service Structure (FSS) cameras. Numerous normal as well as other observations were made, and these are presented in the following list.

1. Piano key tile piece liberated from aft stub carrier panel. This is a tile located on the fuselage portion of the body flap hinge line, just below SSME no. 2. Missing tile was noted during the post landing walk down. After landing, the R-Bar Pitch Maneuver (RPM) imagery was then reassessed and the damaged tile was found, in shadow, below Space Shuttle Main Engine (SSME) no. 2. The estimated dimensions for the missing tile are approximately 4 in by 2 in.
2. Ice/frost noted falling and impacting SSME no. 3 nozzle near 8th hatband. Ice/frost debris originates from LO<sub>2</sub> T-0 umbilical. No damage identified.
3. The roof panels at the 295-ft level of the FSS were first seen lifting after the vehicle cleared the tower. Good imagery was obtained from lift-off-to-tower clear and no motion was identified prior to tower clear. During post-launch walkdown, these fiberglass panels were seen to be destroyed and are planned to be replaced.
4. Umbilical baggie material was loose and flapping on both the LH<sub>2</sub> and the LO<sub>2</sub> umbilicals. Note more pronounced on LH<sub>2</sub> umbilical side. No damage to vehicle was observed from the ground cameras.
5. Large piece of debris seen emanating from LO<sub>2</sub> External Tank/Orbiter (ET/ORB) umbilical area (appears to originate from the +Y side of the ET vertical strut) and falling aft in the SSME plume.
6. A damaged thermal blanket was noted on the port Orbital Maneuvering System (OMS) pod. Later it was determined to measure approximately 2.5-in by 6.8-in and height above Outer Mold Line (OML) of 2 in ± 0.2 in.
7. RADAR reported 21 contacts in the 30hr report between 109 and 138 sec.
8. Shower of dark debris objects coming from the area near the ET aft end at Solid Rocket Booster (SRB) separation. Some particles appear to impact the Orbiter right wing and body flap areas.
9. Debris impact on Left-Hand (LH) side lower surface forward of the body flap after SRB separation, debris measurements (provided by MSFC) are 4.50 by 5.00 in (SRB clock time 124.675 Mission Elapsed Time (MET)).
10. Debris, two or three pieces (dark appearing) seen liberating from -Y side of LO<sub>2</sub> feedline, aft of the forward bipod (near Station 1129), moves upward in view towards fuselage and falls aft. No impact identified. Correlated to NIRD Reportable Issue 117-012.
11. Frayed, rope-like object noted flapping near aft section of LH<sub>2</sub> umbilical area. It was seen at both SRB and ET timeframes. Material was noted still attached to the ET during separation. Rough estimate of string

- dimensions (considering distortion of fish-eye lens) is approximately 14 to 20 in long by approximately 0.4 in wide.
12. Divot noted on the -Y side of the LO<sub>2</sub> feedline aft of the starboard bipod attach. Did not appear to be associated with a hail-repair site when compared to Baseline Closeout Imagery data.
  13. TPS divot in LH<sub>2</sub> acreage just inboard of Xt-1623 LO<sub>2</sub> feed line bracket.
  14. TPS divot in LH<sub>2</sub> acreage just inboard of Xt-1623 LO<sub>2</sub> feedline bracket.

**APPENDIX A**  
**STS-117 MISSION EVENTS**

| <b>EVENT</b>                          | <b>DESCRIPTION</b>                                                                                                                       | <b>ACTUAL GMT</b>                                                            |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| APU Activation                        | APU-1 Gas Generator Chamber Pressure<br>APU-2 Gas Generator Chamber Pressure<br>APU-3 Gas Generator Chamber Pressure                     | 159:23:33:17.045<br>159:23:33:18.528<br>159:23:33:19.872                     |
| SRB HPU Activation                    | LH HPU System A Start Command<br>LH HPU System B Start Command<br>RH HPU System A Start Command<br>RH HPU System B Start Command         | 159:23:37:35.962<br>159:23:37:36.122<br>159:23:37:36.282<br>159:23:37:36.482 |
| Main Engine Start                     | SSME-3 Start Command Accepted<br>SSME-2 Start Command Accepted<br>SSME-1 Start Command Accepted                                          | 159:23:37:57.467<br>159:23:37:57.580<br>159:23:37:57.691                     |
| SRB Ignition                          | SRB Ignition Command                                                                                                                     | 159:23:38:04.012                                                             |
| Throttle Up 104.5 Percent             | SSME-3 Command Accepted<br>SSME-2 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:38:07.867<br>159:23:38:07.876<br>159:23:38:07.883                     |
| Throttle Down to 72 Percent           | SSME-2 Command Accepted<br>SSME-3 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:38:32.988<br>159:23:38:32.997<br>159:23:38:33.004                     |
| Throttle Up to 104.5 Percent          | SSME-3 Command Accepted<br>SSME-2 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:38:52.189<br>159:23:38:52.197<br>159:23:38:52.204                     |
| Maximum Dynamic Pressure (Max Q)      | Derived Ascent Dynamic Pressure                                                                                                          | 159:23:39:07                                                                 |
| Both SRMs to less than 50 psi         | RH SRM Chamber Pressure<br>LH SRM Chamber Pressure                                                                                       | 159:23:40:02.012<br>159:23:40:02.692                                         |
| End SRM Action                        | RH SRM Chamber Pressure<br>LH SRM Chamber Pressure                                                                                       | 159:23:40:07.112<br>159:23:40:07.712                                         |
| SRB Separation Command                | SRB Separation Command Flag                                                                                                              | 159:23:40:07                                                                 |
| SRB Physical Separation               | LH APU A Turbine Loss of Signal<br>RH APU B Turbine Loss of Signal<br>LH APU B Turbine Loss of Signal<br>RH APU A Turbine Loss of Signal | 159:23:40:07.25<br>159:23:40:07.25<br>159:23:40:07.29<br>159:23:40:07.29     |
| OMS Assist Ignition                   | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                                             | 159:23:40:17.5<br>159:23:40:17.6                                             |
| OMS Assist Cutoff                     | R Engine Bipropellant Valve Position<br>L Engine Bipropellant Valve Position                                                             | 159:23:43:08.0<br>159:23:43:08.1                                             |
| Throttle Down for 3g                  | SSME-3 Command Accepted<br>SSME-2 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:45:28.200<br>159:23:45:28.205<br>159:23:45:28.208                     |
| 3G Acceleration                       | Total Load Factor (g)                                                                                                                    | 159:23:46:16.2                                                               |
| Throttle down to 67percent for Cutoff | SSME-3 Command Accepted<br>SSME-2 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:46:22.602<br>159:23:46:22.607<br>159:23:46:22.609                     |
| SSME Shutdown                         | SSME-3 Command Accepted<br>SSME-2 Command Accepted<br>SSME-1 Command Accepted                                                            | 159:23:46:28.922<br>159:23:46:28.927<br>159:23:46:28.929                     |
| Main Engine Cutoff (MECO)             | MECO Command Flag<br>MECO Confirmed Flag                                                                                                 | 159:23:46:29<br>159:23:46:30                                                 |
| ET Separation                         | ET Separation Command Flag                                                                                                               | 159:23:46:50                                                                 |
| APU Deactivation                      | APU-1 Gas Generator Chamber Pressure<br>APU-2 Gas Generator Chamber Pressure<br>APU-3 Gas Generator Chamber Pressure                     | 159:23:52:55.946<br>159:23:53:15.788<br>159:23:53:26.453                     |

