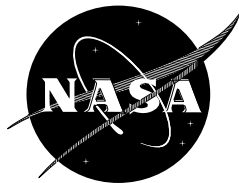


STS-128 SPACE SHUTTLE MISSION REPORT

March 2010



**National Aeronautics and
Space Administration**

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

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STS-128

SPACE SHUTTLE MISSION REPORT

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STS-128 SPACE SHUTTLE MISSION REPORT

INTRODUCTION

The Space Transportation System (STS) -128 Space Shuttle Mission Report presents a discussion of the Orbiter activities on the mission, as well as a summary of the External Tank (ET), the Solid Rocket Booster (SRB), the Reusable Solid Rocket Motor (RSRM) and the Space Shuttle Main Engine (SSME) performance during the 128th mission of the Space Shuttle Program. The primary objective of this mission was to deliver and integrate the Leonardo Multi-Purpose Logistics Module (MPLM), which serves as a pressurized cargo carrier, and carried 15,200 pounds of cargo. STS-128 also delivered a new crewmember to the International Space Station (ISS) and returned another crewmember after almost two months aboard the Station. The mission included three 6.5-hr spacewalks devoted to replacing equipment and preparing the ISS for delivery of the Tranquility Node 3 module and the Cupola viewing port both scheduled to arrive on STS-130.

STS-128 was the 15th mission since the return to flight following the STS-107 mission, and the 30th mission to the ISS. STS-128 was also the 37th flight of the Orbiter 103 vehicle.

The primary objectives of the STS-128 mission were as follows:

1. Dock with the ISS and perform mandatory crew safety briefing.
2. Berth the MPLM to the Node 2 nadir port.
3. Transfer mandatory quantities of water to the ISS.
4. Rotate the Expedition 20 crewmember with the Expedition 20/21 Flight Engineer.
5. Transfer and install Node 3 Air Revitalization System (ARS) rack.
6. Transfer Treadmill-2 (T2) rack and associated system components.
7. Remove and replace the Port (P) 1 Ammonia Tank Assembly (ATA).
8. Transfer all required cargo items.
9. Perform three Extravehicular Activities (EVA's).

The flight vehicle consisted of the OV-103 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-132; three Block II SSMEs that were designated as serial numbers (S/Ns) 2052, 2051, and 2047 in positions 1, 2 and 3, respectively; and two SRBs that were designated BI-139. The two RSRMs were designated flight set RSRM-107. The individual RSRMs were S/N 360W107A (left) and S/N 360W107B (right). Launch pad 39A and Mobile Launch Platform (MLP) -2 were used as the platform for launch of the STS-128 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-128 flight were Frederick W. Sturckow, Colonel, U. S. Marine Corps, Commander; Kevin A. Ford, PhD., Colonel, U.S. Air Force, Retired, Pilot; Patrick G. Forrester, Colonel, U. S. Army, Retired, Mission Specialist 1; Jose M. Hernandez, Civilian, NASA, Mission Specialist 2; John D. Olivas, PhD., Civilian, NASA, Mission Specialist 3; Christer Fuglesang, PhD, Civilian, European Space Agency, Mission Specialist 4; Nicole Passonno Stott, Civilian, NASA, Mission Specialist 5 (Up); and Timothy L. Kopra, Colonel, U. S. Army, Mission Specialist 5 (Down).

STS-128 was the fourth flight for the Commander; the second flight for Mission Specialist 1, Mission Specialist 3, Mission Specialist 4, and Mission Specialist 5 (Down); and the first Shuttle flight for the Pilot and Mission Specialist 5 (Up).

MISSION SUMMARY

The objectives for the STS-128 mission were the delivery of the Multi-Purpose Logistics Module (MLPM) cargo and a new Ammonia Tank Assembly (ATA) to the International Space Station (ISS). Additional objectives were to perform three Extravehicular Activities (EVAs), rotate the ISS Flight Engineer crewmember and transfer critical cargo to the ISS.

Pre-Launch

The first launch attempt on August 25, 2009 [12:36 am Central Daylight Time (CDT)], was scrubbed during the T-9 minute hold, due to thunderstorms within 20 nmi of the launch site.

During the transition to reduced fast-fill for the August 26 (12:10 am CDT) launch attempt, the Liquid Hydrogen (LH₂) inboard fill-and-drain valve closed-position indicator did not illuminate when the valve was commanded closed (IFA STS-128-V-01). The Launch Commit Criteria (LCC) for this condition prevented further operations toward a launch and a 48-hour scrub was declared. Following the draining of the tank, testing by cycling the valve at ambient-temperatures with timing analysis was performed with nominal results. However, during preparations for a launch attempt on August 27 (11:22 pm CDT) just prior to the start of tanking, the Mission Management Team (MMT) decided to delay the launch an additional 24 hr to allow historical data to be gathered and evaluated. These data along with the cycling data were used to develop the rationale to proceed with the launch, even if the same signature recurred. The MMT accepted the rationale and approved the vehicle for launch. During the External Tank (ET) loading in preparation for the launch, the valve indication was nominal.

At approximately 90 sec prior to lift-off, Auxiliary Power Unit (APU) 3 Exhaust Gas Temperature (EGT) 2 became slightly erratic. The transducer output returned to normal approximately 50 sec after lift-off. The maximum peak-to-peak temperature range was 24 °F.

Ascent and Flight Day 1

The STS-128 mission was launched at 241/03:59.36.997 Greenwich Mean Time (GMT) on August 28, 2009 (10:59 pm CDT), on the thirtieth Space Shuttle Program (SSP) mission to the ISS. The Solid Rocket Booster (SRB) was visible through separation. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 241/04:01:50.019 GMT [00/00:02:13.022 Mission Elapsed Time (MET)], and the maneuver was 112.2 sec in duration.

Main Engine Cut-Off (MECO) occurred at 241/04:08:02 GMT (00/00:08:25 MET). The ET separated from the Orbiter at 241/04:08:23 GMT (00/00:08:46 MET).

A nominal OMS-2 maneuver was performed at 241/04:38:37 GMT (00/00:39:00 MET). The maneuver was 62.4 sec in duration with a Differential Velocity (ΔV) of 94.9 ft/sec. The achieved orbit was 84.9 by 127.7 nmi.

The payload bay doors were opened at 241/05:46:53 GMT (00/01:47:16 MET). The Ku-Band antenna was deployed at 241/06:02 GMT (00/02:15 MET).

The OMS-3 Nominal Correction (NC)1 maneuver was a dual-engine, straight-feed firing performed nominally at 241/07:24:45 GMT (00/03:25:09 MET) with the cutoff at 241/07:25:43 GMT (00/03:26:07 MET). Both OMS engines operated nominally. The maneuver was 58.2 sec in duration with a ΔV of 89.2 ft/sec. The resulting orbit was 115.0 by 145.7 nmi.

The Shuttle Remote Manipulator System (SRMS) initialization, power up and checkout were initiated at 241/07:36:00 GMT (00/03:36:24 MET) and completed at 241/08:57:00 GMT (00/04:57:24 MET). During the SRMS End Effector (EE) checkout, when the rigidize carriage mechanism was retracted to the derigidized position, the crew inadvertently issued a capture command instead of a release command (EE Auto mode was selected) (IFA STS-128-V-03). This caused the snare cables to “capture” the carriage mechanism ball screws. The appropriate procedures were repeated to complete the checkout. The rest of the SRMS checkout was nominal. The SRMS was returned to the Pre-Cradle Position at 241/09:00:00 GMT (00/05:00:24 MET).

The Reaction Control System (RCS) F5R thruster was abnormally cold due to a suspected leak (IFA STS-128-V-02). Flight data assessment concluded that the hottest attitude for F5R (inertial with sun-down-nozzle axis) would not have warmed temperatures above the 130 °F operating limit given the large cooling effect from the leak. After analysis was completed, the team recommended closing the affected manifold. The loss of thruster F5R would preclude use of Vernier RCS attitude control for the remainder of the mission.

Flight Day 2

The main activities for Flight Day (FD) 2 were the Thermal Protection System (TPS) and Leading Edge Subsystem (LESS) inspection surveys, Extravehicular Mobility Unit (EMU) checkout, rendezvous tools checkout, and Orbiter Docking System (ODS) ring extension.

The Forward Reaction Control System (FRCS) vernier thruster F5R leak observed on FD 1 was isolated. The manifold-5 isolation valves were closed the morning of FD 2 at 241/18:47:03 GMT (00/14:47:26 MET). Following the manifold closure, the F5R injector temperature measurements, after approximately 7 hrs at Off-Scale-Low (OSL) values, were observed to rise to over 200 °F. Analysis continued on the injector temperature values, which on ground displays were observed to be less than zero; negative injection temperatures were unexpected.

The right-engine OMS-4 NC2 maneuver was performed nominally at 241/20:56:36 GMT (00/16:50:59 MET). The maneuver was 15.8 sec in duration with a ΔV of 12.0 ft/sec. The resulting orbit was 117.8 by 149.4 nmi.

The SRMS 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 241/21:14 GMT (00/17:14 MET), with grapple completed at 241/21:33 GMT (00/17:33 MET). The Starboard RCC survey began with the Flat Field Survey at 241/22:44 GMT (00/18:44 MET), and the survey completed at 242/00:54 GMT (00/20:54 MET). The Nose-Cap RCC survey began at 242/01:23 GMT (00/21:23 MET) and was completed at 242/01:55 GMT (00/21:55 MET). The Port RCC survey began at 242/02:28 GMT (00/22:28 MET) and was completed at 242/03:58 GMT (00/23:58 MET).

The first on-orbit fuel cell purge, which was performed manually, was initiated at 242/02:31:38 GMT (00/22:32:01 MET). During the 23-hour purge interval, the approximate indicated voltage decay was 0.08 Vdc in fuel cell 1, 0.03 Vdc in fuel cell 2, and was 0.08 Vdc in fuel cell 3.

The FRCS thrusters were re-selected at 242/03:42:21 GMT (0/23:42:44 MET) following completion of OBSS survey. The Orbiter remained in Tail-only attitude control during crew sleep since vernier RCS control was not available.

The Orbiter Docking System (ODS) ring extension occurred during Loss of Signal (LOS) (approximately 8 min, 242/06:20 GMT). The crew initiated the power-up sequence, ring extension, and power-down sequence without incident. Ring position was reported to be at 76%, which was nominal.

The NC3 maneuver was a +X maneuver using the L1A and R1A Primary Reaction Control System (PRCS) thrusters and was initiated at 242/06:10:20 GMT (01/02:10:43 MET). The firing time was 12.4 sec with a ΔV of 2.9 ft/sec. The resulting orbit was 119.0 by 149.5 nmi. Engine performance was nominal, and no trim was required.

The Rendezvous Tools checkout was performed and all systems were nominal. The Trajectory Control Sensor (TCS) checkout was completed successfully and was powered off at approximately 242/08:00 GMT (01/04:00 MET). However, a bearing-calibration error was seen during the initial self-test. The error was eventually cleared after subsequent calibrations. The initial error was attributed to a timing issue.

Evaluation of ascent ground imagery was completed and showed that all 14 FRCS thruster rain covers released within specification and no remnants were observed.

All Wing Leading Edge (WLE) Impact Detection System (IDS) ascent summary data was successfully downlinked. Seven indications, all on the Port side, exceeded the 1-Grms reporting criteria. The largest magnitude observed was 3.2 Grms on panel R11. The RCC Damage Assessment Team (DAT) began the initial screening of the FD 2 survey imagery of the Starboard wing, Port wing, and nose cap RCC.

After the downlink of the FD 2 survey video was complete, the Orbiter Communications Adapter (OCA) was configured to 48 Mbps downlink for crew sleep, but it did not work. The system was switched back to 2 Mbps downlink, which made downlink of still images very slow.

Flight Day 3

The main activities on FD 3 were the rendezvous phasing maneuvers, the R-Bar Pitch Maneuver (RPM), and docking with the ISS.

The review of the downlinked Modular Auxiliary Data System (MADS) identified the left OMS pod temperature data was Off-Scale-High (OSH) during ascent (IFA STS-128-V - 05). The measurement data are used for housekeeping and trending purposes and therefore did not impact the successful completion of the mission.

The Nominal Height (NH) OMS-5 maneuver was a dual engine, straight-feed firing occurring at 242/19:58:58 GMT (01/15:59:22 MET) with the cutoff at 242/20:20:06 GMT (01/16:20:30 MET). The firing time was 67.6 sec with a ΔV of 104.9 ft/sec. The resulting orbit was 139.8 by 190.4 nmi. The OMS-6 NC4 maneuver was a dual-engine firing occurring at 242/20:48:19 GMT (01/16:48:43 MET) with the cutoff at 242/20:49:03 GMT (01/16:49:27 MET). The firing time was 44.0 sec with a ΔV of 68.9 ft/sec. The resulting orbit was 176.2 by 192.5 nmi. Engine performance was nominal. The ΔV for the Nominal Corrective Combination (NCC) maneuver was too small to require a maneuver.

The Communication (COMM) mode of the Ku-Band system was selected at 242/19:54:01 GMT (01/15:54:24 MET). The RADAR mode was selected at 242/21:42:29 GMT (01/17:42:52 MET) and the ISS was detected at a range of 141,000 ft. Tracking of the ISS occurred at 242/21:43:14 GMT (01/17:43:37 MET) at a range of 138,000 ft. The RADAR mode operated nominally.

The Terminal Initiation (TI) OMS-7 maneuver was a 11.4-sec, straight feed, left-engine firing. Ignition was at 242/22:26:17 GMT (01/18:26:41 MET) with the cutoff at 242/22:26:28 GMT (01/18:26:52 MET). The ΔV delivered was 8.6 ft/sec and the resultant orbit was a 180.5 by 192.8 nmi orbit.

The Midcourse Correction (MC)1 maneuver was a 1.12-sec +Z RCS firing using six primary thrusters. Ignition was at 242/22:46:16 GMT (01/18:46:40 MET). The ΔV delivered was 0.3 ft/sec and the resulting orbit was 180.4 by 192.7 nmi. The Out-of-Plane Null maneuver was a 0.4-sec RCS firing using two primary thrusters. Ignition was at 242/23:08:12 GMT (01/19:08:36 MET). The ΔV delivered was 0.1 ft/sec and the resulting orbit was 180.5 by 192.7 nmi. The MC2 maneuver was not performed because of the low ΔV that was required. The MC3 was a 1.76-sec -X RCS firing using six primary thrusters. The ignition occurred at 242/19:49:35 GMT (01/15:49:59 MET). The ΔV delivered was 0.41 ft/sec and the resultant orbit was 180.5 by 192.5 nmi. The

MC4 maneuver was a 11.04-sec +X RCS firing using four primary thrusters. Ignition was at 242/23:43:58 GMT (01/19:44:22 MET). The ΔV delivered was 2.56 ft/sec and the resulting orbit was 181.1 by 192.9 nmi.

The RPM was begun at 243/00:03:33 GMT (01/20:03:57 MET). The RPM was initially started in the Digital Autopilot (DAP) B mode, which is a 0.13 deg/sec maneuver rate. The ground controllers requested that DAP A (0.75 deg/sec maneuver rate) be selected. The DAP performance was nominal.

After the RPM, the Ku-Band did not regain track of the ISS. The ground controllers noted that the Ku-Band was moving around in the video that was being downlinked; however, this was the result of the RADAR searching for the target. Since the RADAR could not lock up that close to the ISS, the Ku-Band was returned to the COMM STANDBY mode at 243/00:17:12 GMT (01/20:17:35 MET).

The ODS was activated at 243/00:27:35 GMT (01/20:27:59 MET). The Shuttle captured the ISS at 243/00:53:57 GMT (01/20:54:21 MET). Ring-drive-in began at 243/01:01:56 GMT (01/21:02:20 MET). The system was stopped and allowed to dampen out for approximately 2 min 40 sec. The Shuttle-to-ISS interface seal was obtained at 243/01:09:07 GMT (01/21:09:31 MET), at which time docking operations were complete. The ODS was powered down at 243/01:15:20 GMT (01/21:15:43 MET), and the ODS power-on time was 47 min 45 sec.

The ODS X3 mate-indication came on at 243/01:05:22 GMT (01/21/05:45 MET) and the X4 connector mate-indication came on 1 min 32 sec later at 243/01:06 54 GMT (01/21:07:17 MET). There is no set requirement for the time between the receiving of the two mate indications. The previous mission of OV-103 showed approximately 27 sec between the X3 and X4 connector mate indications. It is mechanically possible for the two indications to lag each other during alignment-pin engagement due to the relative misalignments that may occur between the two rings. Both X-connector mate-indications were ON and this was the desired configuration when mated to ISS. The connectors are inspected as part of the normal required post-flight inspections.

At 243/03:47 GMT (01/23:47:24 MET), the SRMS maneuvered to the OBSS pre-grapple handoff position. The Space Station RMS (SSRMS) unberthed the OBSS at 243/40:28 GMT (02/00:28:24 MET) and maneuvered it to the handoff position. At 243/05:31 GMT (02/01:31:24 MET), the SRMS grappled the OBSS and was maneuvered it to the Ammonia Tank Assembly (ATA) Vent Clear position.

The Leading Edge Structure System (LESS) Problem Resolution Team (PRT) cleared the RCC for entry. The Thermal Protection System (TPS) PRT was still analyzing RPM imagery; however, the team determined that there were no Focused Inspection requirements for the starboard side of the vehicle. The team continued to assess the remainder of the vehicle.

The Station-to-Shuttle Power Transfer System (SSPTS) activation was completed at 243:03:55 GMT (01/23:55:23 MET).

Flight Day 4

The main activities for the day were the unberthing, installation, and ingress of the MPLM, and preparation for the first EVA.

Three Contingency Water Containers (CWCs) were filled as well as the first Portable Water Reservoir (PWR).

The fuel cell temperatures and electrolyte (KOH) concentration levels remained within acceptable limits while at low power levels during the SSPTS operation; fuel cell 2 condenser exit temperature slowly ramped up from 154 to 159 °F, while the KOH went down from an average of 34% to 32% for the inlet and 30% for the exit concentration. The KOH lower limit is 29%.

In response to larger-than-expected consumption of propellant during the post-docking maneuver that was completed with the Russian thrusters, options were assessed to regain Orbiter attitude-control capability of the mated stack, which was lost as a result of the vernier F5R-thruster leak. The first approach involved evaluating the Alternate Primary (Alt Primary) RCS DAP controllability of the mated stack maneuvers for the remainder of docked operations. The second approach was an investigation of the potential techniques and risks of reopening the FRCS manifold 5 isolation valve to regain vernier RCS attitude control. This manifold was closed on FD 2 as a result of the F5R-thruster leak.

The DAT determined that no focused inspection was required for the remaining portions of the vehicle, and continued assessment of items to clear the vehicle for entry.

Flight Day 5

The main activities on FD 5 were the transfer of cargo from the MPLM and the first EVA.

During the 6 hr 35 min first EVA, the returning Ammonia Tank Assembly (ATA) was released from the P1 Truss and stowed on the SSRMS. The ATA remained on the SSRMS until it was moved to the Orbiter during the second EVA. The European Technology Exposure Facility (EuTEF) and Materials International Space Station Experiment (MISSE) 6 were retrieved and stowed in the Orbiter payload bay.

Three CWCs (no. 4, 5, and 6) were filled and transferred to the ISS.

The SRMS was maneuvered from the ATA Vent-Clear position starting at 244/20:47 GMT (03/16:47 MET), and arrived at the MPLM viewing position at 244/20:50 GMT (03/16:50 MET).

The Thermal Protection System (TPS) DAT indicated that the analysis had been completed to clear the vehicle for entry.

Flight Day 6

The main activities on FD 6 were transfer activities. The planned water dump and associated stack maneuvers during FD 6 were not performed per the FD 4 Mission Management Team (MMT) decision to remove these items from the timeline.

The crew performed a troubleshooting procedure and successfully recovered the OCA 48 Mbps downlink capability which was lost on FD 2. The problem appeared to be the result of an incorrect configuration.

The review of MADS ascent data revealed two potential instrumentation issues. The left OMS pod temperature measurement stepped up to off-scale-high approximately 90 sec into ascent (IFA STS-128-V-05). Additionally, the left-wing spar-web strain-gage signal conditioner measurement appeared to display un-calibrated data. Both measurements are used for post-flight data analysis only and were not required for safe continuation of the mission.

The fuel cell 2 stack inlet KOH concentration was momentarily below the 29% concentration limit a number of times after the SSPTS was activated. Data showed that the transients lasted no longer than 2 min. Additionally, these transients corresponded with transients in the Orbiter power level and often are associated with the cryogenic Oxygen (O₂) tank heater cycles. These transients exceeded the Flight Rule limit; however, the transients were not continuous, and thus the fuel cell did not reach steady-state conditions and continuously violate the Flight Rule. Analysis was performed to confirm this condition was acceptable for this remainder of the mission.

Flight Day 7

The main activity on FD 7 was the second EVA to accomplish the ATA change-out.

At initial Extravehicular Mobility Unit (EMU) donning for the second EVA, the EV2 crewmember reported that his Communications Cap Assembly (CCA) had unacceptable communications (IFA STS-128-V-07). The crew changed to the prime CCA and no more communications problems were reported.

The second EVA was successfully completed in 6 hr 39 min and all objectives were achieved.

The Flash Evaporator System (FES) was deactivated to boost the water production rate. Filling of CWCs no. 10 and 11 was completed and filling of CWC no. 12 was delayed until FD 8. Filling of PWR 2 and 3 and a nitrogen repressurization were also planned for FD 8.

The Triangulation (Tri) and Light Intensification Detection and Ranging (LIDAR) Automated Rendezvous (TriDAR) team analyzed the data collected for the TriDAR Development Test Objective (DTO) during the FD 3 rendezvous and docking. This DTO was a demonstration of a 3-dimensional autonomous rendezvous and docking system. Initial indications were that the TriDAR met all of the primary mission objectives. The TriDAR system was also operational during the FD 12 Orbiter undocking and separation.

A test of the Japanese Experiment Module (JEM) H-II Transfer Vehicle (HTV) proximity transmitters was performed. As a result, the Orbiter S-Band system was commanded to Tracking Data and Relay Satellite (TDRS) high-frequency mode from 246/10:38 GMT (05/06:38:24 MET) to 246/12:52 GMT (05/08:52:24 MET) and again from 246/18:56 GMT (05/14:56 MET) to 246/19:49 GMT (05/15:49 MET). The reason for the switch to high frequency was that the JEM HTV proximity transmitters degrade the Shuttle S-band TDRS forward link low-frequency. The S-Band system successfully maintained forward- and return-link during the test.

