NSTS 37455

STS-129 SPACE SHUTTLE MISSION REPORT

July 2010



National Aeronautics and Space Administration

Lyndon B. Johnson Space Center Houston, Texas

NOTE

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SPACE SHUTTLE MISSION REPORT

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STS-129 SPACE SHUTTLE MISSION REPORT

INTRODUCTION

The Space Transportation System (STS) -129 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 129th mission of the Space Shuttle Program.

The purposes of this mission were to deliver to the International Space Station (ISS) Utilization and Logistics Flight (ULF-3), which consisted of two Expedite the Processing of Experiments to the Space Station (ExPRESS) Logistic Carriers (ELC's), a new Materials on International Space Station Experiment (MISSE) carrier, and an S-Band Antenna Support Assembly (SASA) package, plus additional equipment, supplies and scientific experiments that will be used by the continuing crew of six aboard the ISS. In addition, the 11-day flight will include three spacewalks and the installation of two platforms to the ISS truss, or backbone. The platforms will hold spare parts to sustain ISS operations after the Shuttle fleet is retired. Atlantis also brought back station crewmember Nicole Stott after more than two months aboard the orbiting laboratory. This is slated to be the final Space Shuttle crew rotation flight for the Station.

STS-129 was the 16th mission since the return to flight following the STS-107 mission, and the 31st mission to the ISS. STS-129 was also the 31st flight of the Orbiter 104 vehicle.

The primary objectives of the STS-129 mission were as follows:

- 1. Dock with the ISS and perform mandatory crew-safety briefing.
- 2. Return Expedition 21 Flight Engineer crewmember.
- 3. Install, activate and checkout ELC on and Unpressurized Cargo Carrier Attachment System (UCCAS) on the port side of the ISS backbone.
- 4. Install ELC 2 to an upper outboard Payload Attachment System (PAS) and perform a checkout of ELC 2.
- 5. Transfer the SASA to Z1 location and apply heater and operation power.
- 6. Install MISSE-7 onto ELC2 and activate and perform checkout.
- 7. Transfer and install spare oxygen High Pressure Gas Tank (HPGT) on ELC2.

The flight vehicle consisted of the OV-104 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-133; three Block II SSMEs that were designated as serial numbers (S/Ns) 2048, 2044, and 2058 in positions 1, 2 and 3, respectively; and two SRBs that were designated BI-140. The two RSRMs were designated flight set RSRM-108. The individual RSRMs were S/N 360W108A (left) and S/N 360W108B (right).

Launch pad 39A and Mobile Launch Platform (MLP) -3 were used as the platform for launch of the STS-129 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-129 flight were Charles O. Hobaugh, Colonel, U. S. Marine Corps, Commander; Barry E. Wilmore, Captain, U.S. Navy, Pilot; Leland D. Melvin, Civilian, NASA, , Mission Specialist 1; Randolph J. Bresnik, Lieutenant Colonel, U.S. Marine Corps, Mission Specialist 2; Michael J. Foreman, Captain, U. S. Navy, Retired, NASA, Mission Specialist 3; Robert L. Satcher, PhD, Civilian, NASA, Mission Specialist 4; and Nicole Passonno Stott, Civilian, NASA, Mission Specialist 5 (Down).

STS-129 was the third flight for Commander, the second flight for Mission Specialist 1, Mission Specialist 3, Mission Specialist 5 (Down), and the first Shuttle flight for the Pilot, Mission Specialist 2, and Mission Specialist 4.

MISSION SUMMARY

The objectives of the STS-129 mission include returning the Expedition 20/21 International Space Station (ISS) Flight Engineer Nicole Stott, installing two Expedite the Processing of Experiments to Space Station (ExPRESS) Logistics Carriers (ELCs) with spare parts for various ISS systems, preparing the ISS for the arrival of the Tranquility module, and performing three Extravehicular Activities (EVAs).

Pre-Launch

During pre-launch, the fuel cell 2 H_2 Pump Motor Condition (PMC) sensor was erratic. Measurement output ranged from 0.54 to 0.64 without a corresponding change in AC Bus 2. Data spikes were approximately 1 sec in duration. Closure of Kennedy Space Center (KSC) documentation was deferred because the voltage signature did not indicate increased pump load from initial stages of fuel cell flooding, bearing failure, or phase loss. A potential existed that the PMC noise could violate the Launch Commit Criteria limit. At about 320:17:44 GMT, the PMC noise decreased with corresponding changes in the AC 2 bus current.

