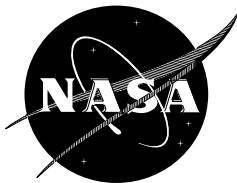


STS-127 SPACE SHUTTLE MISSION REPORT

January 2010



**National Aeronautics and
Space Administration**

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

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STS-127

SPACE SHUTTLE MISSION REPORT

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STS-127 SPACE SHUTTLE MISSION REPORT

INTRODUCTION

The Space Transportation System (STS) -127 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 Reusable Solid Rocket Booster (RSRB), the Reusable Solid Rocket Motor (RSRM) and the Space Shuttle Main Engine (SSME) performance during the 127th mission of the Space Shuttle Program. The purposes of this mission:

STS-127 was the 14th mission since the return to flight following the STS-107 mission, and the 29th mission to the International Space Station (ISS). STS-127 was also the 23rd flight of the Orbiter Vehicle (OV) -105 (Endeavour).

The primary objectives of the STS-127 mission were as follows:

1. Perform ISS crew rotation with NASA Astronaut Timothy L. Kopra with Koichi Wakata of the Japan Aerospace Exploration Agency.
2. Install and activate Japanese Experiment Module-Exposed Facility (JEM-EF) to the Japanese Experiment Module-Pressurized Module (JEM-PM).
3. Deliver and install Japanese Experiment Logistics Module-Exposed Section (ELM-ES) to JEM-EF.
4. Install Integrated Cargo Carrier (ICC) to Payload Orbital Replacement Unit Accommodation (POA).
5. Remove and install six Port 6 batteries and stow the expended batteries in the Payload Bay for return.
6. Perform five Extravehicular Activities (EVAs) in support of ISS operations.
7. Transfer mandatory quantities of water to the ISS.
8. Transfer and stow critical items in the ISS.

The flight vehicle consisted of the OV-105 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-131; three Block II SSMEs that were designated as serial numbers (S/Ns) 2045, 2060, and 2054 in positions 1, 2 and 3, respectively; and two SRBs that were designated BI-138. The two RSRMs were designated flight set RSRM-106. The individual RSRMs were S/N 360W106A (left) and S/N 360W106B (right). Launch pad 39A and Mobile Launch Platform (MLP) -3 were used as the platform for launch of the STS-127 mission.

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

this report. Appendix D provides a list of acronyms, abbreviations and definitions as used throughout this report.

The seven crewmembers that were on the STS-127 flight were Mark L. Polansky, NASA Civilian, Commander; Douglas G. Hurley, Colonel, U.S. Marine Corp, Pilot; David A. Wolf, M.D., NASA Civilian, Mission Specialist 1; Christopher J. Cassidy, Commander, U. S. Navy, Mission Specialist 2; Julie Payette, Civilian, Canadian Space Agency, Mission Specialist 3; Thomas H. Marshburn, M.D., Civilian, Mission Specialist 4; and Timothy L. Kopra, Colonel, U. S. Army, Mission Specialist 5 (Up), and Koichi Wakata, PhD, Japanese Aerospace Exploration Agency, Mission Specialist 5 (Down).

STS-127 was the fourth flight for Mission Specialist 1 and Mission Specialist 5 (Down), the third Shuttle flight for the Commander, the second flight for Mission Specialist 3, and the first Shuttle flight for the Pilot, Mission Specialist 2, Mission Specialist 4, and Mission Specialist 5 (Up).

MISSION SUMMARY

The objectives for the STS-127 mission were to deliver and install the Japanese Experiment Module (JEM) Exposed Facility (EF) and Exposed Section (ES), and deliver and install an Integrated Cargo Carrier-Vertical Light Deploy (ICC-VLD) with spares for transfer to the International Space Station (ISS). Additional objectives were to perform five Extravehicular Activities (EVAs), rotate the ISS Flight Engineer crewmember, and transfer critical cargo items to the ISS.

Pre-Launch

The first launch attempt on June 13, 2009, was scrubbed during External Tank (ET) tanking. When transitioning from fast-fill to topping, Liquid Hydrogen (LH₂) leakage in the area of the Ground Umbilical Carrier Plate (GUCP) exceeded the 40,000 ppm specification during vent-valve cycling. Sensors were reading off-scale high. This signature was similar to that observed during the first launch attempt of STS-119 three months earlier. An attempt was made to cycle the LH₂ vent valve as has been done in the past, but high LH₂ concentrations continued to be observed when the valve was opened. The launch was scrubbed, the ET was drained, and the launch was rescheduled for four days later to allow troubleshooting and re-mating of the GUCP. After area safing, a GUCP interface seal was removed and replaced with a spare seal. The assembly was re-torqued and configured for the second attempt.

The second launch attempt on June 17, 2009, was also scrubbed during ET tanking due to another leak at the GUCP. The leak exhibited a different signature with concentration spikes going off-scale high then quickly recovering. The Space Shuttle Program (SSP) designated a Tiger Team to troubleshoot the anomaly. The Tiger Team identified the External Tank Carrier Assembly skewed 0.357-deg counter-clockwise and undersized alignment pins as the root cause for the flight seal/bellows gapping. An older two-piece seal design and tighter alignment pin tolerances were incorporated. A tanking test was successfully conducted on July 1, 2009, with no off-nominal leakage identified.

Following the start of the countdown for the third launch attempt, scheduled for July 11, 2009, a number of lightning strikes were detected in the vicinity of Pad A across two days. While the vehicle stack was never directly hit, one strike on July 10 hit the Pad mast directly. A voltage and energy exceedance was noted and this condition required a detailed assessment. As a result, the third launch attempt was delayed 24 hr to allow additional time for further evaluation by the launch team to ensure there were no issues with the vehicle.

During the Final Inspection Team walk down a crack was found in the LH₂ pyrotechnic canister foam. A Material Report (MR) was processed to accept the crack as a result of the multiple cryogenic cycles stress (IFA STS-127-V-08). The third launch attempt on July 12, 2009, was later scrubbed during the T-9 min hold due to Return to Launch Site (RTL) weather violations. Prior to the launch scrub, the Tyvek cover on Forward

Reaction Control System (FRCS) F1D thruster was noted to be partially debonded. Since no rain had entered the thruster, a waiver was approved.

The fourth launch attempt on July 13, 2009, was also scrubbed during the T-9 min hold due to lightning within 20 nmi, as well as Return To Launch Site (RTLS) weather violations. The decision had been made to attempt launch without replacing the F1D thruster cover. Following the launch scrub, a 48-hour turnaround was declared, and the Rotating Servicing Structure (RSS) was rolled back to the vehicle stack to allow replacement of all of the FRCS thruster covers.

Weather violations late in the count caused the 5th attempt on July 14th to be scrubbed. A 24-hr turn-around was initiated. During the countdown for the fifth launch attempt on July 15, 2009, a higher-than-typical fuel cell 3 condenser exit temperature was noted. The ground controller asked for verification that the fuel cell 3 electrolyte concentration (KOH) values would remain within operational limits during Station-To-Shuttle Power Transfer System (SSPTS) operation. A low-load test on the fuel cell showed the exit temperature remained within limits and all temperatures remained steady after thermal equilibrium was reached. This test demonstrated that the fuel cell would operate nominally at low-power levels during SSPTS operation.

Flight Day 1

The STS-127 mission was launched on the sixth attempt at 196/22:03:09.984 Greenwich Mean Time (GMT) on July 15, 2009, on the twenty-ninth SSP mission to the ISS.

The Reusable Solid Rocket Booster (RSRB) was visible through separation. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 196/22:05:24.189 GMT [00/00:02:14.205 Mission Elapsed Time (MET)], and the maneuver was 71.2 sec in duration.

Early in ascent, a significant amount of pre-evaporative cooling was noted in the Active Thermal Control System (ATCS), which resulted in the High Load Inboard Duct temperatures dropping. At 196/22:06:02 GMT (000/00:02:52 MET), the crew was requested to switch to the dual heater system-A and system-B configuration.

The Primary Avionics Software System (PASS) flight software performed nominally in the pre-launch phase, and during ascent at 196/22:10:21 GMT (00/00:07:11 MET), the software encountered a Mid-Frequency Executive (MFE) Cycle overrun due to the Ascent Bearing Display map transition. At the same time, the Backup Flight Software (BFS) annunciated eight input/output (I/O) errors because it missed the PASS MFE listen commands. The MFE Cycle overrun phenomenon was a pre-existing condition which was explained in a flight software user note. The overrun did not impact ascent performance.

Main Engine Cut-Off (MECO) occurred at 196/22:11:34 GMT (00/00:08:24 MET). The ET separated from the Orbiter at 196/22:11:56 GMT (00/00:08:46 MET).

Evaluation of ascent ground imagery showed that all 14 FRCS thruster rain covers released within specification. The F4R (right side yaw) thruster cover released at 13.1 sec after launch, but the vehicle speed of 185 mph was within the cover certification limit.

A nominal OMS-2 maneuver was performed at 196/22:41:40.189 GMT (00/00:38:30.205 MET). The maneuver was 63.4 sec in duration with a Differential Velocity (ΔV) of 96.9 ft/sec. The achieved orbit was 125.1 by 85.0 nmi.

The payload bay doors were opened at 196/23:36:45 GMT (00/01:33:35 MET).

The Ku-Band antenna was deployed at 196/23:43:10 GMT (00/01:40:00 MET). The system was powered ON at 196/23:45:39 GMT (00/01:42:29 MET), and the RADAR self-test was started at 196/23:51:02 GMT (00/01:47:52 MET). The Ku-Band system passed the Self-Test. The Crew switched the system in the Communications (COMM) mode at 196/23:55:23 GMT (00/01:52:13 MET) and the system was operating nominally.

The Remote Manipulator System (RMS) initialization, power up and checkout was initiated at 197/00:40 GMT (00/00:02:37 MET) and was completed at 197/03:25 GMT (00/00:05:22 MET). During the Direct-Drive check of the wrist roll joint, a Motor Drive Amplifier (MDA) Demand Voltage Built-In Test Equipment (BITE) was annunciated. This was a known nuisance alarm that occurred three times during ground testing. The crew executed the appropriate malfunction procedure and completed the RMS checkout with no anomalies. The RMS returned to the Pre-Cradle Position at 197/03:34 GMT (00/00:05:31 MET).

An OMS-3 Nominal Correction (NC) -1 maneuver was performed nominally at 197/01:47:38.770 GMT [00/03:44:28.786 MET) with the cutoff at 197/01:47:59.610 GMT (00/03:44:28.786 MET) and both OMS engines operated nominally. The maneuver was 20.4 sec in duration with a ΔV of 31.4 ft/sec. The resulting orbit was 128.0 by 99.3 nmi.

Upon installation of the Galley Iodine Removal Assembly (GIRA), the crew reported that the towel around the Microbial Removal Assembly (MRA) was wet (IFA STS-127-V-01). After removing the towel, the crew found water leakage from around the MRA vents because their plastic caps were only finger tight. The crew replaced the MRA with a spare MRA and no further leakage was reported.

As part of the assessment of the downlinked ascent Modular Auxiliary Data System (MADS) Pulse Code Modulation (PCM) data, seven measurements were investigated as potential instrumentation anomalies (IFA STS-127-V-04). There was no impact to the mission. Three of the readings on the Mid fuselage bottom panels were correlated with localized temperature sensors to be responding to a rapid localized cooling, which

has been seen on other vehicles/flights (OV-103: STS-70 and STS-114; OV-104: STS30 and STS-115). These were considered an in-family response. Two of the readings on the Xo1307 Left-Hand (LH) wing spar cap were inverted from what was expected. The assessment indicated that these are instrumentation errors based on the nominal trajectory and the fact that other gages provided no correlation in the wing response (anomalous bending of the wing). The remaining two readings on the Xo1191 RH wing spar web were indications of a potential blocked Main Landing Gear (MLG) compartment vent. The area was inspected post flight and no out-of-configuration condition was found.

Flight Day 2

A right OMS-3 NC2 maneuver was performed nominally at 197/14:54:09.0 GMT (00/16:50:59 MET) with the cutoff at 197/14:54:19.4 GMT (00/16:51:09 MET). The maneuver was 10.4 sec in duration with a ΔV of 7.7 ft/sec. The resulting orbit was 128.1 by 103.3 nmi. Engine performance was nominal.

The RMS Orbiter Boom Sensor System (OBSS) surveys of the starboard-wing Reinforced Carbon-Carbon (RCC), nose-cap RCC and port-wing RCC were completed nominally. The maneuver for OBSS grapple started at 197/15:28 GMT (00/17:24:50 MET), with the grappling completed at 197/15:48 GMT (00/17:44:50 MET). The Starboard RCC surveys began with the Flat-Field Survey at 197/16:34 GMT (00/18:30:50 MET), and were completed at 197/18:15 GMT (00/20:11:50 MET). The Nose RCC surveys began at 197/18:33 GMT (00/20:29:50 MET) and were completed at 197/19:23 GMT (00/21:19:50 MET). The Port RCC survey began at 197/19:49 GMT (00/21:45:50 MET).

The Orbiter Docking System (ODS) ring extension was completed at 197/23:56:43 GMT (01/01:53:34 MET). No anomalies were noted during the ring extension. The ring extension was performed with a nominal dual-motor drive to the initial position of 76.4% ring extension.

The Rendezvous Tools checkout was performed and all systems were nominal. The Trajectory Control Sensor (TCS) was powered on at 198/00:09:06 GMT (01/02:05:57 MET) and was powered off at 198/00:25:06 GMT (01/02:21:57 MET).

The Reaction Control System (RCS) NC3 maneuver was initiated at 198/00:31:06 GMT (01/02:27:50 MET) with the cutoff at 198/00:31:16 GMT (01/02:28:00 MET). The maneuver was 9.7 sec in duration with a ΔV of 2.2 ft/sec. The resulting orbit was 128.6 by 103.5 nmi. Engine performance was nominal, and no trim was required.

After replacing the microbial filter, the crew observed a leak on the Galley water transfer hose. Additional tightening of the nuts stopped the leak.

Fuel cell 3 continued to perform satisfactorily. The condenser exit temperature was indicating 156 °F in the 140-160 Ampere (A) load range and 155 °F in the 160-190 A load range.

All Wing Leading Edge Impact Detection System (WLEIDS) ascent summary data was successfully downlinked. Ten indications, nine on the Starboard side and one on the Port side, exceeded the 1 Grms reporting criteria. The largest magnitude observed was 3.3 Grms on panel L9. The WLEIDS on-orbit monitoring began at 197/14:30 GMT (00/16:26:50 MET) with Port and Starboard Group 2.

The RCC Damage Assessment Team (DAT) completed the initial screening of the FD 2 survey imagery of the Starboard wing, Port wing, and Nose cap RCC, and obvious damage areas were identified.

The TPS DAT completed review of the OMS pod imagery from the Aft Flight Deck and the TPS tile surfaces during the RCC surveys. No gross damages were identified.

Flight Day 3

The main activities on FD 3 included rendezvous and docking with the ISS, hatch opening, transfer items, and preparations for the first robotic/EVA on FD 4.

The first maneuver of the day was the OMS-5 Nominal Height (NH) using both engines. The time of ignition was 198/13:00:17.2 GMT (01/14:57:07 MET) with the cutoff at 97.2 sec later. The maneuver had a ΔV of 151.2 ft/sec, and the resulting orbit was 188.6 by 128.5 nmi. Engine performance was nominal.

The second maneuver of the day was the OMS-6 NC4, which was a dual-engine firing. The time of ignition was 198/13:45:32.2 GMT (01/15:42:22 MET) with the cutoff 54.6 sec later. The maneuver had a ΔV of 87.9 ft/sec, and the resulting orbit was 188.6 by 178.6 nmi. Engine performance was nominal.

The Nominal Corrective Combination (NCC) maneuver was a multi-axis RCS firing using nine primary thrusters. The time of ignition was 198/14:19:46.6 GMT (01/16:16:36 MET). The ΔV delivered was 1.3 ft/sec and the resulting orbit was 188.5 by 178.6 nmi.

The Ku-Band antenna was taken to the RADAR mode at 198/14:34:12 GMT (01/16:31:02 MET) and detected the ISS within 6 sec at a range of 143,000 ft. The system began tracking the ISS at 198/14:34:48 GMT (01/16:31:38 MET) at a range of 141,000 ft. The radar mode operated as expected and the COMM mode was reselected at 198/17:07:37 GMT (01/19:04:27 MET).

The OMS-7 Terminal Initiation (TI) maneuver was a straight-feed, left OMS engine firing. Ignition was at 198/15:17:26.2 GMT (01/17:14:16 MET) with the cutoff 12.2 sec

later. The ΔV delivered was 9.2 ft/sec, and the resulting orbit was 188.6 by 184.0 nmi. Engine performance was nominal.

The TCS began tracking the ISS at a distance of 5,244.9 ft, closing at 7 ft/sec and worked nominally throughout the rendezvous activities.

The Midcourse Correction (MC)1 RCS maneuver was initiated at 198/15:37:25 GMT (01/17:34:15 MET) and the firing time was 1.3 sec. The ΔV delivered was 0.3 ft/sec. The MC2 RCS maneuver was initiated at 198/16:10:47 GMT (01/18:07:37 MET) and the firing time was 0.9 sec. The ΔV delivered was 0.27 ft/sec. The MC3 RCS maneuver was performed at 198/16:27:48 GMT (01/18:24:38 MET) and the firing time was 9.1 sec. The ΔV delivered was 2.1 ft/sec. The MC4 RCS maneuver was initiated at 198/16:37:47 GMT (01/18:34:37 MET), and the firing time was 3.4 sec. The ΔV delivered was 0.8 ft/sec.

The R-bar Pitch Maneuver (RPM) started at 198/16:56:00 GMT (01/18:52:50 MET) and ended at 198/17:04:20 GMT (01/19:01:10 MET). The peak pitch rate during the maneuver was approximately 0.72 deg/sec. The maximum attitude excursion was in roll and reached approximately 6.8 deg. Performance was nominal.

The Space-to-Space Orbiter Radio (SSOR) locked onto the ISS at a distance of 34,000 ft. A successful audio check was made at 29,000 ft. The SSOR will remain active through undocking to provide a tie of the air-to-ground 1 and space-to-ground 1 communications between Shuttle and ISS, respectively.

The ODS was activated at 198/17:17:51 GMT (01/19:14:41 MET). The Shuttle captured the ISS at 198/17:47:06 GMT (01/19:43:56 MET), and the post-contact thrust (PCT) firing sequence was performed nominally. The stuck dampener condition was observed after docking, and the system was allowed to dampen. Once the oscillations were damped, ring retraction using dual motors was started at 198/17:56:24 GMT (01/19:53:14 MET). About 1 min (at approximately 45%) into the final ring retraction, the ring mechanism indicated misalignment (light went off). The crew issued a ring-drive-stop command per procedure, thus preventing any further retraction. Approximately 2½ min later, after receiving the ring alignment indication, a ring-retract command was issued again. The rest of ring retraction took place without incident. 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 198/18:06:31 GMT (01/20:03:21 MET).

Main Busses B and C were bus tied at 198/18:20 GMT (1/20:16:50 MET) in support of Station-to-Shuttle Power Transfer System (SSPTS) operations. SSPTS Power Transfer Unit (PTU) -1 Orbiter Power Conversion Unit (OPCU) -A and PTU-2 OPCU-A and B were brought on line beginning at 198/21:28 GMT (1/23:24:50 MET).

Hatch opening took place at approximately 198/19:55 GMT (01/21:52 MET). This was the first time that 13 astronauts/cosmonauts were assembled together in one location in orbit at the same time.

A reboost maneuver was performed to avoid a potential conjunction with a small orbital object (Object 84180). The Configuration 3 RCS reboost maneuver imparted approximately 2.5 ft/sec posigrade ΔV (approximately 4,500 ft altitude) and was performed at 199/00:30 GMT (02/02:27 MET), lasting approximately 15 minutes.

Flight Day 4

The main activities on FD 4 were the first EVA and the installation of the JEM Exposed Facility (JEF) on the ISS.

Inertial Measurement Units (IMUs) 1 and 2 were star aligned at 199/13:47 GMT (02/15:44:00 MET).

A Nitrogen (N₂) transfer to the ISS was initiated at 199/16:20:10 GMT (02/18:17:00 MET), and a total of 386.7 lb was transferred. The Oxygen (O₂) repressurization was performed with Shuttle resources that added approximately 25.8 lb to the combined Shuttle/ISS atmosphere. Three Contingency Water Containers (CWCs) were also filled.

The Shuttle Remote Manipulator System (SRMS) maneuvered to the JEF handoff 1 position and received the JEF from the Space Station Remote Manipulator System (SSRMS). The SRMS grapple of the JEF was completed at 199/18:28 GMT (02/20:25:00 MET). The SRMS maneuvered the JEF from this position to the JEF handoff 2 position at 199/19:38 GMT (02/21:34:00 MET). Following the SSRMS relocation to the ISS truss and the regrappling of the JEF, the SRMS ungrappled the JEF at 199/21:02 GMT (02/22:58:51 MET) and moved to the JEF handoff 2 back-off position. The SRMS then moved to the viewing position for the JEF installation at 199/21:12 GMT (03/23:09 MET) to provide viewing support. Subsequent to the successful JEF installation, the SRMS moved to the pre-cradle position at 200/00:17 GMT (03/02:13:51 MET) where it was parked overnight.

At the 199/22:50 GMT (03/00:47 MET) during the SRMS Side-View Camera (RSC) downlink on the Ku-Band Channel 3 and in the TV mode, the bright, washed-out image over-modulated Ku-Band channel 1 and 2 causing drop-outs. This condition has been observed on past missions.

The performance of fuel cell 3 continued to be nominal while operating at a low power level of approximately 60 A with the condenser exit temperature at approximately 160 °F. This results in a KOH concentration of roughly 28-30%. Several sustaining heater cycles have occurred while operating at low power levels due to the lower stack-exit temperature.

The RCC DAT completed the imagery analysis. No focused inspection requirements were identified and the system was cleared for entry.

The Thermal Protection System (TPS) DAT presented preliminary results of the analysis of the imagery obtained from the FD 3 RPM maneuver. Twenty-four items of interest were evaluated by the team, including 8 gap filler/thermal barrier areas and 16 damage sites in the starboard chine area (IFA STS-127-V-03). The team determined that no focused inspection was required. The analysis to clear the system for entry continued.

Flight Day 5

The main activity for FD 5 was the Integrated Cargo Carrier-Vertical Light Deployable (ICC-VLD) unberthing, calibration of the JEM SRMS, and two Public Affairs Office (PAO) events.

The American side of the ISS Waste/Hygiene Compartment (WHC) failed; however, the Russian side remained functional. The "flushing pump" on the WHC continued running after being used. The ISS began to rely on the Russian WHC which can handle six crewmembers. The seven Orbiter crewmembers were restricted to using the Orbiter Waste Collection System (WCS). The Shuttle WCS had sufficient capacity to accommodate the needs of the crew for the duration of the mission; however, it was expected that the Waste Water Tank would become full and require offloading into a CWC.

The SRMS grappled the ICC at 200/13:43 GMT (03/15:40:00 MET), and maneuvered to the ICC handoff to the SSRMS position at 200/14:41 GMT (03/16:38:00 MET). The SSRMS grappled the ICC at 200/15:17 GMT (03/17:14 MET), and the SRMS released the ICC and maneuvered to the second-EVA viewing-position at 200/16:54 GMT (03/18:51:00 MET).

At approximately 200/21:28:10 GMT (03:23:25 MET), the Orbiter Partial Pressure Carbon Dioxide (ppCO₂) level exceeded 5.0 mmHg. The crew was given the option of performing an early Lithium Hydroxide (LiOH) canister change-out and elected to make the change. This was an unplanned LiOH canister change-out, as the LiOH canister was again replaced as part of the standard pre-sleep activity at 201/02:06:10 GMT (04/04:03 MET). Because of the extra crew members, additional LiOH change-outs were deemed likely and consideration was given to using canisters from the ISS stock pile.

The SSPTS was deactivated for the EVA, and this resulted in the fuel cells assuming the entire Orbiter load. The Fuel Cell (FC) 3 current increased from about 60 A to the 130-140 A range. The condenser exit temperature decreased to 156-157 °F. The KOH increased to 30 to 32%. After the EVA, the SSPTS was re-activated and the fuel cell parameters returned to the same values as before the EVA: current around 60 A,

condenser exit temperature about 159-160 °F, acceptable KOH concentration approximately 28%, and several sustaining heater cycles.

Flight Day 6

The main activity for FD 6 was the second EVA and cargo transfer.

The Ku-Band channel 3 Frequency Modulation (FM) mode was over-modulated when receiving video from the SRMS RSC camera. When extremely bright RSC video was routed to Payload 3, channels 1 and 2 dropped out. When another camera was routed, channels 1 and 2 functioned properly. This was a known condition.

The Power Reactant Storage and Distribution (PRSD) O₂/H₂ manifold 1 isolation valves were cycled closed for crew sleep at 201/00:06 GMT (04/02:03 MET) and were reopened at 201/11:12 GMT (04/13:09 MET).

Fuel cell 3 averaged a KOH concentration of about 30.5% during the SSPTS operating period between the first and second EVA. The SSPTS was deactivated prior to second EVA at 201/14:20 GMT (04/16:11MET) requiring the fuel cells to assume the entire Orbiter load. The FC 3 current increase was from about 56 A to the 82 to 140 A range. The condenser exit temperature was 156-158 °F and KOH concentration was 29.5 to 31.5%. The SSPTS was re-activated following the second EVA.

The pressure decay in the Left Orbiter Main Engine (LOME) Gaseous Nitrogen (GN₂) continued to be monitored. The leakage rate of approximately 70 scch corrected value was within the Operational Maintenance Requirements and Specifications Document (OMRSD) File IX limit of 75 scch. This leak was similar to the GN₂ decay that has been observed on this OMS pod during the STS-118, STS-123 and STS-126 missions. The leak was most recently observed following the scrubbed launch attempts on July 11 and 12, subsequently stopped, and resumed again after the July 15 launch. The leak rate was predicted to result in a nuisance alarm, which was projected to possibly occur during crew sleep on FD 11. A chit was being drafted to develop a General Memory (GMEM) update to change the Fault Detection and Annunciation (FDA) limit for the Left OMS GN₂ supply tank pressure. The GN₂ tank FDA limit is 1200 psi and the GMEM was requesting reducing the limit to the 500 psi.

In response to the additional LiOH canister used on FD 5, consideration was given to possibly using canisters from the ISS stockpile. However, the decision was made to return to the original pre-flight LiOH plan unless required otherwise.

The SRMS position was adjusted as required between 201/15:35 GMT (04/17:32 MET) and 201/18:05 GMT (04/20:02 MET) to support the second EVA viewing operations.

The second on-orbit fuel cell purge was commanded beginning at 202/10:56 GMT (05/12:53 MET). During the 108-hour purge interval, the approximate voltage decay was 0.17 Vdc in fuel cell 1, 0.20 Vdc in fuel cell 2, and 0.19 Vdc in fuel cell 3.

At the end of the second EVA, the EV-3 crewmember reported that communications were lost in the left ear, but the communications were satisfactory in the right ear. The EV-3 crewmember reported that communications were fully recovered in the left earpiece after airlock repressurization (IFA STS-127-V-06); Since the unit recovered during repressurization, it was unclear if this was a Moisture Barrier Earphone Diaphragm (MBED) problem or earphone receiver problem. Photographs taken after the EVA showed perspiration in both Communications Carrier Assembly (CCA) ear cups, and the MBED did not show signs of lifting or loss of adhesion. This communication cap was designated as a backup for the remainder of the EVAs. The CCA was returned to Johnson Space Center (JSC) for analysis to determine the cause of the anomaly

Flight Day 7

The main activity for FD 7 was JEM Experiment Logistics Module-Exposed Section (JLE) installation, preparation for the third EVA and crew off-duty time.

At various times during this mission, the ground controllers observed a pink and/or blue hue on over-bright areas of the video image that was downlinked from the SRMS elbow camera (IFA STS-127-V-02). This generally occurred when there are clouds or white areas with Sun reflection. It continued whenever the elbow camera was used. This was observed on both the analog (Ku-Band) and digital (S-Band) downlinks. The crew also saw this on the onboard monitors and it was also visible in the ISS downlink when the camera was routed over to the ISS via the ODS interface (channel 71). This condition did impact SRMS operations.

At 202/11:37 GMT (05/13:34 MET), the ground controllers noticed a half-red/half-green signature on the downlink of the Shuttle Orbital Communications Adapter (OCA) router indicating that the onboard router was locked up or unseated (IFA STS-127-S-01). The crew was asked to reboot the router. The crew reported that after reboot, an error was received. The crew then performed another reboot. The ground again noticed the half-red/half-green signature on downlink. The crew reseated the laptop and rebooted again. Communication was re-established with OCA at 202/11:56 GMT (05/13:53 MET). The crew, however, reported a "blue screen" on the router. The crew checked the seating of the laptop and rebooted. The half-red/half-green signature appeared again. At 202/14:53 GMT (05/16:50 MET), the crew reported that the docked light was not illuminated on the docking station. The crew also reported an error stating that the operating system was not found. It was determined that the laptop would boot when undocked, but not when docked. All connections appeared to be good. The crew was asked to perform a hard-disk swap. The laptop was rebooted while docked and OCA communication was re-established at 202/16:27 GMT (05/18:24 MET).