Flight Day 8

The main activities on FD 8 were off-duty time and camp-out in preparation for the third EVA.

The second on-orbit fuel-cell purge was initiated at 246/17:46:27 GMT (05/13:46:50 MET). During the 111-hour purge interval, the approximate indicated voltage decay was 0.1 Vdc in fuel cell 1, 0.2 Vdc in fuel cell 2, and 0.15 Vdc in fuel cell 3.

The filling of CWC no. 12 and PWR no. 3 was completed. The Nitrogen (N₂) repressurization was also achieved using a total 26.1 lb.

Flight Day 9

The main activity on FD 9 was the third and final planned EVA to deploy the Starboard (S) 3 upper Payload Attachment System (PAS), replace the S0 gyroscope assembly and the Remote Power Control Module (RPCM), and route the Node 3 avionics cables.

EVA 3 was successfully completed in 7 hr 1 min with all tasks completed except for Node 3 avionics cable mating.

The Orbiter Main Landing Gear (MLG) system B and C brake-line heaters were activated at 248/19:00 GMT (07/14:58 MET) to gather additional performance data on the effect of the heaters on the MLG tires thermal environment. This activity was first performed on STS-126 and demonstrated the potential to provide Orbiter attitude flexibility at high-beta angles while maintaining the MLG tires within acceptable temperature limits. Noticeable effects on the brake-line temperatures were seen within 1 hr, with a 6 °F right inboard tire temperature increase over 14 hr 44 min.

At 249/02:39:45 GMT (07/22:37:55 MET), approximately 7 hr 40 min after brake line heater activation, temperature excursions were seen in 3 of 4 right outboard hydraulic brake line temperatures over 2 min. Two temperatures showed increases of up to 27 °F and the third showed a decrease of 6 °F. All temperatures recovered back to the original state within 40 min. No temperature limits were exceeded and there was no flight impact.

Flight Day 10

The main activities on FD 10 were Public Affairs Office (PAO) events and off-duty time.

During the FD 10 crew-highlight High Definition Television (HDTV) downlink, the Mission Control Center (MCC) was unable to view the imagery on the ground. After multiple attempts, the crew confirmed that no configuration anomalies existed. The crew was asked to configure for analog downlink and a successful video downlink was accomplished. It was later determined that a full disk in a piece of ground equipment was the cause of the issue. The disk was cleared and a successful HDTV downlink was later performed.

Flight Day 11

The main activities on FD 11 were the transfer of the MPLM back into the Orbiter payload bay, hatch closure, and rendezvous-tools checkout.

The SSRMS successfully transferred and berthed the MPLM into the payload bay and the MPLM was configured for entry operations. Additionally, the SRMS was maneuvered to the Undocking position at 251/02:01 GMT (09/22:01 MET).

The hatch between the ISS and the Orbiter was closed and the vestibule was leak-checked successfully.

At 250/23:11 GMT (09/19:11 MET) the fuel cell 1 Hydrogen (H₂) flow-meter reading dropped to 0.09533 lb_m/hr. After 27 sec, the reading returned to 0.10579 lb_m/hr. The data showed no corresponding changes in fuel cell 1 Amperes (A), the fuel cell 1 coolant pressure, the fuel cell 1 Oxygen (O₂) flow, the H₂ vent-line temperatures, or the H₂ cryogenic tank 5 pressures. A detailed data review showed that fuel cell 1 H₂ flow-meter transients have occurred multiple times with the same signature during the flight and pre-launch operations.

Operation of the TCS was nominal during the rendezvous-tools checkout in preparation for the undocking activities. The TCS did not display the bearing-calibrations error message as seen during the Rendezvous Tools Checkout prior to docking.

Flight Day 12

The main activities on FD 12 were undocking, fly-around, separation, and the Late Inspection of the RCC.

The third on-orbit fuel cell purge began at 251/17:38 GMT (10/13:38 MET). During the 120-hour purge interval, the approximate voltage decay was 0.15 Vdc for fuel cell 1, 0.10 Vdc for fuel cell 2, and 0.15 Vdc for fuel cell 3. The fuel cell water line and water relief heaters were switched from the A to the B system at 252/01:35 GMT (10/21:35 MET).

The maneuver to the undocking attitude was performed using Alternate Primary Reaction Control System (ALT PRCS) since Vernier RCS attitude control of the Orbiter was unavailable due to the F5R thruster leak and subsequent closure of the FRCS manifold-5 isolation valve. No issues were observed. The Orbiter ALT PRCS thrusters held vehicle attitude within the required deadbands until free drift was initiated.

The Orbiter successfully undocked from the ISS at 251/19:23 GMT (10/15:23 MET). The 6.1-sec Separation 1 maneuver was initiated with a RCS +X pulse at 251/19:50:57 (10/15:50:57 MET). The Separation 2 maneuver was performed at 251/21:05:37 GMT (10/17:05:37 MET). This was a 21.92-sec -X RCS maneuver. The resulting orbit was 194 by 181 nmi. Engine performance was nominal for both burns.

At 251:20:34:55 GMT (10/16:35:18 MET), the aft DAP panel "A" pushbutton contact C failed Redundancy Management (RM) when the crew depressed the button. The "A" pushbutton continued to work nominally using the remaining two contacts.

At 251/21:53:00 GMT (10/17:53:24 MET), the SRMS/OBSS was maneuvered to the Flat-Field position in support of the Late Inspection. The nose, starboard and port surveys were completed with no anomalies. The surveys were completed at 252/02:25 GMT (10/22:25 MET). The OBSS was cradled and latched at 252/03:13:13 GMT (10/23:13:36 MET). The SRMS was cradled and latched at 252/03:52:03 GMT (10/23:52:26 MET), and the SRMS power-down was completed at 252/03:55 GMT (10/23:55 MET).

A waste-water dump was completed successfully at 252/05:01 GMT (11/01:01 MET). A total of 27 lb was dumped overboard.

Flight Day 13

The main activities on FD 13 were stowing the cabin for entry, performing the Flight Control System (FCS) checkout, the RCS hot-fire test, the Shuttle Ionospheric Modification with Pulsed Localized Exhaust Experiment (SIMPLEX) firing, a waste and condensate dump using the FES, and stowing of the KU-band antenna.

Since the SSPTS deactivation, the fuel cell 2 Condenser Exit Temperature (TCE) remained steady at 154 to 155 °F and the KOH concentration stayed between 33 and 35%.

The FCS checkout began at 252/18:37 GMT (11/14:37 MET) and was completed at 252/19:28 GMT (11/15:28 MET). There were no FCS anomalies reported. However, the crew reported that one small piece of debris was floating away from the Orbiter on the port side during the checkout. The crew reported that the debris looked like tape or ribbon. Personnel on the ground reviewed the imagery and determined that the debris was not an issue for landing.

The procedures for RCS hot-fire were initiated at 252/19:32:25 GMT (11/15:32:49 MET) and terminated at 252/19:46:14 GMT (11/15:46:38 MET). All 38 RCS thrusters were fired at least twice for at least 0.240 sec per pulse.

After the RCS hotfire, the RCS F1D thruster injector temperature exceeded 150 °F. The F1D thruster was reassigned to last priority. The injector temperature was monitored for the remainder of the mission with no additional issues identified.

A waste and condensate dump using the FES was initiated at 252/20:00 GMT (11/16:00 MET) and terminated at 253/02:58 GMT (11/22:58 MET). A total of 122.7 lb of waste water was dumped.

A SIMPLEX (OMS-8) maneuver was performed at 253/00:08:38 GMT (11/20:09:02 MET). It was a dual engine, straight-feed maneuver lasting 10.1 sec, and the ΔV was 16.4 ft/sec. The orbit after the maneuver was 179.5 by 191.9 nmi.

The Ku-Band system was powered down and stowed without issue at 253/04:09:48 GMT (12/00:10:12 MET).

The RCC DAT completed the review of all imagery from the Late Inspection and cleared the Orbiter for entry.

Flight Day 14

The main activities on FD 14 were the crew actions to prepare for two deorbit/entry attempts to Kennedy Space Center (KSC). Both deorbit attempts were waved off, at 253/21:21:18 GMT (12/17:21:42 MET) and 253/23:27:54 GMT (12/19:28:17 MET) respectively, due to inclement weather at KSC.

The OMS-9 orbit-adjust maneuver was a dual engine, straight-feed firing that was performed nominally at 253/16:02:37 GMT (12/12:03:00 MET) with the cutoff at 253/16:02:50 GMT (12/12:03:13 MET) and both OMS engines operated nominally. The maneuver was 13.6 sec in duration with a ΔV of 21.9 ft/sec. The resulting orbit was 179.1 by 192.0 nmi.

The fourth on-orbit fuel cell purge was performed at 253/17:34 GMT (12/13:34 MET). During the 48-hour purge interval, the approximate voltage decay was 0.20 Vdc in FC 1, 0.17 Vdc in FC 2, and 0.17 Vdc in FC 3. The system was verified to be operating nominally.

The Payload Bay Doors (PLBDs) were closed and latched at 253/19:45:05 GMT (12/15:45:29 MET). The doors were re-opened at 253/23:47 GMT (12/19:47 MET) after the wave-off of the two KSC landing opportunities. All run-times and indications were nominal.

The Star Tracker doors were closed at 253/20:12:21 GMT (12/16:12:45 MET) with nominal limit switches and run times. The Star Tracker doors were reopened at 254/00:56:14 GMT (12/20:56:38 MET) to support star alignment.

The RCS pressurization and propellant-isolation valves were configured for entry at 253/21:31:04 GMT (12/17:31:28 MET), with the exception of the Forward RCS Manifold 5 valve which remained closed. The RCS pressurization and propellant-isolation valves were re-configured for orbit after the landing opportunities were waved off.

The PRCS Thruster F1D heater was verified operational after observation of nominal heater cycling on at 253/21:56:21 GMT (12/17:56:45 MET) and off at 253/22:26:41 GMT (12/18:27:05 MET). The OMS and RCS heaters were configured for entry at 253/23:18:49 GMT (12/19:19:13 MET).

Flight Day 15 – Entry and Landing

The main activity for FD 15 was PLBD closing, the deorbit maneuver, entry, and landing.

The STS-128 mission was successfully completed with a landing at Edwards Air Force Base (EAFB), CA.

PLBD closing was initially deferred since both KSC landing opportunities on the second landing day were waved off because of unacceptable weather conditions at KSC.

The PLBDs were closed in preparation for the first landing opportunity at EAFB on the second landing day at 254/20:25:32 GMT (13/16:25:55 MET).

The deorbit maneuver for the first landing opportunity at EAFB was a dual-engine straight-feed firing, which was performed on orbit 219 at 254/23:47:37 GMT (13/19:48:00 MET). The maneuver had a duration of 155.6 sec in with a ΔV of 267.8 ft/sec. The orbit after the deorbit maneuver was 192.1 by 22.7 nmi.

The FRCS dump of the propellants using four thrusters began at 255/00:04:01 GMT (13/20:04:24 MET) and the dump was completed 43.2 sec later. A total of 24% (527.0 lb) of propellants were dumped.

Entry Interface (EI) occurred at 255/00:22:01GMT (13/20:22:34 MET).

The main landing gear touchdown occurred on EAFB runway 22 at 255/00:53:20 GMT (13/20:53:43 MET) on September 11, 2009. The nose gear touchdown occurred at 255/00:53:30 GMT (13/20:53:53 MET). The drag chute was deployed at 255/00:53:32 GMT (13/20:53:55 MET). Drag chute jettison occurred at 255/00:54:06 GMT (13/20:54:29 MET). Wheels stop occurred at 255/00:54:33 GMT (13/20:54:56 MET). The rollout was normal in all respects.

The flight duration was 13 days 20 hr 54 min 56 sec. The last APU was shutdown 16 min 6 sec after landing.

Post-Landing

During the post-landing power-on at EAFB, the APU 3 Exhaust Gas Temperature (EGT) transducer 2 was noted as being below ambient, which is essentially off-scale low. This condition is typical of a failure (IFA STS-128-V-06). The companion sensor, APU 3 EGT transducer 1, was nominal during entry and indicated an ambient temperature during the post-landing operations, as expected. The APU 3 EGT transducer 2 was not downlinked during entry and thus was not visible until post-landing.

The Orbiter was ferried from EAFB to KSC. The vehicle departed EAFB on September 20, 2009, after 7 days of preparation for ferry flight. After two fuel stops (Amarillo Airport and Naval Air Station, Ft. Worth, TX) and a night at Barksdale AFB, Louisiana, the vehicle arrived safely at KSC.

PAYLOADS, EXPERIMENTS AND DETAILED TEST OBJECTIVES

LAUNCH PACKAGE OVERVIEW

The International Space Station (ISS) Expedition 17A launch package consisted of the Multi-Purpose Logistics Module (MPLM), the Materials on ISS (MISSE) 6a and 6b Flight Support Equipment (FSE), and the Lightweight Mission Peculiar Equipment Support Structure Carrier (LMC).

The pressurized MPLM carried to orbit six System/Science racks, seven Resupply Stowage Platforms (RSPs), two Resupply Stowage Racks (RSRs), one Integrated Stowage Platform (ISP) and nine Cargo Transfer Bags (CTBs) attached to the Aft End Cone (AEC) structure. This was a total of 15 racks with one ISP within the MPLM, the maximum number of racks and cargo that can be carried within the MPLM. The six System/Science racks include the Node 3 Air Revitalization System, the Combined Operational Load Bearing External Resistance Treadmill (COLBERT) -2, the Deck Crew Quarters (CQ), the Minus Eighty Laboratory Freezer – 2 (MELFI-2) rack, the Materials Science Research Rack (MSRR), and the Fluids Integration Rack (FIR). These System/Science racks enhanced the capability to further support six-member crew operations as well as high-priority Utilization payload objectives. Additionally, one Zero-G Stowage Rack (ZSR) was hard-mounted to an RSR with its contents transferred to ISS.

The LMC is a cross-bay carrier located in Bay 13 of the Payload Bay (PLB). The Orbital Replacement Unit (ORU) integrated onto the LMC for launch was the Ammonia Tank Assembly (ATA) on top and one unoccupied Passive Flight Releasable Attachment Mechanism (PFRAM) on the bottom. For return, the LMC ORUs were the depleted ATA directly mounted on top, and the European Technology Exposure Facility (EuTEF) attached to the bottom PFRAM.

The powered middeck ISS Program Utilization payloads were the General Laboratory Active Cryogenic on ISS Experiment Refrigeration (GLACIER) rear-breather double locker, and the Mice Drawer System (MDS) rear-breather double-locker stowed with six mice. For ascent, the GLACIER samples were Japan Aerospace Exploration Agency (JAXA) Radiation of Silk-Worm Eggs, while the return samples were LADA-Validating Vegetable Production Unit (VPU) Plants, the Human Research Program (HRP) Nutrition and the JAXA Microbe.

CREW ACTIVITY SUMMARY

On FD 3, a successful rendezvous and docking with the ISS was completed using PRCS for the first time at 01/21:03 MET, due to the loss of the F5R Vernier Reaction Control System thruster on FD 1.

On FD4, the Space Station Remote Manipulator System (SSRMS) unberthed the MPLM from the PLB and successfully berthed it to the ISS in the Node 2 Nadir location. During the docked timeframe, the crew performed three scheduled Extravehicular Activities (EVAs), numerous Intravehicular Activity (IVA) activations and checkouts, Remove and Replace (R&R) activities, Public Affairs Office (PAO) events, and middeck/consumables transfer operations.

The first EVA with the EV1 and EV3 crewmembers was successfully completed on FD 5 in 6 hr 36 min. The primary tasks completed were the release of the P1 truss ATA, which was temporarily stowed on the SSRMS arm using the Fixed Grapple Bar (FGB) until the second EVA. Additionally the European Technology Exposure Facility (EuTEF) was retrieved from the Columbus External Payload Facility (EPF) and stowed on the LMC. The EuTEF and the MISSE 6a and 6b payloads were retrieved from the EPF and stowed on the Orbiter PLB sidewall carriers. Power was connected to the LMC to supply the EuTEF with heater power, and telemetry showed about 6 Amperes usage as expected. During the ATA removal, the fluid Quick Disconnect (QD) failed to fully reseal. It remained in this configuration, with no issue to the External Active Thermal Control System (ETACS), until the second EVA. During removal of one of the MISSE 6 Pip Pins, the EV1 crewmember had to use a hammer and a Bearing Motor Roll Ring (BMRRM) anti-rotation latch tool to remove the MISSE 6. Near the completion of the EVA, the EV1 crewmember photographed numerous Micro-Meteoroid/Orbital Debris (MM/OD) hits on handrails and debris panels near the Airlock EVA Tool Stowage Device. This task did not allow for any EVA get-ahead tasks to be completed.

The EV1 and EV2 crewmembers successfully completed the second EVA on FD7 in 6 hr 39 min, and all planned tasks were completed. These tasks included the installation of the new ATA on the Port 1 truss site, including connection of fluid and electrical lines. Following successful installation, ground controllers activated the ETCS with the new ATA in the loop. Other tasks were the Installation of the used ATA on the LMC, the installation of the Fixed Grapple Bar on Starboard 1 truss ATA in preparation for a later mission, and added wire tied to the Airlock handrail to identify a MM/OD strike that caused a sharp-edge hazard. The get-ahead tasks completed included adding the SSRMS Camera Lens Covers on the Latching End Effector (LEE) B wrist and elbow cameras to protect against H-II Transfer Vehicle (HTV) plume contamination, relocating Articulating Portable Foot Restraint (APFR) Tool Stanchion, and adding a wire tie to the Airlock handrail to identify MM/OD strike that caused a sharp edge hazard.

The EV1 and EV2 crewmembers completed the third EVA on FD 9 in 7 hr 1 min. The EVA completed numerous tasks necessary for future assembly flights, and Remove and Replace (R&R) critical hardware for return and refurbishment and future return to ISS. The tasks completed were the deployment of the Starboard (S) 3 Upper Outboard Payload Attach System, replacement of the S0 Rate Gyro Assembly, replacement of the S0 Remote Power Control Module (RPCM), routing of cabling in preparation for STS-130 mission, remove slidewire from Node 1 due to interference, and install Global Positioning System (GPS) antennas no. 2 and no. 4 for HTV arrival.

On FD 11, the MPLM was uninstalled from the ISS using the SSRMS and berthed the MPLM in the PLB. Discovery undocked from the ISS at the beginning of the crew day on FD 12 at 251/19:26 GMT (10/15:26 MET). The ISS flyaround was performed using the High Definition Camera System. The TriDAR data were acquired during the undocking and flyaround.

SIMPLEX data were acquired on FD 13 at the Millstone Hill ground-site by performing two Orbital Maneuvering System (OMS) maneuvers for 10 sec each.

TRANSFER WEIGHT SUMMARY

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

TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Parameter	To ISS, lb _m	From ISS, lb _m
MPLM	14,219	2,933
Middeck	1,281	565
External	2,525	2,736
Totals	18,025	6234

1. **Water** – 747.6 lb_m (Fifteen Shuttle Contingency Water Container-Iodine (CWC-I), one CWC, and 3 Portable Water Reservoirs). In addition, two ISS CWC's were filled with condensate and transferred for Russian processing.
2. **Oxygen** – 9.0 lb_m to repress the ISS prior to hatch closure. No tank-to-tank oxygen was transferred.
3. **Nitrogen** – No nitrogen transferred
4. **Lithium Hydroxide** – Ten canisters to ISS and 16 cans returned to Shuttle.
5. **Food** – 89 containers from the MPLM.
6. **Station-to-Shuttle Power Transfer System** – 1423 kWh.

SIGNIFICANT FIRSTS

The significant firsts for the STS-128 mission were as follows:

1. First flight of Operational Increment (OI) -34 software.
2. Friction-stir process was used on the External Tank (ET) LH₂ tank barrel.
3. Joint F3 liquid air insulation boot was redesigned to improve performance and reduce installation time.
4. Oxygen crossover valve position indication signal monitoring for ground monitoring.

SIGNIFICANT ISS ANOMALIES

No significant anomalies occurred during the docked operations.

MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS

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

ISS MISSION PRIORITIES COMPLETION STATUS

	Task	Flight Day Task Completed
Category 1		
1	Berth MPLM to ISS Node 2 Nadir Port, activate and check out MPLM.	IVA/SSRMS √ FD4
2	Perform mandatory water transfers.	IVA √ FD3-FD11
3	Rotate Expedition 19/20 FE-2 (2J/A) crewmember with Expedition 20/21 FE-2 (17A) crewmember; transfer mandatory crew rotation cargo per Flight 17A Transfer Priority List (TPL) and perform mandatory tasks consisting of the safety briefing, Individual Equipment Liner Kit (IELK) installation, and Sokol suit checkout.	IVA √ FD3
4	Transfer and install N3 ARS rack.	IVA √ FD5
5	Transfer and install T2 rack and associated system components to ISS and temporarily install in interim rack location.	IVA √ FD5
6	Transfer and stow critical items to ISS per 17A TPL.	IVA √ FD3-FD11
7	Transfer and install remaining ISS MPLM racks to the ISS. a. Deck CQ b. MELFI-2 c. FIR d. MSRR	IVA √ FD5 √ FD6 √ FD6 √ FD6
8	Transfer, remove, and replace ATA from the LMC to the P1 site. Remove P1 ATA on FD 5/EV1.	√ FD7/EVA2 /SSRMS
9	Return empty P1 ATA to the LMC.	√ FD7/EVA2 /SSRMS
10	Return MPLM to the Orbiter PLB.	IVA/SSRMS √ FD11
10a	Retract and R&R Node 2 Nadir Bolt 4-1. Retract attempt on FD 6 unsuccessful, R&R on FD 9.	√ FD6, FD9 IVA/Ground
11	Transfer EuTEF/FSE IA from ISS Columbus EPF to LMC.	√ FD5/EVA1 /SSRMS
Category 2		
12	Perform minimum crew handover of 12 hours per rotating crewmember which includes crew safety handover.	IVA √ FD3-FD 11
13	Transfer MISSE 6a & 6b PECs from ISS Columbus EPF to the Orbiter PLB.	√ FD5/EVA1 /SSRMS
13a	Remove and replace the OGS Water ORU Filter.	IVA √ FD9
14	Transfer remaining cargo items per Flight 17A TPL.	IVA √ FD3-FD11

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
	Category 3	
15	<p>Perform HTV preparation tasks.</p> <ul style="list-style-type: none"> a. Checkout Display and Control Panel (DCP) Switch. b. Perform required Onboard Training (OBTs), including Robotic Onboard Trainer (RoBOT) setup/teardown. c. Checkout Hardware Command Panel (HCP). d. Maneuver SSRMS to HTV grapple/berth configuration and perform required checkout in support of HTV grapple/berth. e. Perform Proximity Communications System checkout no. 4 f. Charge Battery Stowage Assembly (BSA)/Rechargeable EVA Battery Assembly (REBA) batteries. g. Resize EMU to support HTV. 	<p>IVA/ Ground/ Robotics Deferred FD6 attempt, FD8 patch uploaded, √ FD12 training completed</p> <p>FD10 FD4 start- FD6 complete</p> <p>FD5 not successful, redo on FD7 was successful FD10</p> <p>FD11</p>
16	Remove and Replace the S0 Rate Gyro Assembly (RGA).	√FD9/EVA3
17	Deploy S3 Upper (Zenith) Outboard Payload Attach System (PAS).	√FD9/EVA3
18	<p>Perform additional Node 3 Prep Tasks.</p> <ul style="list-style-type: none"> a. Pre-route external channel 1/4 power and data cables and channel 2/3 power and data cables from S0 panel A145 across the U.S. Lab and Node 1. b. Temporarily connect Node 1 port/PMA3 heater umbilical. The cables were too short, thus the task cannot be performed so Pressurized Mating Adapter (PMA) 3 cannot be heated. c. Remove and Replace the RPCM S0-1A-D. 	<p>√ FD9/EVA 3 for a. and c</p> <p>Not completed</p> <p>EVA 3/FD9</p>
19	Perform Hydrogen Orbiter Replacement Unit (ORU) Calibration Kit (HOCK) verification on the Oxygen Generation System (OGS) pressure sensor.	√FD9
20	Perform ISS daily payload status checks as required.	IVA √ Daily

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
21	<p>Perform daily middeck activities to support payloads (including cases where Shuttle crew also performs payloads on the ISS).</p> <ul style="list-style-type: none"> a. GLACIER transfer samples on FD 6 to MELFI complete, transfer samples from Minus Eighty Laboratory Freezer for ISS (MELFI) on FD 10 b. Mice Drawer System transfer to ISS c. National Lab Pathfinder (NLP) Vaccine-5 d. HRP/ISS Integrated Immune and Integrated Immune (SDBI 1900) e. HRP/ISS Sleep Long and Sleep Short (SDBI 1634) f. HRP/Spinal Elongation (hardware stowed in Multi-Purpose logistics module (MPLM), three subjects, one ISS crew operator) g. Visual Performance (SDBI 1904). 	<p>IVA</p> <p>√ FD6, FD10</p> <p>√ FD4</p> <p>√ FD2</p> <p>√ Daily</p> <p>√ Daily</p> <p>√ FD10</p> <p>√ FD1</p>
22	Perform ISS payload research operations tasks.	<p>IVA</p> <p>√ Daily</p>
23	Remove MPLM Baseplate Ballast Assemblies (BBA)s and Lamp Housing Assemblies (LHA)s and transfer to ISS. If required, install the failed ISS-BBAs/LHAs back into MPLM. One LHA from MPLM to airlock on FD 4, eight LHA on FD 10 (no BBAs).	<p>IVA</p> <p>√FD4, FD10</p>
24	Perform Crew Quarters outfitting and activation as required to support minimal crew habitation.	<p>IVA</p> <p>√FD5</p>
25	Perform TriDAR Automated Rendezvous and Docking Sensor DTO-701A activities.	<p>IVA</p> <p>√FD3, FD12</p>
26	Install SSRMS Camera Lens Cover on LEE B wrist camera.	<p>EVA</p> <p>√EVA2, FD7</p>
27	<p>The following EVA 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.</p> <ul style="list-style-type: none"> a. Add Wire Tie to Airlock handrail Micrometeoroid Orbital Debris strike to mitigate possible sharp edge hazard. 	<p>EVA</p> <p>√EVA2, FD7</p>
28	Transfer O2 from the Orbiter to the ISS High Pressure Gas Tank (HPGT). Not required. Repressurization of 9 lb to the stack performed prior to hatch closure on FD 11.	<p>N/A (Stack repressurization)</p>
29	Perform Water Process Assembly (WPA) Water Sampling for return for EVA ground testing.	<p>IVA</p> <p>√FD10</p>
30	Perform Russian Segment IVA Operations.	<p>IVA</p> <p>√Daily</p>

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
31	<p>The following IVA tasks are deemed to fit in the existing IVA timelines; however, may be deferred if the timeline is behind schedule. The mission will not be extended to complete these tasks.</p> <ul style="list-style-type: none"> a. Pressurize PMA-3 b. Complete remainder of Crew Quarters outfitting and activation as required supporting full crew habitation. c. Install Node 2 – HTV Power Jumper (W6005) to Node 2 Nadir Vestibule Bulkhead connector (J103). This task can only be completed while MPLM is mated to Node 2 Nadir and the vestibule is pressurized. 	<p>IVA/Imagery</p> <p style="text-align: center;">Defer √FD6</p> <p style="text-align: center;">√FD8</p>
32	<p>Perform Program-approved IVA get-ahead tasks. The following IVA get ahead tasks do not fit in the existing IVA timelines; however, the IVA team will be trained and ready to perform should the opportunity arise.</p> <ul style="list-style-type: none"> a. Perform Node 1 port bulkhead feed-through modifications <ul style="list-style-type: none"> 1. Portable Water (J33) 2. Waste Water (J30) 3. ARS Air Sample (J40) 4. Nitrogen (J44) 5. Oxygen (J45) b. Perform coarse leaks checks of Node 1 port bulkhead feed-through utilizing Pressurized Mating Adapter (PMA) 3 partial depressurization. c. Tape the connectors W3359/P1 to W8250A/P2 [reference DC-to-DC Converter Unit (DDCU) Rack Rotation Jumper] 	<p>IVA/Imagery</p> <p style="text-align: center;">Defer</p> <p style="text-align: center;">Defer</p> <p style="text-align: center;">√FD9</p>
33	<p>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 and Mission Operations have flexibility to select the tasks to be completed based on efficiencies gained in performing the already scheduled required tasks.</p> <ul style="list-style-type: none"> a. Relocate EVA aids for subsequent missions. Articulated Portable Foot Restrain (APFR) relocate on EV2/FD 7 b. Remove Node 1 Slide-wire c. Reposition FGB Local Area Network Connector on Node 1 Port d. Install GPS AA No. 2 and No. 4 on Starboard (S) 0. AA no.2 Multi-Layer Insulation (MLI) had a bigger opening than the other AA#4 MLI, so two wire ties were used to cinch up slack. e. Install Node 1 C2-O2-MM/OD shield. f. Install SSRMS Camera Lens Cover on SSRMS LEE B elbow camera. g. Deploy S3 Lower (Nadir) Outboard PAS h. Install Bootie/Grounding Connector Sleeves <ul style="list-style-type: none"> 1. W4148 Connector Bootie inside S0 2. 2 connectors on MBS Jumper, MBS/MT Nadir 3. ESP2-J57A inside S0 Truss/Bay 3 4. Reposition PMA2 starboard sleeve installed on 2J/A. 	<p>EVA</p> <p style="text-align: center;">√FD7</p> <p style="text-align: center;">√FD9,EVA3 Defer</p> <p style="text-align: center;">√FD9,EVA3</p> <p style="text-align: center;">Defer √FD7,EVA2</p> <p style="text-align: center;">Defer</p> <p style="text-align: center;">√FD7,EVA2 Defer Defer Defer</p>

ISS MISSION PRIORITIES COMPLETION STATUS (Concluded)

	Task	Flight Day Task Completed
34	Reboost the ISS with the Orbiter if mission resources allow and are consistent with ISS trajectory analysis and planning.	Defer
35	Perform payload of opportunity operations to support SIMPLEX, MAUI and SEITE. FD 2 (NC2 firing for SIMPLEX), FD 3 (NC4 firing for SIMPLEX), FD 13 (orbit-adjust firing for SIMPLEX).	IVA/ Ground √ FD2,3,13
36	Perform imagery survey of ISS exterior during Orbiter flyaround after undock.	IVA √ FD12
37	Perform a ground controlled video survey of the ISS external surfaces (Solar Panels, Trusses, Modules, Handrails, Crew Interfaces, Radiators, etc.) while the Orbiter is docked. The imagery is required to document the external configuration and condition of the ISS.	Ground /Imagery √ Daily
38	Perform Station Development Test Objective (SDTO) 13005-U, ISS Structural Life Validation and Extension, during Shuttle mated reboost (ISS Wireless Instrumentation System (IWIS) required, Rover (6 th) accelerometer)	IVA/Ground /Imagery Defer
39	Perform SDTO-13005-U, ISS Structural Life Validation and Extension, during 17A Orbiter undocking (IWIS highly desired, but not required) (only if crew time available).	IVA/Ground √ FD12
40	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during MPLM Berthing and Unberthing (IWIS required).	IVA/Ground /Imagery √ FD4,11

DEVELOPMENT TEST OBJECTIVES

The Detailed Test Objectives (DTOs) were performed satisfactorily.

DTO 695 THRUST OSCILLATION SEAT

The vibration data for the Thrust Oscillation Seat DTO were gathered on the crewmembers seats during launch to assist in the development of the unimpeded crew-performance specifications. The devices that were used to collect the data included accelerometers, visual placards read by the crew, and a camera observing the crewmember seat during ascent.

DTO 696 GRAB SAMPLE CONTAINER REDESIGN FOR SHUTTLE

The cabin air quality was verified using a new container which is 50% smaller and 50% lighter than the current grab-sample container.

DTO 701A TriDAR AUTONOMOUS RENDEZVOUS AND DOCKING SENSOR

The TriDAR Autonomous Rendezvous and Docking (AR&D) Sensor DTO was activated and collected data during the FD3 R-Bar Pitch Maneuver (RPM), docking, one revolution post-docking, and the FD12 undocking and flyaround. TriDAR is a rendezvous and docking 3D vision system. The sensor optimally combines active laser triangulation and LIDAR 3D imaging in a single optical package. The sensor was located on the Orbiter Docking System (ODS) and controlled via A31P Payload General Support Computer (PGSC).

DTO 805 CROSSWIND LANDING PERFORMANCE

This DTO of opportunity was attempted when the drag chute was deployed after nose gear touchdown during landing at Edwards Air Force Base (EAFB). The forecasted crosswinds were for greater than 10 knots, but only a 5-knot steady-state wind was achieved and that level did not meet the DTO criteria.

DTO 854 BOUNDARY LAYER TRANSITION

STS-128 was the second flight of the Boundary Layer Transition (BLT) DTO. Thermocouple data were collected during the Orbiter's boundary layer transition at the high Mach number, high enthalpy during entry. This data will support development of future atmospheric re-entering vehicles.

The BLT flight experiment no. 2 had a tile with protuberance of 0.35-in., which was installed on the lower surface of the left wing. The flight instrumentation configuration was very similar to the first Flight Experiment. The exception was Thermocouple (TC) no. 5 was moved inward of the turbulent wedge and TC no. 3 and TC no. 8 were moved to provide for better monitoring of the aerodynamic heating environment. An additional

Li-900 tile downstream of the 0.35" protuberance tile was added to mitigate any potential tile slumping. Additionally, catalytic coating material was applied to two tiles downstream of the 0.35" protuberance tile to further understand the catalytic characteristics of thermal protection systems during entry heating.

Flight experiment instruments indicated the flight experiment performed as expected. Thermocouple no, 1 indicated the BLT on-set occurred around 904 sec from entry interface. The BLT tool predicted transition to occur near Mach 17.4 based on the post-flight Best Estimated Trajectory (BET). The flight data did not get a complete mapping of the BLT transition time/Mach number and temperature profiles of the protuberance and turbulent wedge area. Studies show that some of the unexpected surface temperature changes could be due to the Orbiter maneuver/roll. In addition, tile 278 created a 0.1-in. to 0.15-in. step at the forward port side fuselage that may have caused an early asymmetric BLT, which affected the BLT flight experiment's protuberance transition time.

The post-flight inspection indicated that the BLT flight experiment performed satisfactory. The leading edge of the trip showed minor coating glazing, but there was no obvious sign of slumping at the trip or downstream tiles.

DTO 900 SHUTTLE REUSABLE SOLID ROCKET BOOSTER CHAMBER PRESSURE, STRAIN GAUGE, AND ACCELERATION RATES DATA COLLECTION

Data were collected during ascent to support future exploration initiatives. The results of this DTO will be published in separate documentation.

SHUTTLE IONOSPHERIC MODIFICATION WITH PULSED LOCAL EXHAUST

The Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) was flown as a payload of opportunity. SIMPLEX observations used ground-based sites to observe Orbital Maneuvering System (OMS) maneuvers to investigate plasma turbulence. SIMPLEX had two pre-flight observation opportunities and one opportunity identified during the mission that resulted in three observations. The first two opportunities were observed by the ALTAIR ground-site and were conducted during the NC2 OMS maneuver on Flight Day (FD) 2, and the NC4 OMS maneuver on FD 3. The third opportunity was an observation by the Millstone ground-site, on FD 13 using two OMS maneuvers for a 10-second duration.

MAUI ANALYSIS OF UPPER-ATMOSPHERIC INJECTIONS

The Maui Analysis of Upper-Atmospheric Injections (MAUI) DTO was flown as a payload of opportunity. The MAUI is one of three Department of Defense (DOD) Space Test Program (STP) payloads of opportunity. Images would be analyzed to better understand the interaction between the spacecraft plume and Earth's upper atmosphere. MAUI observations use ground-based sites to observe Orbiter jet firings. MAUI was not performed since no observations opportunities occurred during the mission.

SHUTTLE EXHAUST ION TURBULENCE EXPERIMENT

The Shuttle Exhaust Ion Turbulence Experiment (SEITE) is one of the three DOD payloads of opportunity using space-based sensors to detect ionospheric turbulence inferred from the radar observations of the OMS maneuver. The SEITE was not performed since no observations opportunities occurred during the mission.

NATIONAL LABORATORY PATHFINDER – VACCINE-5

The National Laboratory Pathfinder Vaccine -5 (NLP-Vaccine-5) was a commercial payload serving as a pathfinder for the use of ISS as a National Laboratory after ISS assembly is complete. The experiment contained several different pathogenic (disease causing) organisms, with the intent of using space flight to develop space flight to develop potential vaccines for the prevention of infections on Earth and in microgravity. The experiment was contained in sixteen Group Activation Packs (GAPs) that were not temperature controlled.

The ascent and descent middeck Short Duration Bioastronautics Investigations (SDBIs) performed during the mission included Human Research Program (HRP) ISS Sleep Long & Short (SDBI 1634), HRP Spinal Elongation, HRP Visual Performance, and ISS Integrated Immune (SDBI 1900).

VEHICLE PERFORMANCE

LAUNCH DELAYS

The first launch attempt occurred on August 25, 2009, and was scrubbed due to lingering thunderstorms in the vicinity of the launch pad. The storms violated weather-rules that were specific to the cumulus-cloud rule, the anvil rule, the atmospheric electric-field-mill rule and the flight-through-precipitation rule.

The second launch attempt occurred on August 26, 2009, and was scrubbed due to a loss of the closed indication on the Liquid Hydrogen (LH₂) fill-and-drain valve that was an LCC violation. The MPS LH₂ Inboard fill-and-drain valve is used to isolate the LH₂ feed system from the ground during LH₂ terminate-replenish. The valve is commanded closed at the beginning of the reduced fast-fill (approximately T-4.5 hr). The valve required verification of being fully closed to provide isolation during fill-line drain as well redundant isolation against overboard loss of propellant during ascent.

The third launch attempt was postponed to August 28th to allow engineers additional time to develop flight rationale based on testing conducted on the suspect valve position indicator and the 8-in. cryogenic valve inside Discovery's Main Propulsion System.

NATURAL ENVIRONMENTS AND FINAL INSPECTION

Natural Environments

The Lift-off (T-0) instantaneous surface conditions (based on measurements at the 60-ft level of Camera Site 3) were as follows; the wind speed was 2 knots, the wind direction was 337 deg, the temperature was 81 °F, the humidity was 90% and the ambient pressure was 29.89 in. Hg.

The Launch (L) -4 hr 50 min Jimsphere was not released because of a Phase-II lightning warning at the Cape Weather-Station. The I-loads were designed with the L-4 hr 20 min high- resolution balloon. This balloon was released approximately 30 min late as a result of the Phase-II lightning warning. Based on the L-2 hr 20 min Day-of-Launch I-Load Update (DOLILU) assessment profile, six excesses of the August 90th percentile database limits for the in-plane component between 52,300 and 55,200 ft, and one excess of the August 95th percentile database limits for the in-plane component between 54,700 and 54,900 ft. There were no wind shear excesses. The maximum measured wind velocity was 72.2 ft/sec at 44,500 ft and 211 deg. There were no violations of the in-plane or out-of-plane wind-change redlines from the L-4:20 DOLILU I-Load-design-wind profile to the final assessments based on the L-2 hr 20 min Jimsphere balloon and the 0330 UTC 50 MHz Doppler Radar Wind Profiler (DRWP).

The L-1:08 Jimsphere balloon was used to clear the roll maneuver region and was validated with the 0231 UTC False Cape 915 MHz profiler. The maximum measured wind velocity in the roll maneuver region was 25.7 ft/sec at 7300 ft and 241 deg.

Final Inspection

Light condensation was observed on the Liquid Oxygen (LO₂) tank and Intertank (IT). Moderate to heavy condensation was observed on the LH₂ tank due to light rain during the time of inspection. Surface temperatures ranged from 64 to 81 °F. There were no observations noted on the LO₂ or LH₂ Thermal Protection System (TPS) acreage, Intertank flanges or Ice/Frost Ramps. Several small frost spots were noted over the I/T valley fastener locations below the LO₂-I/T flange. The LO₂ feedline brackets were clean, with typical ice/frost formations observed at the bracket-base to the tank-fitting interface. The bracket at Xt 1623 experienced some froth on the aft face of the outboard-base-fitting closeout. Typical ice/frost was noted on the LH₂ and LO₂ umbilicals, and a small frost spot was noted on outboard side of LH₂ feedline. A typical crack was observed on the -Y vertical strut cable, and was also present on the first launch attempt. All observations were acceptable based on Ice/Debris documentation.

SOLID ROCKET BOOSTERS

All Reusable Solid Rocket Booster (RSRB) systems performed as expected during the launch- countdown and ascent of the STS-128 mission. Two In-Flight Anomalies (IFA's) were identified.

The Booster Separation Motors (BSM's) performed satisfactorily, and both RSRBs were successfully separated from the External Tank (ET). Reports from the recovery area indicated that the deceleration system performed as designed. The SRB's were retrieved and returned to Kennedy Space Center (KSC) for inspection and preparations for refurbishment.

During post-flight assessment of the parachutes at the Parachute Refurbishment Facility (PRF), the right hand main chute canopy was noted to be damaged with a vertical tear extending from the top vent band to the canopy bottom skirt band (IFA STS-128-B-001). Review of the STS-128 / B1139 right-hand Data Acquisition System (DAS) accelerometer data revealed off-nominal loading of the Solid Rocket Booster (SRB) subsequent to frustum separation and main parachute deployment, indicative of the loss of a single main parachute. Post-flight assessment revealed that all reefing line cutters fired properly resulting in the cutting of both the first and second stage reefing lines. All Sea Water Activation Release (SWAR) links worked properly and the main parachutes were released from the booster. Gore number 5 failed starting from ribbon number 2 and continued through to the vent lines. This large hole appeared to have collapsed the canopy during the first stage of deployment.

During the post-launch imagery review of ground based cameras, several pieces of debris were observed falling aft near the right hand Solid Rocket Booster (SRB) Hold Down Post (HDP) no. 4 between 39 and 45 sec MET (IFA STS-128-B-002). The estimated sizing exceeds the Risk Assessment Mass (RAM). The existing RAM in NSTS 60559 is 0.3 lbm based on calculation of a 26-in. by 2.25-in. by 0.125-in. piece.

REUSABLE SOLID ROCKET MOTORS

The STS-128 Reusable Solid Rocket Motor (RSRM) set performed within established and predicted limits (nominal). No RSR Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specifications Document (OMRSD) violations occurred.

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

There was no indication of Hold-Down Post (HDP) stud hang-up based on preliminary analysis.

EXTERNAL TANK

All External Tank (ET) systems performed as expected during launch countdown and ascent. The ET pre-launch countdown was nominal. Liquid level and Engine Cut-off (ECO) sensors performed as designed. No ET LCC or OMRSD violations occurred. 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 at the Ground Umbilical Carrier Plate (GUCP). All electrical equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly. Liquid level and ECO sensors performed as designed. ET separation was nominal. Since Main Engine Cut-Off (MECO) occurred as expected, entry and breakup occurred within the predicted footprint.

The tank identification was Super Lightweight Tank (SLWT) ET-132.

One in-flight anomaly was identified. Based upon Umbilical Well Camera imagery, foam loss was noted between +Y Jackpad/-Y Bipod Closeouts at LH2 Intertank (IFA STS-128-T-001). The dimensions of this foam loss were estimated to be 10.2 in by 8.0 in. by 1.0 in with a total mass of approximately 0.040 lbm,.

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle Main Engine (SSME) systems performed as expected during the launch countdown and ascent and performance was typical of previous flights. The

SSME pre-launch countdown was nominal. No SSME LCC or ORMSD violations occurred.

Engine "Ready" was achieved at the proper time and thrust build up was nominal. Preliminary flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown. The average SSME specific impulse (Isp) tag value was 452.05 sec at 104.5% Rated Power Level (RPL) the delivered ISP were within the expected range.

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

The commanded Max Q throttle-down was a single-step throttle bucket to 72% RPL [Adaptive Guidance Throttle (AGT) engaged].

The propellant-dump operations data were normal, and the Main Engine Cutoff (MECO) time was Engine Start + 512 sec.

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

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 were identified during the countdown.

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 as expected during ascent. During launch countdown, one MPS LCC violation occurred. No OMRSD violations occurred. One IFA was identified as a result of the LCC violation.

During the transition to reduced fast-fill for the August 26 launch, the Liquid Hydrogen (LH₂) inboard fill-and-drain valve closed Position-Indicator (PI) did not illuminate when the valve was commanded closed (IFA STS-128-V-01). The Launch Commit Criteria (LCC) for this condition prevented further operations toward a launch and a 48-hour scrub was declared. Following the draining of the tank, testing by cycling the valve at ambient-temperatures with timing analysis was performed with nominal results. Ambient, non-invasive checks of the valve were performed prior to pursuing another launch attempt. Approximately 24 hr post-scrub, the LH₂ manifold was pressurized and the PV12 valve was cycled consecutively five times to verify PI performance under ambient conditions. All PIs functioned as expected and all valve cycle timing was nominal during these ambient valve cycles. Additionally, a decay check was performed while PV12 was closed; no gross leakage was noted, indicating that the valve was fully closed and not leaking (which is expected with the 'closed' PI 'ON'). The decay checks were within family.