The Day of Launch I-Loads Updates (DOLILU) were designed using the L-3:35 balloon. A significant wind change had been predicted and was observed between 30,000 and 45.000 ft. The L-4:50 balloon had picked up some of this wind change, but the 50 MHz Profiler data indicated the L-3:35 balloon would pick up much more. The I-load design delay rationale was covered by DOLILU Operations Support Plan (DOSP). Wind Change Redlines (WCR) were exceeded several times, but the rule was never broken. Boundaries must be exceeded over a 7500 ft altitude range to go red, but the largest exceedance that occurred was over a 5100 ft altitude range. The L-1:25 balloon assessment was performed up to 45,000 ft in case the WCR went red; however this assessment showed plenty of margin.

This was the first flight where the no-communication abort boundaries were delivered for the in-plane time.

Flight Day 1 (320/19:28 - 321/09:28)

The STS-129 mission was launched at 320/19:28:09.985 Greenwich Mean Time (GMT) on November 16, 2009, on the thirty-first Space Shuttle Program (SSP) mission to the ISS. The launch azimuth was 51.6 deg.

Solid Rocket Booster (SRB) separation was visible. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following SRB separation. Ignition occurred at 320/19:30:24.2 GMT [00/00:02:14.3 Mission Elapsed Time (MET)], and the maneuver was 84.40 sec in duration.

Main Engine Cutoff (MECO) occurred at 320/19:36:34 GMT (00/00:08:24.0 (MET). The External Tank (ET) separated from the Orbiter at 320/19:35:56 GMT (00/00:08:38.2 MET).

Data review has revealed biased Left Reaction Control System (LRCS) quantities that were computed by the Backup Flight System (BFS) during ascent. Beginning at approximately 90 sec MET, the LRCS fuel and oxidizer quantities-remaining increased over approximately a 20-sec period from 100% to 106% for the oxidizer and 110% for the fuel, respectively. These indicated quantities remained constant for approximately 3 min, and then the quantity values returned to nominal readings over a 2-min period. The down-listed-quantities from the Primary Avionics Software System (PASS) remained at their maximum values (99.9%) throughout this period. Review of the STS-125 data revealed similar behavior for the BFS LRCS computed-quantities during ascent. Analysis suggests the observed signature could be explained by an off-nominal value of the LRCS fuel-tank temperature used in the BFS quantity calculation, but not available in the down-list. The corresponding down-listed variable follows a different signal path and behaved nominally during ascent. This condition did not recur during the remainder of the mission.

A nominal OMS-2 maneuver was performed at 320/20:06:25.2 GMT (00/00:38:16.3 MET). The maneuver was 63.8 sec in duration with a Differential Velocity (Δ V) of 96.9 ft/sec. The achieved orbit was 85.2 by 124.7 nmi.

The Payload Bay Doors (PLBDs) were opened at 320/21:12:17 GMT (00/01:44:07 MET). The Ku-Band antenna was deployed and the self-test was completed with satisfactory results.

At 320/19:54:54 GMT (00/00:26:44 (MET), the Modular Auxiliary Data System (MADS) Pulse Code Modulation (PCM) Built In Test Equipment (BITE) indicated a failed condition for 16 sec, and then continuously starting at 320/19:55:38 GMT (00/00:27:28 MET). The MADS PCM BITE normally indicates a failure when MADS PCM power is removed. However, the command to remove MADS PCM power was not sent until 320/19:58:33 GMT (00/00:30:23 MET). This was after Solid State Recorder (SSR) 1 stopped recording MADS data at 320/19:53:34 GMT (00/00:25:24 MET), so MADS PCM ascent data were not affected.

The Shuttle Remote Manipulator System (SRMS) initialization, power up and checkout was initiated at 320/22:17 GMT (00/02:49 MET). The SRMS was returned to the Pre-Cradle Position at 321/00:12 GMT (00/04:44 MET). All SRMS activities were nominal.

The OMS-3 Nominal Correction (NC) -1 maneuver was performed nominally at 320/23:10:27 GMT (00/03:42:17 MET) with the cutoff at 320/23:10:52.9 GMT (00/03:42:42.9 MET) and both OMS engines operated nominally. The maneuver was 25.9 sec in duration with a ΔV of 39.3 ft/sec. The resulting orbit was 103.8 by 127.4 nmi.

The crew was unable to downlink the High-Definition (HD) video (IFA-STS-129-V-11). Troubleshooting information was provided to the crew. In addition, camera A had a yellow hue on the video; this condition has been noted on this camera during previous missions.