The SRMS grappled the JEM Experiment Logistics Module Exposed Section (JLE) at 202/12:27 GMT (05/14:24 MET), and maneuvered to the JLE unberthing-position at 202/12:52 GMT (05/14:49 MET). Then, the SRMS maneuvered the JLE to the SSRMS handoff position at 202/13:14 GMT (05/15:11 MET). After the SSRMS grappled the

JLE, the SRMS ungrappled the JLE and maneuvered to the JLE-installation viewing position at 202/13:43 GMT (05/15:40 MET). After installation of the JLE was complete, the SRMS was maneuvered at 202/17:20 GMT (05/19:17 MET) to the Battery Removal and Replacement (R&R) viewing position.

Flight Day 8

The STS-127 mission was progressing satisfactorily. The main activity on FD 8 was the third EVA.

The duration of the third EVA was 5 hr 59 min. The third EVA was terminated early because of higher-than-normal Carbon Dioxide (CO₂) levels in one of the suits. Due to the early termination, only two of the six batteries on the Port (P) 6 truss were changed out. One additional battery was removed from the truss, but was left in a temporary stowage position on the ISS.

The SSPTS was deactivated prior to the third EVA at 203/14:32 GMT (06/16:29 MET) requiring the fuel cells to resume providing power for the entire Orbiter load. The SSPTS was reactivated at 204/00:04:53 GMT (07/01:54:54 MET) following the completion of the third EVA.

STS-127 was the first flight of the Contingency Water Container Iodine (CWCI) bags, which can contain approximately 40 lb of water. A total of 10 CWCI's were filled earlier in the mission. The first CWC, which contained approximately 95 lb, was filled.

Flight Day 9

The main activities on FD 9 were cargo transfer, preparation for the fourth EVA, and filling of the second CWC.

An N₂ repressurization was completed using system 1 through the system 2 payload valves, and the second CWC was filled. During the N₂ repressurization and the simultaneous filling of the CWC, the N₂/Water (H₂O) regulator pressure for systems 1 and 2 was decreasing from approximately 18.4 psi to approximately 14.0 psi. In this configuration, the system 2 regulator was responsible for cabin repressurization as well as backfilling the N₂ pressure loss from losing water in the water tanks. The magnitude of the pressure decrease was an understood condition when the Pressure Control System (PCS) was in the N₂ repressurization configuration using the payload valves, which restrict flow to approximately 7 lb/hr when a demand such as a CWC fill is placed on the water tanks. Once the CWC fill was completed, the N₂/H₂O regulator pressure began to recover. The N₂/H₂O system 2 regulator was also opened to allow the pressure to recover.

At 204/19:22:45 GMT (07/21:19:35 MET), the FC 3 sustaining heater came on and stayed on for approximately 21 min 40 sec (IFA STS-127-V-05). Nominal sustaining heater cycles last about 3 to 4 min. To preclude additional heater sustaining heater

cycles, the B-to-C bus tie was removed. This removed the direct connection to the SSPTS powered Main B bus, thus allowing FC 3 to run at a slightly higher-power level. In this configuration, the fuel cell could continue to run with a sustaining heater stuck on, but there would be some impact to consumables, notably, after the undocking time frame when SSPTS was no longer available.

Flight Day 10

The main activities for FD 10 were the fourth EVA and the return of the Integrated Cargo Carrier-Vertical Light Deployable (ICC-VLD) to the payload bay.

The fourth EVA was 7 hr 12 min in duration. All tasks, including all the battery replacements, were completed as planned and without issue.

The main busses A and B were buss tied at 205/09:36 GMT (08/11:27 MET) to gain improved SSPTS transfer of electrical power.

An IMU alignment was performed at 205/12:42 GMT (08/14:39 MET).

During the time interval between 205/16:18 GMT (08/18:15 MET) and 205/16:51 GMT (08/18:48 MET), the GN₂ accumulator pressure on the Left OME increased by 4 psia, peaking at 334 psia. From this peak, the pressure, which had previously been decreasing at a negligible rate, has trended downward at a rate of 1.1 psia/hr. The pressure decay profile in the GN₂ supply tank was being monitored for any changes. A similar behavior was observed in the GN₂ system during the two previous flights of this OMS- pod on STS-118 and STS-126. A GN₂ system repressurization will be performed to avoid a low pressure alarm. This leak will not affect nominal OMS engine usage. Sufficient GN₂ remains in the supply tank to support several Left OME firings. One other firing was planned, deorbit, with the possibility of two Shuttle Engine Ion Turbulence Experiment (SEITE) firing opportunities under consideration.

At 205/21:18 GMT (08/23:15 MET), the ICC was handed off from the SSRMS to the SRMS. The ICC was subsequently berthed in payload bay at 205/22:52 GMT (09/00:49 MET).

The PRSD system O₂/H₂ manifold 2 isolation valves were cycled closed for crew sleep at 205/23:41 GMT (09/01:37:50 MET).

Another occurrence of Global Positioning System (GPS) User Note 110669 was observed in the period between approximately 206/02:54:18 GMT (09/04:51:08 MET) and 206/03:28:06 GMT (09/05:24:56 MET). This was a known condition when the peripheral channel locks onto a satellite continuously and does not perform its normal tasks until a higher priority task interrupts it. As documented in the User Note, the condition self-corrected when channel 3 experienced a Loss-of-Lock on Satellite ID 26. There were no impacts to system performance.

The third and fourth CWCs were filled.

During post-ascent data reviews, it was noted that a small temperature increase had occurred during the Hydraulic System 1 ET Liquid Oxygen (LO₂) actuator retraction. This temperature increase was similar, but not as steep as one seen during the STS-119 post-flight investigation when the Hydraulic System 1 ET Liquid Hydrogen (LH₂) actuator did not fully retract. Further review of data from previous flights on OV-105 show a similar signature for this specific measurement. These actuators were checked after each of those flights and were found to be fully retracted. The ET doors were confirmed closed via earlier TPS surveys. No ET door issues exist for entry.

Flight Day 11

The main activities for FD 11 were Public Affairs Office (PAO) events and crew off-duty time.

The PRSD system O₂/H₂ manifold 2 isolation valves were reopened at 206/09:55 GMT (09/11:52 MET).

Oxygen (O₂) transfer of approximately 45-48 lb to the ISS was initiated at 206/12:57 GMT (09/14:54 MET).

PRSD H₂ Tank 5 was depleted to residual quantity at 206/23:47 GMT (10/01:44 MET).

After the Left OMS GN₂ accumulator manual repressurization that was completed at 206/23:47:44 GMT (10/01:44:34 MET), the accumulator pressure initially remained constant at 332 psia for approximately 7 hr before resuming the downward trend at the previously observed rate of 1.1 psia/hr. The pressure in the GN₂ supply tank appears to have leveled off, only dropping with the manual repressurizations of the accumulator. As discussed earlier, a similar behavior was observed in the GN₂ system in the left pod during STS-118 and STS-126 missions. During the corresponding time frame, the pressure in the GN₂ accumulator saw a similar pressure increase and subsequent decline, while the pressure observed in the GN₂ supply tank leveled off.

The O₂ transfer to the ISS was temporarily terminated at 207/04:19 GMT (10/06:16 MET).

On the ISS, there was failure of the primary heater of the Carbon Dioxide Removal Assembly (CDRA). The CDRA was subsequently configured to operate on the secondary heater only. In this configuration, CDRA was operating in slightly degraded mode but the ppCO₂ was being maintained within acceptable levels on both vehicles. This issue was likely to affect the LiOH canister change-out plan. The impact on the Orbiter's LiOH supply was being assessed.

Flight Day 12

The main activities for FD 12 were the return of the JLE to the payload bay and preparation for the fifth EVA.

The third on-orbit fuel-cell purge, which was an auto purge, was commanded beginning at 207/10:24 GMT (10/12:21 MET). During the 120-hour purge interval, the approximate indicated voltage decay was 0.07 Vdc in fuel cell 1, 0.10 Vdc in fuel cell 2, and was 0.15 Vdc in fuel cell 3. The fuel cell 1 H₂ flowmeter was unpowered for this flight due to anomalous behavior during the STS-126 mission.

The N₂ repressurization was initiated at 207/12:13 GMT (10/14:10 MET) and was completed at 207/16:51 GMT (10/18:48 MET).

The O₂ transfer to the ISS was resumed at 207/11:03 GMT (10/13:00 MET) and completed at 207/12:49 GMT (10/14:46 MET).

At 207/12:50 GMT (10/14:47 MET), the JLE was handed off from the SSRMS to the SRMS. The JLE was subsequently berthed in the Payload Bay at 207/13:45 GMT (10/15:42 MET). The SRMS was then maneuvered to pre-cradle position at 207/13:48 GMT (10/15:45 MET).

The Inertial Measurement Unit's (IMU's) no. 1 and no. 2 were aligned at 207/17:28 GMT (10/19:25 MET). The largest drift rate was -0.002 deg/hr in the IMU 2 X-axis.

After the Left OMS GN₂ accumulator manual repressurization was completed at 207/21:13:55 GMT (10/23:10:45 MET), the accumulator pressure held constant at 332 psia for approximately 7 hr before resuming the downward trend at the previously observed rate of 1.1 psia/hr. The pressure in the GN₂ supply tank has leveled off at approximately 1230 psia, only dropping with the manual repressurization of the accumulator.

The PRSD O₂/H₂ manifold 1 isolation valves were cycled closed for the crew sleep at 207/21:16 GMT (10/23:13 MET).

The Hydraulic System 1 circulation pump was activated by a Table Maintenance Block Update (TMBU) at 207/21:28:20 GMT (10/23:25:10 MET) and the pump operated for 5 min to protect the inlet temperature of the pump.

Flight Day 13

The main activity for FD 13 was the fifth EVA.

The fifth EVA was 4 hr 54 min in duration. All tasks, with the exception of the deployment of the Payload Attach System (PAS) on the Starboard (S) 3 truss, were completed.

The filling of the fourth and final planned Payload Water Reservoir (PWR) was completed at 208/12:53:46 GMT (11/14:50:36 MET). The fifth and sixth CWCs were filled on FD 13, and the seventh CWC was filled at 208/14:00:57 GMT (11/15:57:47 MET).

The PRSD O₂/H₂ manifold 1 isolation valves were reopened at 208/17:51 GMT (11/19:48 MET).

The O₂ tank 5 was depleted to just above residual quantities at 208/18:41 GMT (11/20:38 MET).

At 208/19:00 GMT (11/20:57 MET), the Flash Evaporator System (FES) primary controller B was disabled and primary controller A was enabled.

The PRSD Oxygen/Hydrogen (O₂/H₂) manifold 1 isolation valves were closed for the crew sleep at 208/20:33 GMT (11/22:30 MET).

After the Left Orbital Maneuvering System (LOMS) GN₂ accumulator manual repressurization that was completed at 208/20:34:36 GMT (11/22:31:26 MET), the accumulator pressure on the Left Orbital Maneuvering Engine (LOME) held constant at 332 psia for approximately 8 hr before resuming the downward trend at the previously observed rate of 1.1 psia/hr. The pressure in the GN₂ supply tank leveled off at approximately 1220 psia, only dropping with the manual repressurization of the accumulator.

The O₂ repressurization was completed at 208/20:39 GMT (11/22:36 MET).

The post-undocking OMS maneuver plan concerning two potential SEITE firings was evaluated. Scenarios existed that resulted in the right OMS GN₂ tank pressure decreasing to near the lower Fault Detection Annunciation (FDA) limit of 1200 psi after completing the deorbit maneuver. If this occurred, alarms could be generated by the tank pressure bit-toggling across the FDA threshold during entry. To prevent these possible nuisance alarms, a Backup Flight System (BFS) GMEM was prepared to lower the left and right OMS GN₂ tank pressure FDA limit from 1200 psi to 500 psi.

Flight Day 14

The main activities on FD 14 were hatch closure, undocking, flyaround and the two separation maneuvers.

The PRSD O₂/H₂ manifold 1 isolation valves were reopened at 209/07:57 GMT (12/09:54 MET).

The IMU no. 1 and no. 2 were aligned at 209/13:03 GMT (12/15:00 MET). IMU 3 was later brought up in the operate mode and then aligned with IMUs 1 and 2 at 209/15:58 GMT (12/17:55 MET).

The SSPTS was deactivated at 209/13:49:12 GMT (12/15:46:02 MET) in preparation for undocking.

The ODS hatch was closed at approximately 209/14:59 GMT (12/16:56 MET).

The Orbiter took attitude control with Digital Auto Pilot (DAP) in the Automatic mode at 209/15:08:18 GMT (12/17:05:08 MET) and the maneuver to the undocking attitude was initiated at 209/16:10:10 GMT (12/18:07:00 MET). The maneuver took approximately 31 min and was complete at 209/16:41:18 GMT (12/18:38:08). The DAP was commanded to Free Drift at 209/17:23:09 GMT (12/19:19:59 MET) for the undocking.

The command to undock from the ISS was initiated at 209/17:23:50 GMT (12/19:20:40 MET). Physical separation occurred at 209/17:25:55 GMT (12/19:22:45 MET). The total drive time of 2 min 7 sec for Hook Groups 1 and 2 was nominal. The ODS performed nominally for undocking.

The fly-around was initiated with RCS +X pulses of the L1A and R1A thrusters at 209/17:53:04 GMT (12/19:49:54 MET). The separation 1 maneuver was initiated with RCS +X pulses for 6 sec using thrusters L1A and R1A at 209/18:40:40 GMT (12/20:37:30 MET). The separation 2 maneuver was performed at 209/19:08:40 GMT (12/21:05:30 MET). This was a 42.5 sec RCS +X maneuver using thrusters L1A and R1A.

The operation of the TCS for undocking and fly-around activities was nominal.

After undocking and prior to the separation 1 maneuver, the Ku-Band was taken to the RADAR mode at 209/18:32:25 GMT (12/20:29:15 MET) and locked on to the ISS at an approximate range of 550 ft. The Ku-Band was configured back to the Communications (COMM) mode at 209/19:10:24 GMT (12/21:07:14 MET) at a range of approximately 7425 ft.

The manual repressurization of the LOMS GN₂ accumulator was completed at 209/20:35:36 GMT (12/22:32:MET). Two OMS maneuvers subsequently recharged the accumulator. Sufficient GN₂ remains in the supply tank to support the remaining OMS firings.

The PRSD O₂/H₂ manifold 2 isolation valves were cycled closed for crew sleep at 209/21:53 GMT (12/23:50 MET).

Hydrogen (H₂) Tank 4 was depleted to residual quantity at 209/21:54 GMT (12/23:51 MET).

Flight Day 15

The main activity for FD 15 was the inspection of the Orbiter's RCC panels for Micrometeoroid/Orbital Debris (MM/OD) damage.

The PRSD O₂/H₂ manifold 2 isolation valves were reopened at 210/07:52 GMT (13/09:49 MET).

The SRMS grappled the OBSS at 210/09:31 GMT (13/11:28 MET). The starboard Manipulator Retention Latches (MRLs) were released at 210/09:40 GMT (13/11:37 MET). At 210/09:45 GMT (13/11:42 MET), the OBSS was maneuvered to the Hover position.

The Assembly Conversion Power Unit (APCU) 2 was activated at 210/09:53:06 GMT (13/11:49:56 MET) and supplied 79 watts of power to payloads until it was deactivated at 210/14:33:25 GMT (13/16:30:15 MET).

The WLEIDS began monitoring at 210/10:03 GMT (13/12:00 MET) and ended at 210/18:33 GMT (13/20:30 MET). No triggers were reported during this monitoring period and it was the final on-orbit monitoring period.

The late inspection of the RCC started with the starboard survey at 210/10:37 GMT (13/12:34 MET) and ended with the port survey at 210/13:50 GMT (13/15:47 MET). The OBSS was berthed on the starboard Manipulator Positioning Mechanism (MPM) at 210/14:53 GMT (13/16:50 MET). The SRMS was cradled and latched, and the power-down was completed at 210/15:18 GMT (13/17:15 MET). After the evaluation of the data, the RCC and TPS was cleared for entry.

Oxygen tank 4 was depleted to residual quantity at 210/16:22 GMT (13/18:19 MET).

The OMS-8 maneuver for Shuttle Engine Ion Turbulence Experiment-1 (SEITE-1) was a dual-engine OMS firing initiated at 210/17:28:42.6 GMT (13/19:25:33 MET). Cutoff was 9.8 sec later at 210/17:28:52.4 GMT (13/19:25:42 MET). The ΔV delivered was 16.7 ft/sec. The resulting orbit was 177.0 by 190.8 nmi. Engine performance was nominal.

The OMS-9 Separation-3 maneuver was a straight-feed, LOMS engine firing. Ignition was at 210/20:12:09.6 GMT (13/22:09:00 MET) with the cutoff 11.8 sec later. The ΔV delivered was 10.0 ft/sec, and the resulting orbit was 177.0 by 184.7 nmi. Engine performance was nominal.

Flight Day 16

The main activities for FD 16 were stowing the cabin for entry, performing the Flight Control System (FCS) checkout, the RCS hotfire test, and the deployment of two satellites.

The RCS hot-fire test was initiated at 211/08:36:46 GMT (14/10:33:36 MET) and terminated at 211/08:55:38 GMT (14/10:52:28 MET). All RCS thrusters, except F2F, were fired at least once for at least 0.240 sec per pulse. The F2F thruster failed off during the test and the failure is discussed in the following paragraph. All thrusters, with the exception of F2F have now been fired, and the performance was nominal.

During the RCS hot-fire test, Forward RCS Thruster F2F exhibited low chamber pressure (P_c) of approximately 16 psi. The F2F thruster was declared failed off and automatically deselected by RCS Redundancy Management (RM) at 211/08:48:50 GMT (14/10:45:40 MET) (IFA-STS-127-V-07). This was the first time this 3rd priority thruster fired all mission. The P_c was 16% while injector temperatures showed good propellant flow and soakback. The loss of this thruster did not impact the mission.

The FCS checkout was performed satisfactorily. Auxiliary Power Unit (APU) 1 was started at 211/09:26:59 GMT (14/11:23:49 MET). The APU 1 ran for 5 min 40 sec, with shutdown at 211/09:32:39 GMT (14/11:29:29 MET).

The GPS no. 1 and no. 3 receivers were powered up at 211/09:18:53 GMT (14/11:15:43 MET). As anticipated, both GPS receivers experienced a known condition where the GPS cannot track satellites in the Y-Code. This condition self-corrects at 22:00:00 GMT of the current day when the receivers request the download of a new daily key.

The OMS-10 maneuver for SEITE-2 was a dual-engine firing initiated at 211/11:03:49.1 GMT (14/13:00:39 MET). Cutoff was 9.9 sec later at 211/11:03:59.0 GMT (14/13:00:49 MET). The ΔV delivered was 16.6 ft/sec. The resulting orbit was 187.2 by 174.3 nmi. Engine performance was nominal.

The Orbit Adjust (OA) maneuver was a Primary Reaction Control System (PRCS) multi-axis firing occurring at 211/11:24:09 GMT (14/13:20:59 MET). Cutoff was 21.7 sec later with a ΔV of 5.4 ft/sec being delivered. The resulting orbit was 184.1 by 174.4 nmi. No trim was required.

The Dual Radio Frequency Autonomous Global Positioning System On-orbit Navigator Satellite (DRAGONSat) was deployed at 211/12:33 GMT (14/14:30 MET). The Atmospheric Neutral Density Experiment-2 (ANDE-2) was deployed at 211/17:22 GMT (14/19:19 MET).

The port and starboard MPMs were stowed at 211/17:43 GMT (14/19:40 MET).

The Separation-4 maneuver was a PRCS multi-axis firing. Ignition was at 211/17:48:09 GMT (14/19:44:59 MET) with cutoff 1.3 sec later. The ΔV delivered was 0.3 ft/sec, and the resulting orbit was 184.0 by 174.3 nmi. No trim was required.

The Ku-Band system was stowed and powered down without issue at 211/19:07 GMT (14/21:04 MET).

The DAT completed the review of all imagery from the late inspection and cleared the Orbiter for entry.

The main activities for FD 17 will be payload bay door closure, entry and landing.

Entry and Landing

The STS-127 mission was successfully completed with a landing at Kennedy Space Center, Florida.

Both Payload Bay Doors (PLBDs) were closed nominally by 212/11:02:43 GMT (15/12:59:33 MET) in preparation for landing.

The deorbit maneuver for the first landing opportunity at KSC, a dual-engine straight-feed firing, was performed on orbit 249 at 212/13:41:10 GMT (15/15:38:00 MET). The maneuver was 171.40 sec in duration with a ΔV of 305.1 ft/sec. The orbit after the deorbit maneuver was 184.7 by 22.6 nmi.

The FRCS dump of the propellants began at 212/13:58:30 GMT (15/15:55:20 MET) and was completed 31.7 sec later.

Entry interface occurred at 212/14:16:31 GMT (15/16:13:21 MET).

The main landing gear touchdown occurred KSC runway 15 at 212/14:48:07 GMT (15/16:44:57 MET) on July 31, 2009. The drag chute was deployed at 212/14:48:13 GMT (15/16:45:03 MET). The nose gear touchdown occurred at 212/14:48:20 GMT (15/16:45:010 MET). Drag chute jettison occurred at 212/14:48:51 GMT (15/16:45:21 GMT). Wheels stop occurred at 212/14:49:13 GMT (15/16:46:03 MET). The rollout was normal in all respects.

The flight duration was 15 days 16 hr 46 min 03 sec. The shutdown of the last APU occurred 14 min 58 sec after landing.

Post-Landing

During post-flight removal, two of the LO₂ flight struts were found in wrong positions (IFA-STs-127-V-10). The aft strut was installed in the outboard position, and the outboard mid strut was installed in the aft position. The struts are designed to accommodate ET/Orbiter relative motion during boost and to stabilize/support the Orbiter Main Propulsion System (MPS) valve cluster, lines and gimbals during and after umbilical separation.

PAYLOADS AND EXPERIMENTS

LAUNCH PACKAGE OVERVIEW

The International Space Station (ISS) 2J/A launch package consisted of the Japanese Aerospace Exploration Agency (JAXA) Japanese Experiment Module - Exposed Facility (JEM-EF), the Japanese Experiment Logistics (JEL Module (ELM) – Exposed Section (ES) that launched with the Monitor of All-sky X-ray Imagery (MAXI), Interorbit Communication System-Exposed Facility (ICS-EF) and Space Environment Data Acquisition equipment – Attached Payload (SEDA-AP) and the Integration Cargo Carrier – Vertical Light Deployable (ICC-VLD) that was launched with six attached Port (P) 6 batteries, the Space-to-Ground Antenna (SGANT), a Linear Drive Unit (LDU) and a Pump Module (PM). Five Extravehicular Activities (EVA's) were planned. The STS-127 mission constitutes the 28th mission to the ISS and the 23rd flight of the OV-105 Orbiter.

CREW ACTIVITY SUMMARY

The Space Shuttle Orbiter Vehicle (OV) 105 successfully docked with the ISS on Flight Day (FD) 3. Mission Specialist 5 (Up) transferred to the ISS and the Mission Specialist 5 (Down) transferred to the Shuttle for return to Earth. A RCS reboost maneuver was performed to avoid a potential conjunction with a small orbital object (Object 84180). The Configuration 3 reboost maneuver imparted approximately 2.5 ft/sec posigrade ΔV (approximately 4,500-ft altitude) and was performed at 199/00:30 GMT, (02/02:27 MET) and lasted approximately 15 min.

On FD 4, the first EVA was successful and the crew-members successfully completed the objectives in 5 hr 32 min. On FD 5, the ICC-VLD was unberthed from the Orbiter by the Shuttle Remote Manipulator System (SRMS) and handed off to the Space Station Remote Manipulator System (SSRMS). The SSRMS attached the ICC-VLD to the Mobile Base System (MBS) Payload Orbital Replacement Unit (ORU) Accommodation (POA).

On FD 6, the second EVA was successful and the crewmembers completed the EVA in 6 hr 52 min. During the second EVA, the spare equipment was transferred to the External Stowage Platform (ESP) 3. On FD 7, the SRMS unberthed the ELM-ES from the payload bay and handed off to the SSRMS, which installed the ELM-ES on the JEM-EF. The SSRMS then grappled the ICC-VLD and maneuvered it to the Mobile Transporter position.

On FD 8, the third EVA was successful and the duration of the EVA was 5 hr 59 min. Only a portion of the planned installation of 4 of the 6 batteries on the P6 strut (only two were installed) for the EVA were completed because the EVA was terminated because of high Carbon Dioxide (CO₂) readings in the EV 2 crewmember's suit.

The fourth EVA was replanned to include activities not completed during the third EVA. The EVA was planned for 7.5 hr, which required the approval of the Mission Management Team because of existing documentation that limited an EVA to 6.5 hr. The FD 10 major activity was the fourth EVA, which was successfully completed in 7 hr 12 min. The remaining 4 batteries were installed on the P6 truss. On FD 11, approximately 45 lb of oxygen was transferred to the ISS and the crew participated in two Public Affairs Office (PAO) events. On FD 12, the main activity was continuing the transfers of equipment from the Orbiter and transferring equipment from the ISS that was to be returned to Earth.

On FD 13, the main activity was the fifth EVA, which was successfully completed in 4 hr 54 min. With the completion of this EVA, all of the major EVA objectives were completed for the flight. On FD 14, the Orbiter was undocked from the ISS and a flyaround of the ISS was successfully performed. On FD 15, the crew performed the late inspection of the Orbiter using the SRMS and the Orbiter Boom Sensor System (OBSS). The crew also performed the first of two Shuttle Exhaust Ion Turbulence Experiment (SEITE) maneuver opportunities.

On FD 16, the Flight Control System (FCS) checkout was successfully performed, the second SEITE maneuver was performed and one 2 satellites were deployed. These satellites were the Dual RF Autonomous GPS On-Orbit Navigator Satellite (DRAGONSat) and the Canister for All Payload Ejections/Internal Cargo Unit/ Atmospheric Neutral Density Experiment-2 (CAPE/ANDE-2). On FD 17, the Orbiter returned to Kennedy Space Center on it first landing opportunity on July 31, 2009.

TRANSFER WEIGHT SUMMARY

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

TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Parameter	To ISS, lb _m	From ISS, lb _m
Cargo Bay	22,463	8,499
Middeck	2,175	1,980
Real-time Additions	146	165
Totals		

1. **Water** – The total amount of supply water transferred was 1225.4 lb. This included 10 Contingency Water Containers-Iodine (CWC-I's), 8 CWC's of which 4 were potable water and 4 were technical water, 4 Payload Water Reservoirs and 2 ISS CWC's of condensate for Russian processing.
2. **Oxygen** – A total of 45 lbm of Oxygen were transferred to the Airlock High Pressure Gas Tank (HPGS) on the ISS.
3. **Nitrogen** – A total of 12 lbm of nitrogen was transferred to the Airlock tanks. An additional quantity of nitrogen was used to repressurize the ISS stack.

4. **Lithium Hydroxide (LiOH)** – A total of 20 LiOH canisters were transferred from the Shuttle to the ISS, and were used by the Orbiter during the flight. In addition, 15 used LiOH canisters and 5 unused canisters were transferred to the Orbiter.
5. **Food** – A total of 30 Half Crew Transfer Bags (CTBs) were transferred to the ISS.

SIGNIFICANT FIRSTS

The significant firsts for the STS-127 mission were as follows:

1. The First time utilization of three robotic arms concurrently for an installation task (FD4).
2. First time the JEM RMS performed loaded maneuvers.
3. Completion of the Japanese Kibo Module means that all modules on ISS are now complete
4. 13 humans in one spacecraft orbiting the planet Earth.
5. Koichi Wakata set a record for the first person that has been a crewmember on five different crews without returning to the planet Earth.
6. On launch day, Chris Cassidy became the 500th person to orbit the Earth.
7. Unberthing of the JEM-EF from the Orbiter was the first time utilization of Parallel Latching configuration.
8. The SEITE-1 maneuver was the first SEITE maneuver to have been approved by NASA and operated by the Department of Defense (DoD).

SIGNIFICANT ISS ANOMALIES

On FD11, during Carbon Dioxide Removal Assembly (CDRA) half-cycle 1 operations, the bed 2 temperatures began to rise until a circuit breaker for the Remote Power Control Mechanism (RPCM) Remote Power Controller (RPC), which feeds the primary bed heaters opened. The CDRA was taken offline because specialists believed the anomaly was caused by a primary-heater-control-panel malfunction. The CDRA was re-activated in manual mode. Additional work is on-going to allow the CDRA to be operated automatically, as well as to determine future troubleshooting and change-out activities.

At 200/14:14 GMT (FD 5), the crew reported an error indication on the Waste and Hygiene Compartment (WHC) control panel following an inadvertent dose-pump activation. This occurrence resulted in the Pump Separator Unit [COT] and hoses flooded with pre-treat and a water solution. While the WHC was failed, the ISS crew used the Russian facility and Shuttle crew used the Shuttle WCS. The crew removed the ORUs on FD 5 and reinstalled on FD 6 the Dose Pump, [COT], pump separator, hoses, and the [ACY] Control Panel was replaced. Activation and checkout were successfully completed and the WHC was returned to nominal use.