However, the Mission Management Team (MMT) decided to delay the launch an additional 24 hr to allow historical data to be gathered and evaluated. These data along with the cycling data were used to develop the rationale to proceed with the launch, even if the same signature recurred. The MMT accepted the rationale and approved the vehicle for launch. During the External Tank (ET) loading in preparation for the August 28 launch, the valve indication was nominal.

All LH₂ and LO₂ loading parameters were nominal. The LH₂ inboard fill-and-drain valve performed nominally. The LO₂ and LH₂ Engine Cutoff (ECO) sensors passed all pre-flight checkouts and operated nominally throughout ascent.

The LH₂ pre-pressurization cycle count was 10 cycle with 14 cycles established as the LCC criteria. Engine inlet net positive suction pressure requirements were met throughout the flight. Pressurization performance was nominal indicating proper operation of the Flow Control Valve (FCV) hardware. All three flow control valves performed nominally with 8 cycles on FCV no. 1, 6 cycles on FCV no. 2 and 3 cycles on FCV no. 3.

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 back-pressure used for fastfill, was 73 ppm (System A was used to determine

the maximum concentration). This compares favorably with previous data for this vehicle. The following table summarizes the results.

HAZARD GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	10,000	6700
Hydrogen	73	8
Oxygen	30	8
LD54/55	0	0

Gas Sample Analysis

The measured sample bottle pressures indicate the redesigned Orbiter aft fuselage gas sampler system performed satisfactorily.

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	3.58	0.57	1.65	0.10
2	LH 1	1.47	0.55	2.17	0.04
3	RH 2	1.40	0.89	1.12	0.05
4	LH 2	0.86	0.92	2.42	0.05
5	LH 3	0.12	2.18	1.91	0.08
6	RH 3	0.06	5.38	1.01	0.31

The Ascent Hazard Analysis indicated the maximum hydrogen firing leak rate was 5,030 scim in right-hand bottle no.1. The maximum allowable firing leak rate on ascent is 57,000 scim. The estimated firing leak rates for all sample bottle data from this flight are summarized in the following table.

HYDROGEN FIRING LEAK RATES

Bottle no.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	5,030
2	LH 1	1,020
3	RH 2	1,215
4	LH 2	895
5	LH 3	255
6	RH 3	535

The measured sample bottle pressures indicate the redesigned Orbiter aft-fuselage gas sampler system successfully collected all six samples. It was the second flight for all six bottles.

The oxygen concentrations were within historical levels and safely below the flammability limit. The highest concentration was 2.42% in left hand bottle no. 2. Argon indicated air as the major source of the oxygen and not an Orbiter system leak. The highest helium concentration was 5.38% in right hand bottle no. 3. Due to the low pressures at the time the last bottle acquired its sample and the lack of diluting atmosphere, the last bottle has shown to have the most variation.

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

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS

S/N	Position	Actual pressure, torr	Ar, %	Air from Ar, %	He, %	CO, %	CH ₄ , %	CO ₂ , %	O ₂ from air, %	O ₂ found, %	H ₂ , %	H ₂ pyro corrected, %
1098 FLT-1	RH1	185.0	0.07	7.28	0.57	<0.01	<0.01	<0.01	1.53	1.65	0.10	0.10
1092 FLT-1	LH1	75.8	0.09	9.10	0.55	<0.01	<0.01	<0.01	1.91	2.17	0.04	0.04
1146 FLT-1	RH2	72.3	0.05	4.93	0.89	<0.01	0.01	<0.01	1.03	1.12	0.05	0.05
1096 FLT-1	LH2	44.7	0.11	11.24	0.92	<0.01	0.01	0.01	2.36	2.42	0.05	0.05
1097 FLT-1	LH3	6.27	0.10	10.60	2.18	<0.01	<0.01	0.01	2.23	1.91	0.09	0.08
1147 FLT-1	RH3	3.2	0.07	7.71	5.38	<0.01	<0.01	0.02	1.62	1.01	0.31	0.31

Purge, Vent, and Drain System

The Purge, Vent and Drain (PV&D) system performed nominally throughout the mission and no IFA's were identified from the review and analysis of the data. Purge flow rates and temperatures were nominal.

The Ground crews at Edwards Air Force Base (EAFB) experienced problems connecting the ground-purge ducts to the Orbiter. The delay resulted in the purge not being initiated within 30 minutes (approximately 41 min) of the upper aft safety assessments. The purge was initiated 74 min after touchdown, and this exceeded the 45-min limit.

Reaction Control System

The Reaction Control System (RCS) performed all functions required for successful completion of the mission. One IFA was identified and it is reported in a following paragraph.

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

RCS PROPELLANT LOADING

Parameter	Forward RCS		Left RCS		Right RCS	
	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer	Fuel
Target, %	67.70	67.41	100.48	100.76	100.48	100.76
Target, pounds	1141	712	1523	962	1523	962
Calculated, %	71.81	70.41	100.59	100.69	100.44	100.74
Advertised, lbs	1196.4	737.5	1524.5	961.4	1522.4	961.8
PASS WHI ^a	4.3736	4.2666	4.3689	4.2636	4.3784	4.2092
BFS WHI ^b	4.3783	4.2701	4.3838	4.2752	4.3946	4.2476

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

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1D	4.7	59	1	1
F2D	5.8	74	-1	1
F3D	6.0	77	-2	1
F4D	6.0	77	-2	1
F4R	7.8	104	1	0
F1L	8.1	109	1	0
F2R	8.5	115	2	0
F1F	8.5	116	2	0
F3F	8.8	121	2	0
F3L	8.8	121	2	0
F3U	9.3	129	2	0
F2U	9.3	129	2	0
F1U	9.8	136	2	0
F2F	10.7	152	3	0

The RCS window-protect firing of the F1U, F2U and F3U thrusters was initiated at 241/04:01:39 Greenwich Mean Time (GMT) (00/00:02:02 MET) for total duration of 2.08 sec. The Forward Reaction Control System (FRCS) performance was nominal. The purpose of the window-protect firing is to deflect exhaust from the SRB Booster Separation Motors (BSMs) away from windows during SRB separation.

The ET Separation maneuver was performed at 241/04:08:22 GMT (00/00:08:45 MET) and was a 7.0-sec, 10-thruster translation. The ET Photo +X firing was performed at 241/04:38:37 GMT (00/00:39:00 MET) and had a duration of 20.8 sec.

Following the mission's initial vernier-thruster usage, the F5R thruster injector temperatures began to drop. Thruster F5R was deselected as failed because of a leak when the temperature dropped below the 130 °F Redundancy Management (RM) limit at 241/08:36:51 GMT (00/04:37:14 MET) (IFA STS-128-V-02). As the injector temperatures dropped below 100 °F, discontinuous fuel temperature drops were observed, suggesting fuel leakage/evaporation while the difference between the fuel and oxidizer injector temperatures indicated that the thruster heater was operating. Temperatures continued to drop over the next 3 hr until they went Off-Scale Low (OSL), which is 0 °F. Note that while the Mission Control Center (MCC) calibrations define OSL as 0 °F, the injector temperature transducers, and associated circuitry are capable of outputting temperatures down to -35 °F. When the uncalibrated data were examined, both injector temperatures were found to have dropped well below -35 °F for approximately 4 hr, likely approaching the triple point of Monomethyl Hydrazine (MMH), which is approximately -65 °F. Temperatures stayed below 0 °F for approximately 7 hr before coming back "on scale" at 241/18:37 GMT (00/14:37 MET). The Forward RCS manifold 5 isolation valves were closed by the crew at 241/18:47 GMT (00/14:47 MET) and remained closed for the rest of the flight. Hours after the isolation, the F5R thruster injector temperatures returned to nominal levels and the thruster heater cycled nominally the remainder of the mission.

Prior to docking, F1F and F2F were deselected at 243/00:42:56 GMT (01/20:43:19 MET). ISS capture was completed at 243/00:53:55 GMT (01/20:54:18 MET), and the DAP was moded to Free Drift. The primary thrusters F1L, F3L, F2R, F4R, F1U, F2U, and F3U were then deselected at approximately 20 min after the docking was completed. Because the Orbiter vernier RCS attitude control was unavailable due to the failure of the F5R thruster, the ISS Russian propulsive attitude control system maneuvered the mated stack to the mated Torque Equilibrium Attitude (TEA) flight attitude.

Maneuver to the undock attitude was completed at 251/18:37 GMT (10/14:37 MET). As part of the undocking preparations, thrusters F1U, F2U, and F3U were reselected at 251/18:44:41 GMT (10/14:45:04 MET). Undocking was initiated with a +Z pulse at 251/19:21:05 GMT (10/15:21:28 MET). ISS Undock was nominal. F1F and F2F were reselected at 251/19:31:42 GMT (10/15:32:05 MET). Fly Around initiated with a +X pulse of L1A and R1A at 251/19:50:57 GMT (10/15:51:20 MET). Separation 1 was a 6.1-second +X burn of L1A and R1A at 251/20:37:35 GMT (10/16:37:58 MET). Separation 2 was a 21.92-second +X maneuver performed at 251/21:05:37 GMT (10/17:06:00 MET).

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

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

Control Responsibility	Event Time, GMT	Comments
	243/00:53:55	DAP FREE DRIFT – Docking / ISS Capture
Orbiter	251/17:27:48	DAP LVLH
Orbiter	251/17:29:47	DAP AUTO – Maneuver to Undock attitude (ALT DAP)
ISS	251/19:23:02	DAP FREE DRIFT
Orbiter	251/19:21:05	DAP B/ALT/No Low Z
	251/19:26:32	Undock

The RCS hot-fire was initiated at 252/19:32 GMT (11/15:32 MET) and the hot-fire was terminated 15 min later. Each of the 38 RCS thrusters were fired at least twice for at least 0.240 sec each time. No fail-off or fail-leak problems were detected during the hot-fire. The aft RCS manifold 5 circuit-breaker test was also performed after the hot-fire was completed. The forward RCS manifold 5 circuit-breaker test was not performed because the manifold had been closed to isolate the F5R thruster leak.

Following the RCS hot-fire, the FRCS F1D thruster heater appeared to be ON when expected to be OFF for approximately 4 hr. The steady increase in injector temperatures, as well as the difference between the fuel and oxidizer injector temperatures, indicated that the thruster heater was ON during the time period between 252/18:11 GMT (11/14:11:23 MET) and 252/22:08 GMT (11/18:08:23 MET) while the F1D thruster was firing. The thruster injector temperatures exceeded 150 °F, but stayed below the 157 °F operational limit specified in the applicable Flight Rule. The thruster was placed in lowest priority at 252/22:14 GMT (11/18:14:23 MET), shortly after the F1D heater turned OFF as indicated by an abrupt change in slope of the injector temperature traces. The thruster injector temperatures decreased steadily, reaching a minimum of 92 °F, and then fluctuated with diurnal heating. When the thruster was subsequently placed in a colder environment, the heater activation temperature was reached, and the heater cycled nominally. The F1D thruster was placed back into first priority shortly before the deorbit maneuver. The F1D thruster fired twice, and all temperatures were nominal. Nominal heater cycles were observed at least five times on-orbit and subsequently on the ground at EAFB.

The FRCS dump was initiated with four thrusters at 255/00:04:01 GMT (13/20:04:24 MET) and lasted 43.2 sec. The dump consumed 24% (527 lb) of the FRCS propellant.

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

RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	System	Time of Ignition, GMT	ΔV , ft/sec	Duration, sec
RCS Window Protect	PRCS	241/04:01:38	N/A	2.08
ET Separation	VRCS	241/04:08:22	N/A	7
ET Photo +X	VRCS	241/04:38:37	N/A	20.8
ET Photo Pitch		Not required		
NC3	PRCS	242/06:10:20	2.9	12.4
NCC		Not required		
MC1	PRCS	242/22:46:16	0.3	1.12
Out of Plane Null	PRCS	242/23:08:12	0.1	0.4
MC2		Not required		
MC3	PRCS	242/23:33:59.5	0.42	1.76
MC4	PRCS	242/23:43:58	2.56	11.04
RPM	PRCS	243/00:03:34		
ISS Undocking	PRCS	251/19:26:32		
ISS Fly Around	PRCS	251/19:50:57		
Separation 1	PRCS	251/20:37:35.8		6.1
Separation 2	PRCS	251/21:05:37.9		21.92
RCS Hotfire	PRCS	252/19:32:25		
Forward Reaction Control System Dump	PRCS	255/00:04:01.2		43.2

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

RCS RESIDUAL PROPELLANTS

Parameter	Mission Operations Calculation		PASS Model Calculation ^s	
	%	lb	%	lb
Forward Oxidizer	5.0	67.5	3.6	48.6
Forward Fuel	0.2	1.7	0.3	2.6
Left Oxidizer	35.4	478	33.9	457.7
Left Fuel	32.8	279	33.0	280.5
Right Oxidizer	34.0	459	33.3	449.6
Right Fuel	32.6	277	32.0	272.0

Note:

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

The RCS propellant consumption shown in the following table was calculated by subtracting the PASS Model residuals in the above table from the advertised propellant loads.

RCS PROPELLANT CONSUMPTION

Parameter	Oxidizer, lb	Fuel, lb	Mixture ratio, Oxidizer/Fuel
Forward RCS	1147.8	734.9	1.59
Left RCS	900.3	575.4	1.56
Right RCS	906.3	584.3	1.55

The vernier thrusters were fired a total of 425 times for a total firing time of 385.68 sec. The primary thrusters were fired a total of 21,427 times for a total firing time of 6359 sec.

Orbital Maneuvering System

The Orbital Maneuvering System (OMS) performed nominally throughout the mission and no IFAs were identified from the review and analysis of the data. There were no deviations from documented OMRSD or LCC violations. System temperatures and pressures were within expected ranges and the system valves operated when commanded during the pre-launch period.

The OMS configuration for the STS-128 mission is shown in the following table.

OMS CONFIGURATION

Vehicle/equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 01	40 th	L-OME S/N 115	7 th rebuilt flight - 22 nd flight
Right Pod (RP) 03	38 th	R-OME S/N 106	11 th rebuilt flight - 35 th flight

The OMS maneuvers performed during the mission are shown in the following table.

OMS MANEUVERS

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV , ft/sec
Assist	Dual Engine	241/04:01:49.9	112.3	N/A
OMS-1	Not required			
OMS-2	Dual Engine	241/04:38:37.2	62.3	94.9
OMS-3 (NC1)	Dual Engine	241/07:24:45.0	58.2	89.2
OMS-4 (NC2)	Right Engine	241/20:56:36.2	15.8	12.0
OMS-5 (NH)	Dual Engine	242/19:58:58.4	67.5	104.9
OMS-6 (NC4)	Dual Engine	242/20:48:19.4	44.0	68.9
OMS-7 (TI)	Left Engine	242/22:26:17.1	11.4	8.6

OMS MANEUVERS (Concluded)

Maneuver designation	Configuration	Time of ignition, GMT	Firing time, sec	ΔV , ft/sec
OMS-8 (SIMPLEX)	Dual Engine	253/00:08:38.2	10.1	16.4
OMS-9 (Orbit Adjust)	Dual Engine	253/16:02:37.2	13.6	21.9
OMS-10 (Deorbit)	Dual Engine	254/23:47:37.2	155.6	267.8

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

INTERCONNECT USAGE, %/POUNDS

Parameter	Total, %	Total, pounds
Left OMS	1.592	206.19
Right OMS	0.990	128.21

The propellant usage data are presented in the following table.

PROPELLANT USAGE DATA

Parameters	Left OMS pod		Right OMS pod	
	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, lbm	7051	4254	7051	4254
Residual, lbm (aft gage)	498	259	454	264
Residual, lbm (burn time integration)	393	208	494	224
Residual, lbm (SODB flow rate)	523	278	482	270

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-128 mission. One IFA was identified from the analysis of the data and it is discussed in a later paragraph in this section.

The APU 3 Turbine Exhaust Gas Temperature (EGT) transducer 2 was slightly erratic approximately 1.5 min prior to lift-off for approximately a 30-sec period. On FD 2, to avoid possible nuisance alarms, a TMBU was uplinked at GMT 242/00:03:57 (00/20:04:20 MET) to change the APU 3 EGT 2 Fault Detection & Annunciation (FDA) limit from 1160 °F to OSH (Off-Scale High). This limit is a class 2 backup caution and warning (C&W) alarm in the PASS (Primary Avionics Software System) only. This was done in response to the slightly erratic performance seen during ascent.

This was the first flight of OV-103 with a modification to heat the APU 3 fuel tank GN2 fill Quick Disconnect (QD). For the system 3 modification, the previous APU 3 fuel service line heater was replaced with a new heater which wraps around the APU 3 fuel tank GN2 fill QD and the APU 3 fuel service line. Performance of the new APU 3 fuel

service, fuel test line, and fuel tank GN2 QD 'A' and 'B' heater circuits was nominal during the mission.

To avoid possible nuisance alarms, a Table Maintenance Block Update (TMBU) was uplinked at GMT 243/03:57:19 (01/23:57:42 MET) to change the APU 3 Line Temp 2 FDA limit from 45 °F to 43 °F. This limit is a class 3 SM alarm in PASS. This was done to avoid possible nuisance alarms on-orbit since this temperature reading had been approaching the 45 °F FDA limit before the heater turned on while operating on the 'A' circuit. The lowest temperature seen with the heater operating was 47.189 °F.

For approximately 4.3 days no heater cycles were seen on the APU 3 drain line 'A' heater circuit starting at 247/03:02 GMT (05/23:02 MET). This was due to orbital attitudes that maintained environmental temperatures on the starboard side of the vehicle above the lower set point of the controlling thermostat of this heater circuit. Smaller magnitude reductions in heater circuit duty cycle were also seen on other APU heater circuits on the starboard side of the vehicle during this time period.

APU 1 was used for the flight control system checkout. No water spray boiler cooling was required. APU 2 was started 5 min prior to de-orbit maneuver ignition. APU 1 and 3 were started at Entry Interface (EI) -13 min.

During the post-landing power-on at EAFB, the APU 3 EGT transducer 2 was noted as being below ambient, essentially off-scale low, which is typical of a failure (IFA STS-128-V-06). This measurement was not downlinked during entry and thus was not visible until post-landing. The companion sensor, APU 3 EGT transducer 1, was nominal during entry and indicated an ambient temperature during the post-landing operations, as expected.

APU RUN TIMES

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
1 (310)	00:20:06	00:05:34	01:01:20	01:27:00
2 (403)	00:20:11	00:00:00	01:27:55	01:48:06
3 (408)	00:20:18	00:00:00	01:01:25	01:21:43

APU FUEL CONSUMPTION

APU (S/N)	Ascent, lb	FCS Checkout, lb	Entry, lb	Total, lb
1 (310)	47	16	107	170
2 (403)	51	0	161	212
3 (408)	51	0	125	176

Hydraulics/Water Spray Boiler System

The Hydraulic/Water Spray Boiler (HYD/WSB) system performance was nominal during all phases of the mission. No in-flight anomalies were identified from the review and analysis of the flight data. The WSB PGME/H₂O usage ascent is as follows.

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	249	247	2.8
System 2	259	255	2.0
System 3	253	253	3.1

Circulation pump 1 ran for 1 min and 46 sec to perform elevon-park. No other circulation pump runs were required on-orbit for thermal conditioning or bootstrap re-pressurization.

Nominal Water Spray Boiler (WSB) performance was observed on all three HYD systems during the mission. No WSB water tank/core heater activations were required on-orbit. All three WSB system cores were loaded with approximately 5 lb of the additive mixture (53% water; 47% PGME). The initial PGME/Water Tank loading for WSBs 1, 2 and 3 were approximately 133.8 lb.

HYD system 3 experienced a WSB lubrication-oil cooling overshoot with the APU 3 lubrication oil dropping to 209 °F and recovered to steady-state within 4 min of the overshoot. Similar WSB 3 overshoots occurred on STS-119 and STS-120.

The Port and Starboard Main Landing Gear (MLG) brake-line thermal transients, which occurred during the on-orbit MLG brake-line heaters B and C power-up exercise, were analyzed and determined to be caused by HYD fluid thermal expansion through HYD System 3. HYD System 3 provides an expansion path that is common to all four MLG brake lines (RMG and LMG) on-orbit due to brake switching-valve positions. This condition did not impact the successful completion of the mission. Approximately 7 ½ hr following heater activation, the MLG brake-line temperatures indicated a transient thermal response for approximately 2 min and then gradually recovered in approximately 40 min.

The WSB PGME/H₂O usage during entry 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	241	247	21.4
System 2	259	253	37.7
System 3	257	253	22.4

Power Reactant Storage and Distribution System

The OV-103 Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-128, and no IFAs were identified from the review and analysis of the data.

The loading of the five PRSD tank sets was completed on August 23rd. The stabilization times were 235/13:20 GMT for the Oxygen Tanks (off-loaded) and 235/06:05 GMT for the Hydrogen Tanks. The pre-launch reactant boil-off rate averaged 0.064 lbm/hr-tank for hydrogen and 0.23 lbm/hr-tank for oxygen. A 450 lbm oxygen off-load was performed.

The O₂ Tank 3 had fluid de-stratification along with the associated pressure collapse during the mission. The de-stratification was caused by the tank heater operation followed by negligible acceleration for a long period. Then, a maneuver was performed and the acceleration mixes the stratified fluid-density layers of cryogenic oxygen in the tank. A pressure drop was observed as a result of the fluid de-stratification. The pressure recovered above the critical pressure of O₂ (731 psia) using heat leak into the tank.

The PRSD system supplied the fuel cells with 2159 lb_m of oxygen and 272 lb_m of hydrogen for the production of 3206 kWh of electrical energy. The PRSD also provided 238 lb_m of O₂ to the Orbiter Environmental Control and Life Support System (ECLSS).

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

PRSD TANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb_m
Loaded	102.2	101.8	100.9	101.4	102.2	3971
Off-Loaded	90.4	90.4	90.0	90.0	90.0	3521
Launch	86.9	86.0	86.0	86.0	86.5	3369
Landing	28.7	28.7	50.6	10.3	6.3	973
Hydrogen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb_m
Loaded	101.9	101.5	101.9	101.9	102.8	469.2
Launch	91.7	90.9	92.6	92.2	93.1	423.7
Landing	44.7	52.6	56.4	9.9	1.5	151.8

The Orbiter landed with 973 lb_m of Oxygen (O₂) and 151.8 lb_m of Hydrogen (H₂) remaining in the PRSD system. With the reactants remaining at touchdown, a 75-hr mission extension was possible at the 13.05-kW mission-extension average-power-level. A 100-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.