Flight Day 2 (321/09:28 - 322/09:28)

The main activities on Flight Day (FD) 2 were the exterior-surface surveys with the Orbiter Boom Sensor System (OBSS), the NC2 and NC3 maneuvers, and the Extravehicular Mobility Unit (EMU) checkout. Additional activities included the rendezvous tools checkout, docking-ring extension, and grapple of the ELC 1.

A right OMS-4 NC2 maneuver was performed nominally at 321/11:38:09 GMT 00/16:09:59 (MET). The maneuver was 10.8 sec in duration with a ΔV of 8.0 ft/sec. The resulting orbit was 131.7 by 103.8 nmi. Engine performance was nominal and no trim was required.

The SRMS OBSS surveys of the starboard wing Reinforced Carbon-Carbon (RCC), nose-cap RCC, and port-wing RCC were completed nominally. The maneuver for grappling the OBSS occurred at 321/12:12 GMT (00/16:44 MET), with the unberthing of the OBSS occurring at 321/12:19 GMT (00/16:51 MET). The Starboard RCC surveys began with the Flat Field Survey at 321/13:17 GMT (00/17:49 MET) and was completed at 321/15:08 GMT (00/19:40 MET). The Nose RCC surveys began at 321/15:24 GMT (00/19:56 MET) and was completed at 321/16:00 GMT (00/20:32 MET). The Port RCC survey began at 321/16:22 GMT (00/20:54 MET) and was completed at 321/18:12 GMT (00/22:44 MET). The OBSS was berthed and latched at 321/19:33 GMT (01/00:05 MET).

During OBSS latching, the starboard aft Manipulator Retention Latch (MRL) System 2 latch microswitch was not received. This was a known condition and was not considered an issue. After the OBSS was ungrappled, the SRMS grappled the ELC 1 at 321/19:55 GMT (01/00:27 MET).

All Wing Leading Edge (WLE) Impact Detection System (IDS) ascent-summary data was successfully downlinked. Three indications, all on the Starboard (S) side, exceeded the 1 Grms reporting criteria. The largest magnitude observed was 2.46 Grms on panel L6. The WLE IDS on-orbit monitoring began at 321/14:00 GMT (00/18:32 MET) with Port and Starboard Group 2. The monitoring began 3 hr later than planned due to the delay in downlinking the ascent data.

The first on-orbit Fuel Cell (FC) purge was a manual purge beginning at 321/16:48:21 GMT (00/21:18:11 MET).

The Orbiter Docking System (ODS) ring extension was started at 321/21:25:43 GMT (01/01:57:33 MET) and was completed at 321/21:34:30 GMT (01/02:06:20 MET). The ring extension was performed with dual-motor drive to the initial position of 76.4% ring

extension. During the extension, the ring-alignment Indicator was temporarily lost at 321/21:28:57 GMT (01/02:00:47 MET) for 3 sec and again at 321/21:29:48 GMT (01/02:01:38 MET) for 1 sec. The first loss of ring alignment, at approximately 5%, has occurred during previous flights. However, the second occurrence of misalignment, at approximately 23% during ring extension, was the first recorded loss of ring-alignment as late as 1 min into ring extension. Data evaluation was performed to determine the possible causes for the second occurrence of ring misalignment. Procedures were in place in the event that the loss of the alignment indication occurred again during the docking sequence ring-retraction operations. Loss of alignment during the retraction operation could have extended the duration of the docking timeline to allow the system to regain alignment, but this loss would not prevent docking to ISS. The ODS mechanism was considered ready to support docking activities.

The Rendezvous Tools checkout was performed and all systems were nominal. The Trajectory Control Sensor (TCS) was powered on at 321/23:20 GMT (01/03:52 MET) and was powered off at 321/23:25 GMT (01/03:57 MET).

The Reaction Control System (RCS) NC3 maneuver was initiated at 321/22:43:56 GMT (01/03:15:46 MET). The maneuver was 11.1 sec in duration with a ΔV of 2.5 ft/sec. The resulting orbit was 131.2 by 104.8 nmi. Engine performance was nominal and no trim was required.

The RCC Damage Assessment Team (DAT) and the TPS (Thermal Protection System) DAT concluded their imagery reviews. No gross damages were identified.

The crew was able to successfully downlink High Definition (HD) video after performing the uplinked troubleshooting steps.

After the downlink of the FD 2 survey video was complete, the Orbiter Communications Adapter (OCA) was configured to 48 Mbps downlink, but it did not work (IFA STS-129-S-01). The system was switched to 2 Mbps downlink, which operated successfully, but made the downlink of still images very slow.