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**STS-117 MISSION EVENTS**

| <b>EVENT</b>                                    | <b>DESCRIPTION</b>                                                                                                   | <b>ACTUAL GMT</b>                                        |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| OMS 1 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | Not Required                                             |
| OMS 1 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | Not Required                                             |
| OMS 2 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 160:00:16:34.2<br>160:00:16:34.3                         |
| OMS 2 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 160:00:17:38.3<br>160:00:17:38.4                         |
| Payload Bay Doors Open                          | Right Payload Bay Door Open 1<br>Left Payload Bay Door Open 1                                                        | 160:01:20:10<br>160:01:21:28                             |
| OMS 3 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 160:16:40:44.9<br>160:16:40:44.9                         |
| OMS 3 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 160:16:41:11.1<br>160:16:41:11.1                         |
| OMS 4 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:01:09:49.5<br>161:01:09:49.5                         |
| OMS 4 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:01:11:22.9<br>161:01:11:22.9                         |
| OMS 5 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:15:27:28.1<br>161:15:27:28.1                         |
| OMS 5 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:15:28:19.7<br>161:15:28:19.9                         |
| OMS 6 Ignition                                  | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:17:00:37.3                                           |
| OMS 6 Cutoff                                    | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 161:17:00:49.7                                           |
| Docking                                         | Capture                                                                                                              | 161:19:36:10                                             |
| Undocking                                       | Undocking Complete                                                                                                   | 170:14:42:00                                             |
| Flight Control System<br>Checkout – APU 1 Start | APU-3 Gas Generator Chamber Pressure                                                                                 | 171:14:07:20.804                                         |
| APU 1 Stop                                      | APU-3 Gas Generator Chamber Pressure                                                                                 | 171:14:14:09.654                                         |
| Payload Bay Door Close                          | Left Payload Bay Door Close<br>Right Payload Bay door Close                                                          | 172:14:35:16<br>172:14:37:16                             |
| Payload Bay Door Open                           | Right Payload Bay Door Open 1<br>Left Payload Bay Door Open 1                                                        | 172:17:42:49<br>172:17:44:08                             |
| Payload Bay Door Close                          | Left Payload Bay Door Close<br>Right Payload Bay door Close                                                          | 173:14:32:40<br>173:14:34:17                             |
| APU Activation                                  | APU-3 Gas Generator Chamber Pressure<br>APU-1 Gas Generator Chamber Pressure<br>APU-2 Gas Generator Chamber Pressure | 173:18:38:54.000<br>173:19:05:23.478<br>173:19:05:27.858 |
| Deorbit Maneuver Ignition                       | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 173:18:43:47.3<br>173:18:43:47.4                         |
| Deorbit Maneuver Cutoff                         | L Engine Bipropellant Valve Position<br>R Engine Bipropellant Valve Position                                         | 173:18:46:21.3<br>173:18:46:21.4                         |
| Entry Interface                                 | Orbital Altitude Referenced to Ellipsoid                                                                             | 173:19:18:13                                             |
| Blackout End                                    | Data Locked (High Sample Rate)                                                                                       | No Blackout                                              |
| Terminal Area Energy<br>Management (TAEM)       | Major Mode Code (305)                                                                                                | 173:19:43:24                                             |
| Main Landing Gear Contact                       | Main Landing Gear Left Hand Tire Pressure<br>Main Landing Gear Right Hand Tire Pressure                              | 173:19:49:37<br>173:19:49:37                             |

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**STS-117 MISSION EVENTS**

| <b>EVENT</b>                       | <b>DESCRIPTION</b>                            | <b>ACTUAL GMT</b> |
|------------------------------------|-----------------------------------------------|-------------------|
| Main Landing Gear Weight on Wheels | Main Landing Gear Right-Hand Weight on Wheels | 173:19:49:38      |
|                                    | Main Landing Gear Left Hand Weight on Wheels  | 173:19:49:41      |
| Drag Chute Deployment              | Drag Chute Deploy 1 CP Volts                  | 173:19:49:40.2    |
| Nose Landing Gear Contact          | Nose Landing Gear Left Hand Tire Pressure 1   | 173:19:49:49      |
| Nose Landing Gear Weight on Wheels | Nose Landing Gear Weight on Wheels            | 173:19:49:49      |
| Drag Chute Jettison                | Drag Chute Jettison 2 CP Volts                | 173:19:50:17.9    |
| Wheels Stop                        | Velocity with respect to Runway               | 173:19:50:51      |
| APU Deactivation                   | APU-1 Gas Generator Chamber Pressure          | 173:20:07:34.853  |
|                                    | APU-2 Gas Generator Chamber Pressure          | 173:20:07:45.448  |
|                                    | APU-3 Gas Generator Chamber Pressure          | 173:20:07:56.559  |

# **APPENDIX B IN-FLIGHT ANOMALIES**

## **INTRODUCTION**

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-117 mission.

1. Orbiter
2. Solid Rocket Booster – No anomalies recorded for STS-117
3. Reusable Solid Rocket Motor
4. External Tank
5. Space Shuttle Main Engine - No anomalies recorded for STS-117
6. Systems Engineering and Integration (SE&I)
7. Flight Operations & Integration (FO&I)

## APPENDIX B STS-117 IN-FLIGHT ANOMALY LIST

### ORBITER

| IFA Number   | Title                                                                            | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-01 | Engine 3 LH <sub>2</sub> Pressure Transducer OSH/FA3 Card 14 A/D BITE Indication | <p>At approximately 3.5 min after lift-off, the SSME 3 LH<sub>2</sub> pressure transducer went off-scale high (OSH) instantaneously. This caused the Flight Aft (FA) 3 Multiplexer/Demultiplexer (MDM) to report an Analog/Digital (A/D) Built-In Test Equipment (BITE) on card 14. All other data from the card reported nominally.</p> <p>During post-flight troubleshooting, the console readings fusing a millivolt input matched the expected values, which indicate that the system upstream from the connector is working properly. Sensor readings with the fuses installed indicated a 3.65 V reading on the sensing line between pins 2 and 3. The expected value was to be in the millivolt range. This 3.65 V reading matches the OSH reading of the mated transducer. The transducer has been replaced.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| STS-117-V-02 | TPS Tile and Blanket Anomalies                                                   | <ol style="list-style-type: none"> <li>1. OMS pod - Following the FD1 survey, the crew reported that on the port OMS pod, a 4- to 5-in piece of blanket was sticking up. In addition to crew photographs, an Orbiter Boom Sensor System (OBSS) survey was performed and the R-Bar Pitch Maneuver (RPM) photographs were acquired. The initial review indicated that the damage did not result from a debris impact. Uncertainty remained over the level of exposure of the OMS pod skin beneath the damaged area. Entry thermal analysis, debris transport analysis, and review of ground processing data for this blanket were performed. An EVA was also performed to repair the area. Post-flight imagery showed some separation of the blanket.</li> <li>2. Arrowhead Gap Filler - Tadpole Gap Filler protruding between the RCC Arrowhead plate and a tile.</li> <li>3. Aft Fuselage Gap Filler - Ames Gap Filler protruding between two tiles</li> <li>4. Port External Tank Door (ETD) Tile Damage - Three damaged areas were noted on the outboard side of ETD (Site 870-001 was two damaged areas adjacent to ETD thermal barrier- 4.0 in long by 0.63 in wide. Site 870-002 – damaged area extends over two tiles).</li> <li>5. Starboard ET Door Damage - Site 860-001 on right-hand inboard edge - damage was 1.23-in by 0.91-in that was adjacent to ET thermal barrier. Additional damage on right-hand Inboard edge was 1.23 in. by 0.91-in adjacent to ET thermal barrier</li> <li>6. Reinforced Carbon-Carbon (RCC) Panel 21L Gap Filler - Tadpole gap filler located by RCC Panel 21L</li> <li>7. Tile piece from the aft fuselage body flap interface liberated during liftoff/ascent.</li> </ol> |