Fuel Cell System

Fuel Cells

The overall performance of the OV-103 fuel cell system was nominal for STS-128. No IFAs were identified from the review and analysis of the data. Two issues were identified that are reported in later paragraphs.

The fuel cells installed in OV-103 were serial numbers 109, 107, and 115 in positions 1 through 3, respectively. Fuel Cell startup was initiated on August 24th at 236/14:38:40 GMT and was completed at 236/17:02:32 GMT. Startup and pre-launch operations were nominal. The fuel cells remained running after first launch attempt was scrubbed. The pre-launch baseline Cell Performance Monitor (CPM) values for fuel cell 1 were 2, 4, and 12 mV; for fuel cell 2 were 18, 16, and 24 mV; and for fuel cell 3 were 2, 12, and 20 mV. They were re-established at 241/00:00 GMT after over 4 days of fuel cell operation. These values superseded the initial baseline established at 237/00:25 GMT.

The Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages prelaunch, on-orbit, and postlanding. Full-rate on-orbit data was recorded for 12 min beginning at 242/06:33:22 GMT (01/02:33:45 MET); there were no outliers.

At 250/23:11 GMT (09/19:11:33 MET), the fuel cell 1 H₂ flow-meter reading dropped from 0.10579 lb_m/hr down to 0.09533 lb_m/hr with no corresponding changes in other fuel cell 1 parameters. After 27 sec, the reading returned to 0.10579 lb_m/hr. A detailed data review shows that these occurred multiple times with the same signature during the flight, including during pre-launch operations. The flow-meter had 2826 hrs at the beginning of this flight. Post-landing, the decision was made that these short transients required no further action other than to track future H₂ flow-meter performance.

The fuel cell 2 coolant pressure dropped to 54.8 psia at 255/00:41:07 GMT (13/20:41:30 MET) or about 13 min prior to landing. It continued to change between 54.8 and 55.2 psia for 61 sec and then stabilized above 55 psia. When this occurred, the power level was at 6.6 kW. This was the fifth flight of this fuel cell and it completed the flight with 2002 hr on the reactant regulator and 2010 hr on the stack. With this issue, as well as an observed drift in the condenser exit temp, and the high hours on this fuel cell, the decision was made to remove and replace this fuel cell and place in long-term storage.

The Fuel Cell Alternate Water Line temperatures tended to be high and erratic when Potable Water Storage Tank A quantity was at 100% quantity. With Tank A at 100%, 140 °F fuel cell product water leaks past the Fuel Cell 3 Alternate Water Line Check Valve and sometimes raised the temperatures above the 70 °F thermostat heater turn-on point. This is considered in family and has a negligible impact.

Fuel cell operating times, which is the time accumulated on each fuel cell during the pre-launch, on-orbit, and postlanding, were 457:54:38 (hr:min:sec) for fuel cell 1,

457:42:35 for fuel cell 2, and 456:21:36 for fuel cell 3. The end-of-mission accumulated operating times for these fuel cells are 1156, 2010, and 456 hr, respectively.

The average electrical power level and load was 9.6 kW and 308 Amperes (A). The fuel cells produced 2431 lb_m of potable water and 3206 kWh of electrical energy from 2159 lb_m of O₂ and 272 lb_m of H₂.

The actual fuel cell voltages at the end of the mission were as predicted for fuel cell 1, 0.10 Vdc above predicted, for fuel cell 2, 0.10 Vdc above predicted, and as predicted for fuel cell 3. The voltage margins above the minimum performance curves at 200 A at the end of the mission were 1.06 V above minimum for fuel cell 1, 0.90 V above minimum for fuel cell 2, and 1.22 V above minimum for fuel cell 3.

Station-to-Shuttle Power Transfer System Operation

This was the fourth flight of the Station-to-Shuttle Power Transfer System (SSTPS) on OV-103. The SSPTS transfers and converts power from the 120 Vdc ISS electrical system to supplement fuel cell power to the Orbiter's 28 Vdc buses. The SSPTS supplied 1423 kWh of power to the Orbiter during the docked period. When combined, the Orbiter average electrical power level was 13.9 kW for the mission duration.

The SSTPS activation was completed at 243/03:55 GMT (01/23:55 MET). The fuel cell 2 thermal response was a Condenser Exit Temperature (T_{ce}) of 154 °F, a stack inlet temperature of 181 °F, and a stack exit temperature of 188 °F at a load of 64 A. The average 33.8% KOH was well above the 29% lower limit. The T_{ce} slowly ramped up from 154 °F to 159 °F, while the KOH changed to an average of 31% KOH.

Electrical Power Distribution and Control System

The Electrical Power Distribution and Control (EPDC) system performed nominally during all STS-128 mission phases. The data review and analysis of all available EPDC parameters identified no IFAs or abnormal conditions.

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 6 min 53 sec. The avionics hardware was powered for 4 min 51 sec. The system was ready for rendezvous and docking with ISS.

The application of power for the docking activities was initiated at 243/00:27:35 GMT (01/20:27:58 MET), and the ODS was powered for 47 min 44sec. The initial contact and capture of the ISS occurred at 243/00:53:57 GMT (01/20:54:20 MET). The initial

damping was 2 min 39 sec and performance of the “Disable and Release Dampers” procedure was required because the dampers were engaged.

In preparation for undocking, the ODS was activated at 251/18:55:09 GMT (10/14:55:32 MET). The undocking and separation from the ISS was completed satisfactorily at 251/19:26:22 GMT (10/15:26:45 MET). The ODS was operational for 51 min 46 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. Post-ascent, the Pressure Control System (PCS) was configured to system 2 and a satisfactory checkout was observed in the pre-dock time period. Prior to undocking, PCS system 1 was configured and used for the remainder of the mission. A satisfactory checkout was also observed on PCS 1 in the post-undocking time period.

There were no Orbiter-to-ISS tank-to-tank Nitrogen (N₂) or Oxygen (O₂) transfers performed during this mission. There were three Orbiter/ISS stack repressurizations performed using the Orbiter PCS. The repressurizations were performed by opening the payload N₂ valves with restrictors in line that limited the flow to 7 lb/hr for better cabin-air mixing. During docked operations, three O₂ repressurizations were performed to the ISS using Orbiter O₂.

Airlock System

The Airlock Systems performed nominally throughout the mission. All scheduled in-flight checkout requirements were satisfied with the exception of an external airlock structural heater. This measurement is associated with the internal temperature of the lower bulkhead, which did not cycle using main A power. While on main A power, the bulkhead reached a minimum of approximately 66 °F, which is not cold enough for activation of this heater at its minimum temperature of 40 °F.

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.

Supply and Waste Water System

The Supply Water and Waste Management Systems (SWWMS) performed nominally throughout the mission. Supply water was managed through the use of the Flash Evaporator System (FES), water transfer to the ISS and the dump nozzle.

One Contingency Water Container (CWC) was dumped through the waste-water dump nozzle. The line heater maintained the supply-water dump-line temperature between

65 °F and 95 °F. One waste-water nozzle simultaneous dump was made at a nominal average rate of 1.85 %/min (3.11 lb/min) was performed. Two additional waste-water dumps at a nominal average rate of 1.87 %/min (3.14 lb/min) were performed.

The waste-water dump line temperature was maintained between 59 °F and 99 °F throughout the mission. Early in the mission before the first water dump when the line was empty, the waste-water dump line cycled between the 2 thermostats (control and over-temperature). Similar signatures happened during two previous missions and those were also early in the mission. There is no switch scan for this dump-line heater to determine which heater system is operating. The signature indicated periodic over-temperature thermostat operation. The nominal set-points are approximately 15 °F different, but there is significant heater concentration near the control and over-temperature thermostats.

One CWC was filled with supply water and transferred to the ISS, for a total of 93.5 lb_m. Fifteen (15) CWC-Iodine (CWC-I) were filled with supply water and transferred to the ISS, for a total of 593.2 lb_m. In addition, three Portable Water Reservoirs (PWRs) of iodinated water for a total 60.9 lb_m were filled and transferred to the 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 that causes an intermittent break in continuity.

The vacuum vent-line temperature was maintained between 80 °F and 59 °F.

Smoke Detection and Fire Suppression System

The Smoke Detection and Fire Suppression (SDFS) system operated nominally with no issues. The smoke detector check was accomplished with all smoke detection A and B sensor circuits passing the checkout.

Use of the Fire Suppression System (FSS) was not required.

Active Thermal Control System

The Active Thermal Control System (ATCS) performed satisfactorily throughout the STS-128 mission. No IFAs were identified during the review and analysis of the flight data. The radiators were not deployed this flight.

The FES exhibited a larger pre-evaporative cooling compared to previous missions. The amount of pre-evaporative cooling was as much as 26 ° F. There were no detrimental effects to FES performance.

The Carbon Dioxide (CO₂) level during the on-orbit mission phase was controlled below the flight-rule maximum limit of 5 mmHg except for three occasions when the Partial Pressure Carbon Dioxide (PPCO₂) level exceeded the limit. The highest level recorded was 5.77 mmHg at 253/16:08:00 GMT (12/12:08:23 MET).

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

The ABS B secondary controller was powered 47 min after landing. The ABS operation on system B was for 38 minutes, until the start of ground cooling activation. System A activation was not required.

Flight Software

The Primary Avionics Software System (PASS) and Backup Flight System (BFS) Flight Software (FSW) performed satisfactorily throughout the mission. No IFA's were identified during the review and analysis of the flight data.

Data Processing System Hardware

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

Multifunction Electronic Display System

The Multifunction Electronic Display System (MEDS) performed satisfactorily and no IFA's were identified or reported.

Displays and Controls System

The Display and Controls (D&C) system including lighting, performed nominally during all phases of the STS-128 mission. One IFA was identified during the mission and is discussed below.

Just prior to Separation from ISS, at 251/20:34:55 GMT (010/16:35:18 MET), the Aft Digital Auto Pilot (DAP) panel (A6U) "A" pushbutton contact C failed Redundancy Management (RM) when the crew depressed the button (IFA STS-128-V-08). Contacts A and B were observed as expected. All three contacts had operated nominally prior to this time. This condition was likely caused by the pushbutton not being fully depressed when selected (i.e., switch tease). Similar situations have occurred on previous flights. The crew was asked to depress the pushbutton for 5 additional seconds, and all three contacts were good and went "high" state, as expected. Post-flight, the panel was removed for "A" pushbutton replacement.

Flight Control System

The Flight Controls System (FCS) performed nominally during the preflight, countdown, ascent, orbit, FCS checkout, deorbit preparation, entry, landing and post-landing operations. No IFA's were identified from the review and analysis of the data.

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

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

The FCS hardware checkout performance in the OPS-8 mode was nominal. No anomalies were found in aerosurface drive data, individual channel test data, ORGA and AA test data, nose-wheel steering test data, and DDU/controller data.

The entry performance was nominal from the deorbit maneuver through vehicle touchdown. The pre-deorbit OMS maneuver gimbal profile was as expected with the OMS actuator active and standby channels reaching nominal drive rates. All Aerosurface Actuators (AAs) performed normally. Secondary-differential pressures for all actuators were well within the equalization threshold, and all actuator positions closely tracked the General Purpose Computer (GPC) commands. The entry HYD 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 IFA/s were identified from the review and analysis of the data.

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

power-on was nominal. There is no insight into ADTA performance during the ascent phase until the elevons were parked during the post-insertion period. All ADTA mode/status words were nominal during the elevon-park operations.

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

The entry performance was nominal from the de-orbit maneuver through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 4.8, and deployment timing was within specification at less than 15 sec. The ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at about Mach 3.1. No ADTA dilemmas or Redundancy Management (RM) failures occurred from deployment to wheels-stop.

Inertial Measurement Unit and Star Tracker System

The Inertial Measurement Unit (IMU) system in a nominal manner throughout the mission and no IFA's were identified from the review and analysis of the data.

One adjustment to the on-board IMU accelerometer compensation values was performed for all two of the three IMU's. Also, one adjustment of the IMU drift compensation values was made to one of the IMU's.

The -Y and -Z Star Trackers (STs) performed satisfactorily through the mission. The -Y ST acquired a navigation star 1624 times and missed a navigation star 594 times. The -Z ST acquired a navigation star 86 times and missed a navigation star 73 times.

Global Positioning System Navigation

Overall, Global Positioning System (GPS) performance was nominal. The GPS was powered approximately 5 hr prior to launch and remained ON for the duration of the mission. There were no indications of any anomalous conditions. During entry, a GN&C Annunciation Interface (GAX) message that the GPS was not updating due to a high Figure of Merit (FOM) (FOM greater than 5) condition was experienced for more than 5 min. This GAX message, however, was not a concern since the high FOM condition occurred during the plasma period (roughly between 300,000 ft and 200,000 ft altitude). It is a known possibility that a high FOM condition can occur during the plasma period of the nominal entry flight environment. As expected, no action was required from the crew and the condition cleared on its own once the plasma effect was reduced. A FOM value of 1 was achieved prior to the GPS incorporation into the navigation and remained at 1 through landing and rollout.

STS-128 was a nominal 1-String GPS entry operational flight. The GPS state vector was incorporated into both the PASS and BFS in Major Mode (MM) 304 after performance confirmation based on high-speed C-band tracking. This occurred at

approximately 153,000 ft altitude, immediately after the ground controller requested Tactical Air Command and Navigation (TACAN) be incorporated. The effect was that the PASS and BFS navigation state vector residuals were reduced significantly, as expected. The PASS navigation state vector residuals remained consistently low from GPS incorporation down to incorporation of the Microwave Landing System (MLS) at approximately 16,000 ft) where the PASS automatically stops taking GPS updates.. Likewise, the BFS navigation state vector residuals remained consistently low from GPS incorporation all the way through rollout since the BFS does not process the MLS data.

Communications and Tracking System and Navigation Aids

The Communications and Tracking systems, consisting of the S-Band, Ku-Band, NAVAIDS and antennas, performed nominally during the mission. No IFA's were identified during the review and analysis of the data.

The Audio Distribution System (ADS) and the Ground Interface Command Logic Controller (GCILC) performed nominally throughout the STS-128 mission. No IFA's were identified from the review and analysis of the data.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) and Modular Auxiliary Data System (MADS) performed satisfactorily. One IFA was identified in the MADS for two sensors and these are discussed in the following paragraph.

The review of the downlinked Modular Auxiliary Data System (MADS) identified the left OMS pod temperature data was Off-Scale-High (OSH) during ascent (IFA STS-128-V - 05). The measurement data are used for housekeeping and trending purposes and therefore, these data did not impact the successful completion of the mission.

Mechanical and Hatches System

All mechanical and hatch systems performed nominally throughout the mission. No IFA's were identified during the review and analysis of the data.

Landing and Deceleration System

The landing system performance at Edwards Air Force Base (EAFB) on runway 22 was nominal. This assessment includes all events from landing gear deployment through roll-out, and includes drag chute deployment and brake/deceleration. The nose landing gear tires, flown for the first time, performed nominally and were in good condition. The main landing gear tires also appeared nominal.

There were indications of localized tread loss on the Right-Hand Inboard (RHIB) Main Landing Gear (MLG) tire. This is typically associated with high-heating conditions that are experienced during landing and roll-out. The EAFB concrete is smooth (not

grooved as the runway at KSC) and higher heating is an expected condition for the tires on smooth runways. The loss of tread due to abrasion is less likely on smooth runways as opposed to grooved runways. Grooved runways tend to cause shedding of the tread that helps in dissipating the heat generated during roll out. As such, the appearance of tread wear on the tire is more uniformly spread around the circumference of the tire. For smooth runways, less shedding of tread occurs, and the heat is more likely to be retained in the tread layer. This causes the tread to experience a higher likelihood of generating localized internal heating resulting in "pop-corning" or "blistering" of the rubber and chunking of the tread. While the landing touchdown velocity was within the tire capability limits, it was on the higher end (220.9 kgs) of the experience base. The higher velocities further exacerbate conditions for heating during landing roll-out. The tires also had the appearance of tread reinforcement cord materials on areas of the tire's surface which is a known expected condition that is characteristic of the new-tire design.

Analysis of the post-flight imagery from the STS-128 landing indicates drag chute deployment was as expected and no signs of anomalous conditions for hardware performance were identified.

The landing parameters for the STS-128 mission 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	1634.6	0.0	198.4	220.9	-4.8	-
Nose Landing Gear Touchdown	4884.6	9.6	161.1	184.6		-5.4
Drag Chute Deployment	5389.7	12.4	150.4	175.4		
Drag Chute Disreef	7992.3	20.8	122.8	143.1		
Brakes On	9915.4	29.9	98	112.0		
Drag Chute Jettison	12203.8	46.5	Off-Scale Low	52.9		
Wheels Stop	13217	73.2	0.0	0.0		
Parameter			Data			
Brake Initiation Speed, kgs			112.0			
Brake On Time, sec			43.32			
Rollout Distance, ft			11582.6			
Rollout Time, sec			73.22			
Runway Location, Surface and Degrees			Edwards AFB 22/Concrete			
Orbiter Weight at Landing, lb			222270.7			

LANDING PARAMETERS (concluded)

Parameter	Maximum Brake Pressure, psia	Total Brake Energy, Mft/lb
Left inboard	832.60	23.38
Left outboard	872.25	23.10
Right inboard	634.36	19.12
Right outboard	568.28	10.99

^aKnots equivalent air speed

Aerothermodynamics, Integrated Heating and Interfaces

Data indicate that the overall Orbiter Thermal Protection System (TPS) was normal.

The lower surface structural temperature data indicated normal entry heating. The majority of the recorded structure temperatures were within the flight experience of OV-103. However, the sensors at locations B2 ($T_{max} = 203.7$ °F), S2 ($T_{max} = 101.2$ °F) and S4 ($T_{max} = 67.5$ °F) experienced the most temperature rise for the OV-103 vehicle, and sensors at locations Left Wing (LW) ($T_{max} = 145.6$ °F), P4 ($T_{max} = 111.6$ °F) and P5 ($T_{max} = 116.8$ °F) experienced the highest temperature ever recorded. The sensors at locations LW windward center, $T_{max} = 145.6$ °F, Port (P) 4 (P side mid-aft fuselage, $T_{max} = 111.6$ °F) and P5 (P side aft fuselage, $T_{max} = 116.8$ °F) experienced the highest temperature ever recorded.

The Orbiter Boundary Layer Transition (BLT) appeared to be asymmetric. Based on the STS-128 Best Estimated Trajectory (BET) and the readings of thermocouples from the MADS data, the transition onset time for the starboard side of the vehicle was 1205 sec after entry interface or Mach 8.5 and for the port side was 1038 sec or Mach 13.6 except that a small wedge area downstream of the BLT Flight Experiment had an earlier BLT. The aileron deflection and yaw thruster firings data also indicated that the vehicle had an asymmetric BLT. A search for a potential cause (protrusions in the forward port region of the vehicle) was performed, and one tile was sitting-low, which created a 0.1-in. to 0.15-in. step.

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

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Lower fuselage forward center (B1)	132.5	129.1
Lower fuselage forward left-hand (B2)	203.7	192.6 ^b
Lower fuselage forward mid left-hand (B3)	177.2	186.5
Lower fuselage mid center (B4)	169.3	181.1
Lower fuselage mid aft center (B5)	198.3	197.5

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

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Lower fuselage aft center (B6)	195.7	166.7
Left-wing center (LW)	145.6 ^b	152.3
Right wing center (RW)	106.4	146.0
Port side FRCS forward (P1)	185.1	145.9
Port side fuselage forward center (P2)	132.5	101.0
Port side fuselage forward mid center (P3)	111.6	92.9
Port side fuselage mid aft center (P4)	111.6 ^b	67.3
Port side fuselage aft center (P5)	116.8 ^b	64.8
Starboard side FRCS Forward (S1)	145.6	139.6
Starboard side fuselage forward center (S2)	101.2	138.3 ^b
Starboard side fuselage forward mid center (S3)	80.5	89.7
Starboard side fuselage mid-aft center (S4)	67.5 ^a	94.5 ^{a,b}
Starboard side fuselage aft center (S5)	75.3 ^a	74.4 ^a
Left-hand OMS pod side forward (LP)	88.2	64.4
Right-hand OMS pod side forward (RP)	64.9 ^a	41.1 ^a
Lower body flap center	127.3 ^a	95.7 ^a
Right-hand PLBD forward	72.7 ^a	140.0 ^a
Left-hand PLBD forward	77.9 ^a	97.3 ^a
Right-hand PLBD aft	83.0 ^a	137.8 ^a
Left-hand PLBD aft	88.2	105.1
Right wing upper center	85.6 ^a	132.8 ^a
Left wing upper center	106.4 ^a	100.4 ^a
Forward RCS center	96.0 ^a	74.7 ^a
Forward Fuselage upper center	80.5	97.3

Notes

- ^a Maximum temperature occurred 30 min after wheel stop.
- ^b Maximum temperature ever experienced on the OV-105 vehicle.

Thermal Control System

The Passive Thermal Control System (TCS) performed nominally. All passive TCS temperatures performed nominally and were maintained within acceptable limits.

STS-128 was the second flight to have the MLG brake-line heaters B and C turned on during the docked phase until nominal the nominal undocking phase. The objective was to obtain flight data to support and alleviate attitude-switching while docked to the ISS. The TCS model of the MLG brake-line heaters predictions and agreed very well with flight data.

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	23	143
Upper Surface/Window	0	4
Right OMS pod	1	22
Left OMS pod	3	11
Totals	27	180

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

The starboard main landing gear tires had off-nominal gouges. Tire material loss on the port main landing gear tires and nose landing gear tires was nominal.

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

The retaining device on both External Tank/Orbiter (EO)-2 and EO-3 salad bowls were fully closed, with no clips bent around the perimeter.

Tile and Blanket Flight Assessment

The overall performance of the TPS was satisfactory.

Thirteen TPS items were identified which exceeded pre-defined screening criteria. Nine were cleared using standard procedure/tools and the other four required additional analysis. However, no focused inspection was required based on the data available from FD 2 inspections and FD 3 RPM images. These four areas included:

1. One inboard starboard wing tile substrate exposed forward and outboard of starboard ET door;
2. One belly port wing inboard tile substrates exposed with damage outboard of port ET door (appeared to be several missing putty repairs);
3. One belly port wing inboard tile substrates exposed with damage on the port wing, and
4. One Felt Reusable Surface Insulation (FRSI) Plug was protruding 0.5-in. on the starboard OMS pod. The FRSI plug was from the OMS Pod Carrier Panel.