Flight Day 3 (322/09:28 - 323/09:28)

The main activities on FD 3 were rendezvous and docking with the ISS as well as installation of the ELC 1, and preparations for the first Extravehicular Activity (EVA).

The first maneuver of the day was the OMS -5 Nominal Height (NH) using both engines. The time of ignition was 322/11:50:07 GMT (01/16:21:57 MET) with the cutoff 89.6 sec later. The maneuver had a ΔV of 139.0 ft/sec, and the resulting orbit was 184.4 by 128.4 nmi. Engine performance was nominal.

The second maneuver of the day was the OMS-6 NC4, which was a dual-engine firing. The time of ignition was 322/12:34:16 GMT (01/17:06:06 MET) with the cutoff 52.6 sec

later. The maneuver had a ΔV of 82.3 ft/sec, and the resulting orbit was 185.3 by 174.1 nmi. Engine performance was nominal.

The Nominal Corrective Combination (NCC) maneuver was a multi-axis RCS firing using six primary thrusters. The time of ignition was 322/13:08:17 GMT (01/17:40:07 MET). The ΔV delivered was 0.3 ft/sec and the resulting orbit was 185.1 by 174.1 nmi.

The Ku-Band antenna was taken to the RADAR mode at 322/13:22:44 GMT (01/17:54:34 MET) and detected the ISS within 6 sec at a range of 139,000 ft. The system began tracking the ISS at 322/13:23:20 GMT (01/17:55:10 MET) at a range of 137,000 ft. The RADAR mode operated as expected and the Communications (COMM) mode was reselected at 322/16:08:59 GMT (01/20:40:49 MET).

The OMS-7 Terminal Initiation (TI) maneuver was a straight-feed, left OMS engine firing. Ignition was at 322/14:06:08.9 GMT (01/18:37:58.9 MET) with the cutoff 11.6 sec later. The ΔV delivered was 8.7 ft/sec, and the resulting orbit was 186.3 by 178.7 nmi. Engine performance was nominal.

The Midcourse Correction (MC) -1 maneuver was initiated at 322/14:25:57 GMT (01/18:57:47 MET) and was completed 1.44 sec later. The Δ V delivered was 0.3 ft/sec. The MC2 maneuver was initiated at 322/14:58:44 GMT (01/19:30:34 MET) and was completed 3.35 sec later. The Δ V delivered was 0.8 ft/sec. The MC3 maneuver was performed at 322/15:15:41 GMT (01/19:47:31 MET) and was completed 1.84 sec later. The Δ V delivered was 0.42 ft/sec. The MC4 maneuver was initiated at 322/15:25:42 GMT (01/19:57:32 MET). The maneuver was completed 7.36 sec later. The Δ V delivered was 2.01 ft/sec.

The Trajectory Control Sensor (TCS) began tracking the ISS at a distance of approximately 5300 ft at 322/15:17 GMT (01/19:49 MET) and performed nominally throughout the rendezvous activities. At power-up, a TCS under-voltage message was annunciated. This occurrence was a known condition that is due to round-off errors in the firm-ware.

The R-bar Pitch Maneuver (RPM) started at 322/15:52:39 GMT (01/20:24:29 MET) and ended at 322/16:00:51 GMT (01/20:32:41 MET). The peak pitch-rate during the maneuver was approximately 0.71 deg/sec. The maximum attitude excursion was in roll and reached approximately 3.3 deg. Performance was nominal.

The Space-to-Space Orbiter Radio (SSOR) and Space-to-Space Station Radio (SSSR) had intermittent lock until a range of 5785 ft. A decision was made pre-flight to use SSSR 2 during rendezvous. SSSR 1 had been the primary system on previous missions.

The ODS was activated at 322/16:19:17 GMT (01/20:51:07 MET). The Shuttle captured the ISS at 322/16:51:16 GMT (01/21:23:06 MET), and the Post-Contact Thrust (PCT) firing sequence was performed nominally. Ring retraction using dual motors was

started at 322/16:58:21 GMT (01/21:30:11 MET) and took place without incident. The hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the ring final-position being acquired at approximately 322/17:08:01 GMT (01/21:39:51 MET).

Hatch opening took place around 322/18:30 GMT (01/23:02 MET).

ELC 1 was unberthed from the payload bay with the SRMS at 322/19:46:46 GMT (02/00:18:36 MET) and maneuvered to a handoff position where the Space Station Remote Manipulator System (SSRMS) grappled it at 322/20:23:28 GMT (02/00:55:18 MET). The SRMS ungrappled ELC 1 at 322/20:31:19 GMT (02/01:03:09 MET) and was maneuvered to the Singularity Avoidance Position. ELC 1 was then maneuvered with the SSRMS to the Port 3 (P3) truss where it was installed on the P3 Nadir Unpressurized Cargo Carriers Attachment System (UCCAS).