Approximately two years ago, a number of ungrounded floating-power connector interfaces were discovered on the ISS. These floating interfaces are zero-fault tolerant

should a short circuit occur; thereby producing a catastrophic hazard (crew shock or arcing and sparking) in the form of energized (to 120 Vdc) connectors and back-shells. An effort was undertaken on ISS to electrically insulate these connector interfaces. The plan for the EVA connectors was to build and install electrically insulating sleeves for this purpose. During the installation of one of these sleeves, it was discovered that the sleeve would not fit properly over the interface, and thus the sleeve was not installed as intended. The connector is still considered an ungrounded floating-power connector. Power must be removed when EVA crewmembers are translating on the starboard side of Pressurized Mating Adapter (PMA) 2 during the docked Shuttle Missions. Thermal analysis shows that insulating sleeve provides sufficient thermal protection to allow removal of the Multi-Layer Insulation (MLI) connector cover.

MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS

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

ISS MISSION PRIORITIES COMPLETION STATUS

	Task	Flight Day ^a
	Category 1	
1	Rotate E18/19 FE-2 (15A) crew member with E19/20 FE-2 (2J/A) crew member, transfer mandatory crew rotation cargo per Flight 2 J/A Transfer Priority List (TPL) and perform mandatory tasks consisting of Individual Equipment Liner Kit (IELK) install and Sokol suit checkout	FD 3 ✓
2	Transfer mandatory quantities of water from Orbiter to ISS per Flight 2 J/A TPL	FD4-FD14 ✓
3	Transfer and stow critical items per Flight 2 J/A TPL	FD3-FD5 ✓
4	Install Japanese Experiment Module (JEM) Exposed Facility (JEM-EF) to JEM Pressurized Module (JPM) using SRMS and SSRMS	FD4 ✓
	a. Disconnect JEM-EF Launch to Activation (LTA) cable, install protective cap, and install LTA cables on the ECSH	FD4 ✓
	b. Remove 1 JPM active Exposed Facility Berthing Mechanism (EFBM) contamination cover, and 1 JEM-EF passive EFBM thermal cover.	FD4 ✓
	c. Remove LTA Box (LTAB) thermal cover, remove LTA mode plug and replace with ISS2 mode plug, re-install LTAB thermal cover	FD4 ✓
	d. Activate and perform partial checkout of JEM-EF to allow installation of JEM Experiment Logistics Module - Exposed Section (ELM-ES), Inter-Orbit Communication System (ICS) - Exposed Facility (EF), Monitor of All-Sky X-ray Image (MAXI), and Space Environment Data Acquisition-Attached Payload (SEDA-AP). This includes checkout of EFU #1, 3, 5, 7, 9, 10, and 11 per Appendix H.	FD7 ✓

Note^a The ✓ shows that the item was completed.

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day ^a
5	Install Integrated Cargo Carrier-Vertical Light Deployable (ICC-VLD) on the Payload ORU Accommodation (POA) using Shuttle Remote Manipulator System (SRMS) and SSRMS.	FD5-FD6 ✓
6	Install, activate, and checkout ELM-ES to JEM-EF EFU #10 utilizing SRMS handoff to SSRMS	FD7 ✓
	a. Disconnect ICC-VLD LTA cable and install LTA cables on the ECSH	FD4 ✓
Category 2		
7	R&R P6 batteries (6) using SSRMS	FD8 & FD10 ✓
	a. Reconfigure port CETA cart to alleviate interference with SARJ (Includes rotating WIF #4 and #5 back at a 45 degree angle, rotating the TFR outboard and tying back the brake handles)	FD4 ✓
	b. Stow P3 MT Rail Stop to allow access to WS8	FD4 ✓
8	Install ICS-EF on JEM-EF and activate the heaters.	FD9 ✓
	a. Remove 4 ICS-EF thermal covers: Payload Interface Unit (PIU) cover, sensor cover (forward), top and bottom covers.	FD8 ✓
	b. Release ICS-EF antenna hold mechanisms (2).	FD8 ✓
	c. Perform JEMRMS calibration (to support ELM-ES payload transfers).	FD9 ✓
	d. Install ICS-EF on JEM-EF Exposed Facility Unit (EFU) #7 using JEMRMS and activate survival heaters.	FD9 ✓
	e. Activate ICS-EF components which are required for ICS-EF antenna deployment and activate main heaters.	FD9 ✓
	f. Deploy ICS-EF antenna.	FD9 ✓
9	Install ISS critical spare, Space to Ground Antenna (SGANT) on External Stowage Platform (ESP)3 Site #5 using SSRMS.	FD6 ✓
10	Install ISS critical spare, Pump Module (PM) on ESP3 Site #3 using SSRMS.	FD6 ✓
11	Install ISS critical spare, Linear Drive Unit (LDU) on ESP3 Site #4 using SSRMS.	FD6 ✓
12	Return ICC-VLD, required for future assembly sequence and Shuttle manifesting, to payload bay using SSRMS handoff to SRMS.	FD10 ✓
13.	Remove MAXI contamination (1) cover and install MAXI on EF (EFU#1) using JEMRMS, and activate survival heaters.	FD9 ✓
14	Release SEDA-AP back up launch lock mechanism, and install SEDA-AP on EF (EFU#9) using JEMRMS, and activate survival heaters.	FD9 ✓
15	Return ELM-ES to Orbiter payload bay utilizing SSRMS handoff to SRMS.	FD12 ✓
16	Perform minimum crew handover of 12 hours per rotating crew member which includes crew safety handover.	FD6-FD13 ✓

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day ^a
17	Transfer remaining cargo items per Flight 2J/A TPL.	FD5-FD14 ✓
	a. Perform Radiation Areas Monitors (RAMs) Installation/Return, qty. 24.	FD7 ✓
18	Install, activate, and checkout JEM-EF forward camera (1) remove camera thermal covers (2) and mate connector	FD13 ✓
19	Open Node 1 Port CBCS Center Disk Cover flap (needed for 19S Stage PMA3 relocation).	FD4 ✓
20	Perform the following HTV readiness tasks: a. Install and activate JEM-EF aft camera [needed for HTV1]. 1) Remove camera thermal covers (2), mate connector, and reconfigure DC/DC Converter Unit (DCU) onto aft camera launch mounts. 2) Remove LTAB thermal cover, remove ISS2 mode plug and replace with ISS mode plug, re-install LTAB thermal cover. b. Remove Node2 WIF #14 (due to tight clearance during HTV berthing) c. Open Node 2 zenith CBCS center disk cover flap (needed for HTV backup port)	FD13 ✓ FD13 ✓ FD13 ✓ FD13 ✓ FD8 ✓ FD4 ✓
	Category 3	
21	Perform daily ISS payload status checks as required a. Perform GLACIER maintenance b. Perform ARED maintenance	Daily ✓ FD6 ✓ FD5 ✓
22	The following tasks are deemed to fit within the existing EVA timelines; however, may be deferred if the EVA is behind schedule. The EVA will not be extended to complete these tasks. a. Remove the Grounding Tabs on the JEMRMS End Effector (EE) b. Relocate Grapple bar to P1 ATA Nadir (for 17A ATA R&R). c. Deploy P3 Nadir Unpressurized Cargo Carrier Attachment System (UCCAS) site. (For Flight ULF3) d. Deploy S3 Upper Outboard PAS. (For Flight ULF3) e. Z1 Patch Panel Reconfiguration f. SPDM MLI 1) SPDM Arm 2, wrist flap 2.6, tack down remaining flap (1 of 4) 2) SPDM OCTM2 Wrap blanket rolled up to cover aluminum ground tabs (1.5 flaps remaining)	FD4 ✓ FD4 ✓ FD4 ✓ Deferred to 17A FD13 ✓ FD13 ✓ FD13 ✓ FD13 ✓

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day ^a
	g. Deploy S3 Lower Outboard PAS (For 20A stage; ESP3)	Deferred to 17A
	h. Deploy S3 Lower Inboard PAS and open target cover (For Flight ULF5)	Deferred to 17A
	i. Install Wireless Video System External Transceiver Assembly (WETA) #3 @ CP1 (S3 location)	Deferred to 17A
23	Deploy Atmospheric Neutral Density Experiment (ANDE) 2 payload.	FD16 ✓
24	Deploy DRAGONSAT payload	FD16 ✓
25	Perform daily middeck activities to support payloads (includes cases where Shuttle crew also performs payloads on the ISS).	Daily ✓
26	Perform ISS payload research operations tasks.	FD14 ✓
27	Perform Russian Segment Operations tasks a. Reconfigure and replace cables for Microgravity Measurement Apparatus Laptop Terminal (MLT) and Experiment Laptop Terminal (ELT) in JEM PM and install the Hard Drive to MLT	FD12 ✓
28	Transfer N ₂ from the Orbiter to the ISS Airlock HPGTs. Required transfer quantities shall be consistent with the plan to have A/L tanks full at Shuttle retirement.	FD4-FD12 ✓
29	Transfer O ₂ from the Orbiter to the ISS Airlock High Pressure Gas Tank (HPGT)s. Required transfer quantities shall be consistent with the plan to have ISS Airlock (A/L) tanks full at Shuttle retirement.	FD12 ✓
30	Perform DTO 701 DragonEye	FD3 and FD 14 ✓
	Category 4	
31	Perform Program-approved EVA get-ahead tasks. The following EVA get-ahead tasks do not fit in the existing EVA timelines; however, the EVA team will be trained and ready to perform should the opportunity arise. EVA/MOD has the flexibility to select the tasks to be completed based on efficiencies gained in performing the already scheduled required tasks. a. Deploy S3 Upper Inboard PAS (For Flight ULF6) b. Install gap spanner to replace handrail (HR-0371) on Node 2. c. Install 6 SSPTS floating power connector grounding sleeves. d. Tuck down Lab/Node 2 cables. e. Install JPM EVA On-orbit Installed Handrails (OIH) and On-orbit Installed Worksite Interfaces (OIWIF). f. Retrieve APFR No. 5 and bring inside, remove heat shield and reinstall APFR No. 5 on subsequent EVA	Deferred to 17A FD13 ✓ FD4, FD6 ✓ FD13 ✓ FD13 ✓ FD13 ✓

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day ^a
32	Reboost the ISS with the Orbiter if mission resources allow and are consistent with ISS trajectory analysis and planning.	FD3 ✓
33	Perform imagery survey of the ISS exterior during Orbiter fly around after undock.	FD14 ✓
34	Perform an additional 4 hours per rotating crewmember of ISS crew handover (16 hours per crew member total).	Multiple days ✓
35	Perform MAUI, SEITE, and SIMPLEX crew activities (payloads of opportunity-not required during docked operations)	FD 3 FD15-16
36	Perform Program-approved IVA get-ahead tasks.	
37	Perform Payloads of Opportunity a. Perform Maui Analysis of Upper Atmospheric Injections (MAUI), (payload of opportunity - not required during docked ops). b. Perform Shuttle Exhaust Ion Turbulence Experiments (SEITE) (payload of opportunity - not required during docked ops). c. Perform Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) (payload of opportunity – not required during docked ops)	No opportunity FD15, ✓ FD16 ✓ FD3 ✓
39	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, Dedicated Thruster Firings required	FD11 ✓
40.	Perform SDTO 13005-U ISS Structural Life Validation and Extension during JEM-EF berthing	FD4 ✓
41.	Perform SDTO 13005-U, ISS Structural Life Validation and Extension during Orbiter undocking	Planned

SECONDARY PAYLOADS

Canister for All Payload Ejections/Internal Cargo Unit/Atmospheric Neutral Density Experiment-2 (CAPE/ANDE-2)

The Atmospheric Neutral Density Experiment 2 (ANDE-2) was a secondary payload sponsored by the Department of Defense (DOD) Space Test Program (STP). ANDE-2 consisted of two spherical spacecraft that were ejected from the Canister for All Payload Ejections (CAPE) via the Internal Cargo Unit (ICU) and tracked from the ground. CAPE/ANDE-2 was mounted to the starboard side of Bay 13 in the cargo bay of Endeavour. The two spherical spacecraft, Castor (active satellite) and Pollux (passive satellite) were designed to provide total atmospheric density and composition for orbit determination and collision avoidance, and validate fundamental theories on the calculation of the drag coefficient. The ANDE-2 mission planned to acquire routine Space Surveillance Network (SSN) and Satellite Laser Ranging (SLR) network observations of both spheres, optically tracking the spheres with High Performance CO₂ Ladar Surveillance Sensor (HICLASS) laser system, and determine spin rate and

orientation of the spheres. The ANDE-2 team plans to monitor the spacecraft until entry.

ANDE-2 was deployed from Endeavour at 211/17:22:10 GMT on FD 16 (July 30, 2009) in a completely nominal position.

Two passes over Millstone Hill Radars after the deployment were acquired. The first pass on July 30 at: 211/17:25 GMT reported six separate objects including Endeavour after deployment. Data were collected by Millstone Hill, Haystack, and HAX radars. The second pass on July 30 at 211/19:01 GMT also confirmed contact with six objects including Endeavour. The first contact with Pollux was recorded on July 30 at 211/19:36:52 GMT and the first contact with Castor was on 30 July 30 at 211/21:07:37 GMT.

DRAGONSat: Dual RF Autonomous GPS On-Orbit Navigator Satellite

The Dual RF Autonomous GPS On-Orbit Navigator Satellite (DRAGONSat) was a secondary payload sponsored by the NASA/JSC Aeroscience and Flight Mechanics



CAPE/ANDE-2 Payload

Division. The DRAGONSat experiment is launched via a Department of Defense (DOD) provided Space Shuttle. PICOSAT Launcher 5510 (SSPL), which consisted of a launcher, or garage, designed to hold and eject a satellite payload of 5 in. by 5 in. by 10 in. DRAGONSat was designed to study autonomous rendezvous and docking and

Global Positioning System (GPS) technology. DRAGONSat was mounted to the starboard side of Bay 3 in the cargo bay of Endeavour

DRAGONSat consisted of two individual PICOSAT's that were installed together and when ejected the two satellites were to become two free flyers. One PICOSAT (AggieSat) was developed by Aerospace Engineering students from Texas A&M University (TAMU) and the other PICOSAT (Paradigm or BEVO-1) was developed by Aerospace Engineering students from The University of Texas at Austin (UT).

The objective of the DRAGONSat program was for the two PICOSAT's to both acquire GPS data utilizing a device provided by NASA-JSC and downlink these data to ground stations at Texas A&M University and the University of Texas. Each of the two PICOSAT's was to collect two orbits of GPS data following ejection from the SSPL.

DRAGONSat was successfully deployed at 211/12:35:10 GMT on FD 16 (July 30, 2009). Confirmation that the payload exited the cargo bay was received; however, the two PICOSAT's did not separate as expected. Radar had been tracking DRAGONSat as one object since deployment from the Shuttle. Photographs from the deployment show that the PICOSAT's left the launcher attached and drifted into orbit in that configuration. It appeared that the satellites partially separated, but the PICOSAT's did not completely separate as intended. The exact cause is not known, however, the separation system was demonstrated successfully several times during ground tests. A partial separation did occur, and the AggieSat was powered and beacon signature information has been received. Contacts have been made with AggieSat since deployment by amateur radio operators and at the Texas A&M University ground-site. The signal has been weak due to antenna not being deployed from the body of each satellite. First contact with AggieSat came from the Texas A&M Riverside Ground station on a high (approximately 80 deg) pass over College Station in clear weather on July 31 at 01:23:16 GMT. The first time 2-way communications between Earth and AGGIESAT occurred on August 17 at 18:11:59 GMT.

As of August 17, 2009, no communications have been received from BEVO-1, however it may be transmitting but its signal has not been heard.

Modifications to the UT ground station are being made to increase its reception gain by two to four times. This should provide a better indication as to whether BEVO-1 is transmitting.

If the BEVO-1 signal can be received with a higher gain antenna, it may be possible to recover data from it. It is also possible that if BEVO-1 and AggieSat are able to separate naturally at some time before entry, communication may be established with BEVO-1. Passes of BEVO-1 over Austin will continue to be tracked with the goal of establishing communication with the satellite.

DEPARTMENT OF DEFENSE (DOD) PAYLOADS OF OPPORTUNITY

Maui Analysis of Upper-Atmospheric Injections

The Maui Analysis of Upper-Atmospheric Injections (MAUI) payload experiment matrix involves dedicated Orbital Maneuvering System (OMS), Primary Reaction Control System (PRCS) and Vernier RCS thruster firings. Observations of firings in the vicinity of the ISS, particularly ISS reboost maneuvers, are done passively. Shuttle engine exhaust plumes are observed utilizing optical telescope sensors and all-sky imagers at the Air Force Maui Optical and Supercomputing Site (AMOS) at Maui, Hawaii. Shuttle thruster firings and attitude maneuvers are to be conducted during night passes over AMOS. This is an observational payload of opportunity that contains no flight hardware.

No MAUI observation opportunities occurred during this mission.

Shuttle Exhaust Ion Turbulence Experiments (SEITE)

The Shuttle Exhaust Ion Turbulence Experiments (SEITE) utilizes the Space Shuttle to investigate plasma turbulence caused by the OMS engine exhaust in the Ionosphere using space-based sensors. Data are collected by flying satellites through the plasma turbulence during a conjunction with the Space Shuttle. Observations of density and electric field disturbances are utilized to develop quantitative models of plasma turbulence that affects tracking and imaging radars. This is an observational payload of opportunity that contains no flight hardware.

On FD 2 (July 16, 2009), data were collected during the OMS NC₂ maneuver for a radio beacon test using the Communication/Navigation Outage Forecasting System (C/NOFS) satellite. This test provided some secondary science objectives for the SEITE payload.

SEITE-1 Firing:

On FD 15 (July 29, 2009), a dual OMS firing was executed for the Space Test Program Satellite 1 STPSat1 GMT) satellite observation. The firing duration was for 9.8 sec, starting at: 210/17:28:42 GMT and ending at 210/17:28:51.8 GMT, creating a 17 ft/sec differential velocity and expelling approximately 400 lb of propellant. The observing instrument was the STPSat-1 optical sensor, Spatial Heterodyne Imager for Mesospheric Radicals (SHIMMER), which was pre-programmed the day before the firing to observe optical data of the firing. However, no data were collected due to a command-uplink problem. The SHIMMER sensor shutter was closed at the time of OMS firing as the satellite was in the calibration-mode configuration during the firing.

The SEITE-1 firing was the first SEITE firing to be approved by NASA and operated by the DoD. Even though the sensor did not record data from the firing, incredible video was taken of the firing as it occurred during darkness. There was a bright flash from the OMS engines starting to fire, and then small vapor trails as the engine shutdown. The video is available upon request.

SEITE 2 Firing

On FD 16 (30 July 2009), a dual OMS firing was executed for the C/NOFS satellite observation. The firing duration was for 12 sec, starting at 211/11:03:49 GMT and ending at 211/11:04:01 GMT. The C/NOFS satellite crossed Endeavour's orbit at 211/11:04:32 GMT. The C/NOFS satellite is instrumented with over 10 sensors, 3 of which collected data from the firing for 52 sec during the pass. The choreography of numerous mission events was a critical component to ensure the C/NOFS satellite came within the 300 km range of the sensor suite. As it happened, the combined DoD-NASA ground control team was able to position the two orbiting vehicles to come within 88 km of each other.

The science highlights from the SEITE-2 burn include:

1. Huge ion temperature of 8000 K measured by the ion instrument (IVM).
2. Supersonic ion velocity of approximately 1 km/s measured by the ion instrument (IVM).
3. Prompt electromagnetic pulse (EMP) observed by the electric field instrument (VEFI) before the exhaust cloud reached the satellite.
4. Density enhancement with lack of irregularities in plasma density data from the Langmuir probe instrument (PLP).
5. Large neutral density pulse measured by the neutral wind meter (NWM).

Shuttle Ionospheric Modification with Pulsed Local Exhaust

The objective of the Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) activity is to determine the source of Very High Frequency (VHF) radar echoes caused by the Orbiter and its OMS engine firings when in the Field-Of-View (FOV) of a SIMPLEX radar or radio telescope ground-site. The collected data will be used to examine the effects of orbital kinetic energy on Ionospheric irregularities and to understand the processes that take place with the venting of exhaust materials.

On FD 2, the Advanced Research Project Agency (ARPA) Long Range Tracking and Identification Radar (ALTAIR) site at Kwajalein Island was able to view the NC₂ firing for the SIMPLEX experiment. This is an observational payload of opportunity that contains no flight hardware.

DEVELOPMENT TEST OBJECTIVES

DEVELOPMENT TEST OBJECTIVE 701B DRAGON/EYE FLASH LIDAR

Dragon /Eye Configuration

The DragonEye Development Test Objective (DTO) 701B provided an investigation of the Flash Laser Imaging Detection and Ranging (LIDAR) relative navigation sensor system that the SpaceX "Dragon" vehicle will use during the rendezvous and docking with the ISS. The DragonEye sensor has been tested against ground targets in

terrestrial and airborne environments, but in-space imaging of the actual ISS as a target will increase confidence in the ability of the DragonEye sensor and associated algorithms to perform appropriately on Dragon Demonstration C3.

The DragonEye is a custom assembly that was installed in the Orbiter cargo bay. The DragonEye was mounted to the existing Trajectory Control System (TCS) Carrier Assembly on the Orbiter Docking System (ODS) and in the starboard location, with the TCS-2 in the port location. A photograph of the Orbiter location of the DragonEye is on a following page.

This single assembly contained all the necessary subsystems: laser, sensor, data acquisition, control, and data recording. DragonEye was connected to Orbiter power and to the Standard Switch Panel. The DragonEye was controlled by activating/deactivating aft bus power and by one switch on the Standard Switch Panel.

DragonEye contained two operable subsystems, a heater subsystem and a sensor subsystem. The heater subsystem consisted of the heaters, thermostats, and electronics necessary to keep DragonEye in its survival and operational temperature range. The sensor subsystem consisted of the Flash LIDAR, reference sensors, a data acquisition, and storage system. Each of these two subsystems had an ON and an OFF mode.

DragonEye Operations

The DragonEye Principal Investigators (PI's) used existing Orbiter telemetry for switch positions, power draw, voltage, and local temperatures to observe operations during the mission as the DragonEye was not designed to provide real-time telemetry. Indications were that operation was nominal throughout the approach, docking, and then again for undocking and departure. Following undocking and during departure two power-draw anomalies were seen at approximately undocking plus 15 min and undocking plus 80 min. The Principal Investigators received DragonEye back from the Orbiter in August and were successful in extracting the raw data from the Development Test Objective (DTO). They are now performing Data translation is in process and then the PI's will be able to fully assess performance as well as the two anomalies. The preliminary assessment of data indicates that the DTO's objectives were all fully met.

LIDAR

Assessment of the post-flight data is that the LIDAR's data are complete and with good integrity. At least three reflectors on the ISS were tracked successfully. These data were run through additional post-processing software to get the final product, which will then be correlated against TCS data, and ISS and Orbiter Best Estimate Trajectories (BET) to quantify performance. A portion of the LIDAR function appears to have terminated at undock plus 15 min and the cause is being quantified, but the entire approach, docking, undocking and early departure was successfully captured.

Heaters

The Orbiter aft-bus telemetry cannot detect power draw below 0.3 Amperes (A) and did not indicate that the DragonEye heaters had come on during the mission. However, post-flight review of the onboard DragonEye data (which is able to detect the low power draws) shows that one of the heaters did in fact come on soon after the Payload Bay Doors (PLBD's) were opened, and that this heater then turned off a few minutes after DragonEye sensors were activated for approach. There is no indication that any heaters came on during departure while the sensors were on. After sensors were turned off, it is possible and probable that a heater did come on prior to PLBD closure. The DragonEye DTO only collects data onboard while the sensors are active - heaters are separately controlled and have no feedback other than the power draw. With two heaters active, the power-draw would exceed 0.3A, which is the minimum detectable limit of the Orbiter aft bus, so it is certain that two heaters were never on at any time.

Secondary Sensors

The Inertial Measurement Unit (IMU) and Thermal Imager data are being assessed at a lower priority than LIDAR. At this report was written, all the IMU data appears intact and good. A sample of thermal images was retrieved and these look good but full retrieval of data for this sensor had not been performed when this report was written.

DTO 805 CROSSWIND LANDING PERFORMANCE

Observations at landing were 8 knot winds peaking to 13 knots at 190 degrees at the Shuttle Landing Facility. This DTO of opportunity was not performed during landing due to a 5 knot (peak to 7 knots) crosswind component. At least a 10-knot crosswind at landing is required to meet the requirements of the DTO.

DTO 900 SHUTTLE RSRB CHAMBER PRESSURE, STRAIN GAUGE and ACCELERATION RATES DATA COLLECTION

This DTO collects higher-fidelity data to contribute additional knowledge of Reusable Solid Rocket Motor (RSRM) flight characteristics for booster analysts. It is assumed that data collection was acquired during ascent. No subsequent assessment of the data is available at this time.



DragonEye Mounting to ODS on Endeavour

VEHICLE PERFORMANCE

LAUNCH DELAYS

The first launch attempt on June 13, 2009, was scrubbed during External Tank (ET) tanking. When transitioning from fast-fill to topping, Liquid Hydrogen (LH₂) leakage in the area of the Ground Umbilical Carrier Plate (GUCP) exceeded the 40,000 ppm specification during vent-valve cycling (IFA STS-127-T-001). Sensors were reading off-scale high. This signature was similar to that observed during the first launch attempt of STS-119 three months earlier. An attempt was made to cycle the LH₂ vent valve as has been done in the past, but high LH₂ concentrations continued to be observed when the valve was opened. The launch was scrubbed, the ET was drained, and the launch was rescheduled for four days later to allow troubleshooting and re-mating of the GUCP. After area safing, a GUCP interface seal was removed and replaced with a spare seal. The assembly was re-torqued and configured for the second attempt.

The second launch attempt on June 17, 2009, was also scrubbed during ET tanking due to another leak at the GUCP. The leak exhibited a different signature with concentration spikes going off-scale high then quickly recovering. The Space Shuttle Program (SSP) designated a Tiger Team to troubleshoot the anomaly. The Tiger Team identified the External Tank Carrier Assembly skewed 0.357-deg counter-clockwise and undersized alignment pins as the root cause for the flight seal/bellows gapping. An older two-piece seal design and tighter alignment pin tolerances were incorporated. A tanking test was successfully conducted on July 1, 2009, with no off-nominal leakage identified.

Following the start of the countdown for the third launch attempt, scheduled for July 11, 2009, a number of lightning strikes were detected in the vicinity of Pad A across two days. While the vehicle stack was never directly hit, one strike on July 10 hit the Pad mast directly. A voltage and energy exceedance was noted and this condition required a detailed assessment. As a result, the third launch attempt was delayed 24 hr to allow additional time for further evaluation by the launch team to ensure there were no issues with the vehicle.

The third launch attempt on July 12, 2009, was scrubbed during the T-9 min hold due to Return to Launch Site (RTL) weather violations. Prior to the launch scrub, the Tyvek cover on Forward Reaction Control System (FRCS) F1D thruster was noted to be partially debonded. Since no rain had entered the thruster, a waiver was approved.

The fourth launch attempt on July 13, 2009, was also scrubbed during the T-9 min hold due to lightning within 20 nmi, as well as RTL weather violations. The decision had been made to attempt launch without replacing the F1D thruster cover. Following the launch scrub, a 48-hour turnaround was declared, and the Rotating Servicing Structure (RSS) was rolled back to the vehicle stack to allow replacement of all of the FRCS thruster covers.

Weather violations late in the count caused the 5th attempt on July 13th to be scrubbed. A 48-hr turn-around was initiated. During the countdown for the fifth launch attempt on July 15, 2009, a higher-than-typical fuel cell 3 condenser exit temperature was noted. The ground controller asked for verification that the fuel cell 3 electrolyte concentration (KOH) values would remain within operational limits during Station-To-Shuttle Power Transfer (SSPTS) operation. A low-load test on the fuel cell showed the exit temperature remained within limits and all temperatures remained steady after thermal equilibrium was reached. This test demonstrated that the fuel cell would operate nominally at low-power levels during SSPTS operation.

The sixth launch attempt on July 15th was successful

REUSABLE SOLID ROCKET BOOSTERS

All Reusable Solid Rocket Booster (RSRB) systems performed as expected during the launch-countdown and ascent of the STS-127 mission. The RSRB pre-launch countdown was nominal and two RSRB In-Flight Anomalies (IFAs) have been identified. One significant first flight design change was incorporated for the RSRB. The Power Bus Isolation System (PBIS) cards in the RSRB forward and aft Integrated Electronics Assemblies (IEAs) incorporate a 2 Ampere (A) fuse for system protection.

No RSRB LCC or Operational Maintenance Requirement and Specification Document (OMRSD) violations occurred during the prelaunch operations. However, a RSRB Thrust Vector Controller (TVC) differential pressure spike was noted at ignition, and this condition had no impact on the mission.

Both RSRB's were successfully separated from the ET and reports from the recovery area indicated that the deceleration subsystem performed as designed. Both RSRB's were successfully returned to Kennedy Space Center (KSC) for evaluation and dismantling.

The top layers of Marshall Space Flight Center (MSFC) Convergent Coating (MCC-1) were found missing during the RSRB open inspection (IFA STS-127-B-001). These were found on the aft skirt Thermal Protection System (TPS) acreage.

The left-hand RSRB Enhanced Data Acquisition System (EDAS) assembly did not record a nominal strain response on channel 4 (IFA-STS-127-B-002). The recorded signal was a flat line after the first 3-4 sec of signal conditioner start-up transients. During the post-flight inspection, an open circuit discovered between the strain gage and the strain gage signal conditioner..