There was no credible concern with respect to structural integrity or Guidance Navigation and Control (GN&C) control authority should liberation and impact to Rudder Speed Brake.

After the Damage Assessment Team (DAT) evaluated the FD 2 TPS inspection and FD3 RPM imagery, all thirteen items were cleared from requiring focused inspection.

The late inspection performed on FD 12 resulted in Orbiter TPS being cleared for entry on FD 13.

The SSME Dome-Mounted Heat Shield (DMHS) blankets all appeared to be in excellent condition. There was a small amount of fraying on the aft side of the SSME no. 1 blanket.

One of the starboard-side trailing-edge tiles of the vertical stabilizer appeared to have a fresh white vertical crack from edge to edge.

RCC Flight Assessment

The Orbiter nose-cap appeared to be in nominal condition, as well as left-hand and right-hand Reinforced Carbon-Carbon (RCC) panels.

The late inspection performed on FD 12 resulted in Orbiter RCC being cleared for entry on FD 13.

Windows

No Orbiter Windows issues were reported.

Waste Collection System

The Waste Collection System operated satisfactorily. No problems or IFA's were identified during the mission or from the crew during post-flight debriefings.

EXTRAVEHICULAR ACTIVITY

The crew performed three Extravehicular Activities (EVAs) on STS-128 in a total EVA time of 20 hr, 14 min. Space Shuttle Mission Specialists John D. Olivas, Christer Fuglesang, and Nicole Stott were designated as EV1, EV2, and EV3, respectively. The primary EVA mission objectives were to remove and replace the P1 Ammonia Tank Assembly (ATA), to install the European Technology Exposure Facility (EuTEF) payload on the bottom of the Lightweight Mission Peculiar Equipment Support Structure Carrier (LMC), and to transfer the Materials International Space Station Experiment (MISSE) 6 Payload Equipment Containers (PECs) to the Orbiter payload bay.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was performed on Flight Day (FD) 5 and all planned activities were completed during the 6 hr 35 min EVA.

The highest priority EVA objective on the mission was to perform the Port (P) 1 Ammonia Tank Assembly (ATA) Removal and Replacement (R&R). The highest priority objective on EVA 1 was to remove the ATA from the P 12 truss and temporarily stow the ATA on the Space Station Remote Manipulator System (SSRMS), where it remained until the end of second EVA. The crew performed the preparatory tasks for the P1 ATA removal, including the demating of the four fluid connections and the 2 electrical connections. In addition, the ATA was released and handed off to the SSRMS. The crew then installed an Articulating Portable Foot Restraint (APFR) on the SSRMS. Following the completion of this activity, the EVA crew translated to the Columbus External Payload Facility (EPF).

Upon completion of the APFR being maneuvered to the Columbus module, the Extravehicular (EV) 2 crewmember ingressed the APFR. The European Technology Exposure Facility (EuTEF) payload was released from the EPF and the SSRMS maneuvered the EV2 crewmember and the EuTEF to the Orbiter Payload Bay (PLB), where it was the EuTEF was installed on the bottom of the Lightweight Mission Peculiar Equipment Support Structure Carrier (LMC). Upon completion of the installation, the EV1 crewmember translated to the Columbus EPF to perform the preparatory tasks for removal of the Materials International Space Station Experiment (MISSE) 6 Payload Equipment Containers (PECs), including closing the PECs, demating the connector and releasing the PECs from the stem.

Once cleanup of the EuTEF task was performed, the EV2 crewmember translated to the MISSE worksite to assist the EV1 crewmember with the MISSE 6 task. The EV2 crewmember retrieved one of the MISSE PECs and transferred it to the Orbiter Payload Bay Sidewall Carrier for final installation. Meanwhile, the EV1 crewmember had some issues with removing the pip pin on the MISSE PEC that had been hammered in on STS-123. The EVA documentation allowed the use of the pry bar, the Bearing Motor Roll Ring Module (BMRRM) anti-rotation latch tool and the hammer to assist in

removing the pip pin. The MISSE PEC was released and successfully transferred to the Orbiter Payload Bay sidewall carrier.

EVA glove inspections and post-EVA photographs indicated no glove damage had been incurred during the EVA.

SECOND EXTRAVEHICULAR ACTIVITY

The second EVA was performed on FD 7 and all planned tasks were successfully completed during the 6 hr 38 min EVA.

After egressing the ISS Airlock to begin the EVA, the crew translated to the LMC in the Orbiter PLB to prepare to release the new ATA, which included removal of the ATA Flight Support Equipment (FSE) Multi-layer Insulation (MLI). Once the ATA was released from the LMC, the SSRMS maneuvered the EV3 crewmember and both ATAs (the old one grappled and the new one handled by EV3) to the P1 truss. Both crewmembers installed the new ATA on the truss and the EV1 then mated the 4 fluid connections and 2 electrical connections. With the new ATA installed, EV1 ingressed the APFR on P1 and the old ATA was handed off from the SSRMS to EV2 for the translation back to the LMC. With both crewmembers back at the LMC, the ATA and the MLI was secured on the returning ATA. The Fixed Grapple Bar (FGB) was then removed and installed on the Starboard (S) 1 ATA in preparation for a subsequent flight, which will perform the changeout of the S1 ATA. With additional time available, the crew was able to perform get-ahead tasks on this EVA. The EV3 crewmember installed the SSRMS Camera Light Assembly (CLA) and Camera Light Pan Tilt Assembly (CLPA) lens covers. The EV1 crewmember translated to the Pressurized Mating Adapter (PMA) 3 to mate the Node 1-to-PMA 3 heater umbilical. After 30 min of attempting to perform the task, the crew was pulled off because the cable configuration was not as expected. Following the EVA, the PMA3 was determined to be in a different clocking than the crew expected and trained. The cable length would not accommodate mating the heater umbilical so the task was deleted and not rescheduled for the third EVA.

The EVA glove inspections were performed as required and no damage was noted during the EVA.

THIRD EXTRAVEHICULAR ACTIVITY

The third EVA was performed on FD 9 and all planned tasks were successfully completed during the 7 hr 01 min EVA.

The EVA crew began the EVA by translating to the S3 Upper Outboard Payload Attachment System (PAS). This task was deferred for a previous flight and was required for Flight ULF-3. The crew successfully deployed the PAS. Both crewmembers then translated to the S0 Truss to perform changeout of the Rate Gyro Assembly (RGA). Once The RGA task was completed, the EV2 crewmember

translated to the S0 Truss to perform changeout of the S0 Truss Remote Power Control Module (RPCM). The EV1 crewmember then installed the two GPS antennas on the S0 Truss. Once the GPS antennas were installed, both crew spent some time securing the MLI on the Global Positioning System (GPS) antennas. The EVA crew then routed of the S0-to-Node-3 power and avionics cables. The routing of both cables was completed successfully and 7 of the 8 S0 connectors were mated. The P181 connector could not be soft docked or mated to S0. The connector was left demated, uncapped with one of the grounding connector sleeves secured around the connector for troubleshooting on a future EVA. The Node 1 slidewire was removed.

All glove inspections were nominal and photographs taken post-EVA confirmed that the glove-patch modifications had been effective.

REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Shuttle Remote Manipulator System (SRMS) performed nominally during the mission. STS-128 was the 84th flight of the SRMS, the 24th flight of SRMS S/N 202, the 15th flight of the Orbiter Boom Sensor System (OBSS), and the 5th flight of Inspection Boom Assembly (IBA) S/N 203.

The SRMS On-orbit Initialization began at 241/07:36 Greenwich Mean Time (GMT) [00/03:36 Mission Elapsed Time (MET)] on 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 241/08:01 GMT (00/04:01 MET) and was completed 56 min later. During the End Effector (EE) checkout, the capture switch was inadvertently commanded causing the EE snare wires to snag the ball screw (IFA STS-128-V-03). Downlinked video showed a deflection of the ball screw. Real-time analysis concluded that while there may have been some yielding of two of the screws that hold the ball nut to the stiffening ring, the EE performed its planned activities for the STS-128 mission. Following the mission, the four affected screws will be replaced and a checkout of the EE will be performed.

On FD 2, the SRMS grappled the OBSS at 241/21:33 GMT (00/17:33 MET) and maneuvered the OBSS to the hover-position 17 min later. The starboard Reinforced Carbon-Carbon (RCC) survey was completed at 242/00:54 GMT (00/20:54 MET). The nose-cap RCC survey was completed at 242/01:55 GMT (00/21:55 MET). The port RCC survey was completed at 242/03:58 GMT (00/23:58 MET). In addition to the RCC surveys, the SRMS/OBSS was used to perform an inspection of the Left Orbital Maneuvering System (OMS) pod area where debris was observed to be separating during launch. The OBSS was berthed in the starboard MPMs and the SRMS was returned to the pre-cradle position at 242/05:12 GMT (01/01:12 MET).

On FD 3, the Orbiter rendezvoused and docked with the International Space Station (ISS). The Space Station Remote Manipulator System (SSRMS) grappled and unberthed the OBSS to handoff to the SRMS. The SRMS grappled the OBSS at 243/05:31 GMT (02/01:31 MET). After the SSRMS backed away, the SRMS maneuvered to the Multi-Purpose Logistics Module (MPLM) viewing-position at 243/06:02 GMT (02/02:02). The SRMS Wrist-Roll was driven to place the SRMS in the Ammonia Tank Assembly (ATA) vent-clear position 2 min later.

On FD 4, there were no SRMS activities.

On FD 5, the SRMS maneuvered back to the MPLM viewing-position at 244/20:48 GMT (03/16:48 MET).

On FD's 6 through 10, there were no SRMS activities.

On FD 11, the SRMS maneuvered to the undock-position at 251/02:01 GMT (09/22:01 MET).

On FD 12, the SRMS began the Late Inspection with a maneuver to the flat-field position at 251/21:50 GMT (10/17:50 MET). The Starboard survey began at 251/22:44 GMT (10/18/44 MET) and was completed 58 min later. The nose-cap survey began at 252/00:29 GMT (10/20:29 MET) and was completed 32 min later. The port survey began at 252/01:25 GMT (10/21:25 MET) and was completed 1 hr later. The OBSS was maneuvered to the low-hover position at 252/02:43 GMT 10/22:43 MET) and berthed 28 min later. After releasing the OBSS, the SRMS maneuvered to the pre-cradle position at 252/03:27 GMT (10/23:27 MET) and cradled 24 min later. This completed the SRMS activities for the STS-128 mission.

WING LEADING EDGE IMPACT DETECTION SYSTEM

ASCENT MONITORING

Ascent summary data downloads began when the Wing Leading Edge (WLE) Impact Detection System (IDS) primary and secondary laptops were setup. All units triggered and began recording data on Space Shuttle Main Engine ignition within 0.15 sec of each other. The MET was set to 9.22 sec behind the Data Elapsed Time for both the port and starboard wing units.

All requested ascent summary data and 19 half-sec windows of raw data were received by 13:02 hr (Mission Elapsed Time (MET)). The ascent data analysis was completed and seven probable impact indications (over 1.0 Grms) were identified and reported. The damage likelihood for these indications ranged from less than 1/1000 to 1/500 (Risk Categories I to II). Post-flight analysis of the data found no additional indications at or above 1.0 Grms.

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
103.5	112.7	P	8	1032-J1	1.3	6.7	+	+	+	+	P	P
109.6	118.8	P	8,9	1032-J1	1.3	4.9	+	+	+	+	P	P
110.8	120.0	P	10	1014-J2	1.4	6.7	+	+	+	+	P	P
114.4	123.6	P	7	1019-J1	1.2	6.7	+	+	+	+	P	P
115.7	124.9	P	6	1013-J3	1.1	3.9	+	+	+	+	P	P
119.0	128.2	P	11	1207-J3	3.2	11.7	+	+	+	+	P	P
121.5	130.8	P	16	1021-J2	1.7	5.7	+	+	+	+	P	P

^a P = Probable

ON-ORBIT MONITORING

The WLE IDS recorded 35 triggers, none of which satisfied all impact criteria. Of these 35 triggers, 21 were related to Primary Reaction Control System (PRCS) thruster firings that took place 1 hr prior to docking with the International Space Station (ISS). Of the other 14 triggers, one was a data anomaly and the other 13 are attributed to system/vehicle noise. Review of post-flight data revealed no additional on-orbit indications.

Due to sensor unit battery life limitations, continuous on-orbit monitoring of each Reinforced Carbon-Carbon (RCC) panel was not possible. The WLE IDS monitored each wing with two groups of sensors consisting of 10 and 11 units. On-orbit monitoring was performed when the risk of critical damage to the RCC from Micrometeoroid/Orbital Debris (MM/OD) was expected to be highest. The periods of increased risk to the RCC for STS-128 were during the early and late imagery inspections of the RCC as well as

during docking and undocking operations with the ISS. The overall on-orbit monitoring time for the port wing was 41 hr and 40.5 hr for the starboard wing. One launch scrub reduced the battery life from 21 hr of monitoring time to 20.5 hr per on-orbit group.

CONCLUSIONS

The WLE IDS performed satisfactorily for ascent-impact monitoring. An initial ascent report was published at Launch plus 14 hr. During the mission, seven ascent-impact indications above the 1.0 Grms threshold were reported with damage likelihoods ranging from Category I ($P < 1/1000$) to II ($1/500 > P > 1/1000$). The post-flight review of the data found no additional ascent-impact indications over 1.0 Grms.

No probable on-orbit MM/OD indications were detected as reported during the flight. Of the 35 triggers received during the flight, 21 were related to PRCS thruster firings that took place 1 hr prior to docking with the ISS. Based on the ascent and on-orbit findings from all systems, including WLE IDS, the Orbiter Project Office (OPO) recommended that no focused WLE RCC inspection was required. The late-mission Orbiter Boom Sensor System (OBSS) survey visually inspected the WLE after the Orbiter undocked and prior to entry. No critical damage was found on the WLE RCC panels.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The overall performance of the Government Furnished Equipment (GFE) and Flight Crew Equipment (FCE) was satisfactory.

During the SRMS End Effector (EE) checkout, when the rigidize-carriage mechanism was retracted to the derigidized position, the crew inadvertently issued a capture command instead of a release command (EE Auto mode was selected) (IFA STS-128-V-03). This caused the snare cables to “capture” the carriage mechanism ball screws. The appropriate procedures were repeated to complete the checkout. The rest of the SRMS checkout was nominal. Analysis indicated that some fasteners which attach the ballscrew to the EE carriage may have yielded; these fasteners were replaced post-flight.

During the Extravehicular Mobility Unit (EMU) donning for the second EVA, the EV2 crewmember reported that his Communications Cap Assembly (CCA) had an unacceptable communication problem (IFA STS-128-V-07). The crew changed to the prime CCA and no more communications problems were reported. The prime CCA was also utilized during the third EVA with no issues reported. Post-flight, the failure of the CCA was confirmed. The right microphone rear/noise cancelling port was extremely low or non-operational. Screens from the microphone port were removed to confirm contamination was not blocking audio, but the problem was still present. The microphone transducer was sent for failure analysis, no physical . physical anomalies were identified.

POST-LAUNCH PAD INSPECTION

The post-launch inspection of the Main Launch Platform (MLP) -2, Pad A Fixed Service Structure (FSS), and Pad A apron was conducted on August 29, 2009, from 1:25 a.m. to 3:10 a.m. The inspection proceeded relatively quickly while Safing Teams secured the Pad. The entire Pad, FSS and MLP were inspected. Solid Rocket Booster (SRB) Instafoam was the only flight-hardware found. A 2-in. diameter brass ring/seal was found on the West Pad surface and the source is unknown.

The most substantial non-flight hardware issue noted was the Fondue Fyre liberation from North, West, and East Flame deflectors and liberated concrete from the North West Pad concrete auxiliary structure.

Orbiter lift-off lateral acceleration data indicated a maximum of 0.11g. Hold-down stud hang-ups are typically noted with lateral accelerations above 0.19g.

SRB Hold-down Posts Inspection

HDP No. 1 – The EA934 poured sidewalls were nominal with acceptable minor pitting. The Phenolic shim was nominal. Both firing lines were missing. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.

HDP No. 2 – The EA934 poured sidewalls are nominal with acceptable minor pitting. The Phenolic shim was nominal. Both firing lines were missing. Approximately 6-in. of Range Safety System (RSS) cable remained past the tie off. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.

HDP No. 3 – The inspection showed nominal indications of erosion on the Room Temperature Vulcanizing (RTV) coated blast shield with proper closure.

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

HDP No. 5 – The EA934 poured sidewalls were nominal with acceptable minor pitting. The Phenolic shim was nominal. Both firing lines were missing. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.

HDP No. 6 – The EA934 poured sidewalls were nominal with acceptable minor pitting. The Phenolic shim was nominal. Both firing lines were removed. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.

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

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

Gaseous Nitrogen (GN₂) Purge Lines Inspection

The Left-Hand (LH) probe was erect and slightly bent in the Southwest (SW) direction by 10 deg with protective-tape layering present and no braiding was exposed. No O-ring was present.

The Right-Hand (RH) probe was erect and slightly bent in the Southeast (SE) direction by 15 deg with protective tape layering remaining and no braiding was exposed. The O-ring was present.

Solid Rocket Booster (SRB) T-0 Ground Carrier Assemblies Inspection

The LH SRB Lift-off (T-0) Ground Carrier Assemblies (GCAs) appeared to be in nominal condition with proper demate. Other observations were that the 1J1, 2J1, 3J1 and 5J1 housing had a broken sidewall. Also, the 3J1 and 5J1 pin and socket were raised higher than nominal.

The RH SRB T-0 GCAs appeared to be in nominal condition with proper demating during launch. Other observations were that the 1J1, 2J1, 3J1 and 5J1 housing had broken sidewalls. Also, the 5J1 pin and socket were raised higher than nominal.

Liquid Oxygen (LO₂) and Liquid Hydrogen (LH₂) Tail Service Masts Inspection

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

Main Launch Platform (MLP) Deck Inspection

The MLP deck was in nominal condition. Typical blast erosion was observed in and around the SRB flame holes.

Orbiter Access Arm (OAA) (195-ft level) Inspection

The OAA was retracted and secured with no apparent damage. All slide wire baskets remained secure at 195-ft level with no evidence of damage.

Gaseous Hydrogen (GH₂) Vent Line Ground Umbilical Carrier Plate (GUCP) (215-ft level) Inspection

The GH₂ vent line was latched on the eighth tooth (of eight) on the latching mechanism. The vent line had full no bias and appeared to have no contact with the gimbal strut, and the GN₂ vent line had a nominal arresting cycle.

The External Tank (ET) GUCP 7-inch GH₂ Quick-Disconnect (QD) probe was accessible for inspection and appeared to be undamaged. Both the QD probe sealing surface and the poppet valve assembly were in good condition. The ET GUCP exhibited less than typical blast damage and the pyrotechnic bolt fired nominally. Both the 4-ft and 24-ft flexible hose aluminized blankets were damaged, and both the 4-ft and 24-ft vacuum-jacketed braids were scorched.

Gaseous Oxygen (GOX) Vent Arm (255-ft level) Inspection

The GOX vent arm and hood appeared undamaged. The LH side aluminized blanket appeared to be damaged. The hood windows and purge ducts appeared to be in nominal condition, and the latch mechanism locked properly.

PAD Facility Inspection

Pad A appeared to be in very good condition, and exceptionally clean. The facility experienced some damage due to liberated concrete, and Fondue Fyre. Impact marks were present under the MLP deck that possibly resulted from Fondue Fyre. The door kick-plate appeared loose near the areas of liberated concrete debris.

North SRB Flame Trench Inspection

The SRB flame trench experienced off-nominal erosion with Fondue Fyre. The East flame deflector damage appeared to be 5-ft by 2-ft. The West flame deflector damage appeared to be 4-ft by 1-ft. The North SRB flame trench wall damage appeared to be 3-ft by 1-ft.

Debris Items Found

1. Minor pieces of SRB throat plug material were found on the PAD surface.
2. Small pieces of Fondue Fyre were found on both the East and West Pad surface area.
3. Large pieces of concrete were found on the West Pad surface area.
4. A 2-in. brass ring/seal (East) was found on the West Pad Surface.
A light bulb and cover were missing (North) on the 95-ft level.
5. A small self-tapping screw (South) were found on the 195-ft level.
6. A broken pressure gauge vessel North (N) was found on the 235-ft level.
7. A broken light fixture (SW) was found on the 275-ft level. Also, a series of one-quarter inch GVA GN₂ purge sense lines were damaged.
8. A broken handle (SW) was found on the 275-ft level.

LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

The launch photography satisfactorily provided data for use in determining any possible vehicle damage during the initial stages of the ascent.

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).

A loss of ET TPS was noted on the inboard side of the starboard bipod spindle on the Liquid Hydrogen (LH₂) intertank flange at approximately Xt 1123.

At 0.57 sec [Mission Elapsed Time (MET)], a loss of ET TPS was noted near the lower right-hand corner of the Ground Umbilical Carrier Plate on the edge of the first stringer.

At 0.73 sec MET, the appearance of ice/frost was noted on the Orbiter LH₂ T-zero umbilical interface top and side.

At approximately 20 sec MET, two pieces of debris was observed falling aft along the port fuselage.

At approximately 21 sec MET, debris was observed traveling from the top of the field-of-view and passed under the port wing.

Between 39.6 sec and 45.2 sec MET, several pieces of debris were observed near the Right-Hand (RH) Solid Rocket Booster (SRB) aft skirt Hold-Down Post (HDP) no 4 and falling aft.

At 49.9 sec MET, the radar detected a single object of debris that was first observed 10 ft from the release-location and the Shuttle relative-velocity was 215 ft/sec. The object was observed for 20 ft of travel with a final velocity of 375 ft/sec. Velocity profiles and geometry indicate a release location was within the mid-third of the vehicle. There is a debris observation near the RH SRB at approximately 50 sec MET.

At 55.7 sec, debris was released near the right (+Y) thrust strut.

At 58.7 sec MET, a radar-detected debris event is a correlation between the C1 and X4 radars. In X4, the object is first observed at its release-location and the Shuttle relative-velocity was 110 ft/sec. The Object travels approximately 75 ft before becoming obscured by the vehicle structure with a final vehicle velocity detected by the radar was 580 ft/sec. The object re-emerges and is detected by C1 2045 ft later at 3790 ft/sec. Velocity profiles and geometry indicate a release location was within the mid-third of the vehicle.

At 67.4 sec MET, lightly colored vapor was observed traveling aft on the –Z side of the External Tank (ET). This condition may have been a normal cloud event, but the vapors appear to be different than the vapors typically observed.