The first Contingency Water Container (CWC) was filled, and the Nitrogen (N_2) transfer was initiated at 322/21:17:50 GMT (02/01:49:46 MET).

The DAT determined that there were no requirements for a focused inspection.

Flight Day 4 (323/09:28 - 324/08:58)

The main activities on FD 4 were the first EVA that included S-Band Antenna Structural Assembly (SASA) and ammonia tank bracket installations, Micro-Meteoroid Orbital Debris (MM/OD) shield installations for Node 1 as well as the fixed grapple bar, and lubrication of the Japanese Experiment Module (JEM) Remote Manipulator System (RMS) end effector.

When the crew attempted to configure the Wireless Video System (WVS) V10 to support wireless video operations, the crew reported that the WVS 1 V10 recorder was malfunctioning and destroying tapes (IFA STS-129-V-04). The crew changed the WVS 1 with the monitor 1 V10 recorder and the EVA proceeded as planned.

The first EVA started at 323/14:24 GMT (02/18:56 MET) and was completed at 323/21:01 GMT (03/01:32 MET) for an EVA duration of 6 hr and 38 min. All the planned tasks were completed early. As a result, an additional task of deploying the Payload Attach System (PAS) on the Starboard 3 truss was completed. This task was planned for the third EVA. During this get-ahead task, the EVA crew encountered some difficulty removing some bolts and needed to use a hammer to move a brace out of the way. Additionally during the EVA operations, it was believed that the EV1 crewmember may have bumped into something that caused his Extravehicular Mobility Unit (EMU) Radio Frequency (RF) Camera Assembly (ERCA) to turn off. When the ERCA was turned back on, the video was noisy. This was an explained condition if the crewmember did not firmly apply pressure normal to the switch when turning it on. The EV1 crewmember also reported that audio was lost in the left ear, and later the crewmember

reported that moisture was in the Communications Cap Assembly (CCA) left-ear section.

The flight controllers detected a loss of the Sequential Still Video (SSV) shortly after completion of the first EVA. Troubleshooting was planned to occur during the FD 5 activities.

The second on-orbit fuel cell purge was performed, beginning at 323/09:44 GMT. During the 41-hour purge interval, the approximate performance decay was 0.17 Vdc for fuel cell 1, 0.12 Vdc for fuel cell 2, and 0.20 Vdc for fuel cell 3.

There were only four damage areas in the TPS documented by imagery, and the Leading Edge Subsystem (LESS) team did not have any requests for additional imagery. The TPS was cleared for entry at FD 4 Mission Management Team (MMT) meeting. The Focused Inspection (FI) was not required for STS-129.

Approximately 45 min into the crew-sleep period, a false rapid-decompression alarm was annunciated in the ISS and both the ISS and Orbiter crews were awakened. As part of the emergency-safing procedure, the ISS software shut down all air flow. The shutdown in air flow subsequently triggered a fire alarm in the Columbus module. After verification of nominal pressurization, the ISS crew manually restarted the airflow system. Preliminary indications point to the newly installed Mini-Research Module (MRM) -2 as the source of the false rapid decompression. The Shuttle team performed an analysis to determine why a Caution and Warning (C&W) alarm was not annunciated in the Orbiter. The sampling rate of the Orbiter Interface Unit (OIU) was determined to be the cause. Input data to the SM GPC from the OIU is updated every 10 seconds; however the ISS crew turned off the C&W alarm after 5 seconds, thus the SM GPC never saw the alarm.

Flight Day 5 (324/08:58 - 325/08:28)

The main activities on FD 5 were the grapple of the ELC 2, activation and checkout of the JEM Robotic Manipulator System (RMS), transfer operations, and preparations for the second EVA.

The heater for the APU injector water cooling tank common to all three APUs, did not cycle on as expected (IFA STS-129-V-10) at the controlling thermostat's 55 deg F "on" set point seen on previous flights. The heater is monitored by temperature sensor APU H2O Tank Temp and is controlled by a thermostat.

The crew reported that the light indicators on the Sequential Still Video (SSV) equipment onboard were not correct when asked to troubleshoot the loss of downlink from this equipment. The crew cycled power to the SSV in addition to the flight controllers cycling equipment in the Mission Control Center (MCC). Downlink of still video was recovered as a result of these efforts.