## APPENDIX B

### STS-117 IN-FLIGHT ANOMALY LIST

| IFA Number   | Title                                                 | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-02 | TPS Tile and Blanket Anomalies (Continued)            | <p>OV-104 OMS Pod blankets have been removed and failure analysis is in work. OV-105's OMS Pod-to-tile/blanket interfaces were inspected prior to rollout from the Orbiter Processing Facility (OPF) and area was reworked as required to eliminate any excessive forward-facing step conditions. In addition, the forward edge on any newly installed blankets was bonded to the adjacent tiles to provide additional robustness while the failure analysis is in work. An analysis has been performed for the existing design, bonded configuration, and off-nominal configuration of a 0.25-in forward-facing step condition. The analysis results were satisfactory and the configuration has now been cleared for STS-118. No tadpole gap fillers exist at the forward ET attachment RCC plate or the LESS carrier panels for STS-118. A lower surface survey did identify a tadpole installation at tile interface outboard of the chin panel. The stitching/fabric for the remaining tadpole gap fillers were coated to reduce the potential for fraying. All tadpole gap fillers on OV-105 (STS-118) exist in locations where the vehicle flow washes overboard and therefore is not a transition threat. As a result, a Non-Flight Constraint (NFC) has been completed for STS-118.</p> |
| STS-117-V-03 | Operational Aft (OA) 2 MDM BITE Indication on Card 05 | <p>A fault message was annunciated on MDM OA2 – Card 5, which has flown every OV-104 flight with its first flight on STS-51J (10/85). A BITE Bit 4 (Unable to Transfer Data to/from IOM) and Bit 9 (Internal Error Detected) were annunciated. Card 5 (Discrete Input High) with 3 channels of each 16 discrete inputs was affected. Each channel returned some expected and some unexpected data. The other 15 MDM OA2 cards performed nominally. MDM OA2 Card 5 problem.</p> <p>One observed artifact of this failure has been a toggling of the BITE indication (validity bit). The BITE is reset at regular times. If the timing of the data polling happens to line up with a period after the BITE is reset, but before the test is completed, the bit will report good for that cycle. This will result in the bit toggling in data. One cycle it will report good (when the BITE was just reset), then the next report failed (after the BITE fails again). This does not indicate the BITE is passing periodically. In reality, the BITE is consistently failing. The MDM was power-cycled post-flight and the anomaly signature was repeated. Removal and replacement of the MDS was completed successfully.</p>                                                                       |
| STS-117-V-04 | Camera A Stuck in Near Focus                          | <p>The crew reported that camera A was stuck in near focus. No troubleshooting initially performed due to lack of KU-band time. Troubleshooting was performed later and the response was reported to be sluggish at 161/07:52 GMT. However, approximately 24 hr later, the focus was recovered and the camera operated properly for the remainder of the flight.</p> <p>During post-flight operations, a complete analysis of the vertical-Interval temperature data when video were received from Building 8 will be performed. The standard camera removal and testing were performed.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## APPENDIX B

### STS-117 IN-FLIGHT ANOMALY LIST

| IFA Number   | Title                                                        | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-05 | Leak at Contingency Water Container (CWC) Fill Injector Port | <p>At 168/14:19 GMT (008/14:41 MET), the crew reported that they have been seeing minor leakage at the Mineral/Silver Biocide Injection Port on the Water Transfer Hose during CWC Fills. The crew reported that the leakage was very small and has no impact to when filling CWC's. A towel was wrapped around the port to soak up the leaking water. Upon further investigation, the leakage was believed to be around the injection port of the Shuttle Supply Water Hose Assembly, and started at CWC fill 6 or 7. The CWC fills are either potable or technical water. Samples were taken from potable fills 6, 9 and 16. These samples were returned to ground for analysis to confirm enough silver biocide was added to the water.</p> <p>Failure is most likely in the poppet in the leur connection, past the ball valve. Leak check is done on the ground prior to flight with the ball valve closed, so the leak is probably past the ball valve.</p> <p>Post-flight, the assembly was shipped to JSC and initial troubleshooting concentrated on leak detection at the quick-disconnect area with no leakage found. After the crew debriefing, it was pointed out that the leak was most likely coming the stem valve and not the quick disconnect. Additional testing was conducted focusing on the stem valve.</p> |
| STS-117-V-06 | Space-to-Space Orbiter Radio (SSOR) 1 Loss of Communications | <p>The SSOR primary string was lost. Telemetry indicates abnormal frame synchronization. The problem was first observed at 164/14:26 GMT for about 3 min, and then unit recovered without intervention. The second occurrence was at 164/15:27 GMT for about 5 min, after which crew switched to string 2. The Extravehicular Activities (EVAs) were performed using SSOR string 2.</p> <p>On FD 11, the SSOR 1 was powered for approximately 1 min, and it worked nominally. The SSOR was removed for troubleshooting and other tests. No spare SSORs are available to replace the unit on the vehicle.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| TS-117-V-07  | Digital Umbilical Camera Image Corruption                    | <p>Six of the twenty-nine digital umbilical camera images downlinked on FD 1 have varying degrees of horizontal "tearing" (bands of corruption). Corruption is introduced during image download from the camera to the crew-cabin laptop. JSC Engineering believes this corruption is introduced when the images pass through a firewire conversion board (i.e. not in the Kodak DCS760 camera). This may result from a cold camera-firewire-board. There are no heaters on this firewire board.</p> <p>A second download (post ferry flight) of 117 images was completed. Image corruption was seen in 2 of 30 images. The camera will be returned to JSC for reprocessing for another mission. JSC Engineering evaluation of the cause of the imagery corruption is continuing. An interim disposition to use-as-is (related only to the image corruption) has been approved for the next two flights. For STS-118, the crew will download the images twice from the camera to the laptop to provide a redundant set for analysis, if needed, and for engineering data on camera download performance.</p>                                                                                                                                                                                                                      |

## APPENDIX B

### STS-117 IN-FLIGHT ANOMALY LIST

| IFA Number   | Title                             | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-08 | Monitor 2 Loss of Camera Data     | <p>The crew reported a loss of camera data that was displayed on Monitor 2. The pan-and-tilt values were static (read 3 and 400). The camera lens Field of View (FOV) showed dashes. The problem was evident in both green and white data. The problem appeared in monitor 2 on FD12 and remained throughout the rest of the mission. Monitor power cycles had no affect on the display. The crew verified that the camera data was displayed correctly on Monitor 1.</p> <p>Monitor was tested with a CCTV camera prior to removal from the vehicle. Tests to show if monitor 2 still shows static pan-and-tilt values and dashes in camera lens data fields. From description of the problem, it appears the monitor may have a failure in an internal camera data decoding circuit.</p> <p>The KSC team was not able to reproduce the anomaly. The decision was made to continue with the monitor removal and return the monitor to the vendor for troubleshooting.</p>   |
| STS-117-V-09 | Monitor 1 Flickering and Buzzing  | <p>The crew reported that the Monitor 1 image flickered 4-5 times over a 2-minute period. The crew described during the crew debriefing as, "like white noise causing top half of image to distort and shift over, and became fuzzy. The image was still usable for clearance views, but were just wasn't clear all the time". The problem was accompanied by a buzzing noise that went away when the flickering went away. The noise was not camera specific and changing monitor intensity had no effect on the monitor. The problem occurred for a few minutes and multiple times and it also cleared on its own.</p> <p>The most likely cause is an internal high voltage power supply problem. Anomaly has been seen on previous OV-104 flight and the monitor was replaced.</p> <p>Tests in the OPF did not able to recreate the buzzing and flickering. The monitor was removed and shipped to vendor for troubleshooting.</p>                                        |
| STS-117-V-10 | Panel A6 Annunciator Interference | <p>The crew reported that a high-pitched interference noise was coming from the speakers on the flight deck when the Annunciator Bus Select switch was taken to the MNB position. The crew reported that the noise stopped when the switch was taken to the OFF position. This switch provides main bus power to Annunciator Control Assemblies (ACAs) 4 and 5. This may be a known condition associated with all ACA's. The printed circuit board guides have card extractors (dog ears) at the top. When snapped in place after the boards are installed, they have, by design, a built in slack. The slack causes them to rattle when the box is shook or in operating mode (power vibrations within the card) and, therefore, is not considered as a failure but rather a "live with" situation.</p> <p>Verify that the condition repeats on vehicle in OPF and isolate the noise to a particular ACA(s). Remove ACA(s) and return to NSLD for testing, if required.</p> |