At approximately 106.5 MET, the radar-detected a single piece of debris (object) that was first observed 30 ft from the release-location and the Shuttle relative velocity was 1170 ft/sec. The object traveled approximately 80 ft before becoming obscured by the vehicle structure. The object reemerged at 3300 ft/sec and traveled for an additional 250 ft before track of the object was lost. Velocity profiles and geometry indicate a release location within forward-third of the vehicle. The object reflectivity and ballistic performance is indicative of a piece of foam-ice of unknown size.

At approximately 123 sec MET, several pieces of debris are seen falling aft in the lower- right corner of the Field-of-View (FOV). Most of the debris could not be identified. However, two small pieces of foam can also be seen liberating from an Intertank-stringer in this timeframe, just to the upper-right from the Ground Umbilical Carrier Plate (GUCP).

At approximately 124 sec MET, several small pieces of debris appear to fall under the Orbiter port-wing outboard of the aft landing gear door no. 1. The debris was seen falling under the port wing and appears to turn into a spray and falls aft. A possible impact occurred, but no damage was found on the ascent imagery.

At approximately 124 sec MET, a single piece of debris, which was observed during the SRB separation, was falling aft along the port side of the Orbiter fuselage and under the port wing. The debris appears to turn into a spray and falls aft. This debris was possibly impacted the port wing just outboard and aft of the landing gear door and falls aft.

LAUNCH PAD OBSERVATIONS

At Launch (L) minus 4.153 sec, debris was observed near the port Orbital Maneuvering System (OMS) and Payload Bay Door (PLBD) interface. The Kennedy Space Center (KSC) Image Assessment Team (IAT) indicated that this debris appears to be biological and not debris.

At L-39 sec, 2 pieces of the Gaseous Nitrogen (GN₂) purge line impinges on the Left-Hand (LH) SRB aft skirt Instafoam during lift-off and resulted in a spray of particles. The observation also showed that the debris traveled under the port wing and did not impact the vehicle.

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APPENDIX A **STS-128 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	241/03:54:49.126 241/03:54:50.370 241/03:54:51.513
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	241/03:59:09.114 241/03:59:09.274 241/03:59:09.434 241/03:59:09.594
Main Engine Start	SSME-3 Start Command Accepted SSME-2 Start Command Accepted SSME-1 Start Command Accepted	241/03:59:30.433 241/03:59:30.560 241/03:59:30.682
SRB Ignition	SRB Ignition Command	241/03:59:36.994
Throttle Up 104.5 Percent	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/03:59:40.998 241/03:59:41.009 241/03:59:41.017
Throttle Down to 72 Percent	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/04:00:12.039 241/04:00:12.050 241/04:00:12.057
Maximum Dynamic Pressure (Max Q)	Derived Ascent Dynamic Pressure	241/04:00:27
Throttle Up to 104.5 Percent	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/04:00:32.360 241/04:00:32.370 241/04:00:32.377
Both SRMs at 50 psi	RH SRM Chamber Pressure LH SRM Chamber Pressure	241/04:01:34.994 241/04:01:35.034
End SRM Action	RH SRM Chamber Pressure LH SRM Chamber Pressure	241/04:01:36.994 241/04:01:37.394
SRB Separation Command	SRB Separation Command Flag	241/04:01:39
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	241/04:01:39.594 241/04:01:39.594 241/04:01:39.634 241/04:01:39.634
OMS Assist Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	241/04:01:49.9 241/04:01:50.0
OMS Assist Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	241/04:03:42.3 241/04:03:42.4
Throttle Down for 3g	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/04:07:02.448 241/04:07:02.457 241/04:07:02.464
3G Acceleration	Total Load Factor (g)	241/04:07:02.5
Throttle down to 67 percent for Cutoff	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/04:07:55.249 241/04:07:55.257 241/04:07:55.265
SSME Shutdown	SSME-1 Command Accepted SSME-3 Command Accepted SSME-2 Command Accepted	241/04:08:01.729 241/04:08:01.738 241/04:08:01.745
Main Engine Cutoff (MECO)	MECO Command Flag MECO Confirmed Flag	241/04:08:02 241/04:08:03
ET Separation	ET Separation Command Flag	241/04:08:23

APPENDIX A

STS-128 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	241/04:14:52.006 241/04:14:59.300 241/04:15:07.223
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	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	241/04:38:37.2 241/04:38:37.3
OMS 2 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	241/04:39:39.6 241/04:39:39.7
Payload Bay Doors Open	Right Payload Bay Door Open 1 Left Payload Bay Door Open 1	241/05:45:36 241/05:46:55
OMS 3 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	241/07:24:44.9 241/07:24:44.9
OMS 3 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	241/07:25:43.4 241/07:24:43.5
OMS 4 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	241/20:56:36.2
OMS 4 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	241/20:56:52.2
OMS 5 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	242/19:58:58.4 242/19:58:58.4
OMS 5 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	242/20:00:06.2 242/20:00:06.2
OMS 6 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	242/20:48:19.3 242/20:48:19.4
OMS 6 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	242/20:49:03.4 242/20:49:03.5
OMS 7 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	242/22:26:17.1
OMS 7 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	242/22:26:28.9
Docking	Capture	243/00:53:57
Undocking	Undocking Complete	251/19:26:22
OMS 8 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	253/00:08:38.1 253/00:08:38.2
OMS 8 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	253/00:08:48.5 253/00:08:48.6
Flight Control System Checkout – APU 1 Start	APU-1 Gas Generator Chamber Pressure	252/18:37:31.766
APU 1 Stop	APU-1 Gas Generator Chamber Pressure	252/18:43:03.466
OMS 9 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	253/16:02:37.2 253/16:02:37.2
OMS 9 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	253/16:02:51.2 253/16:02:51.2
Payload Bay Door Close	Left Payload Bay Door Close Right Payload Bay door Close	254/20:23:02 254/20:24:31

APPENDIX A
STS-128 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-2 Gas Generator Chamber Pressure APU-1 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	254/23:42:40.140 255/00:09:11.456 255/00:09:15.873
Deorbit Maneuver Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	254/23:47:37.2 254/23:47:37.3
Deorbit Maneuver Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	254/23:50:12.8 254/23:50:12.9
Entry Interface	Orbital Altitude Referenced to Ellipsoid	255/00:22:01
Blackout End	Data Locked (High Sample Rate)	NO BLACKOUT
Terminal Area Energy Management (TAEM)	Major Mode Code (305)	255/00:47:15
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure Main Landing Gear Right Hand Tire Pressure	255/00:53:20 255/00:53:20
Main Landing Gear Weight on Wheels	Main Landing Gear Right-Hand Weight on Wheels Main Landing Gear Left Hand Weight on Wheels	255/00:53:20 255/00:53:26
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	255/00:53:30
Nose Landing Gear Weight on Wheels	Nose Landing Gear Weight on Wheels	255/00:53:30
Drag Chute Deployment	Drag Chute Deploy 1 CP Volts	255/00:53:32.1
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	255/00:54:06.2
Wheels Stop	Velocity with respect to Runway	255/00:54:33
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	255/01:10:28.506 255/01:10:33.710 255/01:10:39.053

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-128 mission.

1. Orbiter
2. Reusable 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-128-V-01	MPS LH ₂ Inboard Fill and Drain Valve Loss of Closed Indication	<p>During cryogenic loading for the second launch attempt when transitioning to reduced fast-fill, the LH₂ Inboard Fill & Drain (F&D) Valve (PV12) close Position Indication (PI) did not cycle 'on'. The open PI did indicate 'OFF'. This loss of the closed indication violated the Launch Commit Criteria (LCC), resulting in a scrub. PV12 was cycled back to the open position to start draining the External Tank (ET). The open PI cycled to 'on' and the close PI remained 'off' as expected. The open timing was within family. The ET was successfully drained and the PIs remained nominal. Once drained, PV12 was cycled closed for inerting operations; the open and closed PI operated correctly and timing was nominal. The ambient, non-invasive checks of the valve were performed prior to pursuing the next launch attempt. Approximately 24 hr after the scrub, the LH₂ manifold was pressurized, and PV12 was cycled consecutively 5 times to verify PI performance under ambient conditions. All PIs functioned as expected and all valve-cycle timings were nominal during these ambient valve cycles. Additionally, a decay check was performed while PV12 was closed; and no gross leakage was noted, indicating that the valve was fully closed and not leaking, which is expected with the 'closed' PI 'on'. The decay checks were within family. Comparison of the previous flights of OV-105 (including the launch attempt the day prior to the scrub), and other flights of OV-103 and OV-104 showed that all other Main Propulsion System (MPS) parameters performed in family. The Mission Management Team (MMT) decision was to delay the launch an additional 24 hr to allow historical data to be gathered and evaluated. These data along with the cycling data were used to develop the rationale to proceed with the launch, even if the same signature recurred. The MMT accepted the rationale and approved the vehicle for launch. During the ET loading in preparation for the August 28 launch, the valve indication was nominal.</p> <p>Post-Flight: As part of the failure investigation, the fleet F&D valve actuator assemblies were inspected with a borescope. The OV-103 vehicle PV12 actuator inspections revealed minimal wear on the shaft lobe where it had contacted the lever arm during installation. The area is on the side of the lobe and does not affect the lobes contact with the lever during normal valve cycles. The PV12 was found to have a piece of contamination under the microswitch contact arm. Initial troubleshooting has not duplicated the initial failure. PV12 has operated correctly since the position indicator returned during the scrub purge/inert cycling. Further troubleshooting will include electrical checks, removal of the contamination for analysis, LPAT type testing with the detent removed, LPAT test and valve cycling. The PV9/10/11 F&D switch assembly inspections were nominal.</p>

APPENDIX B IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-128-V-02	FRCS F5R Thruster Temperature Drop	<p>During the initial usage of the Vernier Reaction Control System (RCS) on the evening of FD1, the Vernier RCS Thruster F5R fuel and oxidizer injector temperatures began to drop. The F5R Thruster was deselected as 'Fail Leak' when temperatures dropped below the 130 ° F limit. The Orbiter DAP was configured to Tail-Only ALT Primary for crew sleep. The vehicle attitude was modified to place the Sun on the thruster overnight in an attempt to keep the injector temperatures above 90 °F. Injector temperatures continued to drop until the temperature went Off-Scale-Low (OSL) (0 °F). Some ground displays showed temperatures dropping to as low as -35 °F, which initially was thought not possible. However, later analysis showed that the temperature was usable and treated this low temperature as a separate signal-conditioning lesson learned. Temperatures stayed OSL before coming back on scale. FRCS Manifold 5 Isolation valve was closed. Thruster temperatures were recovering prior to manifold valve closure.</p> <p>Post-Flight: The F5R thruster removed and replaced, which required removal of the Forward RCS pod.</p>
STS-128-V-03	RMS Unexpected Capture MSW during End Effector Checkout	<p>During the Shuttle Remote Manipulator System (SRMS) End Effector (EE) checkout, when the rigidize carriage mechanism was retracted to the non-rigidized position, the crew inadvertently issued a capture command when a release command should have been issued (E Auto mode was selected). This caused one of the snare cables to snag on one of the Carriage-mechanism ball screws. The tension in the snare resulted in activating the capture microswitch even though no grapple pin was presented. The crew repeated the appropriate procedures to complete the checkout. Analysis was performed, which assessed the lateral loads imparted by the snare on the ball screw, and determined that the EE was acceptable for the remaining flight operations. The analysis indicated that some fasteners, which attach the ballscrew to the EE carriage, may have yielded and would likely require replacement post-flight.</p> <p>Post-Flight: Fasteners were replaced. Event included in crew lessons learned.</p>

APPENDIX B IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-128-V-04	TPS Anomalies	<p>A total of 13 TPS items were identified that exceeded pre-defined screening criteria and were entered into the TIIMS Database. A total of 9 items were cleared using standard procedures/tools, and the following 4 items required additional analysis:</p> <ol style="list-style-type: none"> 1. D-128-600_2-001 - Belly Inboard Starboard Wing. Tile substrate exposed, tile is damaged forward and outboard of starboard ET door. 2. D-128-700_2-002 - Belly Port Wing Inboard. Tile substrate exposed, tile is damaged outboard of port ET door. Appears to be several missing putty repairs. 3. D-128-700_2-010 - Belly Port Wing Inboard. Tile substrate exposed, tile is damaged on port wing. 4. D-128-AFD-540-001 - FRSI Plug is Protruding on Starboard OMS Pod: FRSI plug is protruding about 1.5 sections (~0.5") of the stacked FRSI plug from OMS Pod Carrier Panel. <p>No focused inspection was required. Post-Flight: Standard post-flight inspections and all TPS anomalies were repaired.</p>
STS-128-V-05	MADS Left OMS Pod Temp Off-Scale-High During Ascent	<p>The left Orbital Maneuvering System (OMS) temperature data stepped to Off-Scale-High (OSH) during ascent. (The sensor has a range of 0 to 1300 °F.) The wire combination is Chromel/Alumel with a K-wire symbol. The thermocouple is attached to 1 channel temperature compensation Thermocouple Reference Junction (TRJ) for accuracy. The measurement is routed to the MADS PCM for commutation and recorded on Master Measurement Unit (MMU) 1/Solid State Recorder (SSR) 1 and the Modular Auxiliary Data System (MADS) Tape Recorder.</p> <p>Post-Flight: Post-flight troubleshooting revealed an open on the return signal to the thermocouple. Thermocouple/TRJ repair was deferred until the STS-133 flow. Also, during troubleshooting, no timing signal could be retrieved from the MADS Pulse Code Modulator (PCM) on the display recorders. PCM was removed and replaced.</p>
STS-128-V-06	APU 3 EGT T2 Sensor Reading Below Ambient Temperature	<p>During post-landing power-up at Edwards AFB, the Auxiliary Power Unit (APU) 3 Exhaust Gas Temperature (EGT) Transducer 2 measurement was noted as being below ambient, essentially "off-scale low, which was typical of failure. Its companion sensor, APU 3 EGT T1 was nominal during entry and as expected indicated ambient temperature post-landing. This measurement was slightly erratic approximately 1.5 min prior to lift-off for about 30 sec. This measurement is not downlinked during entry and thus was not visible.</p> <p>Post-flight: The sensor was removed and replaced.</p>

APPENDIX B IN-FLIGHT ANOMALIES

ORBITER ANOMALIES

IFA Number	Title	Comments
STS-128-V-07	EV2 Unacceptable Communications During EVA 2	<p>At initial donning of the Extravehicular Mobility Unit (EMU) for the second EVA, the EV2 crewmember's backup Communications Carrier Assembly (CCA) had unacceptable communications. The bad communications were only relieved when the crewmember tilted his head all the way to the left. It was reported that the CCA/ microphone boom position was off-nominal. Attempts to re-adjust the microphone position were not successful. The crew changed to EV2's prime CCA. Following the change, no more communication problems were reported.</p> <p>Post-flight: The failure was confirmed on CCA 1208. The right microphone rear/noise cancelling port was non-operational or extremely low. Screens from the microphone port were removed to verify if the screen had contamination that was blocking the audio, but the problem was still present. The microphone transducer was sent to The Receiving Inspection and Test Facility (RITF) for failure analysis. The RITF could not find any physical anomalies that would account for the low output. Due to destructive nature of the RITF analysis, further testing/investigation was not possible. The Failure Investigation Anomaly Report (FIAR) was closed as an unexplained anomaly.</p>
STS-128-V-08	Aft Digital Auto Pilot 'A' Pushbutton Contact C Redundancy Management Failure	<p>The Aft Digital Auto Pilot (DAP) panel (on A6U) 'A' pushbutton contact C failed Redundancy Management (RM) when the crew depressed the button. After reviewing data on the 'A' pushbutton contacts, contacts A and B were seen at the time the C contact failure occurred, but the C contact was not seen. However, all three contacts had been working nominally up to that point and the C contact failure coincided with the last time the crew depressed the "A" pushbutton.</p> <p>Post-Flight: The panel was removed and sent to the NASA Shuttle Logistics Depot (NSLD) for 'A' pushbutton replacement. Subsequent inspection of the switch found normal wear and tear damage on the surfaces of contact C.</p>

APPENDIX B IN-FLIGHT ANOMALIES

SOLID ROCKET BOOSTER ANOMALIES

IFA Number	Title	Comments
STS-128-B-001	Right Hand Main Parachute Canopy Damaged with a Vertical Tear Extending from the Top Vent Band to the Canopy Bottom Skirt Band	Post-flight assessment of the parachutes at the Parachute Refurbishment Facility (PRF), the right hand main chute canopy was damaged with a vertical tear extending from the top vent band to the canopy bottom skirt band. Review of the STS-128 / B1139 right-hand Data Acquisition System (DAS) accelerometer data revealed off-nominal loading of the Solid Rocket Booster (SRB) subsequent to frustum separation and main parachute deployment, indicative of the loss of a single main parachute. Post-flight assessment revealed that all reefing line cutters fired properly resulting in the cutting of both the first and second stage reefing lines. All Sea Water Activation Release (SWAR) links worked properly and the main parachutes were released from the booster. Gore number 5 failed starting from ribbon number 2 and continued through to the vent lines. This large hole appeared to have collapsed the canopy during the first stage of deployment.
STS-128-B-002	Debris Observed Near Hold Down Post No. 4 During Ascent	During the post-launch imagery review of ground based cameras, several pieces of debris were observed falling aft near the right hand Solid Rocket Booster (SRB) Holddown Post (HDP) no. 4 between 39 and 45 sec MET. This observation was reported as NASA Imagery Reporting Database (NIRD) number 128-005 (Reference Figure 1). Due to the limitations and uncertainty of imagery analysis, the imagery laboratories from the two centers vary in their assessments of the size of the biggest piece observed. The Marshall (MSFC) laboratory estimated the piece to be approximately 68.65-in.by 11.28 in. using the frame capture at 39.808 sec MET. Johnson Space Center (JSC) laboratory estimated the size to be 25.6-in.by 7.68-in. from frame 39.797. The estimated sizing exceeds the Risk Assessment Mass (RAM). The existing RAM in NSTS 60559 is 0.3 lb _m based on calculation of a 26-in. by 2.25-in. by 0.125-in. piece. Rubbery debris/contamination was discovered on Space Shuttle Main Engine (SSME) no.3 during post-flight once the vehicle was returned the Orbiter Processing Facility (OPF). The debris was located on the external nozzle surface, between hatbands 5 and 6. The debris was on the inner circumference of the nozzle facing towards engine #2. The largest piece of debris was estimated to have a mass of 7 grams (0.0154 lb _m) and measured about 0.5-in. by 0.5-in. by 0.25-in.

APPENDIX B IN-FLIGHT ANOMALIES

REUSABLE SOLID ROCKET MOTOR ANOMALIES

No RSRM In-Flight Anomalies were identified from the analysis of the data.

APPENDIX B IN-FLIGHT ANOMALIES

SPACE SHUTTLE MAIN ENGINE ANOMALIES

No SSME In-Flight Anomalies were identified from the analysis of the data.

APPENDIX B IN-FLIGHT ANOMALIES

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-128-T-001	Imagery Showed Foam Loss Between +Y Jackpad/-Y Bipod Closeouts at LH ₂ IT	<p>Based upon Umbilical Well Camera imagery, this foam loss was located within the LH₂ / Intertank Flange Closeout between Stringers S13; Panel 1 (S13-1) and Stringer 15; Panel 1 (S15-1) at Station 1124 with a Phi Angle of 10.6 deg. The loss was Inboard and adjacent to the +Y Bipod Closeout; Outboard and Adjacent to the +Y Jack Pad Closeout. The loss is located across a Forward and Aft/window in the Flange Closeout. The dimensions of this foam loss are estimated to be 10.2 in by 8.0 in. by 1.0 in. with a total mass of approximately 0.040 lb_m, based upon modeling, known geometry and available imagery. The current requirements for NSTS 60559 (ET-FLAN-010-01-A) are: less than or equal to 135 sec: 0.025 lb_m; greater than 135 sec: 0.025 lb_m.</p> <p>The area of loss cannot be directly seen in either the SRB or LO₂ Feedline Fairing (ET) cameras. However, if the loss is assumed to have liberated in a single piece, it would have been expected to be seen in either the SRB or the ET camera imagery. Lighting for the ET camera is noticeably reduced shortly after SRB separation. There was no debris observed that were consistent with the loss site as observed through SRB separation (approximately 124s MET). Therefore, the loss is believed to have occurred after 124 sec. MET. The cryoingestion divot assessed release mass in NSSTS 60559 was conservatively set at 0.025 lb_m to ensure that losses from the LH₂-IT Flange Closeout received adequate scrutiny. The most probable cause is cryoingestion from a leak path created by a thermally-induced TPS crack exacerbated as a result of multiple loadings, which extended to the substrate with an available LN₂ reservoir.</p>

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-128-I-001	LH ₂ PV 12 Inboard Fill and Drain Valve did not Indicate Closed when Commanded	<p>On the second launch attempt of STS-128, during the transition to LH₂ fast fill, the LH₂ inboard fill and drain valve (PV12) position indicator did not indicate closed when the valve was commanded closed. This was a violation of Launch Commit Criteria (LCC) MPS-04 and the launch attempt was scrubbed. Following the drain and a warm-up to ambient temperature, the valve was cycled and both open and closed indications were observed. Additionally, a manifold decay test revealed no unexpected leakage across the valve. During the subsequent launch attempt, the valve position indicators functioned correctly. After landing, a small piece of contamination was found under the position indicator lever arm. This contamination was not recovered, but is a potential cause of the anomaly. Inspections of other fill/drain valves identified a few bent position-indicator lever arms, resulting in thorough inspections of all valves with this type of lever arm and repairs were made where required.</p> <p>The SICB approved a one-flight Interim Disposition for STS-129 for this IFA as acceptable to fly-as-is, primarily based on no evidence of systemic MPS Fill and Drain Valve problems (with adequate inspections) and assuming no changes to the existing LCCs.</p>
STS-128-I-002	Ice Internal and External to the LH ₂ T-0 Umbilical.	<p>During the first launch attempt for STS-128 (8/25/09), ice buildup was observed on the -Z side of the LH₂ umbilical, bridging over to the Orbiter TPS. The launch team approved a waiver to LCC ICE-01 and the launch attempt continued (until the launch was scrubbed because of another anomaly. On the 8/28 launch attempt, ice buildup was again observed bridging from the T-0 to the Orbiter, which the launch team addressed with another waiver to ICE-01.</p> <p>Interim closure was given at Control Board on 10/1/09, with some remaining work open on IDBR-01 and NSTS 08303. The umbilical seals were tested for functionality. Improved inspections and awareness. STS-129 imagery to be expedited post-launch. On-orbit inspections of aft areas of vehicle will be made.</p>

APPENDIX B IN-FLIGHT ANOMALIES

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-128-I-003	Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Lift-off Debris).	STS-128 experienced unexpected debris and expected debris exceeding the mass allowable prior to pad clearance. Post-flight investigation identified several areas for improvement. This anomaly was closed based on the following rationale: Risk assessment indicates that given the proposed mitigations, observed debris poses no appreciable increase in risk. The lift-off debris risk is currently characterized as infrequent, catastrophic due to significant limitations in controls and significant uncertainties in analysis. Expected lift-off debris risk is classified as infrequent catastrophic. Unexpected lift-off debris is classified as infrequent catastrophic. Debris release was mitigated for identified potential sources of critical debris by performing repairs and adding inspections for system-level components. Ongoing mitigations include Foreign Object Damage (FOD) awareness, attrition-based removal of hardware, routine inspections and monitoring for facility corrosion. No updates to NSTS documentation are recommended as part of this anomaly closure.
STS-128-I-004	ET TPS Loss on LH ₂ Intertank Flange Near Starboard Bipod at approximately Xt 1123	Mission imagery identified the loss of Thermal Protection System (TPS) near the starboard bipod at approximately Xt 1123. The calculated mass was larger than the risk baseline for that area, and the release is believed to have occurred after 124 sec MET. The cause was an external-debris impact to the Space Shuttle Vehicle (SSV) during ascent due to External Tank (ET) foam -Located on the LH ₂ Tank to Intertank Flange Closeout. The loss mechanism for this debris release area is well understood (cryogenic-ingestion). Although the mass of this debris was calculated to be higher than expected, an analysis performed for this mass still resulted in the risk being classified as remote. Based on this analysis, it is likely that ET project will propose an increase in the NSTS 60559 maximum expected debris mass for the LH ₂ /Intertank (IT) flange cryoingestion failure mode to account for this debris event.