The crew was provided troubleshooting steps to recover the 48 Mbps Orbiter Communications Adapter (OCA) output. The crew was able to recover this capability after replacing a cable. This 48 Mbps mode was not planned for use before the late inspection on FD 10.

Approximately 2 hr into the crew-sleep period, a recurrence of the false rapiddecompression alarm was annunciated in the ISS, and both the ISS and Orbiter crews were awakened. The cause of the false alarms was isolated to a false manual alarm from MRM2. The MRM2 manual alarms were inhibited to prevent future occurrences. The Shuttle crew verified that the Orbiter Caution and Warning (C&W) alarm did annunciate. As part of the emergency-safing procedure, once again, the ISS software shut down all airflow. Additionally, safing procedures resulted in a repressurizing the airlock which was pressurized to 10.2 psi in support of the second EVA camp-out. Due to the repressurization of the airlock the EV crew donned Portable Breathing Apparatus (PBAs), breaking protocol for 7 minutes. Due to the recovery time the EVA crew reverted to the exercise prebreathe protocol. The repressurization of the airlock resulted in a dp/dt decrease in Orbiter, which triggered an Orbiter master-alarm klaxon.

The ISS Carbon Dioxide Removal Assembly (CDRA) was automatically shut down by the rapid-depressurization alarm that occurred at approximately 325/02:47 GMT (04/07:19 MET). During the subsequent restart attempt, the CDRA blower failed to start. CDRA-blower troubleshooting was performed after crew wake up. There was a spare blower on ISS and removal and replacement required approximately two hr.

Flight Day 6 (325/08:28 - 326/07:58)

The main activities on FD 6 were installation of the ELC 2 and the second EVA.

The second EVA started at 325/14:31 GMT (04/19:03 MET) and was completed at 325/20:39 GMT (05/01:11 MET) for an EVA duration of 6 hr and 8 min. All the planned tasks were completed as well as some get-ahead tasks.

During the EVA operations, the video from EV1's EMU Radio Frequency (RF) Camera Assembly (ERCA) was noisy as it was on the first EVA. A power cycle cleared the issue.

The EV1 crewmember also reported some loss of audio from the CCA (IFA STS-129-V-02). Prior to the start of Airlock depressurization, the audio was nominal. Just prior to egress, the audio began to dropout and dropouts continued throughout the EVA. In addition, the EV1 crewmember was not able to hear expected EMU caution and warning tones. It was not known if these audio issues were related to each other or to the audio issues that EV1crewmember experienced during the first EVA. Analysis of this anomaly was initiated. The third on-orbit fuel-cell purge was performed beginning at 325/21:34 GMT (05/02:06 MET). During the 60-hour purge interval, the approximate performance decay was 0.16 Vdc for fuel cell 1, 0.20 Vdc for fuel cell 2, and 0.22 Vdc for fuel cell 3.

Flight Day 7 (326/07:58 - 327/07:29)

The main activities for FD 7 were crew off-duty time, a Public Affairs event, and preparations for the third EVA.

Troubleshooting of the EV1 crewmember's audio issues during the first and second EVAs isolated the problem to the CCA. The audio in that CCA was degraded and the CCA was returned for troubleshooting. The EV1 crewmember was not scheduled to perform any other EVAs.

Starting at approximately 326/21:52 GMT (06/02:34 MET), the Fuel Cell (FC) 3 Oxygen (O₂) flow-meter measurement became erratic, fluctuating from an Off-Scale Low (OSL) value to an elevated value of approximately 4 lb_m/hr. No obvious electrical faults were seen in the FC 3 Mid Power Controller (MPC) telemetry or current, and all other FC 3 parameters remain normal. Adequate insight remained for determining the FC 3 health, and the O₂ flow can be calculated from other FC measurements. This O₂ flow-meter experienced similar erratic data during the STS-122 mission.

The Auxiliary Power Unit (APU) injector-cooling-water-tank temperature continued to track below the set-point of 55 °F (IFA STS-129-V-10). The APU tank was operating on the A-string heaters. During FD 7, the temperature reached a steady-state value of 49 °F. The water-tank-heater thermostat lower set-point was not activated, although the temperature was below the activation temperature seen on previous missions. The thermostat set-point was below its Acceptance Test Procedure (ATP) value of 50.4 °F, but the temperature was still within the temperature-sensor instrumentation-accuracy range.

Flight Day 8 (327/07:29- 328/07:00)

The main activities on FD 8 were the third EVA, which included the transfer of the High Pressure Gas Tank (HPGT), installation of the Materials on International Space Station Experiment (MISSE) -7, and deployment of the Starboard 3 Zenith PAS.