REUSABLE SOLID ROCKET MOTORS

The STS-127 Reusable Solid Rocket Motor (RSRM) set performed within established and predicted limits (nominal). No RSRM LCC or OMRSD violations occurred during

the tanking and pre-launch operations. No IFA's were identified from the analysis and review of the flight data.

Based upon preliminary data, the RSRM ballistic performance was nominal. Preliminary data indicates that RSRB and ET separation occurred as predicted

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

EXTERNAL TANK

No ET LCC or OMRSD violations occurred. Likewise, no ET Interim Problem Reports (IPRs) were required during the STS-127 launch countdown. One pre-launch IFA was identified during the review and analysis of the data during the countdown. Three IFA's were identified from the flight data analysis.

The first launch attempt on June 13, 2009, was scrubbed during External Tank (ET) tanking when transitioning from fast-fill to topping, the Liquid Hydrogen (LH₂) leakage in the area of the Ground Umbilical Carrier Plate (GUCP) exceeded the 40,000 ppm specification during vent-valve cycling (IFA STS-127-T-001). Sensors were reading off-scale high. A more detailed discussion of this anomaly is contained in Appendix B.

All ET systems performed as expected during launch countdown and ascent. The ET pre-launch countdown was nominal.

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

ET separation was nominal. Since Main Engine Cut-Off (MECO) occurred as expected, re-entry and breakup is anticipated to be within the predicted footprint.

The Final Inspection Team (FIT) report for the ET showed the LO₂ tank surface was observed to be dry, except for some condensate visible on the +Z side of the nose cone. Intertank condensate was light and some condensate was observed on the GUCP legs running into the downstream Intertank valleys. The LH₂ condensate was moderate (rain in the area during 95-ft level inspection). Typical ice/frost was noted on the aft interface hardware. Surface temperatures ranged from 72 to 100 °F on the LO₂ tank, 81 to 87 °F on the Intertank, and 66 to 75 °F on the LH₂ tank. There were no observations noted on the LH₂ or LO₂ Thermal Protection System (TPS) acreage, Ice Frost Ramps (IFR's), or Intertank flanges. The LO₂ feedline brackets had ice/frost formations. Ten TPS stress cracks were noted in the intertank stringer valleys and

typical cracks were observed on the vertical strut cable tray. All observations were acceptable per NSTS documentation.

The post-launch camera and film review showed a loss of foam in the aft Inboard corner of the LO₂ Ice-Frost Ramp at Station 718 (IFA STS-127-T-002). The timing of this loss is unknown and cannot be determined for the film or photographs. Consequently, this loss may have violated the NSTS documentation. The dimensions of the foam loss event are 7.2-in. by 5.1-in. with a total mass of approximately 0.044 lb_m. A more detailed discussion of this anomaly is contained in Appendix B.

The post-launch review and analysis of the ascent photography showed a loss of foam at several locations on the Intertank (IT) (IFA STS-127-T-003). A total of 38 Intertank foam losses were observed with the largest on Stringer 11 of panel 1 at Station 1052. The dimensions for this loss are approximately 34.7-in. in length by 5.2-in. wide by 0.6 in. deep, with a mass of 0.255lb_m. A more detailed discussion of this anomaly is contained in Appendix B.

The post-launch camera and film review revealed three losses of TPS material at the + Y and -Y bipod closeouts (IFA STS-127-T-004). The ET Camera captured the TPS loss from the -Y Outboard Bipod that occurred at approximately 26 sec. Both of these foam losses were within the requirements of established documentation for debris losses. A more detailed discussion of this anomaly is contained in Appendix B.

SPACE SHUTTLE MAIN ENGINES

All SSME systems performed as expected during launch countdown and ascent and performance was typical of previous flights. The SSME pre-launch countdown was nominal. No IFA's were identified from the review and analysis of the flight data.

The predicated average SSME specific impulse (ISP) tag value was 451.71 sec at 104.5% Rated Power Level (RPL), and data indicates the delivered ISP was within the expected range.

There were two first flight design changes to the Space Shuttle Main Engines (SSME). The first incorporated the use of the new Norbar Ultrasonic Extensometer for the measurement of engine joint bolt stretch values and the second incorporated the new Kevlar Insulation System on the rigid fuel bleed duct for engine 2060 in place of the former electrodeposited nickel plated process.

No SSME LCC or ORMSD violations occurred during the pre-launch operations.

Engine "Ready" was achieved at the proper time, all LCC's were met, and thrust build up was nominal. Flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown.

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

The commanded Max Q throttle down was a two-step throttle bucket to 100% and 72% RPL with Adaptive Guidance Throttle (AGT) engaged.

Propellant dump operations data appears normal and Main Engine Cutoff (MECO) time was engine start + 506 sec.

Initial review of Advanced Health Monitoring System (AHMS) vibration measurements indicates nominal performance. No Failure Identifiers (FIDs) were reported to the Vehicle Data Table (VDT) from start-preparation through propellant dump on all engines. All accelerometer measurements appeared healthy.

A 60-kilobyte data dropout occurred in the downlink data, which lasted about 50 sec for SSME 1. This did not impact engine performance and the 128 kilobyte data was available.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown. No OMRSD or LCC violations occurred.

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

ORBITER SYSTEMS

Main Propulsion System

All Main Propulsion System (MPS) systems performed nominally throughout the launch countdown and ascent. No MPS In-Flight Anomalies (IFAs) were identified during the mission. No Operations and Maintenance Requirements and Specifications Document (OMRSD) or Launch Commit Criteria (LCC) violations were identified during the loading for STS-127.

During the Final Inspection Team walkdown, frost was noted on the LH₂ inboard pyrotechnic canister (IFA STS-127-V-08). A crack was noted upon closer inspection. An evaluation was performed based on NSTS documentation, which determined that while the frost was acceptable, the crack was not addressed and thus not acceptable. Documentation was drafted to accept the crack for flight. This crack was the result of stresses of multiple cryogenic cycles. Localized cracks in thick TPS (foam) applications such as the LH₂ pyrotechnic canister are common when thermal stressing is induced when loading cryogenic propellants. On-site observations by the final inspection team show that this crack did not have any offset, and no evidence of cryogenic-pumping. The defect was shown to be stable in size, shape and character for the extent of the loading. Cracks of this type are due to outer fiber strain and are not indicative of dislodged foam, which could become a debris concern. Only frost has been built up as a result of this defect and frost in any degree does not exceed NSTS-08303 allowances.

The ascent data showed no anomalous valve movements during the prelaunch, Main Engine Cut-Off (MECO), post-MECO and entry/landing events. All timings were within the required specifications and within the current historical database.

The LO₂ and LH₂ Engine Cutoff (ECO) sensors passed all pre-flight checkouts and operated nominally throughout ascent.

The GH₂ pre-pressurization cycle count was 8 cycles, which is well below the LCC limit criteria of 14 cycles. Engine inlet net positive suction pressure requirements were met throughout the flight. Pressurization performance was nominal, which indicates proper operation of the Flow Control Valve (FCV) hardware.

Hazardous Gas Concentrations

The aft hazardous gas concentrations during loading were nominal. The maximum hydrogen concentration level in the Orbiter aft compartment, with the normally elevated system backpressure used for fastfill are shown in the following table (System A was used to determine the maximum concentration). This compares favorably with previous data for this vehicle.

HAZARDOUS GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	9500	6240
Hydrogen	154	25
Oxygen	40	15
LD54/55	0	0

Gas Sample Analysis

The gas sampler system performed nominally. The measured sample bottle pressures indicate that all six samples were collected from the redesigned Orbiter aft fuselage gas sampler system. The two highest oxygen concentrations were 4.19% in the right-hand number 2 bottle, and 3.58% in right-hand number 1 bottle. Both concentrations were close to but below the flammability limit. The presence of argon in the samples indicates air was the source of the oxygen. The highest estimated hydrogen system leak was 10.800 SCIM in bottle right hand number 1. The estimated leak rate was 6-10 times the other bottles but below the flammability limit. The remaining bottle data was nominal. The following table presents a summary of the bottle pressure and gas concentration for the STS-127 mission.

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	3.38	0.42	3.58	0.22
2	LH 1	1.40	0.35	2.26	0.03
3	RH 2	1.32	0.54	4.19	0.03
4	LH 2	0.90	0.58	2.91	0.07
5	LH 3	0.17	0.49	2.02	0.10
6	RH 3	0.07	6.03	0.14	0.93

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rate is shown in the following table. None of the firing leak rate data exceeded the 57,000 scim limit.

HYDROGEN FIRING LEAK RATES

Bottle no.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	10,800
2	LH 1	740
3	RH 2	740
4	LH 2	1290
5	LH 3	440
6	RH 3	1,735

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

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS

S/N	Position	Actual pressure in torr	Ar, %	Air from Ar, %	He, %	CO, %	CH ₄ , %	CO ₂ , %	O ₂ from air, %	O ₂ found, %	H ₂ , %	H ₂ pyro corrected, %
1120 FLT-1	RH1	175.0	0.15	15.52	0.42	<0.01	0.04	<0.01	3.26	3.58	0.26	0.22
1111 FLT-2	LH1	72.6	0.09	10.06	0.35	<0.01	0.16	<0.01	2.11	2.26	0.03	0.03
1125 FLT-1	RH2	68.4	0.18	19.59	0.54	<0.01	0.16	<0.01	4.11	4.19	0.03	0.03
1114 FLT-2	LH2	46.6	0.12	12.74	0.58	<0.01	0.17	<0.01	2.68	2.91	0.07	0.07
1117 FLT-1	LH3	8.65	0.10	10.39	0.49	0.01	<0.01	0.02	2.18	2.02	0.11	0.10
1129 FLT-1	RH3	3.42	0.05	5.67	6.03	0.43	<0.01	0.03	1.19	0.14	1.16	0.93

Purge, Vent, and Drain System

The Purge, Vent and Drain (PV&D) system performed nominally during launch, entry and landing. The PV&D measurements were nominal with the exception of one Differential Pressure (ΔP) reading during entry. The forward fuselage-to-side window measurement had an elevated magnitude. This condition did not impact the flight in any manner, and there are not hardware concerns for this measurement.

Reaction Control System

The Reaction Control System (RCS) performed all functions required for successful completion of the mission. The RCS was used to perform a 16-min reboost maneuver to raise the orbital parameters of the ISS. One In-Flight Anomaly (IFA) was identified from the monitoring and data analysis, and it is discussed in the following paragraph.

The RCS thruster F2F failed off and was deselected by Redundancy Management (RM) during the hotfire checkout (IFA STS-127-V-07). The chamber pressure (P_c) reached a maximum value of 16.0 psia instead of the nominal of approximately 152 psia. The P_c was continuously rising during the 400 msec pulse followed by an exceedingly long tail-off (approximately 20 sec and the nominal is < 1 sec). The RM deselected the thruster after it failed to reach the minimum threshold pressure (approximately 36 psia) within the allotted time (240 msec), and a failure message was generated with a time tag of 211/08:48:50 GMT [14/10:45:40 Mission Elapsed Time (MET)]. Injector temperatures' signatures were consistent with a nominal firing. Likewise, the Guidance, Navigation and Control data showed the expected rates for a full-thrust pulse were generated.

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

RCS PROPELLANT LOADING

Parameter	Forward RCS		Left RCS		Right RCS	
	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer	Fuel
Target, %	79.85	79.06	100.48	100.76	100.48	100.76
Target, lb	1305	811	1523	962	1523	962
Calculated, %	84.24	82.42	100.66	100.79	100.57	100.81
Advertised, lb	1364.3	839.6	1525.4	962.2	1524.2	962.4
PASS WHI ^a	4.3206	4.2580	4.3848	4.2294	4.2662	4.2486
BFS WHI ^b	4.3282	4.2648	4.4103	4.2606	4.2778	4.2597

Notes:

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

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

All Tyvek covers released at nominal speeds although it should be noted that the F4R cover released just below the specified maximum speed for a side-firing thruster cover (190 mph). Tyvek cover release speeds and vehicle alpha/beta angles at cover release are given in the following table

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1D	4.4	53	5	8
F3D	5.3	65	5	7
F2D	5.8	72	5	6
F1L	6.2	78	5	6
F4D	6.4	80	5	6
F2U	8.1	106	5	4
F3L	8.2	108	5	4
F2R	8.3	110	5	4
F2F	9.2	123	5	3
F1U	9.3	124	5	3
F3F	9.9	135	5	3
F3U	10.0	187	5	0
F1F	10.4	142	5	2
F4R	13.1	187	5	0

During the countdown scrubs preceding the STS-127 launch, two Tyvek covers partially debonded and ultimately required replacement. The first was discovered following STS-127 launch scrub on June 12, 2009. Prior to performing the R&R, thruster F3D's Tyvek rain cover was found partially debonded, exposing a portion of the thruster nozzle. The F3D's thrust chamber was inspected following cover removal; no water intrusion was found. A replacement cover was installed. This is an explained condition because high

winds and heavy rain causes the Super 77 adhesive dots holding the parachute portion of the cover down had failed.

A second cover from thruster F1D was found with the leading edge debonded prior to the July 12, 2009, launch attempt. This cover was exposed to wind/rain associated with a storm 2 days prior that had also caused a pad lightning strike. Video showed that all Super77 dots had failed and the parachute was inflating from ground winds. The condition was waived and the countdown continued, but was scrubbed. The F1D cover remained installed for another launch attempt on July 13, 2009. Winds on July 13 caused the bond to degrade farther, but since there was no rain, the count continued until another scrub occurred. At that point, a 48-hour scrub was declared and all 14 Tyvek covers were replaced prior to the final countdown on July 15, 2009.

The RCS maneuvers and firing data are shown in the following table.

RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	Engine/System	Time of Ignition, GMT	ΔV , ft/sec	Duration, sec
RCS Window Protect	RCS	196/22:05:13	N/A	2.08
ET Separation	RCS	196/22:11:55	N/A	6
ET Photo +X	RCS	196/22:12:04	N/A	11.0
ET Photo Pitch	RCS	196/22:12:08	N/A	N/A
NC3	RCS	198/00:31:06.29	2.2	9.7
Nominal Corrective Combination (NCC)	RCS	198/14:19:46.6	1.3	Not recorded (multi axis)
MC1	RCS	198/15:37:25.8	0.3	1.3
MC2	RCS	198/16:10:47.5	0.2	0.9
MC3	RCS	198/16:27:48.0	2.1	9.1
MC4	RCS	198/16:37:47.5	0.8	3.4
ISS Docking	RCS	198/17:47:05	N/A	N/A
Collision Avoidance	RCS	199/00:30:14.4	2.5	~16 minutes
ISS Undock	RCS	209/17:26:06	N/A	N/A
ISS Fly Around	RCS	209/17:53:04	N/A	N/A
Separation 1	RCS	209/18:40:40	N/A	6.0
Separation 2	RCS	209/19:08:40	N/A	42.5
Separation 3	RCS	210/20:12:09.6	10.0	11.8
RCS Hotfire	RCS	211/08:55:38	N/A	N/A
Orbit Adjust	RCS	211/11:24:09	5.4	21.7
Separation 4	RCS	211/17:48:09	0.3	1.3
Forward Reaction Control System Dump	RCS	212/13:58:30.6	N/A	31.7

The residual propellants and propellant consumption at the end of the mission are shown in the following two tables.

RCS RESIDUAL PROPELLANTS

Parameter	Mission Operations Calculation		PASS Model Calculation ^s	
	%	lb	%	lb
Forward Oxidizer	2.2	29.7	.4	5.4
Forward Fuel	0.0	0	0.0	0.0
Left Oxidizer	52.0	702	51.6	696.6
Left Fuel	51.4	436.9	51.3	436.1
Right Oxidizer	51.6	696.6	50.7	684.5
Right Fuel	50.8	431.8	50.8	431.8

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

RCS PROPELLANT CONSUMPTION

Parameter	Oxidizer, lb	Fuel, lb	Mixture ratio, Oxidizer/Fuel
Forward RCS	1131.9	700.6	1.62
Left RCS	662.3	420.6	1.57
Right RCS	673.2	425.1	1.58

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

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

Control Responsibility	Control Start, GMT	Comments
	189/17:47:05	DAP FREE DRIFT - Docking / ISS Capture
Orbiter	198/18:11:43	DAP LVLH
ISS	198/18:15:59	DAP FREE DRIFT
Orbiter	198/18:16:13	DAP AUTO (MNVR to Mated TEA).
ISS	198/18:54:02	DAP FREE DRIFT
Orbiter	198/18:56:58	DAP AUTO (Stack Attitude Control)
ISS	198/19:44:00	DAP FREE DRIFT
Orbiter	199/00:13:37	DAP AUTO – Reboost
ISS	199/01:10:13	DAP FREE DRIFT
Orbiter	209/15:08:18	DAP AUTO
ISS	209/16:03:41	DAP FREE DRIFT (vestibule leak check)
Orbiter	209/16:07:37	DAP AUTO - Maneuver to Undock attitude
ISS	209/17:01:10	DAP FREE DRIFT (Logic configuration)

**CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE
(Concluded)**

Control Responsibility	Control Start, GMT	Comments
Orbiter	209/17:02:49	DAP AUTO
ISS	209/17:23:09	DAP FREE DRIFT (Driver configuration)
Orbiter	209/17:23:34	DAP B/ALT/No Low Z
ISS	209/17:26:06	Undock

Orbital Maneuvering System

The Orbital Maneuvering System (OMS) performed nominally throughout the STS-127 mission. There were no deviations from documented OMRSD or LCC violations on the July 15th launch. All pre-launch operations were nominal for launch. The system temperatures and pressures were within expected ranges and system valves operated when commanded during the on-orbit operations. No IFA's were identified during the review and analysis of the flight data.

OMS CONFIGURATION

Vehicle/equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 03	34 th	L-OME S/N 107	4 th rebuilt flight - 20 th flight
Right Pod (RP) 04	30 th	R-OME S/N 113	4 th rebuilt flight - 7 th flight

A total of 11 OMS maneuvers were performed during the mission. Pertinent data concerning each maneuver are shown in the following table.

OMS MANEUVERS

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV, ft/sec/interconnect usage, %
Assist	Dual Engine	196/22:05:24	71.2	N/A
OMS-2	Dual Engine	196/22:41:40	63.5	96.9
OMS-3 (NC1)	Dual Engine	197/01:47:38	20.2	31.4
OMS-4 (NC2)	Right Engine	197/14:54:09	10.4	7.7
OMS-5 (NH)	Dual Engine	198/13:00:17	97.2	151.2
OMS-6 (NC4)	Dual Engine	198/13:45:32	55.6	87.9
OMS-7 (TI)	Left Engine	198/15:17:26	12.2	9.2
OMS-8 (SEITE1)	Dual Engine	210/17:28:42	9.8	16.7

OMS MANEUVERS (Concluded)

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV , ft/sec/ interconnect usage, %
OMS-9 (Separation 3)	Left Engine	210/20:12:09	11.8	10.0
OMS-10 (SEITE -2)	Dual Engine	211/11:03:49	9.9	16.6
(Deorbit)	Dual Engine	212/13:41:10	171.4	305.1

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

INTERCONNECT USAGE, %/POUNDS

Parameter	Total, %	Total, lb
Left OMS	1.553	235.83
Right OMS	3.837	267.82

PROPELLANT USAGE DATA

Parameters	Left OMS pod		Right OMS pod	
	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, lb _m	7051	4254	7050	4254
Residual, lb _m (aft gage)	653	462	580	314
Residual, lb _m (firing-time integration)	688	357	639	276
Residual, lb _m (SODB flow rate)	635	361	589	343

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-127 mission. There were no IFAs recorded against the APU system during this flight.

The run times and fuel consumption for the APUs during STS-127 are summarized in the following tables.

APU RUN TIMES

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
1 (304)	00:21:09	00:05:40	1:00:11	1:27:00
2 (311)	00:21:25	00:00:00	1:27:38	1:49:03
3 (303)	00:21:37	00:00:00	1:00:33	1:22:10

APU FUEL CONSUMPTION

APU (S/N)	Ascent, lb	FCS Checkout, lb	Entry, lb	Total, lb
1 (304)	50	16	126	192
2 (311)	55	0	173	228
3 (303)	58	0	137	195

During the many launch attempts, it was noted that the APU 1 Fuel Pump Drain Line Pressure 1 reading was slowly increasing and approaching the 25 psia Fault Detection and Annunciation (FDA) limit. This limit is an alarm class 3 Systems Management (SM) alert in the Backup Flight System (BFS) only. During the launch attempt on July 12, 2009, a Table Maintenance Block Update (TMBU) was processed to change the APU 1 Fuel Pump Drain Line Pressure 1 FDA limit from 25 psia to 49 psia. This was done as a precaution to avoid ringing nuisance alarms during ascent. The pressure rise was within specification limits and did not impact the mission in any manner.

To avoid possible nuisance alarms, the APU 3 Fuel Pump Drain Line Temperature 2 FDA limit was changed from 43 °F to 40 °F. The first TMBU uplinked at 197/06:28:08 GMT (00/08:24:58 MET) . The second TMBU uplinked at 197/07:55:20 GMT (00/09:52:10 MET) changed the FDA limit from 40 °F to 36 °F. The first TMBU has been processed on every OV-105 flight starting with STS-118 because the initial APU 3 drain line heater cycle has not occurred until after 43 °F FDA limit had been reached. The second TMBU was processed because a loss of signal period was coming up and the heater was close to, but had not reached the temperature that heater cycling occurred on previous missions. The minimum temperature reached by the measurement was 40.191 °F. This issue did not impact the mission.

Hydraulics/Water Spray Boiler System

The performance of the Hydraulic/Water Spray Boiler (HYD/WSB) system was nominal throughout the STS-127 mission as well as in all of the launch attempts. No IFAs were identified from the flight data and postflight analysis.

All HYD Elevon, Rudder Speed Brake (RSB) and Thrust Vector Control (TVC) actuator switching valves were observed to switch to their proper positions with all HYD circulation pumps operating nominally.

All three WSB system cores were loaded with approximately 5.0 lb of the additive mixture [53% water; 47% Propylene Glycol Monomethyl Ether (PGME)]. The initial PGME/Water Tank loading for WSBs 1, 2 and 3 was approximately 133.8 lb. Nominal WSB performance was observed on all three systems during pre-launch and ascent.

ASCENT WATER SPRAY BOILER TEMPERATURES AND PGME/WATER USAGE

WSB	Spray Start Temperature, °F	Steady State Temperature, °F	PGME/H ₂ O Usage, lb
System 1	257	253	253
System 2	261	253	253
System 3	243	247	247

The WSB System 1 and 2 vent heater operated at 100% duty-cycle because of ET cryogenic propellants loading effects. Water Spray Boiler PGME/H₂O usage during Entry for spray cooling is shown in the following table.

ENTRY WATER SPRAY BOILER TEMPERATURES AND PGME/WATER USAGE

WSB	Spray Start Temperature, °F	Steady State Temperature, °F	PGME/H ₂ O Usage, lb
System 1	255°F	251°F	27.8
System 2	251°F	251°F	40.3
System 3	247°F	247°F	32.4

Power Reactant Storage and Distribution System

The Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-127. The PRSD system supplied the fuel cells with 2441 lb_m of oxygen and 307 lb_m of hydrogen for the production of electrical energy. Hydrogen Tanks 4 and 5 and Oxygen Tank 4 and 5 were depleted to residual quantities. No IFAs were identified during the mission or the post-flight data review.

The fuel cells produced 3621 kWh of electrical energy from 2441 lb_m of oxygen and 307 lb_m of hydrogen supplied by the PRSD system. The total oxygen supplied to Shuttle/ISS Environmental Control and Life Support System (ECLSS) was 374 lb_m. The Orbiter also transferred 45 lb_m of oxygen to ISS during this mission.

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

PRSD TANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb _m
Loaded	101.8	101.4	101.4	101.8	101.4	3966
Launch	98.3	98.3	97.9	97.9	97.9	3829
Landing	41.8	36.1	38.8	6.3	6.8	1014

PRSD TANK QUANTITIES (Concluded)

Hydrogen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb _m
Loaded	101.5	101.9	101.0	102.3	101.5	467.5
Launch	91.3	91.7	92.2	92.6	91.3	422.4
Landing	38.7	39.1	44.0	2.0	1.1	114.9

A 101-hour mission extension capability existed at landing, based upon the PRSD O₂ (the limiting reactant) tank landing quantities at the average fuel cell flight power level of 9.6 kW. A 79-hour mission extension was possible at the 12.59 kW mission-extension average power-level with the reactants remaining at touchdown.

Fuel Cell System

Fuel Cells

The overall performance of the OV-105 fuel cell system was nominal during the STS-127 mission. The fuel cells produced 2749 lb_m of potable water and 3621 kWh of electrical energy from 2441 lb_m of oxygen and 307 lb_m of hydrogen. One IFA was identified and it is discussed in a later paragraph in this subsection.

Fuel cell operating times, which are the times accumulated on the fuel cells during the pre-launch, on-orbit, and post-landing operations were 497 hr 21 min 03 sec for fuel cell 1, 496 hr 47 min 37 sec for fuel cell 2, and 496 hr 32 min 14 sec for fuel cell 3. The end-of-mission accumulated operating times for these fuel cells are 956, 543, and 2141 hours, respectively.

The average electrical power level and load was 9.6 kW and 308 Amperes (A). When combined with the Station-to-Shuttle Power Transfer System (SSPTS), the average Orbiter electrical power level was 13.47 kW for the mission duration. During the 376.77-hr mission, the fuel cells produced 3621 kWh of electrical energy and 2749 lb_m of potable water consuming 2441 lb_m of oxygen and 307 lb_m of hydrogen. Four fuel cell purges were performed, occurring at approximately 25, 133, 252, and 368 hours MET.

The actual Fuel Cell voltages (175-A load) at the end of the mission were as predicted. Fuel cell 1, fuel cell 2 was 0.10 Volts (V) above predicted, and fuel cell 3 was as predicted for. The voltage margins above the minimum performance curves at 175 A at the end of the mission were 0.94 V above minimum for fuel cell 1, 0.94 V above minimum for fuel cell 2, and 0.62 V above minimum for fuel cell 3.

At 204/19:22:31 GMT (07/21:19:21 MET), the fuel cell 3 sustaining heater began a 21.4-min cycle after having cycles in the 3-4 min range (IFA STS-127-V-05). Up to that time, 304 Sustaining Heater cycles had been identified on this flight for a total of 606 cycles since SSPTS was installed on this vehicle three flights prior to STS-127. To preclude another sustaining- heater cycle as well as the potential for a “stuck-on

sustaining heater”, the ground controllers broke the bus-tie between Main Bus B (MNB) to Main Bus C (MNC) (the standard SSPTS configuration), and the load on fuel cell 3 was increased to raise the Stack Exit Temperature (Tse) above the 185.6 °F turn-on temperature. To maximize the SSPTS capability in the configuration, a Main Bus A (MNA) to MNB bus-tie was used. No more sustaining heater cycles were observed for the remainder of the flight.

Station-to-Shuttle Power Transfer System Operation

This was the fourth flight of SSPTS on OV-105. The Station-to-Shuttle Power Transfer System (SSPTS) transfers and converts power from the 120 Vdc ISS electrical system to supplement fuel cell power to the Orbiter 28-Vdc buses. The system is activated after the Orbiter is docked to ISS and transfers up to about 6 kW of power from ISS to the Orbiter. The SSPTS performed nominally and supplied 1454 kWh of electrical energy to the Orbiter. When combined with the energy from the fuel cells, the Orbiter average electrical power level was 13.47 kW.

Cell Performance Monitor and Fuel Cell Monitoring System

The prelaunch baseline Cell Performance Monitor (CPM) values for fuel cell 1 were 2, 2, and 22 mV, for fuel cell 2 were 14, 24, and 20 mV, and for fuel cell 3 were 2, 2, and 4 mV. They were established at 193:04:30 GMT, approximately 2 hours after the completion of the Fuel Cell Calibration requirement.

The Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages during the pre-launch, on-orbit, and post-landing operations. Full-rate on-orbit data were recorded for 12 min beginning at 197:23:28:34 GMT (01/01:25:24 MET) and no outliers were identified.

Electrical Power Distribution and Control System

The Electrical Power Distribution and Control (EPDC) system performed nominally during all mission phases of STS-127. The data review and analysis of all available EPDC parameters identified no abnormal conditions or IFAs.

1. Fuel cell voltages and currents;
2. Power Transfer Unit voltages and currents;
3. Essential bus voltages;
4. Control bus voltages;
5. Forward Power Control Assemblies voltages and currents;
6. Mid Power Control Assemblies voltages and currents;
7. Aft Power Control Assemblies voltages and currents;
8. AC bus voltages and currents;
9. AC bus Monitor/auto switch status and overload/over-voltage alarm
10. Main bus to Control bus RPC status
11. Forward, Mid and Aft Motor Control Assemblies operations status

12. Fuel cell to Essential bus switch status
13. Main bus to Essential Bus RPC and switch status
14. Drag chute Pyro Controller Functions

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

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

Orbiter Docking System

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

The initial application of power to the ODS and ring extension were performed nominally during FD 2 and the ODS was activated for 10 min 19 sec, and the avionics hardware was powered for 5 min 5 sec. The system was ready for rendezvous and docking with the ISS.