## APPENDIX B

### STS-117 IN-FLIGHT ANOMALY LIST

| IFA Number   | Title                                             | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-11 | MADS Recorder Tape Speed Uncommanded Increase     | <p>At wheel stop, the Modular Auxiliary Data System (MADS) recorder "Percent tape used" changed speed from 15 in/sec to 60 in/sec, and continued at this rate until End of Tape (EOT). Normally, the recorder would continue recording data on the runway (at 15 in/sec) until EOT. All indications are the flight data were recorded successfully, but the data on the runway was not recorded. Tests will be performed on the vehicle to determine whether the MADS Control Module (MCM) did send the 60 ips command erroneously.</p> <p>The most probable cause is in the capstan servo system. The "take-up tension sensor switch" which by-passes the servo and applies full voltage to the capstan motor drive circuit. This switch may have failed in the closed condition due possibly to vibration causing the motor to operate at a non-standard speed, likely a speed greater than 60 in/sec. This happens to be the case. The recorder did not respond to playback commands during postflight testing and the recorder was removed from the vehicle for further troubleshooting and testing.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| STS-117-V-12 | Orbiter Salad Bowl Kahr-Lon Liner Coating Flaking | <p>During the STS-117 inspection of OV-104 umbilical well at Dryden Flight Research Center (DFRF), the outer coating of the left-hand salad-bowl Kahr-Lon liner was noted to be flaking off. The flaking of the coating material was approximately 0.001-in to 0.003-in thick, and the Kahr-Lon fabric remained intact beneath the missing coating.</p> <p>An evaluation of the removed salad bowl from OV-104 has been completed. Thus far, no material defect has been found on the Kahr-Lon liner coating due to process escape and its application. Also, no damage was found to the Kahr-Lon fabric beneath the worn Teflon coating area. The results of the inspection did not find any indication of substrate (aluminum) deformity. The salad bowl will be shipped to the Kahr-Lon installer after the quality inspection has been completed. At the Installer's facility, a similar inspection will be performed for material/process defect. The top coating will be evaluated for wear and the state of the Kahr-Lon for further use. Also, the Kahr-Lon will be removed and a substrate deformity check will be completed..</p> <p>Since Kahr-Lon fabric was found with no damage, the initial indications are no excessive/unusual loading occurred during the flight. Data from the manufacturer of the salad bowl has been requested to use in performing a fit check stack of the bowl-to-monoball. The process/procedure documentation for mating the Orbiter with the ET was evaluated and only one item was found and it removed and replaced the right-hand ET bolt and loosened torque on the left-hand bolt to 40000 lb. After reviewing vendor hardware documentation it was determined that the OV-105 salad bowls currently installed are of a different pedigree.</p> |

## APPENDIX B

### STS-117 IN-FLIGHT ANOMALY LIST

| IFA Number   | Title                                                    | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-V-13 | Micro-Strain Gage Units (MSGU) Units Failed to Take Data | <p>During the post-flight review of the STS-117 MSGU flight data, it was discovered that the three MSGU units (S/Ns 1057, 1058, and 1070) did not take data during the flight. These units had originally passed pre-flight functional testing and programming, but failed to take data during ascent.</p> <p>Four units (S/N 1006, 1030, 1048, 1050 and 1065) failed prior to flight during pre-flight functional testing. Formal documentation declared these units non-functional before flight. An investigation into the root cause of these failures will be conducted when the units are shipped back to JSC in mid-September.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| STS-117-V-14 | Port Fwd MPM Pedestal Stow Indications Not On            | <p>During Port MPM stow on FD 12 at GMT 170/23:48:49, neither of the two each Forward pedestal limit switches indicated 'Stow' as expected when the motors were deenergized at the end of the MPMs stow travel. Approximately 2 min 55 sec later, the Forward System 1 'Stow' indication did occur. The forward Stow System 2 indication occurred approximately 4 min prior to touchdown. The RMS MPM stow was performed in nominal dual motor run. The Stow/Deploy motors are controlled by the Shoulder limit switches.</p> <p>The crew did not notice the absence of the Fwd stow indications, as they were monitoring SM94 and only have the Shoulder indications. This situation is allowed per the flight rules. The flight rule does not consider either of the two each Forward stow indications for entry. Only one shoulder and one of either the mid- or aft-pedestal are required for entry.</p> <p>During rigging verification, the PRT determined that no applicable specification exists for the current MPM configuration, which was modified during the implementation of the over-center stop modification. The Orbiter contractor has taken an action to update the specification to encompass the current MPM configuration.</p> |

**APPENDIX B  
STS-117 IN-FLIGHT ANOMALY LIST**

**SOLID ROCKET BOOSTER**

No In-flight anomalies were identified during the review of the Solid Rocket Booster data.

**APPENDIX B  
STS-117 IN-FLIGHT ANOMALY LIST**

**REUSABLE SOLID ROCKET MOTOR**

| <b>IFA Number</b> | <b>Title</b>                                | <b>Comments</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-M-001     | Gas Penetrations through Nozzle Joint 2 RTV | Distinct and non-distinct gas penetration were found around the full circumference of Joint 2 through the Room Temperature Vulcanizing (RTV) material on both RSRM nozzles. This recurring observation for most flight and static test motors has now been identified as an anomaly. Gas penetration through Joint 2 RTV is not consistent with the original design intent, but is not unexpected based on the accumulated flight experience. This phenomenon and each occurrence is carefully evaluated for any challenge to flight rationale and level of risk assessment. However, this non-optimum performance of the RTV thermal barrier is an anomaly in accordance with Program documentation. This anomaly has been closed as an explained anomaly. |

**APPENDIX B  
STS-117 IN-FLIGHT ANOMALY LIST**

**EXTERNAL TANK**

| IFA Number    | Title                                                                                                    | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-T-001 | Post-Launch Camera and Film Review showed LH <sub>2</sub> Acreage Foam Loss at STA 1160 During Launch    | <p>External Tank (ET) Camera footage revealed one area of TPS loss at 134.5 sec Mission Elapsed Time (MET) from the LH<sub>2</sub> acreage at Station 1160, directly aft of the +Y bipod fitting. It appears that the piece of liberated LH<sub>2</sub> acreage foam may have impacted the LO<sub>2</sub> feedline breaking into one large piece and another smaller piece. There does not appear to be any collateral damage observed on the LO<sub>2</sub> feedline from this event in the Orbiter Umbilical photographs. The total volume of the debris loss was estimated to be approximately 13.98 in<sup>3</sup>.</p> <p>Based on the timing of the foam loss event and video evidence, it can be concluded that the physics of this foam loss can be assigned as a cryopumping- driven foam loss event.</p>                                                                                                                                                                                                                                                                                                                                                                  |
| STS-117-T-002 | Post-launch Camera and Film Review Showed Loss of LH <sub>2</sub> Acreage Foam at Stations 1623 and 1871 | <p>Post-launch review and analysis of ascent photography showed a loss of LH<sub>2</sub> acreage foam at stations 1623 and 1871 adjacent to the inboard LO<sub>2</sub> feedline support brackets. The dimensions of the foam loss at station 1623 were 8.1 in length by 4.05 in width by 0.5 in diameter. The mass of the loss was 0.012 lb. and the event occurred at 369 sec Mission Elapsed Time (MET). The dimensions of the foam loss at station 1871 were 6.6 in length by 6.02 in width by 0.5 in depth. The mass of the foam loss was 0.011 lb, and the event occurred at 403 sec MET. Both of these losses within NSTS 60559 requirements for LH<sub>2</sub> acreage foam loss for MET's greater than 135 sec.</p> <p>The most probable cause is cryopumping, which is supported by the design-induced defects associated with the inboard LO<sub>2</sub> feedline support fitting closeout at station 1623. Pressure buildup associated with the cryopumping expands beyond the edge of the LO<sub>2</sub> Feedline Support Closeout and follows the crushed foam which is inherently weaker as compared to the PDL-1034 material, thus producing the observed event.</p> |

**APPENDIX B  
STS-117 IN-FLIGHT ANOMALY LIST**

**SPACE SHUTTLE MAIN ENGINE**

No Space Shuttle Main Engine in-flight anomalies were identified for this mission.