The third EVA started at 327/13:23 GMT (06/17:54 MET) and was completed at 327/19:04 GMT (06/23:35 MET) for a duration of 5 hr and 41 min. While suiting up for the third EVA, the bite-valve came off of the EV2 crewmember's drink bag. This resulted in delaying the start time of the third EVA by approximately one hr. All the planned tasks for the EVA were successfully completed.

When powering the Payload Bay (PLB) floodlights, the electrical bus current signature was less than expected for an illuminated floodlight. Troubleshooting by the crew

identified the failure of the PLB mid-starboard floodlight (IFA STS-129-V-03). The failure of the floodlight was of no impact to mission success or crew safety.

Three Payload Water Reservoirs (PWR's) and two CWC's were filled on FD 8 for transfer to the ISS. The fills were initiated at 327/16:08 GMT (06:20:01 MET) and were completed at 327/20:39 GMT (07:01:10 MET). PWR's 1, 2, and 3 contained approximately 15.4 lb_m, 17.8 lb_m, and 14.7 lb_m, respectively, for a total of approximately 47.9 lb_m. CWC's 12 and 13 contained approximately 85.7 lb_m and 84.9 lb_m, respectively, for a total of approximately 170.6 lb_m.

Flight Day 9 (328/07:00- 329/06:30)

The main activities for FD 9 were the reboost maneuver, a crew conference, crew offduty time, hatch closure, and rendezvous tools checkout.

The fourth on-orbit fuel cell purge was initiated at 328/07:24 GMT (07/11:56 MET). During the 58-hr interval since the third purge, the approximate performance decay was 0.17 Vdc for fuel cell 1, 0.15 Vdc for fuel cell 2, and 0.16 Vdc for fuel cell 3.

A transfer of Oxygen (O₂) to the ISS was completed at 328/14:20 GMT (07/18:52 MET). Approximately 40 lb_m of O₂ were transferred.

In preparation for the reboost of the ISS, the handoff of attitude control to the Orbiter occurred at 328/09:38:58 GMT (07/14:10:48 MET) with the 13-deg maneuver to the reboost attitude beginning at 328/09:40:52 GMT (07/14:12:42 MET). The Configuration 3 Vernier Reaction Control System (VRCS) reboost maneuver began at 328/10:07:10 GMT (07/14:39:00 MET) for a duration of 27 min. The reboost resulted in an altitude increase from 187 nmi by 179 nmi to 189 nmi by 180 nmi. The 16-deg maneuver back to the Torque Equilibrium Attitude (TEA) began at 328/10:38:28 GMT (07/15:10:18 MET) and attitude control was returned to the ISS at 328/11:18:18 GMT (07/15:50:08 MET).

The hatch between the ISS and the Orbiter was closed at 328/18:12 GMT (07/22:44 MET), and the vestibule was leak-checked successfully.

The rendezvous tools checkout was successfully completed.

The crew reported on FD9 a number of onboard cabling and video issues during FD 1 setup activities. The issues included video-tapes jamming in the Wireless Video System (WVS) 1 Video Tape Recorder (VTR), intermittent video on the Monitor 2 VTR, and an inability to display Digital Television (DTV) video on the Aft Flight Deck (AFD) Monitor 2 (IFA STS-129-V-08). With the exception of the WVS 1 VTR video-tape jamming issue (IFA STS-129-V-04), all issues were resolved by the crew by exchanging VTR locations or changing cables.

Flight Day 10 (329/06:30 - 330/06:30)

The main activities on FD 10 were undocking, the fly-around, a waste water dump, and the Late Inspection of the RCC.

The Wing Leading Edge Impact Detection System (WLEIDS) began monitoring at 329/08:30 GMT (08/13:02 MET) and ended at 329/20:00 GMT (08/23:32 MET). No triggers were reported during this monitoring period, and it was the final WLEIDS on-orbit monitoring period.

The Orbiter resumed attitude control with Digital Auto Pilot (DAP) in the automatic-mode at 329/08:40:35 GMT (08/13:12:25 MET) and the maneuver to the undocking attitude was initiated at 329/09:11:28 GMT (08/13:43:18 MET). The maneuver had a duration of approximately 28 min and was completed satisfactorily. The DAP was commanded to Free Drift at 329/09:33:49 GMT (08/15:05:39 MET) for the undocking.

The command to undock from the ISS was initiated 329/09:53:16 GMT (08/15:25:06 MET). The total drive time approximately 2 min for Hook Groups 1 and 2 was nominal. The ODS performed nominally for undocking.