The application of power for the docking activities was initiated at 198/17:17:50 GMT (01/19:14:40 MET), and the ODS was powered for 54 min 31sec. The initial contact and capture of the ISS occurred at 198/17:47:06 (01/19:43:56 MET). The initial damping was 3 min 36 sec and performance of the “Disable and Release Dampers” procedure was necessary to ensure that any stuck dampers were disengaged.

In preparation for undocking, the ODS was activated at 209/16:58:49 GMT (12/18:55:39 MET). The undocking and separation from the ISS was completed satisfactorily at 209/17:25:56 GMT (12/19:22:46 MET). The ODS was operational for 47 min 10 sec for the undocking of the Orbiter.

Life Support Systems

Atmospheric Revitalization Pressure Control System

The Atmospheric Revitalization Pressure Control System (ARPCS) performed nominally throughout the mission, and no IFAs were identified during the mission nor during the post-flight review and analysis of the ARPCS data. PCS System 1 was configured and used for the entire mission. The checkout of ARPCS system 1 was performed and completed successfully. The ARPCS system 2 checkout was confirmed after undocking during the previous flight of OV-105 (STS-126).

An Orbiter-to-ISS tank-to-tank oxygen transfer was performed and approximately 45 lb. was transferred. An Orbiter-to-ISS tank-to-tank nitrogen transfer was performed and approximately 12 lb was transferred. There Orbiter ARPCS performed five Orbiter/ISS stack repressurizations performed prior to undocking. The repressurizations were performed by opening the payload nitrogen valves with restrictors in-line that limited the flow to 7 lb/hr for better cabin-air mixing. There were two Orbiter oxygen repressurizations performed prior to docking with ISS. Three other oxygen repressurizations were performed through the ISS using Orbiter oxygen during docked operations.

There were no Orbiter based EVAs during this mission. All water line and vestibule heaters cycled on all systems. The Vestibule was successfully leak checked for docking and undocking operations.

Airlock System

The Airlock Systems performed nominally throughout the mission. The external airlock structural heater, associated with the internal temperature lower-bulkhead measurement did not cycle using main A power. While on main A power, the measurement reached a minimum of approximately 63 °F, which is not cold enough for activation of this heater. The minimum/maximum heater cycle range is 40/85 °F. This heater has activated during previous missions with the temperatures in the 60 to 62 °F range. There is no indication that the heater is failed, only that the thermostat did not get cold enough to activate the heater while on Main A.

Supply and Waste Water System

The Supply Water and Waste Management System performed nominally throughout the mission. Supply water was managed through the use of the FES, water transfer to the ISS and the dump nozzle. One CWC was dumped through the waste water dump nozzle. The line heater maintained the supply water dump line temperature between 70 °F and 102 °F. Two simultaneous waste water nozzle dumps were performed at a nominal average rate of 1.90%/min (3.19 lb/min). One additional waste water dump at a nominal average rate of 1.93%/min (3.24 lb/min) was performed. The wastewater dump line temperature was maintained between 52 °F and 77 °F throughout the mission. Eight CWC's were filled with supply water and transferred to the ISS, for a total of 749.8 lb_m. Ten CWC-I's were filled with supply water and transferred to the ISS, for a total of 749.8 lb_m. In addition, 4 Portable Water Reservoirs (PWRs) of iodinated water were filled for a total 75.3 lb_m and transferred to ISS.

The quantity sensors in the supply water tanks A, B, C and D exhibited quantity dropouts throughout the mission. Such dropouts have been experienced in previous flights, and the problem was caused by either contamination on the collector bar and/or a surface defect on the collector bar of the potentiometer, which causes an intermittent break in continuity. These dropouts are understood problems and are deferred for a quantity sensor replacement during OMDP or during the turnaround flow.

Vacuum vent line temperature was maintained between 80°F and 57 °F.

Smoke Detection and Fire Suppression System

The Smoke Detection and Fire Suppression (SDFS) operated nominally with no issues. The Smoke detector check accomplished, and all Smoke detection A and B Sensor circuits passed. Use of the Fire Suppression system was not required.

Active Thermal Control System

The Active Thermal Control System (ATCS) performed nominally throughout the mission and no IFA's were identified during the review and analysis of the flight data. The radiators were not deployed this flight.

The Flash Evaporator System (FES) exhibited a larger pre-evaporative cooling compared to previous missions. The amount of pre-evaporative cooling was as much as 33 °F. The pre-evaporative cooling also occurred in the hi-load duct causing the duct temperature to decrease below the minimum control temperature. The crew was requested to switch on the A/B heater from the nominal A heater operation. The duct temperatures recovered to the nominal temperature control range was maintained. There were no detrimental effects to FES performance.

The crew compartment Partial Pressure Carbon Dioxide (PPCO₂) peaked at 6.77 mmHg because of the ISS Carbon Dioxide Removal Assembly (CDRA) failure because of an electrical short that tripped the Remote Power Controller (RPC). This 6.77 mmHg level violated both the Shuttle flight rule limit of 5mmHg maximum and the ISS flight-rule limit of 6 mmHg maximum; however, there was no adverse effect reported by the crew. Some expired Russian Lithium Hydroxide (LiOH) cartridges were used to supplement the Carbon Dioxide (CO₂) removal to preserve the stock-pile of ISS of cartridges, but flight data indicated that there was very little CO₂ absorption capability left in the cartridges.

The Ammonia Boiler System (ABS) tank A and B in-flight leak rate was calculated at approximately 0.02 lb_m/day for tank A and 0.01 lb_m/day for tank B with the maximum allowable leak rate being no more than 0.05 lb_m/day.

The ABS B system secondary controller was powered after landing, and operated for 42 min. The ABS B system operation was terminated with the activation of the ABS system A secondary controller. System A ran for 13 min and was shutdown when the Ground Support Equipment (GSE) cooling was initiated.

Flight Software

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

The left OMS Gaseous Nitrogen (GN₂) tank pressure experienced a slow leak of approximately 14 psi/day, which created a risk of an alarm possibly waking the crewmembers. The General Memory Update (GMEM), which was to change the current low-level tank-pressure limit from 1200 psi to 500 psi. The GMEM was uplinked to the PASS FSW, and the GMEM was used in the Major Mode (MM) 201 to prevent the crew being awakened.

Data Processing System Hardware

The data review and analysis of Data Processing System (DPS) parameters have been completed. The Integrated DPS subsystem performed nominally, with no IFAs identified.

Multifunction Electronic Display System

The Multifunction Electronic Display System (MEDS) performed nominally and the hardware and software performance was satisfactory throughout the mission. No IFAs were identified from the review and analysis of the data.

On FD 14 prior to undocking from the ISS, the Multifunction Display Unit (MDU) Aft Flight Deck (AFD) 1 unit reported a lamp failure in the downlist. The error cleared 3 sec later. This message was attributed to the crew adjusting the brightness setting, and this condition is covered in a MEDS Software User Note.

On FD 14 during the Flyaround undocking from the ISS, Integrated Display Processor (IDP) 1 experienced a transient loss of communication with its commanded MDU Cathode Ray Tube (CRT) 1 as well as with general Purpose Computer (GPC) 4. This transpired as the crewmember performed an IDP Major Function Switch reassignment. The IDP 1 and MDU CRT 1 automatically rebooted successfully and continued to perform nominally for the duration of the flight.

On FD 14 prior to Crew off-duty time, MDU CRT 1 reported lamp failure luminance message. The error cleared 42 sec later. This occurred during night-to-day pass, and meets conditions of MEDS user note.

Displays and Controls System

The Display and Controls (D&C) system, including lighting, performed nominally during all phases of STS-127 and no IFAs were identified from the data review and analysis.

Flight Control System

The Flight Controls System (FCS) performed nominally during the pre-launch countdown, and throughout the mission operations.

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

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

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

Air Data Transducer Assembly

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

All four ADTAs functioned nominally from power-on until nominal data loss at the T-minus-20-min transition on launch day. The ADTA self-test performed shortly after power-on was nominal. All ADTA mode/status words were nominal during elevon park.

Entry performance was nominal from de-orbit through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.8, and deployment timing was within specification at less than 15 sec. ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at about Mach 3.0.

Inertial Measurement Unit and Star Tracker System

The Inertial Measurement Unit (IMU) system performed nominally throughout the mission and no IFAs were identified from the review and analysis of the flight data.

During the flight, one adjustment was made to the on-board IMU accelerometer compensations, and three adjustments were made to the IMU drift compensation values.

The Star Tracker (ST) performed nominally throughout the mission and no IFAs were identified from the review and analysis of the flight data.

Global Positioning System Navigation

Overall, Global Positioning System (GPS) operation during STS-127 was nominal. All three GPS strings were powered ON approximately 5 hr prior to launch. During the power-up sequence, the Miniature Air-to-Ground Receivers (MAGRs) were powered ON prior to the GPS Input/Output (I/O) being activated. This sequence has now become standard for day-of-launch power up as the sequence eliminates any potential time-out errors which could have been generated by the GPC's polling unpowered MAGR receivers.

On entry day, the GPS state vector was incorporated into the PASS and BFS about 15 min after going to Major Mode (MM) 301. At 44 min 21sec prior to the de-orbit maneuver, the GPS was inhibited in both PASS and BFS as planned. Once in MM304 and after performance confirmation with high-speed C-band tracking, the GPS state vector was again set to Auto incorporate in both PASS and BFS. The GPS state vector was incorporated into the PASS and BFS 20 min 51 sec after Entry Interface (EI) at approximately 152,000 ft altitude. The effect was that the PASS and BFS navigation state residuals were reduced significantly, as expected.

The anomalous condition documented under DR110669 (Satellite Tracking on a Carrier Sideband can Degrade the GPS Solution) occurred on GPS #2 during docked operations. The GPS peripheral channel became 'stuck' on low elevation satellite PRN-6 for 4:42 (m:ss) until a loss-of-lock on a NAV channel interrupted the condition and proper operation was restored. There was no mission impact and no action was taken.

Also during docked operations GPS 2 tracked satellite PRN-18 after the satellite became 'unusable' but before the 2nd Space Operations Squadron, (2SOPS) realized the satellite transmissions were erroneous. The satellite was tracked several times on navigation channels as well as on the peripheral channel over a two hour period before 2SOPS commanded OFF the satellite transmitter. Although tracked during this period, the PRN-18 satellite data was apparently not decoded by the GPS receiver (as evidenced by 'stuck' peripheral channel behavior) and was not used in the GPS navigation solution. This behavior did not significantly affect the GPS navigation solution. Again, there was no mission impact and no action was taken.

Beginning with FCS checkout, all three GPS receivers remained ON until about 10 min after landing. During entry, the GPS high Figure of Merit (FOM) period usually encountered in the Plasma region cleared before GPS incorporation into PASS navigation. No "instances of invalid data nor FOM Chimneys occurred during the critical

phase of entry (below 140,000 ft altitude), where the GPS satellite geometry is less dynamic.

Communications and Tracking System and Navigation Aids

The Communications and Tracking systems performed satisfactorily during the mission, and no IFAs were identified from the review and analysis of the flight data. Likewise, the Navigation Aids (NAV AIDS). The S-Band system 1 was in operation for 22 hr and 21 min, which satisfied in-flight requirements.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) and Modular Auxiliary Data System (MADS) hardware performed nominally throughout the mission. One IFA was identified from the review and analysis of the data and are discussed in the following paragraphs.

As part of the assessment of the downlinked ascent MADS PCM data, seven measurements were identified as anomalous (IFA STS-127-V-04). None of these measurements impacted the mission.

Three readings on the Mid fuselage bottom panels were correlated with localized temperature sensors to be responding to a rapid localized cooling which has been seen on other vehicles/flights and is considered an in-family response.

Two readings on the Xo1307 Left-Hand (LH) wing spar cap were inverted from what was expected. The preliminary assessment indicates that these are instrumentation errors given the nominal trajectory and the fact that other gages do not correlate with the wing response that these readings indicate (anomalous bending of the wing).

Two readings on the Xo1191 RH wing spar web were indications of a potential blocked Main Landing Gear (MLG) compartment vent. Even though close-out photographs do not show a blockage, and all vent covers have been accounted for, a safety assessment was performed of the blocked vent and found that the compartment can carry the increase in pressure. The assessment was that these two readings are most likely instrumentation errors.

Mechanical and Hatches System

All mechanical and hatch systems performed within the specification. No IFAs were identified during the review and analysis of the flight data.

During the -Z Star Tracker Door closure, motor 2 ran for approximately 0.4 sec longer than motor 1 due to a delayed CLOSED 2 limit-switch indication. However, the -Z Star Tracker Door closure was well within dual motor time. A similar condition was noted during STS-126 and was accepted as-is, so a recurrence was considered likely.

During post-flight removal, two of the LO₂ flight struts were found in wrong positions (IFA-STS-127-V-10). The aft strut was installed in the outboard position, and the outboard mid strut was installed in the aft position. The struts are designed to accommodate ET/Orbiter relative motion during boost and to stabilize/support the Orbiter Main Propulsion System (MPS) valve cluster, lines and gimbals during and after umbilical separation.

Landing and Deceleration System

The Landing System performance at KSC was nominal. This assessment includes all events from landing gear deployment, main gear touchdown, nose gear touchdown, through roll out, and including drag chute deployment and brake/deceleration. It was the second flight of the nose landing gear tires. They were in good condition and performed nominally. The main landing gear tires appeared nominal. Normal appearance of tread cord materials on areas of the tire's surface, which is a known expected condition characteristic of the new tire design. Analysis of the post-flight imagery from the STS-127 landing indicates parachute deployment was as expected and no signs of anomalous conditions for hardware performance exist. Post-flight inspection of the drag chute hardware at the parachute refurbishment facility is complete and no anomalies were noted. The landing and rollout parameters are shown in the following table.

LANDING PARAMETERS

Parameter	From threshold, ft	Time from MLG touchdown, sec	Speed, keas ^a	Speed, kgs	Sink rate, ft/sec	Pitch rate, deg/sec
Main Landing gear touchdown	1873.1	0.00	208.4	207.5	LH 5.3	
Drag Chute Deployment	3996.2	6.297	180.8	183.0		
Drag Chute Disreef	5108.0	10.205	164.1	166.7		
Nose Landing Gear Touchdown	5844.2	13.005	149.7	152.3		-4.28
Brakes On	10117.3	38.172	71.8	71.8		
Drag Chute Jettison	10922.1	44.981	Off-Scale Low	55.6		
Wheels Stop	11915.4	68.405	0.0	0.0		
Parameter			Data			
Brake Initiation Speed, keas			71.8			
Brake On Time, sec			30.3			
Rollout Distance, ft			10042.3			
Rollout Time, sec			68.41			
Runway Location, Surface and Degrees			KSC 15 - Concrete			
Orbiter Weight at Landing, lb			215858			

LANDING PARAMETERS (Concluded)

Parameter	Maximum Brake Pressure, psia	Total Brake Energy, Mft/lb
Left inboard	612.0	4.09
Left outboard	612.0	6.64
Right inboard	756.0	9.82
Right outboard	636.0	6.79

^aKnots equivalent air speed

Aerothermodynamics, Integrated Heating and Interfaces

The Kennedy Space Center (KSC) reports indicated the overall Orbiter Thermal Protection System (TPS) looked normal. The lower structural temperature data indicated normal entry heating and was within the range expected for this weight (215,317.8 lb) and the 51.6 deg inclination. The recorded structure temperatures are within the flight experience of OV-105. However, sensors at locations B3, P4 and LP experienced the most temperature rise for the OV-105 vehicle and sensors at locations P2 and P3 experienced the minimum temperature ever recorded. 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)	137.7	126.7
Lower fuselage forward left-hand (B2)	182.5	176.5
Lower fuselage forward mid left-hand (B3)	166.6	178.4***
Lower fuselage mid center (B4)	145.6	147.2
Lower fuselage mid aft center (B5)	187.8	181.8
Lower fuselage aft center (B6)	187.8	161.3
Left-wing center (LW)	126.7	136.2
Right wing center (RW)	176.5	134
Port side FRCS forward (P1)	178.4***	108.6
Port side fuselage forward center (P2)	147.2	102.6
Port side fuselage forward mid center (P3)	181.8	87.2
Port side fuselage mid aft center (P4)	161.3	105.1* ***
Port side fuselage aft center (P5)	126.7	71.9*
Starboard side FRCS Forward (S1)	176.5	116.8
Starboard side fuselage forward center (S2)	178.4***	113.6
Starboard side fuselage forward mid center (S3)	147.2	77.4
Starboard side fuselage mid-aft center (S4)	181.8	69.4
Starboard side fuselage aft center (S5)	161.3	61.7*
Left-hand OMS pod side forward (LP)	126.7	77.1***
Right-hand OMS pod side forward (RP)	176.5	61.7*
Lower body flap center	136.2	136.2
Right-hand PLBD forward	77.9*	117.5*
Left-hand PLBD forward	80.5*	130.2*

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA (Concluded)

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Right-hand PLBD aft	83.0*	105.0*
Left-hand PLBD aft	88.2*	115.2*
Right wing upper center	106.4*	118.2*
Left wing upper center	109.0*	133.5*
Forward RCS center	103.8*	74.8*
Forward Fuselage Upper Center	83	94.9

Notes

^a Maximum temperature occurred 30 min after wheel stop.

a. Maximum temperature ever experienced on the OV-105 vehicle.

From MADS surface thermo-couples, the Boundary Layer Transition (BLT) was symmetric and occurred at BP 1600 (X/L = 0.6) around Mach 10.0 (1162 sec after EI) based on a pre-flight EOM trajectory. From MADS surface thermo-couples, the Boundary Layer Transition (BLT) was symmetric and occurred at BP 1600 (X/L = 0.6) around Mach 10.0 (1162 sec after EI) based on a pre-flight EOM trajectory.

The majority of the vehicle windward surface thermal sensors indicated that BLT occurred around Mach 10 except two sensors at X/L = 0.3 showed BLT occurring around Mach 6.5. During on-orbit imagery, a protruding Arrowhead blanket was noted, and the post-flight measurement indicated it protruded about 0.14 in. Based on this height, the BLT tool predicted BLT would occur around Mach 10, which agreed with the flight data. Data show that the reason for the other two sensors at the X/L = 0.3 did not indicate transition occurring around Mach 10 was because they were outside the BLT turbulent wedge. Based on the KSC vehicle surface roughness report, this vehicle had the Keq value around 0.110" ~ 0.120" and it is predicted to have natural BLT occurring around Mach 6 to 8. Those two sensors outside the BLT turbulent wedge recorded the natural BLT occurring around Mach 6.5, which agreed with the prediction. The thermal sensor flight data indicated the vehicle had symmetrical BLT. The aileron deflection and yaw thruster data also showed the vehicle had a symmetrical BLT.

Thermal Control System

The Passive Thermal Control System (TCS) performed nominally, however there were several notable points of interest. The pre-launch data from the five launch scrubs did not reveal any issues. No IFAs were identified from the review and analysis of the flight data.

STS-127 was the first flight of the OV-105 APU GN₂ Quick Disconnect (QD) heater modifications. All systems performed as expected: however, the Tempasure label data on the QD caps showed lower-than-expected temperatures.

After STS-126, the starboard low-point drain-line heater was replaced because of a failed-off condition. This heater cycled low early in the mission on system A; however was nominal on system B. TCS recommended visual inspection of this heater's insulation. After landing, the sustaining heater for fuel cell 2 turned on without coolant flow for 62 sec. This resulted in a possible over-temperature condition of the fuel cell coolant.

Thermal Protection System and Post-Landing Assessment

Post-Landing Assessment

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

SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE

Orbiter Surface	Impacts greater than 1 in.	Total impacts
Lower surface	18	82
Upper Surface/Window	0	6
Right OMS pod	1	10
Left OMS pod	2	9
Totals	21	107

Tile and Blanket Flight Assessment

The overall performance of the TPS was satisfactory.

The Thermal Protection System (TPS) Debris Assessment Team (DAT) completed review of the Orbital Maneuvering System (OMS) pod imagery from the Aft Flight Deck and the TPS tile surfaces during the RCC surveys. No gross damages were identified.

The TPS DAT preliminary results of the analysis of the imagery obtained from the FD 3 R-Bar Pitch Maneuver (RPM) identified twenty-four items of interest. These included 8 gap filler/thermal barrier areas and 16 damage sites in the starboard chine area (IFA STS-127-V-03). The team determined that no focused inspection was required.

The analysis to clear the system for entry was completed later in the mission and the vehicle was cleared for entry.

RCC Assessment

The Reinforced Carbon-Carbon (RCC) performed satisfactorily. The surveys of the starboard-wing RCC, nose-cap RCC and port-wing RCC were completed nominally. The Starboard RCC surveys began with the Flat-Field Survey at 197/16:34 GMT (00/18:30:50 MET) and were completed at 197/18:15 GMT (00/20:11:50 MET). The Nose RCC surveys began at 197/18:33 GMT (00/20:29:50 MET) and were completed at

197/19:23 GMT (00/21:19:50 MET). The Port RCC survey began at 197/19:49 GMT (00/21:45:50 MET) approximately 1 hr later.

The RCC DAT completed the initial screening of the FD 2 survey imagery of the Starboard wing, Port wing, and Nose cap RCC, and obvious damage areas were identified.

The RCC DAT completed the imagery analysis. No focused inspection requirements were identified and the system was cleared for entry.

The late inspection of the RCC started with the starboard survey at 210/10:37 GMT (13/12:34 MET) and ended with the port survey at 210/13:50 GMT (13/15:47 MET). The vehicle was cleared for entry after the analysis of the late inspection data.

Windows

The examination and evaluation of the windows was not completed at the time this report was written.

Waste Collection System

The Waste Collection System operated satisfactorily and no IFA's were identified from the crew following the mission. One note of interest is presented in the following paragraph.

The American side of the ISS Waste/Hygiene Compartment (WHC) failed; however, the Russian side remained functional. The "flushing pump" on the WHC continued running after being used. The ISS began to rely on the Russian WHC which can handle six crewmembers. The seven Orbiter crewmembers were restricted to using the Orbiter Waste Collection System (WCS). The Shuttle WCS had sufficient capacity to accommodate the needs of the crew for the duration of the mission; however, it was expected that the Waste Water Tank would become full and require offloading into a CWC.

EXTRAVEHICULAR ACTIVITY

The crew performed five Extravehicular Activities (EVAs) on STS-127 in a total EVA time of 30 hr, 29 min. Space Shuttle Mission Specialists David Wolf, Tim Kopra, Tom Marshburn and Chris Cassidy were designated as EV1, EV2, EV3, and EV4, respectively. The primary EVA mission objectives were to prepare the Japanese Experiment Module Exposed Facility (JEF) for installation, transfer three spare Orbital Replacement Units (ORUs) to the International Space Station (ISS), and Remove and Replace (R&R) six batteries on the P6 upper Integrated Element Assembly (IEA). The Airlock campout prebreathe protocol was utilized in preparation for all of the EVAs.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was performed by EV1 and EV2 on Flight Day (FD) 4. The highest priority objective on the first EVA was to prepare the JEF for installation onto the Japanese Experiment Module Pressurized Module (JPM). The EV1 crewmember removed and jettisoned the JPM active berthing mechanism contamination cover, while the EV2 crewmember worked in the Payload Bay (PLB) to ready the JEF for removal from the Orbiter. EV2 removed and stowed the JEF passive berthing mechanism contamination cover and disconnected the Launch-to-Activation (LTA) cables that had previously provided power to the JEF. While in the PLB, EV2 also disconnected the LTA cables from the Integrated Cargo Carrier – Vertical Light Deployable (ICC-VLD) in preparation for its deployment onto the Payload ORU Accommodation (POA) base on a subsequent flight day. After leaving the PLB, EV2 translated to the ISS to retrieve EVA tools from the tool boxes on the Z1 truss. During his translation to Z1, EV2 opened the Node 1 port window cover in preparation for a future Pressurized Mating Adapter (PMA) 3 relocation. He also opened the Node 2 zenith window cover to provide a contingency berthing port for HII Transfer Vehicle (HTV).

The EV1 crewmember worked in parallel to release bolts from the Ammonia Tank Assembly (ATA) as a get-ahead task for a future mission. EV2 then reconfigured the port Crew and Equipment Translation Aid (CETA) cart by tying back the brake handles and rotating the various hardware to support the battery Removal and Replacement (R&R) operations on subsequent EVAs. Next, the crew worked together on the Port (P)3 truss segment to deploy an Unpressurized Cargo Carrier Attachment System (UCCAS) that had been lodged in an intermediate position during a deployment attempt on STS-119. The crew used a newly designed tool to release the UCCAS and successfully deploy the UCCAS into its final configuration. The Starboard (S) 3 Zenith Payload Attachment System (PAS) deployment was deferred from first EVA to a future EVA.

The first EVA was completed in a total EVA time of 5 hr and 32 min. The EVA glove inspections and post-EVA photographs indicated no glove damage had been incurred during the EVA.

SECOND EXTRAVEHICULAR ACTIVITY

The second EVA was successfully completed on FD 6 in a total EVA time of 6 hr and 52 min. This EVA was performed by the EV1 and EV3 crewmembers. The crew began the EVA by egressing the Quest Airlock and translating to the ICC-VLD on the POA to initiate the ORU transfers. First, the EV1 and EV2 crewmembers removed the Flight Releasable Attachment Mechanism (FRAM) base, which housed the Space-to-Ground Antenna (SGANT) and its Flight Support Equipment (FSE). Riding the Space Station Remote Manipulator System (SSRMS), EV1 translated with the SGANT assembly to the External Stowage Platform 3 (ESP-3), where the SGANT FRAM was installed with assistance from EV3. EV1 remained on the SSRMS and transferred two additional ORUs, the Pump Module (PM) and Linear Drive Unit (LDU), from the ICC-VLD to ESP-3. All three ORUs will serve as spares and will remain on ESP-3 until such time that these ORUs are needed. In addition to providing visual cues during the ORU installation operations, EV2 relocated a Fixed Grapple Bar to the Ammonia Tank Assembly (ATA) in preparation for the ATA R&R on STS-128.

Glove inspections were performed per procedure and no damage was noted throughout EVA.

THIRD EXTRAVEHICULAR ACTIVITY

On FD 8, the EV1 and EV4 crewmembers performed the third EVA in 5 hr and 59 min. The first objective of the third EVA was to prepare payloads for transfer by the Japanese Experiment Module Remote Manipulator System (JEM RMS) from the JEM Experiment Logistics Module – Exposed Section (JLE) to the JEF. EV4 translated to the JLE to remove the Multi-Layer Insulation (MLI) and ready the payloads for transfer, while EV1 relocated a Node 2 Worksite Interface Adapter (WIF) to eliminate clearance concerns with the HTV. The crew then proceeded to the Port (P) 6 Integrated Equipment Assembly (IEA) to begin the Battery Removal and Replacements (R&Rs). Upon arrival at the worksite, the Articulating Portable Foot Restraints (APFRs) were set-up to provide work platforms for the operations. The EV4 crewmember ingress the APFR on the P6 IEA and released the first spent battery from the truss. This battery was temporarily stowed on a nearby handrail using EVA tools, thereby creating an open slot in the truss in which to install the first new battery. Operating from an APFR on the P6 long-spacer, EV1 removed the first new battery from the ICC-VLD, which was grappled and transferred to the worksite by the SSRMS. Using a “shepherding” technique, EV1 transferred the battery to EV4 for installation on the truss. Once the new battery was secure, EV4 removed the second spent battery and shepherded it to EV1 for installation onto the ICC-VLD for return. EV1 released the second new battery from the ICC-VLD and shepherded it to P6 for installation by EV4. With two new batteries in place on the truss, EV4 released the third spent battery, which EV1 then installed onto the ICC-VLD.

Although the pre-flight plan was to R&R four batteries during the third EVA, design limitations with the Extravehicular Mobility Unit (EMU) Carbon Dioxide (CO₂) scrubbing

system resulted in elevated CO₂ levels in EV4's suit, causing the EVA to end after only two new batteries had been installed. The battery that had been temporarily stowed at the beginning of the task remained in its temporary location between EVAs, resulting in additional analysis after the EVA to verify the integrity of the unexpected configuration.

All glove inspections performed during EVA 3 were nominal.

FOURTH EXTRAVEHICULAR ACTIVITY

The fourth EVA was conducted on FD 10 by the EV3 and EV4 crewmembers. The sole objective on this EVA was to complete the remaining P6 Battery R&Rs. The EV3 and EV4 crewmembers were translated to the P6 truss to continue the operations that had commenced on the third EVA. EV4 ingressed an APFR on the P6 long spacer and released the third new battery from the ICC-VLD. This battery was then shepherded to EV3, and then installed onto the truss. EV3 then removed the fourth spent battery from the truss and shepherded it to the ICC-VLD with assistance from EV4. EV4 installed this battery for return prior to removing the fifth new battery from the carrier. Once removed, the fifth new battery was handed-off to EV3 who installed it on the P6 IEA. EV3 then removed the sixth and final spent battery, which was subsequently installed onto the ICC-VLD. EV4 removed the final new battery from the ICC-VLD and transferred it to EV3 for installation onto the truss, thereby completing the replacement of all six batteries on the P6 upper IEA. Lastly, the battery that had been temporarily stowed during the third EVA was installed onto the ICC-VLD for return. Due to rising CO₂ levels for EV4, similar to those experienced during EVA 3, the crew deferred the worksite clean-up tasks and returned to the Airlock to end the EVA.

The fourth EVA was completed in a total EVA time of 7 hr and 12 min. The EVA glove inspections and post-EVA photographs indicated no glove damage had been incurred during the EVA.