## APPENDIX B STS-117 IN-FLIGHT ANOMALY LIST

### SYSTEM ENGINEERING AND INTEGRATION

| IFA Number    | Title                                                                                                | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------|------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-I-001 | ET Foam LH <sub>2</sub> Acreage Loss                                                                 | During ascent on STS-117, a debris event was observed on the LH <sub>2</sub> acreage at station Xt 1160. The debris event occurred at 134.5 sec MET and resulted in a foam loss of 0.019 lbm. This estimated debris mass violated the NSTS 60559 allowable of 0.004 lbm before 135 sec. There is a historical trend for foam losses in this area below the ET Bipod similar to what was observed on this flight and on STS-114. The ET Post-Flight Assessment Team identified the most probable cause of this debris event as cryopumping due to induced damage during processing at either the Michoud Assembly Facility or at the Kennedy Space Center (KSC). The risk of LH <sub>2</sub> acreage foam losses from cryopumping due to induced damage is enveloped by the LH <sub>2</sub> ice-frost ramp and adjacent acreage debris risk in IDBR-01                                                                                                                                                                                                                                                                                                               |
| STS-117-I-002 | Secondary Helium Bubbling Differential Pressure Rise From 0.064 to 0.128 psid at T - 1 minute 43 sec | The helium injection system passed a Ground Launch Sequencer (GLS) one-time (snapshot) checkout at T-3 min 20 sec. At T-1 min 44 sec, one differential pressure ( $\Delta P$ ) measurement went out of Launch Commit Criteria (LCC) limits. The other two LCC parameters remained within limits and the primary and secondary solenoid valves were confirmed closed (backup measurements per LCC). Troubleshooting was not able to recreate the event; however, reverse/erratic flow troubleshooting did prove the theory of pressure waves in the venturi being interpreted as flow. Sufficient checks of the system are in place with the LCC and console operators that monitor pressures after Helium flow termination. The system passed multiple leak checks, revealing no leaks from ground hardware. Specification 79K11681, OMRS, and OMI's require thorough functional checkout of the Helium injection system to be performed every mission.                                                                                                                                                                                                             |
| STS-117-I-003 | Helium bubbling Outlet Pressure Decayed to 6 psig Prior to T-0                                       | The small leak (200-300 scim) that caused this pressure decay, which is less than 0.25-percent of the provided flow (70 scim), did not impact the function or performance of the helium injection system during ET loading and launch operations. The pressure decay, discovered during post-launch data reviews, indicates a leak in the system between the Helium bubbling shutoff valves in the Ground Support Equipment (GSE) panel and the ET helium bubbling quad check valves (flight). The most probable cause is a leak at the GSE Ground Umbilical Carrier Plate (GUCP) final flexible hose-to-Quick Disconnect (QD) connection, pre- and post-flight GSE feedline checks were successful, showing no signs of leaks in the system; however, no post-launch checks of the ET or interface connection were possible. Evidence of normal wear of the sealing surface was seen when the GUCA and 3/8-inch QD's were disassembled for cleaning. The leak experienced during STS-117 is orders of magnitude less than the worst-case leak that would be large enough to reduce the Helium flow to the ET to below the Interface control Document (ICD) limits. |

## APPENDIX B STS-117 IN-FLIGHT ANOMALY LIST

### SYSTEM ENGINEERING AND INTEGRATION

| IFA Number    | Title                                                                                | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-I-004 | Red Tape Loss from Diagonal Strut Adjustment Nut (LH SRB)                            | During SRB post-flight assessment, a piece of red tape was found on the adjustment nut on the back side of the diagonal strut assembly. The material is approximately 2 in by 2 in. There was some apparent heat effects/erosion of the tape indicating release of debris. For STS-117 ET -124 hail damage repairs, numerous debris catchers were held in place by this red tape that were installed all over the integrated vehicle. This is the fifteenth occurrence of tape or tape residue found in post-flight since STS-26RA. The deviation will be added to the ET OMI that installs the enclosure) to remove all materials used for temporary enclosure or debris catcher, as well as a verification step to verify the removal.                                                                                                                                                                                                                                                                                 |
| STS-117-I-005 | Tile Piece From the Aft Fuselage Body Flap Interface Liberated During Liftoff/Ascent | Review of footage from Main Launch Platform (MLP) camera E020 revealed a piece of aft stub carrier panel tile liberating at about T-2.709 sec before lift-off.. Based on post-landing imagery, the estimated dimensions for the missing tile are 5 in by 3 in with an estimated mass loss of 0.017 lbm. On STS-117, the fracture surface characteristics of the broken tile carrier panel are of a cantilevered failure, not a hard debris impact, therefore the most probable cause of the damage would be a low-energy distributed load. This loading could have occurred during SSME 2 removal in the Vehicle Assembly Building (VAB) (a non-standard operation). For the vertical orientation in the VAB, this tile/work location has tight access due to the proximity of SSME 2. The Orbiter Project asserts that operational procedures are in place to protect the carrier panel Thermal Protection System (TPS) from operationally-induced damage during standard SSME work in the Orbiter Processing Facility. |
| STS-117-I-006 | Liftoff Debris                                                                       | Debris release was mitigated for identified potential sources of critical debris by: (1) removing (non-recurrent) items (2) adding inspections of system level components (e.g. fire hose case corrosion, grating clips and cable tray cover securing) and (3) replacement of M-clips for Minerally Insulated (MI) cables on the FSS with P-clips. A comparison was conducted of the first flight on Pad A versus Pad B after major modification efforts. Based on STS-117 and STS-114 post-launch walkdown debris items and the effectiveness of IFA mitigations applied to Pad A prior to STS-117, the Liftoff Debris environment appeared to be much better on STS-117 (Pad A) compared to STS-114 (Pad B).                                                                                                                                                                                                                                                                                                           |
| STS-117-I-007 | FOD Found in Aft Compartment                                                         | Post-flight inspection of the Aft Compartment of the Orbiter revealed the presence of two foreign objects. A piece of Ensolite Foam used to protect hardware during integration, and a non-metallic scraper that is used to remove or shape non-metallic materials during integration. Neither item had been identified as lost before flight. A Lost-and-Found PR was initiated to document finding the objects. In-Flight Anomaly (STS-117-K-052) was initiated to document the investigation and corrective action.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

## APPENDIX B STS-117 IN-FLIGHT ANOMALY LIST

### SYSTEM ENGINEERING AND INTEGRATION (Concluded)

| IFA Number    | Title                                                                                                               | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-I-008 | LH <sub>2</sub> Acreage NCFI Foam Loss Inboard of LO <sub>2</sub> Feedline Bracket Fwd Base @ Xt 1623 and @ Xt 1871 | LH <sub>2</sub> Tank Acreage Xt 1623 /Xt 1871 inboard LO <sub>2</sub> Feedline Bracket Base and LH <sub>2</sub> Acreage inboard of base PDL closeouts (IFA-STS-117-T-002). Similar debris events occurred on previous missions. The probable cause is attributed to cyropumping-driven divots. Corrective actions are under assessment and include redesign configurations and/or process improvements to reduce void sizes. An Engineering change is under review for in-line design change using different material.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| STS-117-I-009 | Port OMS Pod Blanket Damage During Ascent                                                                           | This anomaly was determined to be caused by Orbiter Thermal Protection System (TPS) installation issues, and not by an integrated ascent environment. Integrated ascent environments are established and documented in the aerodynamics and loads data books.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| STS-117-I-010 | Rope-Like Material Noted Moving in Umbilical Well Imagery                                                           | During review of STS-117 movies from the LH <sub>2</sub> umbilical well 16MM camera, a frayed rope-like material was seen with one end loosely dangling during the ET separation timeframe. The material is estimated to be approximately 0.4 in wide and 14 to 20 in long, and the material remained attached to the ET umbilical following separation from the Orbiter. Smaller rope-like material has been noted on film from missions STS-100, -113, and -116. Troubleshooting discovered the problem as most likely a process omission. A 5-in wide glass cloth (belly band) was installed around the ET umbilical perimeter for STS-94 (May 1997) and subsequent to improve foam strength after foam damage was noted during STS-57. Fire barrier coating was supposed to be applied to outside surfaces of foam and cloth bands. Misinterpretation of unclear umbilical insulation installation requirements resulted in delivery of umbilicals containing a approximately 1-in wide strip of glass tape where fire barrier was not applied. The thermal environment during ascent subjects unprotected cloth to heating, fraying, and degradation, allowing it to become detached. The out-of-print configuration existed on both the LH <sub>2</sub> and LO <sub>2</sub> umbilicals. KSC work procedure updates will be implemented for subsequent flights to positively verify the proper installation of fire barrier to the glass cloths. |