APPENDIX B IN-FLIGHT ANOMALIES

IFA Number	Title	Comments
STS-128-I-005	Debris Observed near Solid Rocket Booster (SRB) Right-Hand Hold Down Post (HDP) no. 4 During Ascent. Also, a Foreign Material Deposit was Recovered from Space Shuttle Main Engine (SSME) no. 3 during Post-flight Inspections	<p>Ascent imagery revealed several pieces of debris liberating near HDP no. #4 of the starboard SRB from 39.6 to 45.2 sec MET. After an extensive post-flight review, the material was identified to be Viton-coated nylon from the aft skirt of the SRB. The Viton/nylon material is intended to erode away early during ascent due to engine plume heating, and some fragments can break free during that process. Debris fragments were observed on STS-128 and a number of previous flights. It was previously believed that this debris would always fall away from the vehicle, but a deposit of Viton/nylon was discovered post-flight on the nozzle of SSME no. 3 (IIFA STS-128-I-006) countered this assumption. A subsequent debris transport analyses discovered that fragments of the Viton/nylon material can become entrained in the recirculation flow aft of the vehicle and move forward relative to the vehicle, impacting the Orbiter with sufficient velocity to cause critical damage to tiles on the underside of the body flap and aft fuselage.</p> <p>The Control Board approved a one-flight Interim Disposition of this Integrated IFA as an accepted risk for STS-129. Previously, Viton/nylon fabric fragments were considered unexpected debris because it was not considered credible for the fragments to move “upstream” and impact the vehicle. Now that critical damage vehicle impacts are known to be possible, the Viton/nylon fabric fragments will be added as a new expected ascent debris source.</p>
STS-128-I-006	Debris Observed On SSME Hatbands	<p>Rubbery debris/contamination was discovered on SSMEs no. 2 and 3 after the vehicle was returned the Orbiter Processing Facility (OPF) but was later discovered to have been present prior to ISS docking. The debris was located on the external nozzle surface, with the largest piece of debris estimated to have a mass of 7 grams and measured about 0.5-in. by 0.5-in. by 0.25-in. This observation was originally reported as IIFA STS-128-I-006, but was later transferred to IIFA STS-128-I-005 for disposition.</p>

APPENDIX B IN-FLIGHT ANOMALIES

FLIGHT SOFTWARE ANOMALIES

No Flight Software In-Flight Anomalies were identified from the analysis of the data.

APPENDIX B IN-FLIGHT ANOMALIES

FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-128-N-001	MISSE PIP Pins Straight PEC Will Not Re-Engage	<p>During the first Extravehicular Activity (EVA) of STS-128, both Push in Pull (PIP) pins on the straight Passive Experiment Carrier (PEC) Light Weight Adapter Plate Assembly (LWAPA) socket were unable to be re-engaged by EV1 crewmember. This occurred after both pins were hammered out using the EVA hammer, prybar, and Bearing Motor Roll Ring Module (BMRRM) tool. The PIP pins were hammered out so that the ball detents on the PIP pins were pulled out of the receptacle slot. The crew was unable to push the ball detent back into the receptacle slot.</p> <p>The two PIP pins are only tethered. Affected hardware coming back in Orbiter Payload Bay on STS-131/19A.</p>

APPENDIX B IN-FLIGHT ANOMALIES

MOD ANOMALIES

No MOD in-flight anomalies were identified during the STS-128 Mission.

APPENDIX C

DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-128 MER Daily Reports by Michael D. Wright, Lead MER Manager:

Launch and First Daily Report, dated August 29, 2009
Second Daily Report, dated August 29, 2009
Third Daily Report, dated August 30, 2009
Fourth Daily Report, dated August 31, 2009
Fifth Daily Report, dated September 1, 2009
Sixth Daily Report, dated September 2, 2009
Seventh Daily Report, dated September 3, 2009
Eighth Daily Report, dated September 4, 2009
Ninth Daily Report, dated September 5, 2009
Tenth Daily Report, dated September 6, 2009
Eleventh Daily Report, dated September 7, 2009
Twelfth Daily Report, dated September 8, 2009
Thirteenth Daily Report, dated September 9, 2009
Fourteenth Daily Report, dated September 10, 2009
Fifteenth Daily Report, dated September 11, 2009
Landing Plus 2 Hour Report, dated September 12, 2009
Mission Summary Report, dated September 2009

ET/SRB/RSRM/SSME REPORTS

STS-128 In-Flight Anomalies, David W. Morr, USA-Huntsville, October 9, 2009
STS-128 HOSC Console Flash Report, Dino Diluigi, USA-Huntsville, August 29, 2009
STS-128 Post-Launch SRB Debris Open Assessment, Thomas F. Ford, NASA-KSC, September 2, 2009
STS-128 RSRM Flash Report, Robert Zahl, ATK, August 29, 2009

ORBITER REPORTS

STS-128 Quick-Look Landing and Deceleration Report, C. C. Heinol, Boeing-Houston, September 25, 2009
STS-128 Landing and Deceleration Mission Summary, Thomas L. Hoffman, Boeing-Houston, October 2, 2009
STS-128 Tire Wear Pattern Data, Thomas L. Hoffman, Boeing-Houston, October 2, 2009
STS-128 Communications and Tracking Report, C. J. Stafford, Boeing-Houston, September 25, 2009
STS-128 Displays and Controls and Lighting Report, Patrick.Ngo, Boeing-Houston, September 28, 2009
STS-128 Shuttle Remote Manipulator System, Stephen M. Tabladillo, MDA-Houston, September 28, 2009
STS-128 HYD/WSB System Report, Charles A. Ritrivi, Boeing-Houston, October 1, 2009
STS-128 PRSD System Mission Report, Johnny D. Wong, Boeing-Houston, October 5, 2009
STS-128 Main Propulsion System Report, Trina A. Martingano, Boeing-Houston, September 7, 2009
STS-128 Mechanical Systems Data Review, Jeff Goodmark, Boeing-Houston, September 29, 2009
STS-128 Auxiliary Power Unit System, Christopher N. Adi, Boeing-Houston, September 25, 2009
STS-128 OI/MADS Sensors, Signal Conditioners and Fuel Cell Monitoring System, Dwight A. Favors, Boeing-Houston, September 25, 2009
STS-128 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, September 30, 2009
STS-128 OAFGSS Report, Lillian P. Gibson, Boeing-Houston, October 30, 2009

STS-128 FO&I In-Flight Anomalies (Verbal), Ray Serna, NASA-JSC, September 24, 2009
 STS-128 Data Processing System Integrated Report, James T. Westergard, Boeing-Houston, October 20, 2009
 STS-128 EPDC Mission Report, William D. Peterson, Boeing-Houston, September 28, 2009
 STS-128 ATCS and ARS Post-Flight Mission Report, Carmelo S. Asuncion, Boeing-Houston, October 10, 2009
 STS-128 Life Support System Report (ARPCS and Airlock Systems), Erich L. Bass, Boeing-Houston, October 1, 2009
 STS-128 Orbiter Docking System Summary, Robert E. Davis, NASA-JSC, September 17, 2009
 STS-128 OMS Report, James M. Garza, Boeing-Houston, October 2, 2009
 STS-128 RCS Mission Report, E.J. Fitzgerald, PhD, Boeing-Houston, October 10, 2009
 STS-128 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, October 28, 2009
 STS-128 Fuel Cells Mission Report, Johnny D. Wong, Boeing-Houston, October 5, 2009.
 STS-128 Global Positioning System Report, Ray Nuss, NASA-JSC, October 1, 2009
 STS-128 Thermal Control System Summary, Than X. Nguyen, Boeing-Houston, September 25, 2009
 STS-128 Purge, Vent and Drain Report, C. C. Heinol, Boeing-Houston, September 25, 2009
 STS-128 Flight Control System and ADTA Mission Report, Howard Damoff, Boeing-KSC, September 18, 2009
 STS-128 Final Mission Events List, Vernon C. Hill, ESCG-Houston, October 1, 2009
 STS-128 WLE IDS Post Flight Report, Jennifer C. Hodge, Boeing-Houston, October 8, 2009
 STS-128 SE&I In-Flight Anomalies, R. Morehead, NASA-JSC, December 22, 2009
 STS-128 Windows Report, Orlando Torres, Boeing-KSC, September 29, 2009
 STS-128 ADS and GCILC System, Arnold A. Arrington, PhD, Boeing-KSC, October 2, 2009
 STS-128 Display and Controls, Quoc P. Ngo, Boeing-Houston, September 28, 2009
 STS-128 Mechanical Systems – PLBD, MPM and Ku-Band Deploy, Link Salvador, Boeing-Houston October 2, 2009
 STS-128 Waste Collection System, Wendy F. Parker, Hamilton Sundstrand, November 13, 2009
 STS-128 Purge, Vent and Drain Report, Chip C. Heinol, Boeing-Houston, October, 9, 2009

OTHER REPORTS

STS-128 CSR Final Report, Shelby J. Lawson, NASA-JSC, November 12, 2009
 STS-128 Final Landing Debris Runway Report, Thomas F. Ford, NASA-KSC, September 14, 2009
 STS-128 Final Debris Maps, Thomas F. Ford, NASA-KSC, September 2, 2009
 STS-128 Pre-EVA no. 1 Data, Jeff Outlaw, Hamilton Sundstrand, September 1, 2009
 STS-128 Extravehicular Activity Report for EVA 1, Shannon L. Cagle, Hamilton Sunstrand, September 2, 2009
 STS-128 Extravehicular Activity Report for EVA 2, Glenda Sparks, Hamilton Sunstrand, September 4, 2009
 STS-128 Post EVA no. 3 Report, Samuel D. Hower, Hamilton-Sunstrand, September 6, 2009
 STS-128 Final Extravehicular Activity Report, Maria Tullar, NASA-JSC, September 29, 2009
 STS-128 L-1 Day Walk Down, Thomas F. Ford, NASA-KSC, August 26, 2009
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 STS-128 Second Post-Drain Inspection, Eric W. Linderman, NASA-KSC, August 25, 2009
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 STS-127 prop30 Mass Properties Report, Barbara C. Schill, USA-Houston, August 4, 2009
 STS-128 Imagery Reports, Imagery Integration Group, NASA-JSC, August 30 to September 2, 2009
 STS-128 MER 3 Day Shift 3 Report, Larry R. Rhodes, Boeing-Houston, August 31, 2009
 STS-128 Ferry Data, Donald E. McCormack, NASA-JSC, September 28, 2009
 STS-128 Main DC Bus A, B, and C Hours, Karen D. Jordan, USA Space Operations, September 14, 2009

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
A	Ampere
AA	Accelerometer Assembly
ABS	Ammonia Boiler System
ADS	Audio Distribution System
AEC	Aft End Cone
ADTA	Air Data Transducer Assembly
AGT	Adaptive Guidance Throttling
AHMS	Advanced Health Monitoring System
ALT PRCS	Alternate Primary Reaction Control System
APCA	Aft Power Control Assembly
APCU	Assembly Power Conversion Unit
APFR	Articulating Portable Foot Restraint
APU	Auxiliary Power Unit
AR&D	Autonomous Rendezvous and Docking
ARPCS	Atmospheric Revitalization Pressure Control System
ARAS	Air Revitalization System
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
ATP	Acceptance Test Procedure
BET	Best Estimate Trajectory
BFS	Backup Flight System
BFS WHI	Backup Flight System Initial Weight of Helium Load
BLT	Boundary Layer Transition
BMRRM	Bearing Motor Roll Ring Motor
BSM	Booster Separation Motor
CCA	Communications Carrier Assembly
CDT	Central Daylight Time
CLA	Camera Light Assembly
CLPA	Camera Light Pan Tilt Assembly
CO ₂	Carbon Dioxide
COLBERT	Combined Operational Load Bearing External Resistance Treadmill
COMM	Communications
CPM	Cell Performance Monitor
CTB	Crew Transfer Bag
C&W	Caution and Warning
CWC	Contingency Water Container
CWCI	Contingency Water Container Iodine

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
D & C	Display and Control
DAP	Digital Autopilot
DAS	Data Acquisition System
DAT	Debris Assessment Team
DDU	Data Display Unit
DMHS	Dome Mounted Heat Shield
DOD	Department of Defense
DOLILU	Day of Launch I Load Update
DPS	Data Processing System
DRWP	Doppler Radar Wind Profiler
DTO	Development Test Objective
ΔP	Differential Pressure
ΔV	Differential Velocity
EAFB	Edwards Air Force Base
ECLSS	Environmental Control and Life Support System
ECO	Engine Cut-off
EE	End Effector
EGT	Exhaust Gas Temperature
EI	Entry Interface
ELM-ES	Experiment Logistics Module-Exposed Section
EMU	Extravehicular Mobility Unit
EO	External Tank/Orbiter
EOM	End-of-Mission
EPDC	Electrical Power Distribution and Control
EPF	External Payload Facility
ESP	External Stowage Platform
ET	External Tank
ETACS	External Active Thermal Control System
EuTEF	European Technology Exposure Facility
EV	Extravehicular (Crewmember)
EVA	Extravehicular Activity
FCE	Flight Crew Equipment
FCMS	Fuel Cell Monitoring System
FCS	Flight Control System
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection Annunciation
FES	Flash Evaporator System

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
FGB	Fixed Grapple Bar
FID	Failure Identifier
FIR	Fluids Integration Rack
FOM	Figure of Merit
FOV	Field of View
FRCS	Forward Reaction Control System
FRSI	Felt Reusable Surface Insulation
FSE	Flight Support Equipment
FSS	Fixed Service Structure/Flight Support System
FSW	Flight Software
G/g	Gravity
GAP	Group Activation Packs
GAX	GN&C Annunciation Interface
GCA	Ground Carrier Assembly
GCILC	Ground Command Interface Logic Controller
GFE	Government Furnished Equipment
GH ₂	Gaseous Hydrogen
GLACIER	General Laboratory Active Cryogenics ISS Experiment Refrigeration
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
GUCP	Ground Umbilical Carrier Plate
H ₂	Hydrogen\
HDP	Holddown Post
HDTV	High Definition Television
HPFTP	High Pressure Fuel Turbopump
HPOTP	High Pressure Oxidizer Turbopump
HRP	Human Research Program
HTV	H II Transfer Vehicle
HYD	Hydraulic
IAT	Image Assessment Team
IBA	Inspection Boom Assembly
IDS	Impact Detection System

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
IELK	Individual Equipment Liner Kit
IFA	In-Flight Anomaly
IMU	Inertial Measurement Unit
ISP	Integrated Stowage Platform
IT	Intertank
IVA	Intravehicular Activity
I _{SP}	Specific Impulse
ISS	International Space Station
JAXA	Japanese Aerospace Exploration Agency
JEM	Japanese Experiment Module
JSC	Johnson Space Center
KOH	Electrolyte
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LEE	Latching End Effector
LESS	Leading Edge Subsystem
LH	Left Hand
LIDAR	Light Intensification Detection and Ranging
LH ₂	Liquid Hydrogen
LMC	Lightweight Mission Peculiar Equipment Support Structure Carrier
LMG	Left Main Gear
LO ₂	Liquid Oxygen
LOS	Loss Of Signal
LP	Left Pod/Launch Package
LW	Left Wing
MAUI	Maui Analysis of Upper Atmospheric Modification
MADS	Modular Auxiliary Data System
MC	Midcourse Correction
MCC	Mission Control Center
MDA	Motor Drive Amplifier
MDCA	Main Distribution Control Assembly
MDS	Mice Drawer System
MDU	Multifunction Display Unit
MECO	Main Engine Cutoff
MEDS	Multifunction Electronics Display System
MELFI-2	Minus Eighty Laboratory Freezer-2
MET	Mission Elapsed Time

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
MFE	Mid-Frequency Executive
MISSE	Materials International Space Station Experiment
MLG	Main Landing Gear
MLP	Main Launch Platform
MLS	Microwave Landing System
MM	Momentum Manager/Major Mode
MMH	Monomethyl Hydrazine
MM/OD	MicroMeteoroid/Orbital Debris
MMT	Mission Management Team
MPC	Mid Power Controller
MPLM	Multi-Purpose Logistics Module
MPS	Main Propulsion System
MSSR	Materials Science Research Rack
N	North
N ₂	Nitrogen
NASA	National Aeronautics and Space Administration
NAVAID	Navigation Aids
NC	Nominal Correction
NCC	Nominal Correction Combination
NH	Nominal Height
NLP Vaccine-5	National Laboratory Pathfinder Vaccine-5
NSTS	National Space Transportation System
O ₂	Oxygen
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter
ODS	Orbiter Docking System
OI	Operational Instrumentation/Operational Increment (Software)
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
OSH	Off-Scale High

APPENDIX D

STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
OSL	Off-Scale Low
OPO	Orbiter Project Office
P	Port
PAO	Public Affairs Office
PAS	Payload Attachment System
PASS	Primary Avionics Software System
PASS WHI	PASS With Initial Helium Load
PCM	Pulse Code Modulation
PCS	Pressure Control System
PCT	Post-Contact Thrust
PDU	Power Drive Unit
PEC	Payload Equipment Container
PFRAM	Passive Flight Releasable Attachment Mechanism
PGME	Propylene Glycol Monomethyl Ether
PGSC	Payload General Support Computer
PI	Payload Interrogator/Position Indicator
PLB	Payload Bay
PLBD	Payload Bay Door
PMA	Pressurized Mating Adapter
PPCO ₂	Partial Pressure Carbon Dioxide
PRCS	Primary Reaction Control System
PRF	Parachute Refurbishment Facility
PRSD	Power Reactant Storage and Distribution System
PRT	Problem Resolution Team
PV&D	Purge, Vent and Drain
PWR	Payload Water Reservoir
QD	Quick Disconnect
RAM	Risk Assessment Mass
R&R	Remove and Replace
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RGA	Rate Gyro Assembly
RH	Right Hand
RHC	Rotational Hand Controller
RHIB	Right Hand InBoard
RJD	Reaction Jet Driver
RM	Redundancy Management
RMG	Right Main Gear

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STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
RMS	Remote Manipulator System
RNS	Relative Navigation System
RP	Right Pod
RPCM	Remote Power Controller Module
RPL	Rated Power Level
RPM	R-Bar Pitch Maneuver
RSB	Rudder Speed Brake
RSRB	Reusable Solid Rocket Booster
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Racks
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System
RSU	Rate Sensor Unit
RTV	Room Temperature Vulcanizing (material)
S	South/Starboard
S&A	Safe and Arm
SDBI	Short Duration Bioastronautics Investigations
SDFS	Smoke Detection and Fire Suppression
SE	Southeast
SE&I	Systems Engineering and Integration
SEITE	Shuttle Engine Ion Turbulence Experiment
SIMPLEX	Shuttle Ionospheric Modification with Pulsed Firings
SLWT	Super Lightweight Tank
SMRD	Spin Motor Rotation Detector
S/N	Serial Number
SRB	Solid Rocket Booster
SRGA	SRB Rate Gyro Assembly
SRMS	Shuttle Remote Manipulator System
SRSS	Shuttle Range Safety System
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
ST	Star Tracker
STP	Space Test Program
STS	Space Transportation System
SW	Southwest
SWAR	Sea Water Activation Release

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STS-128 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
SWMMS	Supply Water and Waste Management System
T2 TREADMILL	See COLBERT
TACAN	Tactical Air Navigation System
TC	Thermocouple
TC _e	Condenser Exit Temperature
TCS	Thermal Control System/Trajectory Control Sensor
TDRS	Tracking and Data Relay Satellite
THC	Translation Hand Controller
TI	Terminal Phase Initiation/Transfer Initiation
TMBU	Table Maintenance Block Update
TEA	Torque Equilibrium Attitude
TPS	Thermal Protection System
Tri	Triangulation
TriDAR	Triangulation Ranging Automated Rendezvous
TSM	Tail Service Mast
TVC	Thrust Vector Controller
VDT	Vehicle Data Table
VPU	Vegetable Production Unit
VRCS	Vernier Reaction Control System
W	West
WLE	Wing Leading Edge
WLE IDS	Wing Leading Edge Impact Detection System
WSB	Water Spray Boiler
ZSR	Zero-G Stowage Rack

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STS-128 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
MHz	MegaHertz
hr	hour
In.	inch
Kbps	kilobits per second
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
Mbps	Megabits per second
min	minute
mmHg	Millimeters of Mercury
mph	miles per hour
mV	milliVolt
nmi	nautical mile
%	percent
%/min	percent per minute
ppCO ₂	partial pressure carbon dioxide
ppm	parts per million
psi	pound per square inch
psia	pound per square inch absolute
psid	pound per square inch differential
scim	standard cubic inch per minute
sec	second
V	Volt
Vdc	Volt direct current