FIFTH EXTRAVEHICULAR ACTIVITY

The EV3 and EV4 crewmembers successfully completed the fifth EVA on FD 13 in a total EVA time of 4 hr and 54 min. The crew began the EVA by working individually on separate tasks. EV4 translated to the Z1 and reconfigured the Patch Panel to provide power redundancy to the ISS attitude control system, while EV3 manipulated MLI on the Special Purpose Dexterous Manipulator (SPDM). The crew then translated to the JEF and worked together to install two Vision Equipment (VE) cameras. Following the VE installation, the crew members completed a series of get-ahead tasks including JPM Handrail and WIF installation, Laboratory-cable restraint, Node 2 gap spanner installation, and APFR relocations. To avoid the rising CO₂ levels observed during EVA 3 and 4, the fifth EVA was deliberately reduced in duration. As a result, the Starboard (S) 3 Zenith PAS deployment was not attempted and was deferred to a future EVA.

Glove inspections were performed throughout the fifth EVA and no damage was noted by the crewmembers or by engineering teams during their review of post-EVA glove imagery.

REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Shuttle Remote Manipulator System (SRMS) performed nominally during the mission.

The SRMS on-orbit Initialization began at 197/00:42 GMT [00/02:38 Mission Elapsed Time (MET)] Flight Day (FD) 1. The port and starboard Manipulator Positioning Mechanisms (MPMs) were deployed and the SRMS shoulder brace was released. The SRMS checkout began at 197/ 02:15 GMT (00/04:11 MET) and was completed 1 hr and 10 min later.

On FD 2, the SRMS grappled the Orbiter Boom Sensor System (OBSS) at 197/15:48 GMT (00/17:44 MET) and maneuvered the OBSS to the hover-position at 197/15:58 GMT (00/17:54 MET). The survey of the Starboard Reinforced Carbon-Carbon (RCC) was completed at 197/18:15 GMT (00/20:11). The survey of the Nose RCC was completed at 197/19:23 GMT (00/21:19 MET). The survey of the Port RCC was completed at 197/21:54 GMT (00/23:50 MET). The OBSS was berthed in the MPMs and the SRMS was returned to the pre-cradle position.

On FD 3, the Orbiter completed the rendezvous and docking with the International Space Station (ISS). The SRMS maneuvered to the Japanese Experiment Module-Exposed Facility (JEF) to the unberthed- clear position at 198/18:43 GMT (01/20:39 MET). The SRMS wrist joints were moved to provide a view inside the End Effector and were maneuvered back to the JEF unberthed-clear position at 198/22:49 GMT (02/00:45 MET)

On FD 4, the SRMS grappled the JEF from the Space Station Remote Manipulator System (SSRMS) at 199/18:28 GMT (02/20:24 MET). After the SSRMS released and cleared the grapple fixture, the SRMS maneuvered to the handoff-position at 199/19:38 GMT (02/21:34 MET). After handing the JEF back to the SSRMS, the SRMS maneuvered to the JEF installation-viewing position at 199/21:07 GMT (02/23:50 MET). The SRMS maneuvered back to the pre-cradle position at 200/00:18 GMT (03/02:14 MET).

On FD 5, the SRMS maneuvered from the pre-cradle position and grappled the Integrated Cargo Carrier (ICC) at 200/13:45 GMT (03/15:41 MET). The ICC was unberthed and maneuvered to the ICC pitch-position before reaching the ICC low-hover position at 200/14:13 GMT. (03/16:09 MET). Prior to handing off the ICC to the SSRMS, the SRMS maneuvered the ICC to intermediate positions before arriving at the handoff-position at 200/14:34 GMT (03/16:09 MET). After the SSRMS grappled the ICC, the SRMS ungrappled the ICC, backed off, and maneuvered to the second EVA viewing-position at 200/16:53 GMT (03/18:49 MET) where it remained until FD 7.

On FD 6, the SRMS remained at the Viewing Position for the second EVA. Adjustments were made to the position to provide better viewing support of EVA activities.

On FD 7, the SRMS maneuvered from the Viewing Position for the second EVA to grapple the JEM Experiment Logistics Module-Exposed Section (JLE) at 202/12:26 GMT (05/14:22 MET). After unberthing the JLE and maneuvering to the low-hover position and the SRMS maneuvered to several intermediate positions before maneuvering to the JLE-handoff position at 202/13:07 GMT (05/15:03 MET). After the SSRMS grappled the JLE, the SRMS ungrappled, backed away, and maneuvered to the JLE-install-viewing position at 202/13:41 GMT (05/15:37 MET). After JLE installation, the SRMS maneuvered to the battery remove-and-replace viewing-position at 202/17:13 GMT (05/19:50 MET).

On FD 8 and 9, there were no SRMS activities.

On FD 10, the SRMS maneuvered from the battery Remove-and-Replace (R&R) viewing- position to grapple the ICC at 205/21:17 GMT (08/23:13 MET). When the SSRMS was clear, the SRMS maneuvered to intermediate positions before arriving at the Low Hover Position at 205/21:55 GMT (08/23:50 MET). The SRMS berthed the ICC at 205/22:18 GMT (09/00:14 MET). After berthing the ICC, the SRMS maneuvered to the Pre-Cradle Position at 205/22:57 GMT (09/00:53 MET).

On FD 11, there were no SRMS activities.

On FD 12, the SRMS began its first maneuver to grapple the JLE from the SSRMS at 207/12:37 GMT (10/14:33 MET) and grappled the JLE 13 min later. The SRMS then maneuvered the JLE through several intermediate positions before arriving at the JLE Low Hover Position at 207/13:25 GMT (10/15:21 MET). The JLE was berthed in the payload bay 17 min later, and the SRMS maneuvered to the Pre-Cradle Position at 207/13:48 GMT (10/15:44 MET).

On FD 13 and 14, there were no SRMS activities.

On FD 15, the SRMS grappled the OBSS at 210/09:30 GMT (13/11:26 MET) and unberthed it to the Low Hover Position 14 min later. The Starboard survey began at 210/10:37 GMT (13/11:26 MET) and was completed 53 min later. The Nose Cap Survey began at 210/11:54 GMT (13/13:50 MET) and was completed 29 min later. The Port Survey began at 210/12:54 GMT (13/14:50 MET) and was completed 52 min later. The OBSS was maneuvered to the Low Hover Position and berthed at 210/14:53 GMT (13/16:49 MET). After releasing the OBSS, the SRMS maneuvered to the Pre-Cradle Position and was cradled at 210/15:15 GMT (13/17:11 MET).

On FD 16, the Port MPMs were stowed at 211/17:40 GMT (14/19:36 MET) and the Starboard MPMs stowed 2 min later.

WING LEADING EDGE IMPACT DETECTION SYSTEM

The Wing Leading Edge Impact Detection System (WLE IDS) system performed well for ascent impact monitoring.

ASCENT MONITORING

All units triggered and began recording data on Main Engine Ignition within 0.15 sec of each other. The Mission Elapsed Time (MET) was set to 9.20 sec behind Data Elapsed Time (DET) (MET = DET - 9.20 sec) for both port and starboard wing units.

A total of 10 impact probable cases above 1.0 Grms (9 on the starboard wing and 1 on the port wing) were found and reported during the flight. Post-flight analysis of the data found no additional indications above 1.0 Grms.

The analysis of the ascent data was completed and the findings identified 10 probable impact indications over 1.0 Grms. The damage likelihood for these indications ranged from less than 1/1000 to 1/100 (Risk Categories I to IV). The following table shows the 10 probable impact indications.

SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 GRMS

Times ^a		Location			Magnitude		Criteria				Impact ^b	
MET, Hr	DET, hr	Wing	RCC	Unit-Channel	Max. Grms	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post-Flt
103.3	112.5	Stbd	Chine	1165-J2	2.6	10.2	+	+	+	+	P	P
106.5	115.7	Stbd	Chine	1165-J1	2.1	7.0	+	+	+	+	P	P
106.6	115.8	Stbd	9	1171-J2	3.3	12.3	+	+	+	+	P	P
109.5	118.7	Stbd	8	1185-J1	2.2	13.5	+	+	+	+	P	P
109.5	118.7	Stbd	5,6	1152-J3	1.6	7.2	+	+	+	+	P	P
110.4	119.6	Stbd	8,9	1191-J1	1.1	3.7	+	+	+	+	P	P
113.1	122.3	Stbd	9	1171-J2	1.4	5.1	+	+	+	+	P	P
122.9	132.1	Stbd	9,10	1171-J2	1.9	7.2	+	+	+	+	P	P
126.6	135.8	Stbd	7	1160-J3	1.1	4.5	+	+	+	+	P	P
135.8	145.0	Port	14	1187-J1	1.1	4.9	+	+	+	+	P	P

^a P = Probable

ORBIT MONITORING

The on-orbit monitoring by the WLEIDS recorded 10 triggers, none of which satisfied all the impact criteria. Analysis of the 10 triggers (9 events) resulted in 2 questionable Micro-Meteoroid Orbital Debris (MM/OD) impact indications. Review of post-flight data revealed no additional on-orbit indications.

SUMMARY OF MM/OD IMPACTS

Times ^a	Location			Magnitude		Criteria				Impact ^b	
GMT	Wing	RCC	Unit-Channel	Measured G peak	Scaled G peak	Transient	Local	Spectral	Shock	In-Flt	Post-Flt
197/16:21:44	Stbd	6	1151-J3	4.65	9.98	+	+	+	+	Q	Q
199/02:14:49	Port	9	1179-J1	0.54	0.56	+	+	+	+	Q	Q

^a.Q=Questionable

CONCLUSIONS

The WLE IDS system performed well for ascent impact monitoring. An initial ascent report was published at L+14 hours. During the mission, ten ascent impact indications above the 1.0 Grms threshold were reported with damage likelihoods ranging from Category I (<1/1000) to IV (<1/100 and >1/200). Post-flight review of the data found no additional ascent indications over 1.0 Grms.

An unusually large number of indications took place after 135 sec MET during this flight. Only one of these indications was above 1.0 Grms. The rest were not analyzed until after the flight, when all of the raw data for ascent could be downloaded from the sensor units. Due to their low magnitude, these indications can be regarded as non-damaging.

Two questionable MM/OD indications were detected and reported during flight, but were not considered probable impacts since they did not meet the multi-sensor corroboration criteria.

Based on the ascent and on-orbit findings from all systems, including WLE IDS, the Orbiter Project Office recommended that a focused WLE RCC inspection was not required. The late mission Orbiter Boom Sensor System (OBSS) survey visually inspected the WLE after the Orbiter undocked from the ISS and prior to entry. No damage was found.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The overall performance of the Government Furnished Equipment (GFE) and Flight Crew Equipment (FCE) was nominal. Four In-Flight Anomalies (IFAs) were identified and are discussed in the following paragraphs. None of the anomalies impacted the successful completion of the mission.

Upon installation of Galley Iodine Removal Assembly (GIRA), the crew reported that the towel around the Microbial Removal Assembly (MRA) was wet (IFA STS-127-V-01). After removing the towel, the crew found water leakage from around the MRA vents because their plastic caps were only finger tight. The crew replaced the MRA with a spare and no leakage was reported. Postflight testing showed no leaks and the anomaly was closed as an unexplained condition.

At various times during this mission, the ground controller observed a pink and/or blue hue on over-bright areas of the video image downlinked from the Shuttle Remote Manipulator System (SRMS) elbow camera (IFA STS-127-V-02). This generally occurs when there are clouds or white areas with sun reflection. This condition was noted numerous times during the mission, and was observed on both the analog (Ku-Band) and digital (S-Band) downlinks. The crew can see this on the onboard monitors and it is also visible in the International Space Station downlink when that camera is routed over to Station via the Orbiter Docking System interface on channel 71. This camera had a modification (delay line module bypass kit) to correct a previous hue problem. As a part of this repair, the peak white level setting was adjusted higher than the other Color Television Cameras (CTVCs) have been adjusted. Vender testing showed this condition was caused by a level-adjustment, which was corrected.

At the end of the second EVA, the EV-3 crewmember reported that communications were lost in the left ear, but the communications were satisfactory in the right ear. The crewmember reported that communications were fully recovered in the left earpiece after airlock repressurization (IFA STS-127-V-06). Since the unit recovered during repressurization, it was unclear if this was a Moisture Barrier Earphone Diaphragm (MBED) problem or earphone receiver problem. Photographs taken after the EVA showed perspiration in both Communications Carrier Assembly (CCA) ear cups, and the MBED did not show signs of lifting or loss of adhesion. This communication cap was designated as a backup for the remainder of the EVAs. The CCA was returned to Johnson Space Center (JSC) for analysis to determine the cause of the anomaly. This condition was not repeated during postflight acceptance testing.

During entry preparations, the crew reported that Headset Interface Unit (HIU) at the Pilot-position was failed (IFA STS-127-V-09). The crew replaced the failed unit with a spare HIU. Postflight testing at JSC identified an intermittent failure in the wire harness, which was replaced.

POST-LAUNCH PAD INSPECTION

The post launch inspection of Launch Pad A, Fixed Service Structure (FSS), Pad Apron and Main Launch Platform (MLP) -3 was conducted on July 15, 2009, from 1955 to 2205 EDT. The inspection proceeded relatively quickly while Safing Teams secured the Pad. The entire PAD, FSS and MLP were inspected. Due to lighting conditions, the infield and perimeter will be inspected during daylight hours. No flight hardware was found. The most substantial non-flight hardware issue noted is the Fondue Fyre liberation from the North Solid Rocket Booster (SRB) flame-deflector and the resulting collateral damage to the (Liquid Oxygen (LO₂) Bridge Tower.

The Orbiter lift-off lateral acceleration data indicated a maximum of 0.07g. Hold-down stud hang-ups are typically noted with lateral accelerations above 0.19g.

The following inspection items reflect the post-launch condition of the SRB Hold-Down Posts (HDPs):

1. HDP no. 1 – The EA934 poured sidewalls were nominal with minor pitting in the Southwest, and Northeast sidewalls and some acceptable erosion was found on the Northwest edge. The Phenolic shim was nominal. Both firing lines were missing. No galling or chatter marks were noted in the chamfer of the thru hole and the stud was set down.
2. HDP no. 2 – The EA934 poured sidewalls were nominal with acceptable minor pitting on Northwest and Southwest sidewall. The Phenolic shim was nominal and one of the two firing lines was present and it measured 1 ft. Approximately 2-ft of the Range Safety System (RSS) cable remained past the tie off. No galling or chatter marks were noted in the chamfer of the thru hole and the stud was set down.
3. HDP no. 3 – This HDP showed nominal indications of erosion on the Room Temperature Vulcanizing (RTV) -coated blast shield with proper closure.
4. HDP no. 4 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.
5. HDP no. 5 – The EA934 poured sidewalls were nominal with minor acceptable pitting on the Southwest, and Northwest wall. The Phenolic shim was nominal. Both firing lines were missing. No galling or chatter marks were noted in the chamfer of the thru hole and the stud was set down.
6. HDP no. 6 – The EA934 poured sidewalls are nominal with several pits identified. The largest was measured 2 in. x ½-in.l, which is acceptable. The Phenolic shim was nominal. Both firing lines were removed. No galling or chatter marks were noted in the chamfer of the thru hole and stud was set down.
7. HDP no. 7 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.
8. HDP no. 8 – This HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure and the RSS cable was missing.

The following inspection items reflect the post-launch condition of the Gaseous Nitrogen (GN₂):

1. The Left-Hand (LH) probe was erect and slightly bent to the Southwest by 10 deg with no protective-tape layering present and thus, the braiding was fully exposed. No O-ring was present. As a result, an investigation was performed to determine if any protective-tape-layering was applied.
2. The Right-Hand (RH) probe was erect and slightly bent to the Southeast by 10 deg with protective-tape layering remaining with no exposed braiding. No O-ring was present.

The following inspection items reflect the post-launch condition of the SRB T-0 Ground Carrier Assemblies (GCAs):

1. The LH SRB T-0 GCAs appeared to be in nominal condition with proper demate. However, the housing of four GCAs had broken sidewalls.
2. The RH SRB T-0 GCAs appeared to be in nominal condition with proper demate. However, the housing of four of the GCAs had broken sidewalls.

An inspection of both the LO₂ and LH₂ Tail Service Masts (TSMs) showed the TSMs to be undamaged and both bonnets appeared to have closed properly.

An inspection of the MLP Deck showed the deck to be in nominal condition with typical blast erosion in and around the SRB flame holes.

The Inspection of the Orbiter Access Arm (OAA) at the 195-ft level showed that the OAA was retracted and secured with no apparent damage. Also, the slide wire baskets were still at the 195-ft level with no evidence of damage.

The following inspection items reflect the post-launch condition of the GH₂ vent line on the Ground Umbilical Carrier Plate (GUCP) at the 215-ft level.

1. The GUCP was latched on the sixth tooth of eight on the latching mechanism.
2. The vent line had a full South bias and appeared to have contacted the left gimbal strut. It was South of the center in the latching mechanism as seen from the FSS.
3. The External Tank (ET) GUCP 7-inch GH₂ Quick-Disconnect probe was accessible for inspection and appeared to be undamaged.
4. Both the Quick Disconnect (QD) probe sealing surface and the poppet valve assembly were in good condition.
5. The ET GUCP exhibited less than typical blast damage and the pyrotechnic bolt fired nominally.
6. Four -ft of the flexible hose aluminized blanket was destroyed.
7. The vacuum-jacketed line was scorched.
8. Special attention was focused on the GUCP Left and Right leg pivot assemblies that exhibited nominal separation and deceleration cycle with no apparent damage.

The following inspection items reflect the post-launch condition of the Gaseous Oxygen (GOX) vent-arm inspection at the 255-ft level.

1. The GOX vent arm and hood appeared undamaged.
2. The RH side vent flexible-duct aluminized blanket was torn.
3. The hood windows and purge ducts appeared to be in nominal condition and the latch mechanism locked properly.

The following inspection items reflect the post-launch condition of the Pad Facility.

1. Pad A appeared to be in very good condition, and exceptionally clean.
2. The Facility experienced some damage due to liberated Fondue Fyre:
 - a. Damage to structural I-beam was observed on the LO₂ bridge tower.
 - b. Impact marks were present under the MLP deck possibly from Fondue Fyre.
 - c. Facility hand rail appeared bent possibly from Fondue Fyre.

The North SRB Flame Trench Inspection showed off-nominal erosion with Fondue Fyre. The damage appeared to be 3-ft by 4-ft by 8 in. and appeared to be near an existing repair.

Debris that was found during the inspection was as follows:

1. Minor pieces of SRB throat plug material were found on the PAD surface.
2. Large pieces of Fondue Fyre were found on both East and West Pad surface.
3. MLP deck level – LH MLP SRB flame hole water baggie was still tied.
4. MLP deck level – E-01(NE) camera lens appeared destroyed.
5. MLP deck level – Grommet from aluminized blanket was found on GH₂ vent-line.
6. MLP deck level – Scale was found by the North Rain Bird.
7. MLP deck level – Typical SRB slag was found.
8. 75-ft level – Rubber Seal/Gasket.
9. 95-ft level – One piece of rust scale.
10. 95-ft level – Light Bulb and cover missing
11. 115-ft level – Scale was found on the Orbiter Work Platform girder
12. 115-ft level – Rubberized paint
13. 115-ft level – Scale was found by the elevators
14. 175-ft level – ¼-in. nut and bolt assembly was found
15. 203-ft level – Rust scale was found on stair-well landing
16. 203-ft.level – 1-in. by 8-in. piece of angle iron was found on stairwell landing
17. 203-ft level – Scale was found on the ET/Intertank platform
18. 275-ft level – Missing J-bolt
19. North SRB Flame Trench – Insulated copper strand wire was found measuring 5-in.

LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

VEHICLE OBSERVATIONS

The launch photography provided data for the evaluation by the Debris Assessment Team to determine the condition of the Thermal Protection System (TPS). All of the observations have been analyzed and have been closed.

At minus 7.989 sec, a water leak in the sound suppression water system was observed.

At minus 3.371 sec, rust was observed falling from the South side of LH₂ Tail Service Mast (TSM).

At minus 2.071 sec, a piece of plastic was observed falling from the LH₂ TSM near the TSM door sill.

At 0.2 to 3.5 sec Mission Elapsed Time (MET), multiple pieces of debris are seen emanating from under the Main Launch Platform (MLP) during lift-off.

At 0.718 sec MET, water bag debris was noted rising above the MLP at Reusable Solid Rocket Booster (RSRB) ignition.

At 1.151 sec MET, pad debris, possibly water baggy rope, is observed striking the RSRB nozzle extension. The debris emanates from the flame hole. No damage was identified.

At 1.244 MET, a light colored rope-like object was noted bouncing on the Main Launch Platform (MLP) deck.

At 1.254 sec MET a swinging cable was noted Inside of LO₂ TSM.

At 4.613 sec MET, facility debris that may be larger than acceptable was observed before the tower was cleared by the vehicle.

At 9.3 sec MET, several areas of paint liberation were observed on localized areas of the Fixed Service Structure (FSS) during lift-off with some pieces appearing to be larger than the allowable for this condition.

At 13.142 sec MET – The Tyvek cover from the F4R thruster released slightly late, based on the 13-sec cut-off. The cover falls aft over starboard wing and clears the vehicle. The entire Tyvek cover released as one piece.

At 34.795 MET, a dark area was noted on the hot wall of Space Shuttle Main Engine (SSME) no. 2.

At 40.5 sec MET, possible debris was released outboard of LO₂ feedline-aft of camera but forward of the Xt 1129 bracket.

At 49.707 sec MET, debris is observed emanating from the LO₂ feedline at approximately Xt 1399.

At approximately 59 sec MET, External Tank (ET) TPS was released from the Ice/Frost Ramp (IFR) no. 1464, and no vehicle impact was observed.

At 101.47 sec MET a Thermal Protection System (TPS) loss from the External Tank (ET) on the outboard side of the LO₂ feedline bellows at approximately Xt 1106. The loss is classified as a small popcorn-type loss.

At 101.5 MET, ET TPS loss was noted on the +Y side of the Liquid Oxygen (LO₂) feedline. This was a small "popcorn" loss, and no vehicle impact was identified.

At 103.3 sec MET, multiple pieces of debris (believed to be ET TPS) were first seen outboard of the LO₂ feedline and forward of the LH₂ inter-tank flange. The debris fell aft and up towards the Orbiter fuselage. No Orbiter impacts were identified, but the view was washed out along the starboard fuselage and starboard wing.

At 106.2 MET, debris (probably ET TPS) was observed falling aft along the LO₂ feedline and impacting the outboard side of the LO₂ feedline near Xt 1151, causing a divot in the TPS.

At 106.3 MET, a large spray (believed to be ET TPS) was seen outboard of the LO₂ feedline and forward of the Liquid Hydrogen (LH₂) intertank flange. The debris spray appears to impact the Orbiter fuselage given the appearance of approximately three light-spots identified on the Orbiter fuselage. Imagery taken during the R-Bar Pitch Maneuver (RPM) verified damage to the Orbiter's tile.

At 106.5 sec MET, a large spray (believed to be ET TPS) is first seen outboard of the LO₂ feedline and forward of the LH₂ inter-tank flange. The debris spray appears to impact the underside of the Orbiter forward fuselage. At least three residual features can be seen on the tile following the debris spray. The debris spray then appears to travel aft along the Orbiter fuselage. This ascent imagery debris is a possible correlation to the Wing Leading Edge Impact Detection System (WLEIDS) indication at the starboard chine that was reported at 106.5 sec MET and starboard panel 9 that was reported at 106.6 sec MET.

At 109.4 sec MET, multiple pieces of debris (believed to be ET TPS) were first seen outboard of the LO₂ feedline and forward of the LH₂ intertank flange. The debris falls aft and up towards the Orbiter fuselage. No Orbiter impacts were identified but the view was washed out along the starboard fuselage and starboard wing.

At approximately 115.2 sec MET, a single piece of debris was seen falling aft and potentially striking the Orbiter on the starboard side, outboard of External Tank/Orbiter (EO) 1 attachment point.

At approximately 118 to 530 sec MET, red and white flexible material was visible between the -Z/-Y (back side) of the LH₂ umbilical and the LH₂ electric cable tray.

At 120 sec MET, debris passes through field-of-view with respect to starboard aft pointing Solid Rocket Booster (SRB) camera, and passes over the starboard wing. The debris first appeared near LH₂ intertank flange on the +Y side of the ET near the SRB. No vehicle impact was observed.

At 121.0 sec MET, at least two pieces of debris above and outboard of the starboard wing that were in the Field of View (FOV) appear to fall aft over the starboard wing. No impact to the Orbiter was noted.

At 122.8 sec MET, a single piece of debris was first seen outboard of the Orbiter starboard fuselage and was travelling aft along the fuselage. No impact to the Orbiter was noted; however, the view was washed out along the starboard fuselage and starboard wing.

At approximately 125 sec MET, a single piece of debris was first seen near the Orbiter fuselage and the debris fell outboard and aft of the port wing. No vehicle contact was noted.

At approximately 126 sec MET, debris was observed falling from the LO₂ tank region.

At 126.4 sec MET, a single piece of debris was first seen near the port bipod foot and it was falling outboard and aft. No impact to the vehicle was noted.

At 126.5 sec MET, several pieces of debris were first seen outboard of the Orbiter starboard fuselage travelling aft over the wing. No impact to the vehicle was noted; however, the view is washed out along the starboard fuselage and starboard wing.

At approximately 127 sec MET, debris (believed to be ET TPS) emanated from the -Y bipod attach area and impacted the left SRB above the External Tank Attachment (ETA) ring/Integrated Electronics Assembly (IEA) after SRB separation.

At 132.9 sec MET, debris was observed entering the FOV from forward of the ET camera and inboard of the LO₂ feedline.

At 134.1 sec MET, debris, potentially ET TPS, was released inboard of the LO₂ feedline near the ET camera and fell aft from inboard of the LO₂ feedline.

At 134.8 sec MET, a single piece of debris was first observed outboard of the LO₂ feedline between approximately Xt locations 1204 to 1269. The debris falls aft under the wing and no impact to the vehicle was noted.

At approximately 137.9 sec MET, a spray of debris was observed falling aft from outboard of the LO₂ feedline aft of Xt 1205 Ice Frost Ramp (IFR).

At 158.0 sec MET, debris was observed from aft of bipod and inboard of LO₂ feedline.

At approximately 165.8 sec MET, a single piece of debris was first observed aft of the port bipod foot. The debris travelled up toward the Orbiter fuselage and is then seen aft of the bipod travelling down towards the ET. The debris then travels up towards the Orbiter belly and appears to impact the vehicle and then fall aft.

At approximately 375.8 sec MET, multiple pieces of debris were observed falling aft during the "roll to heads up" maneuver. The debris emanates from forward of the ET camera and inboard of LO₂ feedline. Some of the debris appears to impact the ET between the bipod legs, and some appears to rebound off the ET to impact the Orbiter. The debris appears to be rectangular in shape.

At 400.7 sec MET, multiple pieces of debris are first seen between the ET and Orbiter as the debris travelled into the FOV. The debris probably impacted the vehicle. No vehicle damage was noted.

At approximately 526 sec MET, unidentified linear-shaped debris travelled from the +Y side of the view and moved in the -Y direction across the field of view. Two smaller similar-colored pieces of debris were visible following the same trajectory as the linear-shaped debris. No vehicle contact was noted.

The following items are not designated by MET as the release time is unknown. As a result of the many of these observations were well outside the experience for a flight.

1. Loss of ET TPS from LO₂ Ice Frost Ramp at approximately Xt 718.
2. Missing ET TPS on the forward section of the Intertank IFR 949 on the inboard side of the Gaseous Oxygen (GO₂) pressure line.
3. Loss of ET TPS on Intertank acreage stringer bipod closeout in the +Z quadrant, Xt 1029 (Panel 1).
4. Missing piece of TPS identified inboard of LO₂ feedline fairing on Intertank acreage +Z quadrant (Xt 1030).
5. Missing piece of TPS identified inboard forward of bipod identified from crew hand-held imagery (Xt 1041).
6. Missing piece of TPS on Intertank acreage stringer forward of bipod at the +Z quadrant at Xt 1045.
7. Missing TPS on Intertank acreage stringer forward of the port bipod closeout on the +Z quadrant at Xt 1068.
8. Missing TPS on Intertank acreage liberated following ET separation and the pitch Maneuver (Xt 985)

9. Missing ET TPS on Intertank acreage at approximately Xt 980 on the +Z+Y quadrant.
10. Missing ET TPS on Intertank acreage at approximately Xt 990 on the +Z+Y quadrant.
11. Missing ET TPS on Intertank acreage at approximately Xt 1017 on the +Z+Y quadrant.
12. Missing ET TPS on Intertank acreage at approximately Xt 1020 on the +Z+Y quadrant.
13. Missing ET TPS on Intertank acreage at approximately Xt 1034 on the +Z+Y quadrant.
14. Missing ET TPS on Intertank acreage at approximately Xt 1063 on the +Z+Y quadrant.
15. Missing ET TPS on LH₂ Intertank Flange at ~Xt 1123. (Location approximately at 310 deg and 285 deg).
16. Three missing pieces of ET TPS were identified on outboard aft section of port bipod closeout at Xt 1129.
17. Missing pieces of ET TPS noted on IFR 1399.
18. Missing pieces of ET TPS on starboard Thrust Strut at approximately Xt 1916.
19. Missing pieces of ET TPS on starboard Thrust Strut at approximately Xt 1929.
20. Missing pieces of ET TPS on starboard Thrust Strut at approximately Xt 1936.
21. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1079. The loss was well outside of the experience base.
22. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1079. The loss was well outside of the experience base.
23. Four missing pieces of ET TPS noted on -Z side of the ET at Xt 1063. The loss was well outside of the experience base.
24. Two missing pieces of ET TPS noted on -Z side of the ET at Xt 1064. The loss was well outside of the experience base.
25. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1079. The loss was well outside of the experience base.
26. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1060. The loss was well outside of the experience base.
27. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1041. The loss was well outside of the experience base.
28. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1023. The loss was well outside of the experience base.
29. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1056. The loss was well outside of the experience base.
30. Missing pieces of ET TPS noted on -Z side of the ET at Xt 968. The loss was well outside of the experience base.
31. Two missing pieces of ET TPS noted on -Z side of the ET at Xt 961. The loss was well outside of the experience base.
32. Missing pieces of ET TPS noted on -Z side of the ET at Xt 931. The loss was well outside of the experience base.
33. Missing pieces of ET TPS noted on -Z side of the ET at Xt 1067. The loss was well outside of the experience base.