**APPENDIX B  
STS-117 IN-FLIGHT ANOMALY LIST**

**FLIGHT OPERATIONS AND INTEGRATION**

| IFA Number    | Title                                            | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STS-117-N-001 | Mated VRCS Propellant Use Greater than Predicted | <p>During the 7 hour period (starting ~GMT 163/18:27:12) while Shuttle maintained VRCS attitude control at the SAW TEA attitude (R=179.82, 68.02, 2,23), the Shuttle consumed more propellant than pre-flight predicts. Flight usage was 3 times more than simulations. Flight data reflects a yaw disturbance at the TEA that is not manifested in the simulations. The commanded flight attitude during this hold period was not the true TEA as confirmed by the ISS momentum manager stabilized attitude with a 1.28 deg. offset from the Shuttle commanded TEA.</p> <p>The following closure rationale for this item was presented and agreed to by the FOICB:</p> <ul style="list-style-type: none"> <li>- Actual prop use on subsequent flights has agreed with predicted values for attitude holds and attitude maneuvers</li> <li>- Future attitude holds will all be nominally controlled by ISS CMGs</li> <li>- Mitigation techniques are in place to counter any high prop use if Shuttle is in control for extended attitude hold.</li> </ul> |

## **APPENDIX C**

### **DOCUMENT SOURCES**

#### **MER DAILY REPORTS**

The following STS-117 MER Daily Reports by Luis Saucedo, Lead MER Manager:

First Daily Report (Ascent Plus 2-Hour Report), dated June 8, 2007  
Second Daily Report, dated June 9, 2007  
Third Daily Report, dated June 10, 2007  
Fourth Daily Report, dated June 11, 2007  
Fifth Daily Report, dated June 12, 2007  
Sixth Daily Report, dated June 13, 2007  
Seventh Daily Report, dated June 14, 2007  
Eighth Daily Report, dated June 15, 2007  
Ninth Daily Report, dated June 16, 2007  
Tenth Daily Report, dated June 17, 2007  
Eleventh Daily Report, dated June 18, 2007  
Twelfth Daily Report, dated June 19, 2007  
Thirteenth Daily Report, dated June 20, 2007  
Fourteenth Daily Report, dated June 21, 2007  
Fifteenth Daily Report, dated June 22, 2007  
Landing Plus 2 Hour Report, dated June 22, 2007

#### **ET/SRB/RSRM/SSME REPORTS**

STS-117 SRB, RSRM and ET Console Flash Report, Charles E. Martin, USA-Huntsville, June 8, 2007.  
STS-117 Initial Event Times, David W. Morr, MSFC, June 8, 2007  
STS-117 Preliminary Event Times, David W. Morr, MSFC, June 9, 2007  
STS-117 Final Event Times, David W. Morr, MSFC, June 19, 2007  
STS-117 RSRM Flash Report, Glen A. Ricks, MSFC-Huntsville, June 8, 2007.  
STS-117 Revised RSRM Flash Report, Glen A. Ricks, MSFC-Huntsville, June 15, 2007.  
STS-117 RSRM-96 FET Executive Summary, L. J. Manuel, MSFC-Huntsville, July 6, 2007

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### ORBITER REPORTS

STS-117 Hydraulics System Debriefing, Charles A. Ritrivi, Boeing-Houston, June 25, 2007  
STS-117 Consolidated Landing Report, Lonnie W. Jenkins, Boeing-Houston, July 5, 2007  
STS-117 ADTA Report, Howard A. Damoff, Boeing-Houston, July 5, 2007.  
STS-117 Communications and Tracking Report, Martha M. May, Boeing-Houston, July 6, 2007  
STS-117 Ascent Hazard Analysis Report, C. Heinol, Boeing-Houston, August 16, 2007  
STS-117 Windows Inspection Report, Orlando Torres, Boeing-KSC, August 6, 2007  
STS-117 Displays and Controls Final Report, P. Ngo, Boeing-Houston, July 25, 2007  
STS-117 Shuttle Remote Manipulator System, Leissa Smith, MDA-Houston, July 23, 2007  
STS-117 HYD/WSB/Actuators Final Report, Jeffery S. Goza, Boeing-Houston, July 20, 2007  
STS-117 PRSD System Mission Report, Johnny D. Wong, Boeing-Houston, July 13, 2007  
STS-117 Main Propulsion System Flight Report, John A. Chan, Boeing-Houston, July 13, 2007  
STS-117 Mechanical and Hatches Mission Report, Jeff Goodmark, Boeing-Houston, July 22, 2007  
STS-117 Auxiliary Power Unit System, Christopher N. Adi, Boeing-Houston, July 12, 2007  
STS-117 Electrical Power and Distribution and Control, W. D. Peterson, Boeing-Houston, July 13, 2007  
STS-117 OI/MADS Mission Reports, Dwight A. Favors, Boeing-Houston, July 11, 2007  
STS-117 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, July 11, 2007  
STS-117 Data Processing System Integrated Report, Lynna Wood. Boeing-Houston, July 24, 2007  
STS-117 ATCS Post-Flight Mission Report, Carmelo Asuncion, Boeing-Houston, July 13, 2007  
STS-117 Atmospheric Revitalization System Mission Report, Christopher J. Hoffmann, Boeing-Houston, July 13, 2007  
STS-117 Life Support Systems Report (ARPCS and Airlock Systems; Supply Water and Waste Water Management, and Fire and Smoke Detection System), Isaac Andu, Boeing-Houston, July 12, 2007  
STS-117 Orbiter Docking System, Robert E. Davis, Boeing-Houston, July 19, 2007.  
STS-117 OMS Report, Donald E. Varanauski, Boeing-Houston, July 13, 2007  
STS-117 OMS Propellant Summary, Donald E. Varanauski, Boeing-Houston, July 13, 2007  
STS-117 RCS Mission Report, Mickie Equia, Boeing-Houston, July 12, 2007  
STS-117 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, July 13, 2007  
STS-116 Fuel Cells and PRSD Mission Report, Johnny D. Wong, Boeing-Houston, October 13, 2006.  
STS-117 Global Positioning System Report, Greg Pool, Boeing-Houston, July 12, 2007

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STS-117 Thermal Control System Mission Summary, Bill Andrews, Boeing-Houston, July 30, 2007.  
STS-117 Mechanisms and MPMs, Link Salvador, Boeing-Houston, July 13, 2007  
STS-117 Purge, Vent and Drain Report, F. Merheb, Boeing-Houston, July 12, 2007  
STS-117 Communications and Tracking Mission Report, Martha M. May, Boeing-Houston, July 6, 2007  
STS-117 Flight Controls Mission Report, Donald E. Marquith, Boeing-Houston, July 5, 2007  
STS-117 Landing Gear Door Impacts, Scott L. McClay, Boeing-KSC, June 26, 2007  
STS-117 Landing Rollout Distances, Scott L. McClay, Boeing-KSC, June 26, 2007  
STS-117 WLE IDS Post Flight Report, Jon M. Maynard, Boeing-Houston, September 7, 2007.  
STS-116 CSR Final Report, Michael Darnell, JSC-MO3, August 29, 2007  
STS-116 Payload and Experiments Report, Michael Darnell, NASA-JSC, August 29, 2007  
STS-117 Final Mission Events List, Vernon C. Hill, ESCG-Houston, received January 15, 2007.  
STS-117 Integrated Anomalies, J. J. Hill, JSC-MS3, September 13, 2007

## OTHER REPORTS

STS-117 K-1 Day Pad Walkdown, Thomas F. Ford, NASA-KSC, dated June 7, 2007  
STS-117 Final Debris Hits, Thomas F. Ford, NASA-KSC, July 30, 2007  
STS-117 Orbiter Post Landing Inspection Report, Debris Assessment, Thomas F. Ford, NASA-KSC, June 26, 2007  
STS-117 Integrated Imagery FD 1 Daily Report, Myrella D. Beyer, USA-Houston, June 9, 2007  
STS-117 Integrated Imagery FD 2 Daily Report, Myrella D. Beyer, USA-Houston, June 10, 2007  
STS-117 Integrated Imagery FD 3 Daily Report, Myrella D. Beyer, USA-Houston, June 11, 2007  
STS-117 Revised Integrated Imagery FD 4 - Daily Report, David Melendrez, NASA-JSC, June 11, 2007  
STS-117 Integrated Imagery FD 5 Daily Report, David Melendrez, NASA-JSC, June 12, 2007  
STS-117 Integrated Imagery FD 6 Daily Report, David Melendrez, NASA-JSC, June 13, 2007  
STS-117 Integrated Imagery FD 11 Daily Report, David Melendrez, NASA-JSC, June 18, 2007