34. Missing pieces of ET TPS noted on –Z side of the ET at Xt 904. The loss was well outside of the experience base.
35. Missing pieces of ET TPS noted on –Z side of the ET at Xt 913. The loss was well outside of the experience base.
36. Missing pieces of ET TPS noted on –Z side of the ET at Xt 967. The loss was well outside of the experience base.
37. Missing pieces of ET TPS noted on –Z side of the ET at Xt 1021. The loss was well outside of the experience base.
38. Missing pieces of ET TPS noted on –Z side of the ET at Xt 918. The loss was well outside of the experience base.
39. Missing pieces of ET TPS noted on –Z side of the ET at Xt 877. The loss was well outside of the experience base.
40. Missing pieces of ET TPS noted on –Z side of the ET at Xt 965. The loss was well outside of the experience base.

LAUNCH PAD OBSERVATIONS

During the lift-off at 9.3 sec MET, paint was liberated from the Fixed Service Structure (FSS). Several areas of paint liberation were observed on localized areas of the FSS during liftoff with some pieces appearing to be larger than a "quarter".

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APPENDIX A

STS-127 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	196/21:58:24.506 196/21:58:24.540 196/21:58:24.713
SRB HPU Activation	LH HPU System A Start Command LH HPU System B Start Command RH HPU System A Start Command RH HPU System B Start Command	196/22:02:42.064 196/22:02:42.264 196/22:02:42.424 196/22:02:42.584
Main Engine Start	SSME-3 Start Command Accepted SSME-2 Start Command Accepted SSME-1 Start Command Accepted	196/22:03:03.424 196/22:03:03.548 196/22:03:03.678
SRB Ignition	SRB Ignition Command	196/22:03:09.984
Throttle Up 104.5 Percent	SSME-2 Command Accepted SSME-1 Command Accepted SSME-3 Command Accepted	196/22:03:13.825 196/22:03:13.834 196/22:03:13.860
Throttle Down to 99 Percent	SSME-2 Command Accepted SSME-1 Command Accepted SSME-3 Command Accepted	196/22:03:27.745 196/22:03:27.755 196/22:03:27.781
Throttle Down to 72 Percent	SSME-2 Command Accepted SSME-1 Command Accepted SSME-3 Command Accepted	196/22:03:49.986 196/22:03:49.995 196/22:03:50.021
Maximum Dynamic Pressure (Max Q)	Derived Ascent Dynamic Pressure	196/22:04:00
Throttle Up to 104.5 Percent	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	196/22:04:04.382 196/22:04:04.386 196/22:04:04.395
Both SRMs at 50 psi	RH SRM Chamber Pressure LH SRM Chamber Pressure	196/22:05:08.384 196/22:05:09.544
End SRM Action	RH SRM Chamber Pressure LH SRM Chamber Pressure	196/22:05:10.684 196/22:05:11.484
SRB Separation Command	SRB Separation Command Flag	196/22:05:13
SRB Physical Separation	LH APU A Turbine Loss of Signal RH APU B Turbine Loss of Signal LH APU B Turbine Loss of Signal RH APU A Turbine Loss of Signal	196/22:05:13.864 196/22:05:13.864 196/22:05:13.904 196/22:05:13.904
OMS Assist Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	196/22:05:24.1 196/22:05:24.2
OMS Assist Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	196/22:06:35.6 196/22:06:35.7
Throttle Down for 3g	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	196/22:10:33.031 196/22:10:33.034 196/22:10:33.044
3G Acceleration	Total Load Factor (g)	196/22:11:17.1
Throttle down to 67 percent for Cutoff	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	196/22:11:28.073 196/22:11:28.075 196/22:11:28.085
SSME Shutdown	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	196/22:11:34.473 196/22:11:34.475 196/22:11:34.485
Main Engine Cutoff (MECO)	MECO Command Flag MECO Confirmed Flag	196/22:11:34 196/22:11:36

APPENDIX A

STS-127 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
ET Separation	ET Separation Command Flag	196/22:11:56
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	196/22:19:29.676 196/22:19:47.720 196/22:20:02.873
OMS 1 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	Not Required
OMS 1 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	Not Required
OMS 2 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	196/22:41:40.1 196/22:41:40.2
OMS 2 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	196/22:42:43.8 196/22:42:43.9
Payload Bay Doors Open	Right Payload Bay Door Open 1 Left Payload Bay Door Open 1	196/23:35:25 196/23:36:46
OMS 3 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	197/01:47:38.6 197/01:47:38.8
OMS 3 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	197/01:47:59.4 197/01:47:59.4
OMS 4 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	197/14:54:09.0
OMS 4 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	197/14:54:19.6
OMS 5 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/13:00:17.2 198/13:00:17.2
OMS 5 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/13:01:54.6 198/13:01:54.6
OMS 6 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/13:45:32.2 198/13:45:32.2
OMS 6 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/13:46:28.2 198/13:46:28.2
OMS 7 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/15:17:26.2
OMS 7 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	198/15:17:38.6
Docking	Capture	198/17:47:06
Undocking	Undocking Complete	209/17:25:56
OMS 8 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	210/17:28:43.2 210/17:28:43.2
OMS 8 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	210/17:28:53.2 210/17:28:53.2
OMS 9 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	210/20:12:10.2
OMS 9 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	210/20:12:22.4
Flight Control System Checkout – APU 1 Start	APU-1 Gas Generator Chamber Pressure	211/09:26:57.636
APU 1 Stop	APU-1 Gas Generator Chamber Pressure	211/09:32:35.446
OMS 10 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	211/11:03:49.0 211/11:03:49.2

APPENDIX A
STS-127 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
OMS 10 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	211/11:03:59.2 211/11:03:59.2
Payload Bay Door Close	Left Payload Bay Door Close Right Payload Bay door Close	212/10:59:48 212/11:01:41
APU Activation	APU-2 Gas Generator Chamber Pressure APU-1 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	212/13:36:17.970 212/14:03:33.236 212/14:03:37.493
Deorbit Maneuver Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	212/13:41:10.1 212/13:41:10.1
Deorbit Maneuver Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	212/13:44:01.7 212/13:44:01.7
Entry Interface	Orbital Altitude Referenced to Ellipsoid	212/14:16:31
Blackout End	Data Locked (High Sample Rate)	NO BLACKOUT
Terminal Area Energy Management (TAEM)	Major Mode Code (305)	212/14:41:46
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure Main Landing Gear Right Hand Tire Pressure	212/14:48:07 212/14:48:09
Main Landing Gear Weight on Wheels	Main Landing Gear Right-Hand Weight on Wheels Main Landing Gear Left Hand Weight on Wheels	212/14:48:10 212/14:48:13
Drag Chute Deployment	Drag Chute Deploy 1 CP Volts	212/14:48:12.8
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	212/14:48:20
Nose Landing Gear Weight on Wheels	Nose Landing Gear Weight on Wheels	212/14:48:20
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	212/14:48:51.5
Wheels Stop	Velocity with respect to Runway	212/14:49:13
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	212/15:03:42.156 212/15:03:54.800 212/15:04:08.003

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-127 mission.

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

APPENDIX B IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-127-V-01	Microbial Removal Assembly Leak	<p>Upon installation of the Galley Iodine Removal Assembly (GIRA), the crew reported that the towel around the Microbial Removal Assembly (MRA) was wet. After removing the towel, water leakage was found from around the MRA vents because their plastic caps were only finger tight. The crew replaced the leaking MRA with a spare and no further leakage was reported.</p> <p>Post-Flight Action: The GIRA (S/N 1013) was returned and tested at the Flight Crew Equipment (FCE) JSC facility. Testing did not reproduce any leakage from the unit. The team closed the anomaly as an unexplained condition.</p>
STS-127-V-02	RMS Elbow Camera Pink and Blue Hues in Over-bright Images	<p>At various times during this mission, the Ground Controllers observed a pink and/or blue hue on over-bright areas of the video image downlinked from the Shuttle Remote Manipulator System (SRMS) elbow camera. This generally occurred when there were clouds or white areas with sun reflection, and this condition was noted numerous times during the mission whenever the elbow camera was used. This condition was been observed on both the analog (Ku Band) and digital (S- Band) downlinks. The crew observed this condition on the onboard monitors and it was also visible in the International Space Station (ISS) downlink when that camera was routed over to the ISS via the Orbiter Docking System (ODS) interface. The Color TV Camera (CTVC) does not have a peak white-clip circuit for saturated scenes nor does the Closed Circuit TV (CCTV) Video Switching Unit. However, since no other CTVC onboard is exhibiting this condition, the camera may well be adjusted to a somewhat higher-peak-white-level than the other cameras. This camera was last flown on the STS-118 when it developed a magenta hue. The fix for that problem was to install a delay-line-module bypass kit. Possibly as part of this repair, the peak-white level setting was adjusted to a higher value than the other CTVCs had been adjusted.</p> <p>Post-flight Action: The camera is a newly certified -507 CTVC configuration which had the "delay line module bypass kit" installed to resolve a previous flight problem on STS-118. STS-127 was the first use of the -507. The camera was returned to the vendor who confirmed that this is a level adjustment problem and not a failed component problem. The camera has been adjusted and is now in final acceptance testing for return to inventory for subsequent flight use as needed.</p>

APPENDIX B IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-127-V-03	TPS Anomalies	<p>A complete listing of the Thermal Protection System (TPS) Tile, Blanket, and Reinforced Carbon-Carbon (RCC) Regions of Interest (ROI) evaluated by the Tile and RCC Damage Assessment Teams (DAT) are documented in the TPS Imagery Inspection Management System (TIIMS) Database.</p> <p>No focused inspection was required based on the data available from Flight Day (FD) 3 R-Bar Pitch Maneuver (RPM) images and FD 2 inspections.</p> <p>The following 7 items required additional analysis:</p> <ol style="list-style-type: none"> 1. Lower Nose Fuselage: Tile substrate exposed just outboard of the starboard outboard corner of Nose Landing Gear Door (NLGD). The angle between the damage axis and x-axis is 24.5 deg. Photogrammetry depth was estimated to be 0.1 +0.1/-0.05 in. 2. Lower Forward Fuselage: Tile substrate exposed tile is slightly aft and outboard of starboard aft corner of NLGD. The angle between the damage axis and x axis is 5 deg. Photogrammetry estimated depth to be 0.35 +/- 0.1 in. 3. Lower Forward Fuselage: The most-outboard cavity in 4-cavity cluster, which is aft and outboard of starboard aft corner of NLGD. The angle between the damage axis and x axis is 56 deg. Photogrammetry estimates depth to be less than 0.1 in. 4. Lower Forward Fuselage: Inboard-most cavity of 2-cavity cluster that is aft and outboard of starboard aft corner of NLGD. The angle between damage axis and x axis is 71 deg. Photogrammetry estimates depth to be 0.35 +/- 0.1 in. 5. Lower Forward Fuselage: The most-inboard cavity in 4-cavity cluster, which are aft and outboard of starboard aft corner of NLGD. The angle between the damage axis and x axis is 77 deg. Photogrammetry estimates depth to be 0.15 +/- 0.1 in. 6. Lower Forward Fuselage: The second-most inboard cavity in 4 cavity cluster, labeled b in image. The cluster is aft and outboard of starboard aft corner of NLGD. The angle between the damage axis and vehicle axis is 70 deg. Photogrammetry estimates depth to be 0.15 +/- 0.1 in. 7. Lower Forward Fuselage: The third-most inboard cavity in 4 cavity cluster labeled c in image, and the cluster is aft and outboard of starboard aft corner of NLGD. The angle between the damage axis and x axis is 56 deg. Photogrammetry estimates depth to be 0.25 +/- 0.1 in. <p>Post-flight Action: Standard Post-flight inspections and all TPS anomalies have been repaired.</p>

APPENDIX B IN-FLIGHT ANOMALIES

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IFA Number	Title	Comments
STS-127-V-04	MADS Off-Nominal Measurement Signatures	<p>As part of the assessment of the downlinked ascent Modular Auxiliary Data System (MADS) Pulse Code Modulation (PCM) data, seven measurements were investigated as potential instrumentation anomalies. There was no impact to the mission.</p> <ol style="list-style-type: none"> 1. Three readings on the Mid-fuselage bottom panels – These readings were correlated with localized temperature sensors responding to a rapid localized cooling that has been seen on other vehicles/flights (OV-103: STS-70 and STS-114; OV-104: STS-30 and STS-115) and are considered an in-family response. 2. Two readings on the Xo1307 Left-Hand (LH) wing spar cap – These readings were inverted from what was expected. The preliminary assessment indicates that these are instrumentation errors given the nominal trajectory and the fact that other gages do not correlate the wing response that these readings indicate (anomalous bending of the wing). 3. Two readings on the Xo1191 RH wing spar web – These readings were indications of a potential blocked Main Landing Gear (MLG) compartment vent. Even though close-out photographs and all vent covers have been accounted for, the team performed a safety assessment of the blocked vent and found that the compartment can carry the increase in pressure. The team's preliminary assessment is that these two readings are most likely instrumentation errors. No single point failure could explain the Xo1307 and Xo1191 abnormal readings. <p>No single point failure could explain the Xo1307 and Xo1191 abnormal readings Post-Flight Action: Post-flight visual inspections of the sensors verified sensors and wire splices were properly installed. Wing glove inspection showed no evidence of vent blockage or loose objects. Continuity tests were performed with satisfactory results. The signal conditioners were re-calibrated. Anomalies traced to MADS PCM which was R&R.</p>

APPENDIX B IN-FLIGHT ANOMALIES

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IFA Number	Title	Comments
STS-127-V-05	Fuel Cell 3 Coolant Inlet Long Heater Cycle	<p>At 07/21:19:48 MET, the Fuel Cell 3 (FC 3) sustaining heater turned on when the FC stack-outlet temperature reached 185 °F, which was identical to previous sustaining heater cycles. The sustaining heater was expected to turn off when the FC stack-outlet temperature reached a value 2 °F higher than the "on" temperature, typically lasting 3 to 4 min on previous cycles. During this sustaining heater cycle, the FC stack-outlet temperature increased to 193 °F before the sustaining heater turned off at 07/21:41:12 MET, which was approximately 21 min after the heater turned on.</p> <p>To avoid any further FC 3 sustaining heater cycles, at 07/21:46:37 MET, the Main Bus C (MNC) bus-tie to Main Bus B (MNB) was taken off, resulting in higher loads and higher temperatures on FC 3. For the remainder of the mission, no sustaining heater cycles have occurred because the power levels have been between 90-110 Amperes (A), which kept the stack exit temperature at 190 to 194 °F.</p> <p>At 08/11:31:57 MET, the MNA was bus-tied to MNB to allow additional load sharing between the two busses and maximize Station to Shuttle Power Transfer System (SSPTS) power transfer. This was predicted to cost approximately 6 hr of non-SSPTS margin, but still ensured protection for a 16+2 day mission. If the sustaining heater were to fail-on for the remainder of the mission, the consumables impact would be about 10 hr, still allowing for a 16+2 day mission.</p> <p>Post-Flight Action: Documentation was issued against this anomaly, but there was no need for an Interim Problem Report (IPR). The Ground Operations at Kennedy Space Center (KSC) prepared procedures to perform in the event of a failed-on sustaining heater after landing. Fuel Cell 3 was already scheduled to be Removed and Replaced (R&R) due to the lack of available operating hours to complete another mission. Fuel Cell 3 was R&R due to expected exceeding operating hours. Failure analysis at vendor is on-going.</p>
STS-127-V-06	EV-3 Communications Cap Loss of Audio	<p>At 201:21:48 GMT, the EV-3 crewmember reported that he had lost communications in the left ear during the EVA. EV-3 also stated he had good communications in his right ear. The crewmember reported that communication was fully recovered in his left earpiece when he repressurized in the airlock. Since the unit recovered during repressurization, it is unclear if this is a Moisture Barrier Earphone Diaphragm (MBED) problem or earphone receiver problem. Post-EVA photography indicates perspiration in both CCA ear cups, but MBED did not show signs of lifting/loss of adhesion. Since the CCA earphone audio recovered, both the MBED and receivers are still suspect.</p> <p>Post-flight testing and troubleshooting were completed and CCA/CCEM S/N 1180 successfully passed post-flight acceptance testing.</p>

APPENDIX B IN-FLIGHT ANOMALIES

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IFA Number	Title	Comments
STS-127-V-07	FRCS F2F Thruster Failed Off During RCS Hotfire	<p>During the RCS Hot-Fire test, Forward Reaction Control System (FRCS) thruster F2F exhibited low chamber pressure (Pc) of approximately 16 psi. The thruster was declared failed-off and automatically deselected by RCS Redundancy Management (RM) at 211/08:48:50 GMT (14/10:45:40 MET). This was the first time this third-priority thruster fired during the mission. The Pc was 16% while injector temperatures showed good propellant flow and soakback. Ground personnel believed satisfactory rates indicating a good thruster firing, which would mean that the RM fail was caused by a bad Pc transducer or a Pc tube blockage due to Fuel-Oxidizer Reaction Products (FORP). The thruster was automatically deselected by RM and the mission will not be impacted by the loss of this thruster. This thruster had a good Hot Fire on STS-123, which was the last time this thruster was fired. The thruster has had about 125 pulses (was second-priority on STS-118 and STS-123) since the last time the thruster was flushed (2005).</p> <p>Post Flight Action: FRCS module was removed and the thruster R&R'. Electrical checks of MDM and signal conditioner found no pressure measurement instrumentation anomalies. White Sands Test Facility (WSTF) checkout duplicated flight signature and showed the cause was Pc sensor tube blockage. WSTF extracted a small piece of RTV lodged in Pc tube. The RTV is consistent with that used for installing Tyvek rain covers. Tyvek cover R&R procedure will be updated to install throat plugs in forward-firing thrusters prior to RTV removal if cover changeout required.</p>
STS-127-V-08	LH ₂ Inboard ET Pyrotechnic Canister Crack in Foam TPS	<p>During the Final Inspection Team walkdown, frost was noted on the LH₂ inboard pyrotechnic canister. Upon closer inspection, a crack was noted. An evaluation determined that while the frost was acceptable, the crack was not addressed and thus an MR was drafted to accept the crack as-is. This was due to stress from multiple cryogenic-cycles.</p> <p>Localized cracks in thick TPS (foam) applications such as the LH₂ Pyrotechnic canister are common when thermal stressing is induced by the loading of cryogenic propellants. On-site observations by the final inspection team show that this crack does not have any offset and no evidence of cryo-pumping. The defect has shown to be stable in size shape and character for the extent of the loading. Cracks of this type are due to outer fiber strain and are not indicative of dislodged foam which could become a debris concern. Only frost has been built up as a result of this defect and frost in any degree does not exceed NSTS-08303 allowances.</p> <p>Post Flight Action: Reviewed all available photographs and data to help further characterize the anomaly. Reviewed drawing requirements regarding acceptability of material defects. Reviewed foam installation paper and ensured there were no disconnects from drawing requirements. Updated to NSTS 08303 Ice/Debris Inspection Criteria to address foam cracking in this location (with supporting rationale).</p>

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IFA Number	Title	Comments
STS-127-V-09	Failed Headset Interface Unit (HIU)	<p>At 212/12:20 GMT, the crew reported that the Pilot's HIU had failed. They also reported it worked fine during ascent. The crew found a spare HIU for the Pilot's use. The crew replaced the failed HIU (with spare and reported no further problems with Pilot's communications.</p> <p>Post Flight Action: Troubleshooting found intermittent failure on the wire harness when cable flexed. The cable was removed and scrapped.</p>
STS-127-V-10	LO ₂ Flight Struts Installed In The Wrong Position	<p>During post flight removal, Two LO₂ Flight Struts were found in wrong positions. The Aft Strut was installed in the outboard position, and the Outboard (mid) Strut was installed in the aft position.</p> <p>The struts are designed to accommodate ET/Orbiter relative motion during boost and to stabilize/support Orbiter Main Propulsion System (MPS) valve cluster, lines and gimbals during and after umbilical separation.</p> <p>Post Flight Action: The OV-103 configuration was verified and found to be per print. A process escape review will be conducted to identify the root cause and prevent a repeat of this condition.</p>

APPENDIX B IN-FLIGHT ANOMALIES

REUSABLE SOLID ROCKET BOOSTER ANOMALIES

IFA Number	Title	Comments
STS-127-B-001	Top Layers if MSFC Convergent Coating (MCC-1) Missing on the Aft Skirt TPS Acreage (Both Left- and Right- Hand) Post Flight of STS-127 SRB	<p>Cohesive loss of MCC-1 from the LH Aft Skirt TPS acreage at approximately 90 deg (+y axis), measuring 1.25 in² and ranging from 0.1 to 0.2 in. deep. The analysis indicates a post-separation time of occurrence.</p> <p>Cohesive loss of MCC-1 from the RH Aft Skirt TPS acreage in two locations, adjacent to the single Booster Separation Motor (BSM), measuring 2.0-in² by 0.2 in. deep and 1.7-in² by 0.2 in. deep. There have been no documented instances of failure between layers. The fracture surfaces were darkened. MCC-1 layers should be adhered in accordance with established NSTS documentation. An ascent time of occurrence could not be ruled out by the analysis.</p>
STS-127-B-002	Left-Hand SRB Enhanced Data Acquisition system (EDAS) Assembly Channel 4 Did Not Record Nominal Strain Response	<p>Left hand SRB EDAS channel 4 did not record nominal strain response. The recorded signal was a flat line after the first 3-4 seconds of signal conditioner start-up transients. Technicians discovered an open circuit between the strain gage and the strain gage signal conditioner. The Jiffy Pin on one of three strain gage pigtail wires (orange/white) was not locked into the J3 Jiffy Junction, which is one of four Jiffy Junctions connecting the strain gage to the strain gage signal conditioner. This condition creates an off-scale high (+5VDC) input into the signal conditioner causing initial filter settling and subsequent flat response seen in the recorded data for channel 4.</p> <p>EDAS preflight testing and initialization procedures for BI139 and BI140 (the last two EDAS flights) have been changed to incorporate resistance and voltage measurements at each strain gage signal conditioner bridge cal header to confirm proper connections between the gage and its signal conditioner, as well as, gage excitation. These procedures have also been clarified to perform strain module liveliness testing in a manner to excite the strain bridge in both polarities. Preflight liveliness testing will be recorded during initialization RODS (previously viewed real-time) to provide a record of preflight liveliness response.</p>

APPENDIX B IN-FLIGHT ANOMALIES

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-127-T-001	LH ₂ Vent Valve Was Opened and LD23 and LD 25 Leak Detectors Went Off-Scale (> 60,000 ppm)	<p>While fueling for initial launch attempt of STS-127/ET-131, during the transition from LH₂ fast-fill reduced to topping, the LH₂ vent valve was opened and the LD23 and LD25 leak detectors went off-scale high (>60K ppm). The vent valve was cycled open and closed (4 times) and each time the valve opened, the hydrogen leakage again repeated off-scale high for 4 cycles. Launch scrub was called due to violation of the Launch Commit Criteria (LCC) limit of 40,000 ppm</p> <p>Following the initial launch scrub, the RG42521 seal and Quick Disconnect were both replaced. As a result of the ongoing alignment problem, the decision was made to shave the right-hand side of left foot and add 0 .030-in thickness shim to right-hand pivot assembly.</p> <p>Prior to the transition from LH₂ Topping to Replenish during t second launch attempt, the LD23 and LD25 leak detectors indicated an increasing amount of leakage during vent valve cycling. This condition has not been observed in any previous loadings. The leakage maintained an approx. 10-12000 ppm indication. During the transition from topping to replenish, as the vent valve opened, the GH₂ leakage reached approximately. 60000 ppm. Troubleshooting continued, and the valve was cycled at least 8-10 more times. During troubleshooting, the leakage indication spiked and violated the HAZ-09 LCC limit. A second launch scrub was called as a result of the GH₂ leakage.</p> <p>The following actions were taken to overcome the alignment problem:</p> <ol style="list-style-type: none"> 1. Teams were formed to evaluate the seal design, material properties and to perform high-fidelity testing of the assembly. 2. Measurements taken prior to Quick Disconnect (QD) disassembly. 3. Evaluation of measurements was performed, recommendation to revert to 2-piece seal design (previously flown on STS-116 and STS-117 missions). 4. QD reassembled with 2-piece seal, which was authorized by Field Engineering Change KET-0098. 5. Ground Umbilical Carrier Plate (GUCP) feet were redesigned to move pivot point to fit brackets (based on optical measurements of actual bracket locations), which were authorized by the MRB disposition per KSC Action Request K09044. 6. Shims (washers) were added to reduce gaps on each side of pivot pin assemblies and maintain alignment, which was authorized by MRB disposition per KSC Action Request K09044 <p>A successful tanking test was performed, and there was no leakage evident during the tanking test, the two launch scrubs and the launch.</p>

APPENDIX B IN-FLIGHT ANOMALIES

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-127-T-002	Post-Launch Camera and Film Review Showed Loss of Foam in the Aft Inboard Corner of the LO ₂ ICE-Frost Ramp at Station 718	<p>Post-launch camera and film review showed loss of foam in the Aft Inboard Corner of the LO₂ Ice-Frost Ramp (IFR) at Station 718. The dimensions of the foam loss event are 7.2-in. by 5.1-in. with a total mass of approximately 0.044 lb_m. The current requirements for NSTS documentation are 0.020-lb_m less than or equal up to 135 sec or at greater than 135 sec</p> <p>LESS THAN OR EQUAL TO 135 seconds: 0.020 lb_m and 0.051 lb_m for greater than 135 sec. The timing of this loss is unknown and cannot be determined for the film or photographs. Consequently, this loss may have violated the NSTS documentation. The most probable cause for the observed foam loss from the XT 718 LO₂ IFR forward, outboard face is the interaction of void-differential pressure, pop-corning, and erosion/recession effects. The liberation of foam is believed to have occurred in multiple pieces. The material loss did not exceed the maximum expected loss as provided by Lockheed Martin to SE&I. The cumulative loss mass did not exceed the risk assessment mass defined in NSTS documentation.</p>
STS-127-T-003	Post-Launch Camera and Film Review Showed Loss of Foam at Several Locations on the Intertank	<p>Post-launch camera and film review showed loss of foam at several locations on the Intertank (IT). A total of 38 Intertank foam losses were observed with the largest on Stringer 11 of panel 1 at Station 1052. The dimensions for this loss are approximately 34.7-in. in length by 5.2-in. wide by 0.6 in. deep, with a mass of 0.255lb_m (unknown if one piece). The most probable cause is a Void-delta pressure event occurring after the 135 sec MET Ascent Sensitive Transport Time (ASTT) with possible additional material liberation due to pop-corning and recession/erosion effects.</p> <p>Based on the events of STS-127/ET-131, a Seven Elements Risk Assessment tool was completed for the Intertank Acreage. It was determined that the risk associated with TPS debris above the maximum-expected debris masses for Cause 5 Automatic Sprayed Foam Application Deficiencies is subject to an increase in risk from the Remote-Catastrophic to Infrequent Catastrophic. The assessment tool was used as part of the Safety Issue Briefing to the ET Project and SSP for the IFAs on STS-127/ET-131. Hazard Report T.02 will be updated accordingly to reflect this increase in risk.</p> <p>Forty eight (48) bond adhesion tests were performed on the +Z side of the ET Intertank. Forty-seven of these tests failed cohesively and one failed adhesively. The adhesive failure pulled at 51.9 psi. Three (3) of the cohesive failures exhibited low cohesive strength values of 15.7, 20.1 and 23.8-psi. Additional tests were performed adjacent to the 3 low cohesive value test sites (within 2-in. of the initial test site on the same stringer), all resulting in high values of 80.7, 52.0 and 41.9 psi. The adhesion tests met the success criteria for ET-133.</p>

APPENDIX B IN-FLIGHT ANOMALIES

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-127-T-004	Post launch camera and film review revealed three losses of TPS material at the + Y and -Y Bipod Closeouts	<p>Post launch camera and film review revealed three losses of TPS material at the + Y and -Y Bipod Closeouts. The ET Camera, captured the TPS loss from the -Y Outboard Bipod that occurred at approximately 26 sec.</p> <p>Cryogen-Ingestion of LN₂ to a void formation through a leak path or through the wiring under the Bipod closeout, which allowed cryogenics to leak from the Intertank during tanking into a foam void (from processing) or a crack (formed by the multiple tankings).</p> <p>The dimensions of the foam loss event on the +Y Inboard Bipod Closeout were approximately 2.8-in. by 1.7-in. by 1.0-in. at the maximum, with a mass of 0.002 lbm.</p> <p>The dimensions of the foam loss event on the -Y Inboard Bipod Closeout are approximately : 5.6-in. by 4.4-in. by 1.6-in. at the maximum, with a mass of 0.012 lbm.</p> <p>Both of these foam losses were within the requirements of established documentation for debris losses.</p>

APPENDIX B IN-FLIGHT ANOMALIES

REUSABLE SOLID ROCKET MOTOR ANOMALIES

No RSRM in-flight anomalies were identified during the STS-127 mission.

APPENDIX B IN-FLIGHT ANOMALIES

SPACE SHUTTLE MAIN ENGINE ANOMALIES

No SSME in-flight anomalies were identified were the STS-127 mission.

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-127-I-001	Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Lift-off Debris)	Lift-off debris risk is currently characterized as infrequent, catastrophic due to significant limitations in controls and significant uncertainties in analysis. Debris release has been mitigated for identified potential sources of critical debris by removal of abandoned hardware, performing repairs, and adding inspections for system-level components (e.g. removal of abandoned 275-ft level nitrogen purge line, relocation of 95-ft level light fixture, and inspection of electrical cabinet handles). Ongoing mitigations include Foreign Object Damage (FOD) awareness, attrition-based removal of hardware, routine inspections and monitoring for facility corrosion. The recommendation was accepted and the IIFA was closed. Risk Assessment indicates that given the proposed mitigations, observed debris poses no appreciable increase in risk.
STS-127-I-002	Ice Internal and External to the LH ₂ T-0 Umbilical	Ice/frost build-up inside and outside the peripheral seal on the LH ₂ T-0 Umbilical Carrier Plate has been observed on three flights since STS-126. NSTS 08303 has no acceptable definition of ice/frost buildup on the Orbiter vehicle at this interface. Ice adherence to the Orbiter vehicle could lead to the release of unexpected debris that may cause critical Orbiter Thermal Protection System (TPS) damage during the ascent phase of the mission. An internal ice buildup would not be visible pre-launch during the final inspections, therefore, the corrective actions for this condition must preclude or minimize the propensity for ice accumulation internal to the peripheral seal. Ice external to the peripheral seal can be observed in the majority of areas around the seal by the final inspection team, which has lead to the acceptance of two preflight waivers to Launch Commit Criteria (LCC) ICE-01 for the observed conditions. A fault-tree assessment has identified proximate and intermediate causes with the leading theory being the cold cavity temperature in combination with low differential pressure to ambient, along with possible water intrusion from rain or condensation, allowing moisture intrusion into the umbilical cavity resulting in ice formation. Interior ice is mitigated by the enhanced processes for installation and verification of the peripheral seal for environmental conditions causes described on the fault tree. In the event ice/frost is observed external to the peripheral seal on STS-128, the size and mass estimates will be assessed by Element and SE&I personnel and if decided it is not a threat to the vehicle, a LCC ICE-01 waiver will be written and submitted to the Mission Management Team (MMT) for approval.

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-127-I-003	LH ₂ Leak at External Tank (ET) Ground Umbilical Carrier Plate (GUCP)	<p>During the first two launch attempts of ET-131/STS-127, hydrogen leak detectors 23 and 25 located at the ET/GUCP interface observed leakage exceeding the LCC Haz-09 limit of 40,000 ppm. After the second scrub, an Investigation Team was formed. The team developed a working theory that leakage occurred between the flight and ground sides of the quick-disconnect assembly, and these occurred as a result of various factors including ET-131 carrier plate clocking, ET-131 hinge brackets clocked and offset, and potential for GUCP movement during assembly that combined to exceed the capability of the seal hardware. Hardware modifications and procedural changes after the second scrub addressed these factors and resulted in a hardware assembly that minimized initial misalignment and reduced the potential for movement during assembly. The STS-127 Investigation Team will continue working to identify all credible scenarios. The External Tank Project is conducting testing at MSFC to obtain data that will be used in evaluation of the scenarios and help provide a most probable cause. Upon completion of the investigation, final disposition rationale will be developed and submitted.</p>
STS-127-I-004	ET TPS Loss at LO ₂ IFR 718	<p>During STS-127, post-ET separation imagery documented an ET TPS loss on the 718 LO₂ Ice Frost Ramp (IFR). The MSFC ET Project Anomaly Team (EPAT) estimated the total divot to be 0.044 lb_m using CATIA modeling and that would exceed the risk assessment mass if it occurred as a single-piece release during the Aerodynamic Sensitive Transport Time (ASTT) timeframe prior to 135 sec MET. A Debris Transport Analysis (DTA) was performed using void differential Pressure (ΔP) failure mechanism with a 25-100 ft/sec pop-off velocity normal to the ET surface and with a 0-4 ft/sec pop-off velocity to simulate a pop-off velocity normal to the aft face of the IFR. Other known debris sources forward of the LO₂ Feedline Closeout location were also evaluated and a DTA was performed for the 949 Intertank IFR. Only the DTA with the low normal pop-off velocity correlates with the imagery to show the 718 LO₂ IFR as a possible source of the debris seen at 126 sec MET. However, there is no direct evidence that this debris originates from the 718 LO₂ IFR. The Probabilistic Risk Assessment (PRA) risk was calculated to be approximately 1/480, which is consistent with an increased risk over the previous Space Shuttle Program accepted risk. Final closure will depend on completion of the MSFC investigation and incorporation of any mitigation steps into the hardware or procedure baseline.</p>

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-127-I-005	ET Intertank TPS Foam Losses	<p>During the STS-127 ascent, multiple pieces of debris were observed in the ET feed-line camera liberating from the ET Intertank (IT) beginning at approximately 104 sec MET. The Post-ET separation umbilical well imagery revealed 38 losses from the IT, 12 of which were on the +Z side of the ET, and the remaining losses were on the -Z side. The integrated concern centers on the potential for debris to strike and cause significant damage to the Orbiter TPS. The mass of the largest piece of debris (assuming a single piece) was approximately 0.255 lb_m (liberating at approximately 134 sec), which exceeded NSTS 60559 risk assessment masses of 0.004 lb_m (<135 sec) and 0.015 lb_m (>135 sec). The failure mode is most likely adhesion, as indicated by the imagery assessment that multiple losses extend to the substrate. An adhesive failure occurs when the bond between the foam and the substrate is weakened, as opposed to a cohesive failure, which occurs due to a weakness within the foam itself. To date, no root cause has been determined. The investigation team concluded that the likely cause was contamination prior to foam application. Potential contributors identified were:</p> <ol style="list-style-type: none"> 1. Potential for contaminants being introduced due to numerous moves around the plant, 2. The loss of the plant environment for approximately a month after Hurricane Katrina, 3. The longtime interval between prime and foam application (61 days for ET-131, 88 days for ET-132), 4. Inadequate cleaning prior to foam application due to experience levels of the cleaning technicians and/or the use of an in-effective solvent (MEK does not remove salts effectively). <p>A debris transport analysis presented to the Debris Integration Group (DIG) suggests that there are two areas of high debris risk on the +Z side of the IT. Adhesion testing was conducted to gain confidence that ET-132 did not have any gross areas of reduced TPS bond strength. A total of 168 of 170 adhesion tests failed in cohesion, and the remaining 2 failed in adhesion with high-tensile-strength values. These test results could indicate that there were no gross areas of low-bond-strength on the IT for ET-132.2. The final 18 adhesion tests were conducted on areas of the IT that were believed to be areas of high debris risk to the Orbiter. A total of 16 of 18 tests failed in cohesion, one failure with thin fuzzy film at 56.9 psi, and one adhesive failure at 53.2 psi, both of which give some indication of no gross adhesion issues in these areas.</p>

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-127-I-006	ET TPS Loss Outboard Section of the -Y Bipod Closeout	At approximately 126 sec MET, A debris loss was observed liberating from the outboard side of the -Y Bipod Closeout. Post-flight evaluation revealed that the loss went to the substrate. The mass of the loss was calculated to be approximately 0.068 lb _m , which exceeded the NSTS 60559 risk assessment mass of 0.025 lb _m . The failure mode for this loss is believed to be cryoingestion. Cryoingestion occurs when a leak path is created from the intertank to a reservoir formed under the closeout. The cryoingestion failure mode is common for this location due to the complex nature of the closeout and the presence of wiring underneath it, which runs to the intertank. The time of loss is consistent with the cryoingestion failure mode, and consistent with losses at this location from other flights. The increase in mass was likely related to additional subsurface cracking or gaps between heater wires caused by multiple cryogenic cycles. The risk from this event is ascent debris impact on, and damage to, the Orbiter. SE&I performed an integrated debris risk assessment for the STS-127 event. The analysis assumed that a 0.069 lb _m single piece of debris could liberate between 117 and 137 sec MET. The risk to tile was calculated to be 1 in 5,000. The overall risk was calculated to be 1 in 5,000 for the -Y Bipod. Based on this updated risk assessment, the likelihood of this event remains as remote. An additional risk analysis is in progress with an ET supplied maximum expected liberation mass of 0.14 lb _m . An assessment of the updated risk analysis would be required before final closure of this IIFA.
STS-127-I-007	Layer of Marshall Convergent Coating (MCC)-1 Missing on Aft Skirt Acreage	During the STS-127 post-flight assessment of Solid Rocket Booster (SRB) hardware, three incidences of Marshall Convergent Coating (MCC-1) loss were discovered and reported post-flight. MCC-1 is not expected to liberate during ascent or post-SRB separation. It is classified as unexpected debris. Given the post-flight condition of the hardware, testing has been difficult, but enough information has been gathered to discern a lower strength of MCC-1 in the recovery overlap area on the Aft Skirt compared with nominal acreage areas. MCC-1 is sprayed in a spiral pattern on flight structures from bottom to top. During recovery sprays on BI-138 Aft Skirts and Right-Hand (RH) Frustum, the robot software failed to initialize the spiral pattern for the first rotation of the structures. BI-139 RH Forward Skirt is the only BI-139 structure that had experienced MCC-1 spray interrupt/recovery overlap. Fault Tree draft is completed and under ART-270 team review. The BI-143 Left-Hand (LH) Aft Skirt has been identified as having two spray interrupt/recovery overlap bands. Plans will be developed to address BI-143 LH Aft Skirt.

APPENDIX B IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE ANOMALIES

IFA Number	Title	Comments
STS-127-S-01	OCA Hard Drive Failure	<p>At 05/13:34 MET, the Orbiter Communications Adapter (OCA) was noticed to be half-red/half-green signature on the downlink of the STS OCA Router indicating that the onboard router was locked up or unseated. The crew was asked to reboot the router. Seven minutes later, the crew reported that after rebooting the OCA NDIS.SYS error was received indicating that the driver is missing or not configured or the OCA Card is missing or misconfigured. The crew then performed another reboot. Again seven minutes later, the half-red/half-green signature again appeared on the downlink. The crew reseated the laptop and rebooted it. At 05/13:53 MET, communications were re-established with the OCA. The crew, however, reported a blue screen on the router. The crew checked the laptop seating and again rebooted it.</p> <p>At 05/14:25 MET, the half-red/half-green signature appeared again. At 05/16:50 MET, the crew reported that the docked light was not illuminated on the docking station. The crew also reported an error that the operating system was not found. At 05/17:23 MET, the laptop would boot when undocked, but not when docked. All connections appeared to be good, just the docked light did not illuminate as expected. At 05/18:11 MET, crew was asked to perform a hard disk swap. At 05/18:24 MET, the laptop rebooted while docked and OCA communication was re-established.</p> <p>Post-Flight Plan: Standard destowing and return to JSC for troubleshooting. The OCA router hard drive will be re-tested and the drive history parameters will be examined upon return.</p>

APPENDIX B IN-FLIGHT ANOMALIES

FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-127-N-001	LTA Cable Out of Configuration	<p>On EVA1, the crew was not able to properly configure the cables on ECSH in bay 13. The configuration was not in a certified configuration for landing. The crew used copper wire to secure the loose connector to a cleat. Also, FO&I noted that the tie strap on bay 13 ECSH SIP for the ICC-VLD LTA cable was broken during EVA1 routing of the LTA cable. FO&I obtained pictures of the current on-orbit configuration of the ECSH in bay 13, and also performed structural analysis and testing. FO&I concluded that the current on-orbit configuration was safe for return.</p> <p>For the tie strap, structural analysis verified cable routing was acceptable for landing. Post-flight inspection and evaluation was performed. The hardware was removed post flight, so no repairs required.</p>
STS-127-N-002	SSP1 Talkback Transition Failure SSP1 Talkback Transition Failure	<p>Upon ejection of the DRAGONSAT PICO satellite from the Space Shuttle Program Launcher (SSPL), the PICO2 HERE talkback on SSP1 did not transition to barberpole as expected. The PICO2 HERE talkback is driven by an optical sensor inside the launcher that causes the PICO2 HERE talkback to show barberpole when the PICOSAT is no longer in the launcher (i.e. completely ejected). Despite crew confirmation and video showing that the PICOSAT completely ejected from the launcher, the PICO2 HERE talkback indicated that the satellite was still in the launcher. The failure of the talkback to transition to barberpole, (i.e. remaining gray) was caused by an anomaly with either the sensor or the talkback itself.</p> <p>Post-Flight Plan: KSC will perform a test that will cause an indicator to transition from barberpole to gray and back to barberpole. If this is successful and there is no time lag on the indicator, then the panel is exonerated.</p>

APPENDIX B IN-FLIGHT ANOMALIES

MOD ANOMALIES

No MOD in-flight anomalies were identified during the STS-127 mission.

APPENDIX C

DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-127 MER Daily Reports by Michael D. Wright, Lead MER Manager:

Launch and First Daily Report, dated July 16, 2009
Second Daily Report, dated July 16, 2009
Third Daily Report, dated July 17, 2009
Fourth Daily Report, dated July 18, 2009
Fifth Daily Report, dated July 19, 2009
Sixth Daily Report, dated July 20, 2009
Seventh Daily Report, dated July 21, 2009
Eighth Daily Report, dated July 22, 2009
Ninth Daily Report, dated July 23, 2009
Tenth Daily Report, dated July 24, 2009
Eleventh Daily Report, dated July 25, 2009
Twelfth Daily Report, dated July 26, 2009
Thirteenth Daily Report, dated July 27, 2009
Fourteenth Daily Report, dated July 28, 2009
Fifteenth Daily Report, dated July 29, 2009
Sixteenth Daily Report, July 30, 2009
Seventeenth Daily Report, dated July 31, 2009
Landing Plus 2 Hour Report, dated July 31, 2009
Mission Summary Report, dated August 5, 2009

ET/SRB/RSRM/SSME REPORTS

STS-127 Anomalies, David W. Morr, USA-Huntsville, September XX, 2009
STS-127 HOSC Console Flash Report, David W. Morr, USA-Huntsville, July 15, 2009
STS-127 Post-Launch SRB Debris Open Assessment, Thomas F. Ford, NASA-KSC, July 20, 2009

ORBITER REPORTS

STS-127 Landing and Deceleration Report, C. C. Heinol, Boeing-Houston, August 14, 2009
STS-127 Landing and Deceleration Mission Summary, Brian Warkentine, Boeing-Houston, August 21, 2009
STS-127 Communications and Tracking Report, C. J. Stafford, Boeing-Houston, August 10, 2009
STS-127 Displays and Controls and Lighting Report, Patrick.Ngo, Boeing-Houston, September 8, 2009
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STS-127 PRSD System Mission Report, Johnny D. Wong, Boeing-Houston, August 21, 2009
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STS-127 OI/MADS Sensors, Signal Conditioners and Fuel Cell Monitoring System, Dwight A. Favors, Boeing-Houston, August 10, 2009
STS-127 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, August 19, 2009

STS-127 OAFGSS Report, James J. Kiely, Boeing-Houston, October 21, 2009
STS-127 FO&I In-Flight Anomalies, Ray Serna, NASA-JSC, September 24, 2009
STS-127 Data Processing System Integrated Report, Lynna L. Wood, Boeing-Houston, August 21, 2009
STS-127 EPDC Mission Report, William D. Peterson, Boeing-Houston, August 10, 2009
STS-127 ATCS Post-Flight Mission Report, D. J. Veselka, Boeing-Houston, August 21, 2009
STS-127 Life Support Subsystem Report (ARPCS and Airlock Systems), Erich L. Bass, Boeing-Houston, August 19, 2009
STS-127 Orbiter Docking System Summary, Robert E. Davis, NASA-JSC, August 21, 2009
STS-127 OMS Report, James M. Garza, Boeing-Houston, September 24, 2009
STS-127 RCS Mission Report, James M. Garza, Boeing-Houston, August 21, 2009
STS-127 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, October 10, 2009
STS-127 Fuel Cells Mission Report, Johnny D. Wong, Boeing-Houston, August 21, 2009.
STS-127 Global Positioning System Report, Ray Nuss, NASA-JSC, August 11, 2009
STS-127 Thermal Control System Summary, James V. Byerly, Boeing-Houston, August 21, 2009
STS-127 Purge, Vent and Drain Report, C. C. Heinol, Boeing-Houston, August 19, 2009
STS-127 Flight Control System and ADTA Mission Report, Howard Damoff, Boeing-KSC, September 8, 2009
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STS-127 Windows Report, Orlando Torres, Boeing-KSC, September 29, 2009
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STS-127 Final Debris Maps, Thomas F. Ford, NASA-KSC, August 5, 2009
STS-127 Extravehicular Activity Report for EVA 1, Shannon L. Cagle, Hamilton Sunstrand, July 18, 2009
STS-127 Extravehicular Activity Report for EVA 2, Glenda Sparks, Hamilton Sunstrand, July 20, 2009
STS-127 Post EVA no. 3 Report, Samuel D. Hower, Hamilton-Sunstrand, July 22, 2009
STS-127 ExtraVehicular Activity Report for EVA 4, Glenda Sparks, Hamilton Sunstrand, July 24, 2009
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STS-127 Final Extravehicular Activity Report, Bridget R. Ziegelaar,, NASA-JSC, September 18, 2009
STS-127 L-1 Day Walk Down, Thomas F. Ford, NASA-KSC, August 23, 2009
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APPENDIX D

STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
A	Ampere
AA	Accelerometer Assembly
ABS	Ammonia Boiler System
ADTA	Air Data Transducer Assembly
AFD	Aft Flight Deck
AGT	Adaptive Guidance Throttling
AMOS	Air Force Maui Optical Supercomputing Site
ANDE	Atmospheric Neutral Density Experiment
APCU	Assembly Power Conversion Unit
APFR	Articulating Portable Foot Restraint
ARPA	Advanced Research Project Agency
APU	Auxiliary Power Unit
ARPCS	Atmospheric Revitalization Pressure Control System
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
BET	Best Estimate Trajectory
BFS	Backup Flight System
BITE	Built-In Test Equipment
BLT	Boundary Layer Transition
CAPE	Canister for All Payload Ejections
CCA	Communications Carrier Assembly
CDRA	Carbon Dioxide Removal Assembly
CDT	Central Daylight Time
CETA	Crew and Equipment Translation Aid
C/NOFS	Communication/Navigation Outage Forecast System
CO ₂	Carbon Dioxide
COMM	Communications
CPM	Cell Performance Monitor
CRT	Cathode Ray Tube
CTB	Crew Transfer Bag
CVTC	Color Television Camera
CWC	Contingency Water Container
CWCI	Contingency Water Container Iodine
D & C	Display and Control
DAP	Digital Autopilot
DAT	Debris Assessment Team
DDU	Data Display Unit
DET	Data Elapsed Time

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
DOD/DoD	Department of Defense
DPS	Data Processing System
DRAGON Sat	Dual Radio Frequency Autonomous Global Positioning System On-Orbit Navigation Satellite
DTO	Development Test Objective
ΔP	Differential Pressure
ΔV	Differential Velocity
ECLSS	Environmental Control and Life Support System
ECO	Engine Cut-off
EDAS	Enhanced Data Acquisition System
EF	Exposed Facility
EI	Entry Interface
ELM-ES	Experiment Logistics Module-Exposed Section
EMP	Electromagnetic Pulse
EMU	Extravehicular Mobility Unit
EO	External Tank/Orbiter
EOM	End-of-Mission
EPDC	Electrical Power Distribution and Control
ES	Exposed Section
ESP	External Stowage Platform
ET	External Tank
ETA	External Tank Attachment
EV	Extravehicular (Crewmember)
EVA	Extravehicular Activity
FC	Fuel Cell
FCE	Flight Crew Equipment
FCMS	Fuel Cell Monitoring System
FCS	Flight Control System
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection and Annunciation
FES	Flash Evaporator System
FID	Failure Identifier
FIT	Final Inspection Team
FM	Frequency Modulation
FOM	Figure of Merit
FOV	Field of View
FRAM	Flight Reusable Attachment Mechanism

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
FRCS	Forward Reaction Control System
FSS	Fixed Service Structure/Flight Support System
FSE	Flight Support Equipment
FSW	Flight Software
G/g	Gravity
GCA	Ground Carrier Assembly
GFE	Government Furnished Equipment
GH ₂	Gaseous Hydrogen
GIRA	Galley Iodine Removal Assembly
GMEM	General Memory
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GN ₂	Gaseous Nitrogen
GO ₂ /GOX	Gaseous Oxygen
GPC	General Purpose Computer
GPS	Global Positioning System
Grms	Gravity root mean square
GSE	Ground Support Equipment
GUCP	Ground Umbilical Carrier Plate
H ₂	Hydrogen
H ₂ O	Water
HDP	Holddown Post
HICLASS	High Performance Carbon Dioxide Ladar Surveillance Sensor
HIU	Headset Interface Unit
HPFTP	High Pressure Fuel Turbopump
HPGS	High Pressure Gas Tank
HPOTP	High Pressure Oxidizer Turbopump
HTV	H II Transfer Vehicle
HYD	Hydraulic
ICC	Integrated Cargo Carrier
ICS	Inter-Orbit Communications-Exposed Facility
ICU	Internal Cargo Unit
IDP	Integrated Display Processor
IEA	Integrated Electronics Assemblies
IFA	In-Flight Anomaly
IFR	Ice Frost Ramp
IMU	Inertial Measurement Unit

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
I/O	Input/Output
IPR	Interim Problem Report
ISP	Specific Impulse
ISS	International Space Station
IVM	Ion Instrument
JAXA	Japanese Aerospace Exploration Agency
JEF	JEM Exposed Facility
JEM	Japanese Experiment Module
JEM-EF	Japanese Experiment Module-Exposed Facility
JEM-PM/JPM	Japanese Experiment Module-Pressurized Section
JLE	JEM Exposed Section
JSC	Johnson Space Center
KOH	Electrolyte
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LDU	Linear Drive Unit
LDRI	Laser Dynamic Range Imager
LH	Left Hand
LIDAR	Light Intensification Detection and Ranging
LH ₂	Liquid Hydrogen
LiOH	Lithium Hydroxide
LO ₂	Liquid Oxygen
LOME	Left Orbital Maneuvering Engine
LOMS	Left Orbital Maneuvering System
LP	Left Pod/Launch Package
LTA	Launch-to-Activation
LVLH	Local Vertical Local Horizontal (Attitude)
MAGR	Miniature Air-to-Ground Receiver
MAUI	Maui Analysis of Upper Atmospheric Modification
MADS	Modular Auxiliary Data System
MAXI	Monitor of All-Sky X-ray Imagery
MBED	Moisture Barrier Earphone Diaphragm
MBS	Mobile Base System
MC	Midcourse Correction
MCC-1	Marshall Convergent Coating-1
MDA	Motor Drive Amplifier

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
MDCA	Main Distribution Control Assembly
MDU	Multifunction Display Unit
MECO	Main Engine Cutoff
MEDS	Multifunction Electronics Display System
MET	Mission Elapsed Time
MFE	Mid-Frequency Executive
MLG	Main Landing Gear
MLI	Multi-Layer Insulation
MLP	Main Launch Platform
MM	Momentum Manager/Major Mode
MM/OD	MicroMeteoroid/Orbital Debris
MMT	Mission Management Team
MNA	Main Bus A
MNB	Main Bus B
MNC	Main Bus C
MPC	Mid Power Controller
mph	mile per hour
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MR	Material Report
MRA	Microbial Removal Assembly
MRL	Manipulator Retention Latch
MSU	Mass Storage Unit
N ₂	Nitrogen
NASA	National Aeronautics and Space Administration
NAV	Navigation
NAVAID	Navigation Aids
NC	Nominal Correction
NCC	Nominal Correction Combination
NH	Nominal Height
NSTS	National Space Transportation System
NWM	Neutral Wind Meter
O ₂	Oxygen
OA	Orbit Adjust (Maneuver)
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
ODS	Orbiter Docking System
OI	Operational Instrumentation
OMDP	Orbiter Maintenance Down Period
OME	Orbital Maneuvering Engine
OMRSD	Operational Maintenance and Requirements Specification Document
OMS	Orbital Maneuvering System
OPCU	Orbiter Power Conversion Unit
ORGA	Orbiter Rate Gyro Assembly
ORU	Orbital Replacement Unit
OV	Orbiter Vehicle
P	Port
PAO	Public Affairs Office
PAS	Payload Attachment System
PASS	Primary Avionics Software System
PBIS	Power Bus Isolation System
P_c	Chamber Pressure
PCM	Pulse Code Modulation
PCS	Pressure Control System
PCT	Post-Contact Thrust
PCU	Power Control Unit
PDU	Power Drive Unit
PGME	Propylene Glycol Monomethyl Ether
PI	Payload Interrogator
PLB	Payload Bay
PLBD	Payload Bay Door
PLP	Probe Instrument
POR	Payload Orbital Replacement Unit
PORA	POR Accommodation
PPCO ₂	Partial Pressure Carbon Dioxide
PRCS	Primary Reaction Control System
PRSD	Power Reactant Storage and Distribution System
PTU	Power Transfer Unit
PV&D	Purge, Vent and Drain
PWR	Payload Water Reservoir
QD	Quick Disconnect
R&R	Remove and Replace

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RH	Right Hand
RHC	Rotational Hand Controller
RJD	Reaction Jet Driver
RM	Redundancy Management
RMS	Remote Manipulator System
ROME	Right Orbital Maneuvering Engine
RP	Right Pod
RPC	Remote Power Controller
RPCM	RPC Mechanism
RPL	Rated Power Level
RPM	R-Bar Pitch Maneuver
RSB	Rudder Speed Brake
RSC	RMS Side View Camera
RSRB	Reusable Solid Rocket Booster
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System/Rotating Service Structure
RTLS	Return to Launch Site
RTV	Room Temperature Vulcanizing (material)
S	South
S&A	Safe and Arm
SDFS	Smoke Detection and Fire Suppression
SE	Southeast
SEDA-AP	Space Environment Data Acquisition-Attached Payload
SE&I	Systems Engineering and Integration
SEITE	Shuttle Engine Ion Turbulence Experiment
SGANT	Space-To-Ground Antenna
SHIMMER	Spatial Heterodyne Imager for Mesospheric Radicals
SLR	Satellite Laser Ranging
SLWT	Super Lightweight Tank
SM	System Management
SMRD	Spin Motor Rotation Detector
S/N	Serial Number
SPDM	Special Purpose Dexterous Manipulator
SRGA	SRB Rate Gyroscope Assembly
SRMS	Shuttle Remote Manipulator System

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STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
SRSS	Shuttle Range Safety System
SSME	Space Shuttle Main Engine
SSOR	Space-to-Space Orbiter Radio
SSP	Space Shuttle Program
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
ST	Star Tracker
STBD	Starboard
STP	Space Test Program
STS	Space Transportation System
SW	Southwest
TACAN	Tactical Air Navigation System
TCS	Thermal Control System/Trajectory Control Sensor
THC	Translation Hand Controller
TI	Terminal Phase Initiation/Transfer Initiation
TMBU	Table Maintenance Block Update
TPS	Thermal Protection System
Tse	Stack Exit Temperature
TSM	Tail Service Mast
TVC	Thrust Vector Controller
VDT	Vehicle Data Table
VE	Visual Equipment
VEFI	Electronic Field Instrument
VHF	Very High Frequency
VLD	Vehicle Light Deployable
W	West
WCS	Waste Collection System
WHS	Waste and Hygiene Compartment
WIF	Worksite Interface Adapter
WLE	Wing Leading Edge
WLEIDS	Wing Leading Edge Impact Detection System
WSB	Water Spray Boiler
V	Volt

APPENDIX D

STS-127 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<u>Unit of Measure</u>	<u>Explanation</u>
°F	degree Fahrenheit
deg	degree
deg/sec	degree per second
ft	feet
ft/sec	feet per second
Grms	gravity root mean square
hr	hour
In.	inch
keas	knots estimated air speed
kgs	knots ground speed
kW	Kilowatt
kWh	Kilowatt hour
lb	pound
lb _m /lbm	pound mass
lb/min	pound per minute
min	minute
mmHg	Millimeters of Mercury
msec	millimeters per second
mph	miles per hour
nmi	nautical mile
%	percent
ppCO ₂	partial pressure carbon dioxide
psi	pound per square inch
psia	pound per square inch absolute
scim	standard cubic inch per minute
sec	second
Vdc	Volt direct current