STS-117 ExtraVehicular Activity Report for EVA 1, Dennis Dawson, Hamilton Standard, June 12, 2007  
STS-117 ExtraVehicular Activity Report for EVA 2, Jon C. Golden, Hamilton Standard, June 14, 2007  
STS-117 ExtraVehicular Activity Report for EVA 3, Wade J. Frost, Hamilton Standard, June 16, 2007

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STS-117 ExtraVehicular Activity Report for EVA 4, Chun H, Yau, Hamilton Standard, June 18, 2007

STS-117 ExtraVehicular Activity Mission Report, David A. Foltz, NASA-JSC, July 11, 2007

STS-117 Ice/Debris Team Report, Thomas F. Ford, NASA-KSC, received June 12, 2007

STS-117 Launch + 2 Day Ascent Performance Report, David Blake, Boeing-Houston, June 10, 2007

STS-117 Landing and Debris Reports, Thomas F. Ford, NASA-KSC, June 26, 2007

STS-117 EVA Summary Report, David A. Foltz, NASA-JSC, July 9, 2007

STS-117 Landing Gear Door Impacts, Scott L. McClay, Boeing-KSC, June 26, 2007

STS-117 Landing Rollout Distances, Scott L. McClay, Boeing-KSC, June 26, 2007

STS-117 WLE IDS Post Flight Report, Jennifer C. Babst, Boeing-Houston, January 2, 2006.

## **APPENDIX D**

### **ACRONYMS AND ABBREVIATIONS**

| <b>Acronyms</b> | <b>Explanation</b>                   |
|-----------------|--------------------------------------|
| AA              | Accelerometer Assembly               |
| ABS             | Ammonia Boiler System                |
| AC              | Alternating current                  |
| ACA             | Annunciator Control Assembly         |
| ADTA            | Air Data Transducer Assembly         |
| AHMS            | Advanced Health Monitoring System    |
| A/D             | analog-to-digital                    |
| AJIS            | Alpha Joint Interface Struts         |
| APFR            | Articulating Portable Foot Restraint |
| APU             | Auxiliary Power Unit                 |
| AR              | Argon                                |
| ARCU            | American-to-Russian Converter Unit   |
| ARS             | Atmospheric Revitalization System    |
| ASA             | Aerosurface Actuator                 |
| ATCS            | Active Thermal Control System        |
| BCI             | Baseline Configuration Imaging       |
| BET             | Best Estimate Trajectory             |
| BF              | Body Flap                            |
| BFC             | Backup Flight Controllers            |
| BFS             | Backup Flight System                 |
| BGTS            | Beta Gimbal Transition Structures    |
| BLT             | Boundary Layer Transition            |
| BITE            | Built In Test Equipment              |
| BSR             | Bite Status Register                 |
| CCTV            | Closed Circuit Television            |
| CDR             | Commander                            |
| CEI             | Contract End Item                    |
| CETA            | Crew Equipment Transition Aid        |
| CMG             | Control Moment Gyroscope             |
| CWC             | Contingency Water Container          |
| DAP             | Digital Autopilot                    |
| DAT             | Damage Assessment Team               |
| DBC             | Data Bus Coupler                     |
| DBIA            | Data Bus Isolation Amplifier         |
| D&C             | Display and Control                  |
| DCP             | Docking Control Panel                |
| DDU             | Data Display Unit                    |
| DLA             | Drive Lock Assembly                  |
| DOD             | Department of Defense                |
| DPS             | Data Processing System               |
| DSO             | Development Secondary Objective      |
| DTN             | Data Trend Notice                    |
| DTO             | Development Test Objective           |

## **APPENDIX D**

### **ACRONYMS AND ABBREVIATIONS**

| <b>Anomaly</b> | <b>Explanation</b>                            |
|----------------|-----------------------------------------------|
| $\Delta V$     | Differential Velocity                         |
| EAFB           | Edwards Air Force Base                        |
| ECLSS          | Environmental Control and Life Support System |
| ECO            | Engine Cutoff                                 |
| EDAC           | Error Detection and Correction                |
| EI             | Entry Interface                               |
| EIU            | Engine Interface Unit                         |
| EMU            | Extravehicular Mobility Unit                  |
| EO             | ET/Orbiter                                    |
| EOM            | End-of-Mission                                |
| EPDC           | Electrical Power Distribution and Control     |
| ESP            | External Stowage Platform                     |
| ESU            | Electrical Switching unit                     |
| ET             | External Tank                                 |
| ETRS           | EVA Temporary Rail Stop                       |
| EVA            | Extravehicular Activity                       |
| FA             | Flight Aft                                    |
| FBMBT          | Flexible bearing mean bulk temperature        |
| FCC            | Flat Connector Circuit                        |
| FCMS           | Fuel Cell Monitoring System                   |
| FCS            | Flight Control System                         |
| FD             | Flight Day                                    |
| FDA            | Fault Detection Annunciator                   |
| FDF            | Flight Data File                              |
| FES            | Flash Evaporation System                      |
| FET            | Field Effect Transistor                       |
| FGB            | Functional Energy Block                       |
| FID            | Failure Identifiers                           |
| FIT            | Final Inspection Team                         |
| FOM            | Figure of Merit                               |
| FRCS           | Forward Reaction Control System               |
| FRGF           | Flight Releasable Grapple Fixture             |
| FRSI           | Flexible Reusable Surface Insulation          |
| FSE            | Flight Service Equipment                      |
| FSS            | Flight Service Structure                      |
| FWD            | forward                                       |
| G or g         | Gravity                                       |
| GEI            | Ground environmental instrumentation          |
| GG             | Gas Generator                                 |
| GMT            | Greenwich mean time                           |
| G N & C        | Guidance, Navigation and Control              |
| GOX            | Gaseous Oxygen                                |
| GPC            | General Purpose Computer                      |

## **APPENDIX D**

### **ACRONYMS AND ABBREVIATIONS**

| <b>Anomaly</b> | <b>Explanation</b>                           |
|----------------|----------------------------------------------|
| GPS            | Global Positioning System                    |
| GSE            | Ground Support Equipment                     |
| GUCP           | Ground Umbilical Carrier Plate               |
| HDP            | Holddown Post                                |
| He             | Helium                                       |
| HGDS           | Hazardous Gas Detection System               |
| HPFTP          | High-Pressure Fuel Turbopump                 |
| HPOTP          | High-Pressure Oxidizer Turbopump             |
| HYD            | Hydraulic                                    |
| IBA            | Inspection Boom Assembly                     |
| IDP            | Integrated Data Processor                    |
| IEA            | Integrated Equipment Assembly                |
| IELK           | Individual Equipment Liner Kit               |
| IFA            | In-flight Anomaly                            |
| I/O            | Input/output                                 |
| IMU            | Inertial Measurement Unit                    |
| IPL            | Initial Program Load                         |
| ISS            | International Space Station                  |
| ITS            | Integrated Truss Segment                     |
| IVA            | Intravehicular                               |
| KBU            | Keyboard Unit                                |
| KSC            | Kennedy Space Center                         |
| LCC            | Launch Commit Criteria                       |
| LESS           | Leading Edge Structure System                |
| LFL            | Lower Flammability Limit                     |
| LiOH           | Lithium Hydroxide                            |
| LPFTP          | Low Pressure Fuel Turbopump                  |
| LPOTP          | Low Pressure Oxidizer Turbopump              |
| LRSI           | Low Temperature Reusable Surface Insulation  |
| MADS           | Modular Auxiliary Data System                |
| MAUI           | Maui Analysis of Upper Atmosphere Injections |
| MAGR           | Miniature Airborne-to-Ground Receiver        |
| MBA            | Mobile Base System                           |
| MC             | Midcourse Correction                         |
| MCC-H          | Mission Control Center-Moscow                |
| MCIU           | Manipulator Controller Interface Unit        |
| MDM            | Multiplexer/Demultiplexer                    |
| MEC            | Master Events Controller                     |
| MER            | Mission Evaluation Room                      |
| MECO           | Main Engine Cutoff                           |
| MEDS           | Multifunction Electronic Display System      |
| MET            | Mission Elapsed Time                         |
| MIA            | Multiplexer Interface Unit                   |

## **APPENDIX D**

### **ACRONYMS AND ABBREVIATIONS**

| <b>Anomaly</b> | <b>Explanation</b>                                              |
|----------------|-----------------------------------------------------------------|
| MLP            | Mobile Launch Platform                                          |
| MLS            | Microwave Landing System                                        |
| MM             | Momentum Manager/Major Mode                                     |
| MMCA           | Mid-Motor Controller Assembly                                   |
| MMOD           | MicroMeteoroid Orbital Debris                                   |
| MMT            | Mission Management Team                                         |
| MNB            | Main Bus B                                                      |
| MNC            | Main Bus C                                                      |
| MPM            | Manipulator Positioning Mechanism                               |
| MPS            | Main Propulsion System                                          |
| MRL            | Manipulator Release Latch                                       |
| MSBLS          | Microwave Scanning Beam Landing System                          |
| MT             | Mobile Transporter                                              |
| MTU            | Master Timing Unit                                              |
| NASA           | National Aeronautics and Space Administration                   |
| NORAD          | North American Defense (Center)                                 |
| NSLD           | NASA Shuttle Logistics Depot                                    |
| OA             | Operational Aft                                                 |
| OAA            | Orbiter Access Arm                                              |
| OBSS           | Orbiter Boom Sensor System                                      |
| OCASL          | Operator-Commanded Auto Sequence                                |
| ODS            | Orbiter Docking System                                          |
| OFI            | Operational Flight Instrumentation                              |
| OGS            | Oxygen Generation System                                        |
| OI             | Operational Instrumentation                                     |
| OME            | Orbital Maneuvering Engine                                      |
| OMRSD          | Operational Maintenance and Requirements Specification Document |
| OMS            | Orbital Maneuvering System                                      |
| OPF            | Orbiter Processing Facility                                     |
| OPS            | Operational Sequence                                            |
| ORGA           | Orbiter Rate Gyro Assembly                                      |
| OTV            | Orbiter TV                                                      |
| OV             | Orbiter Vehicle                                                 |
| PAD            | Portable Foot Restraint Attachment Device                       |
| PAS            | Payload Attachment System                                       |
| PASS           | Primary Avionics Software System                                |
| PCM            | Pulse Code Modulation                                           |
| PCMMU          | Pulse Code Modulation Master Unit                               |
| PCR            | Payload Changeout Room                                          |
| PCS            | Pressure Control System                                         |
| PDGF           | Power and Data Grapple Fixture                                  |

## **APPENDIX D**

### **ACRONYMS AND ABBREVIATIONS**

| <b>Acronyms</b>   | <b>Explanation</b>                             |
|-------------------|------------------------------------------------|
| PDI               | Payload Data Interleaver                       |
| PDL               | Polymer Development Laboratory                 |
| PDU               | Power Drive Unit                               |
| PGME              | Propylene Glycol Monomethyl Ether              |
| Ph.D.             | Doctor of Philosophy                           |
| PLBD              | Payload Bay Door                               |
| PMBT              | Propellant Mean Bulk Temperature               |
| PPCO <sub>2</sub> | Partial Pressure Carbon Dioxide                |
| ppm               | parts per million                              |
| PQRS              | Propellant Quantity Gaging System              |
| PRSD              | Power Reactant Storage and Distribution System |
| PRT               | Problem Resolution Team                        |
| psia              | Pound per square inch                          |
| PSIG              | Propulsion Systems Integration Group           |
| PV                | Photovoltaic                                   |
| PVD               | Purge, Vent and Drain                          |
| PVR               | Photovoltaic Radiator                          |
| PWR               | Payload water reservoir                        |
| QD                | Quick Disconnect                               |
| RAMBO             | Ram Burn Observation                           |
| RCC               | Reinforced Carbon-Carbon                       |
| RCS               | Reaction Control System                        |
| RHC               | Rotational Hand Controller                     |
| RJD               | Reaction Jet Driver                            |
| RM                | Redundancy Management                          |
| ROOBA             | Recharge Oxygen Orifice Bypass Assembly        |
| RPM               | R-Bar Maneuver                                 |
| RSB PDU           | Rudder Speed Brake Power Drive Unit            |
| RSRM              | Reusable Solid Rocket Motor                    |
| RTV               | Room Temperature Vulcanizing (material)        |
| S&A               | Safe and Arm                                   |
| SARJ              | Solar Alpha Rotary Joint                       |
| SAW               | Solar Array Wing                               |
| SDBI              | Short Duration BioAstronautics Investigation   |
| SDFS              | Smoke Detection and Fire Suppression           |
| SM                | Service Module                                 |
| SM                | System Management                              |
| SLWT              | Super Lightweight (ET)                         |
| SMCC              | Service Module Control Computer                |
| SMDP              | Service Module Debris Panels                   |
| SMRD              | Spin Motor Rotation Detector                   |
| SMTc              | Service Module Terminal Computer               |
| S/N               | Serial Number                                  |

**APPENDIX D**  
**ACRONYMS AND ABBREVIATIONS**

| <b>Acronyms</b> | <b>Explanation</b>                               |
|-----------------|--------------------------------------------------|
| SRB             | Solid Rocket Booster                             |
| SRGA            | Station rate gyro assembly                       |
| SRMS            | Shuttle Remote Manipulator System                |
| SRSS            | Shuttle Range Safety System                      |
| SSME            | Space Shuttle Main Engine                        |
| SSOR            | Space-to-Space Orbiter Radio                     |
| SSP             | Space Shuttle Program`                           |
| SSRMS           | Space Station Remote Manipulator System          |
| SSTS            | Short Space Truss Segment                        |
| SSV             | Space Shuttle Vehicle                            |
| SSU             | Sequential Shunt Unit                            |
| ST              | Star Tracker                                     |
| STS             | Space Transportation System                      |
| STP-H2          | Space Test Program-Houston                       |
| SUPA            | Shuttle Urine Pre-treat Assembly                 |
| TCS             | Thermal Control System/Trajectory Control Sensor |
| THC             | Translational Hand Controller                    |
| TI              | Terminal Phase Initiation/Transfer Initiation    |
| TIG             | Time Of Ignition                                 |
| TPL             | Transfer Priority List                           |
| TPS             | Thermal Protection System                        |
| TSM             | Tail Service Mast                                |
| TVC             | Thrust Vector Controller                         |
| UA              | Unexplained Anomaly                              |
| USOS            | United States On-Orbit Segment                   |
| USTO            | United States Thrusters Only                     |
| V               | Volt                                             |
| VAB             | Vehicle Assembly Building                        |
| VSSA            | Video Stanchion Support Assembly                 |
| WCS             | Waste Collection System                          |
| WLE             | Wing Leading Edge                                |
| WLEIDS          | Wing Leading Edge Impact Detection System        |
| WSB             | Water Spray Boiler                               |
| WVS             | Wireless Video System                            |

**APPENDIX D**  
**ACRONYMS AND ABBREVIATIONS**

| <b>Symbol/Acronym</b> | <b>Explanation</b>               |
|-----------------------|----------------------------------|
| A                     | Ampere                           |
| deg/sec               | degree per second                |
| °F                    | degrees Fahrenheit               |
| Ft                    | Feet                             |
| GH <sub>2</sub>       | gaseous hydrogen                 |
| GN <sub>2</sub>       | gaseous nitrogen                 |
| GO <sub>2</sub>       | gaseous oxygen                   |
| Hr                    | hour                             |
| In.                   | inch                             |
| kW                    | Kilowatt                         |
| kWh                   | Kilowatt hours                   |
| Lb                    | Pound                            |
| lbm                   | pound-mass                       |
| LH <sub>2</sub>       | liquid hydrogen                  |
| LO <sub>2</sub>       | liquid oxygen                    |
| min                   | minute                           |
| Mlbf                  | Million pounds force             |
| mmHg                  | millimeters Mercury              |
| nmi                   | nautical mile                    |
| O <sub>2</sub>        | Oxygen                           |
| ppm                   | parts per million                |
| psia                  | pound per square inch absolute   |
| scim                  | standard cubic inches per minute |
| sec                   | second                           |