The fly-around was initiated with RCS +X pulses of the L1A and R1A thrusters at 329/10:17:48 GMT (08/15:49:38 MET). The operation of the TCS for undocking and fly-around activities was nominal.

After undocking and prior to the separation 1 maneuver, the Ku-Band was taken to the RADAR mode at 329/10:06:30 GMT (08/14:38 MET) and locked on to the ISS at an approximate range of 198 ft. The Ku-Band was configured back to the Communications (COMM) mode at 329/11:30:57 (08/16:02:47 MET) at a range of approximately 6000 ft.

The Separation 1 maneuver was initiated with RCS +X pulses for 6.16-sec using thrusters L1A and R1A at 329/11:04:29.GMT (08/16:36:19 MET). The Separation 2 maneuver was performed at 329/11:32:30 GMT (08/17:04:20 MET). This was a 6.48-sec RCS -X maneuver using thrusters F2F and F3F.

After undocking, the waste water dump was initiated at approximately 329/12:07:38 GMT (08/17:39:28 MET), exhibited a nominal waste dump rate until approximately 329/12:19:36 GMT (08/17:51:26 MET) when the waste-dump rate suddenly decreased (IFA STS-129-V-05). A survey of the waste nozzle indicated no excessive ice buildup. A condensate CWC dump was planned for FD 11, which would bypass the filter and verify the remainder of the dump line was clear. If required, an In-Flight Maintenance (IFM) procedure could have been performed to connect the Waste Collection System (WCS) to a valve that would bypass the filter. Current estimates indicated that the IFM would not be required because there was enough volume in the waste tank for the remainder of the mission. Evaluation into the cause of the blockage was initiated.

At 329/13:14 GMT (08/17:45 MET) the SRMS maneuvered from the pre-cradle position and grappled the berthed OBSS at 329/13:29 GMT (08/18:00 MET). The SRMS then unberthed the OBSS and maneuvered to the OBSS-hover position at 329/13:38 GMT (08/18:08 MET). At 329/14:03 GMT (08/18:34 MET) the OBSS starboard survey was initiated with the maneuver to flat field position. The OBSS was berthed at 3 hr 27 min later after the completion of the starboard, nose-cap and port surveys.

The RCC DAT and the TPS DAT conducted their imagery reviews. No gross damages were identified.

The crew transferred the ISS Node 1 Heritage Panel to the shuttle, originally the panel was planned to be brought down on STS-131but a real time decision was made to bring it down on STS-129. The panel dimensions were 78 in by 22 in by 0.5 in and weighed 33 pounds. Placement into the airlock was not an option and the panel is longer than the width of the ditch in the middeck. The panel was bungee corded to the D-rings and taped to the starboard wall in the ditch, against the avionics bay and near the side hatch.

Flight Day 11 (330/06:30 - 331/06:30)

The main activities on FD 11 were the Flight Control System (FCS) checkout, the RCS hot-fire test, two OMS firings, a public affairs event, and a water dump.

The OMS-8 Shuttle Exhaust Ion Turbulence Experiment (SEITE) maneuver was performed at 330/09:29:14.2 GMT (09/14:01:10 MET). It was a dual-engine firing lasting 10.1 sec, and the ΔV was 17.7 ft/sec. The orbit after the maneuver was 177.5 by 191.2 nmi. Engine performance was nominal.

The FCS checkout began at 330/10:50:51 GMT (09/15:22:41 MET) and was completed at 330/10:54:33 GMT (09/15:26:23 MET). APU 1 ran for 3 min 42 sec, and no FCS anomalies were identified.

The procedures for the RCS hot-fire were initiated at 330/11:36:02 GMT (09/16:07:58 MET) and terminated at 330/11:42:06 GMT (09/16:14:02 MET). All 38 RCS thrusters were fired at least twice for at least 0.240 sec per pulse. No anomalies occurred.

The OMS-9 Shuttle lonospheric Modification with Pulsed Local Exhaust (SIMPLEX) maneuver was dual-engine firing with ignition at 330/14:08:46 GMT (09/18:40:42 MET) with the cutoff at 330/14:08:56 GMT (09/18:40:52 MET). The firing time was 10.1 sec with a ΔV of 17.9 ft/sec. The resulting orbit was 179.4 by 189.9 nmi.

The Condensate CWC was successfully dumped through the waste-water dump nozzle, which exonerates the waste-dump nozzle as the cause the failure to complete the waste water dump on FD 10.

A waste water tank dump was attempted through the High Capacity Filter using the conventional dump configuration, and it was unsuccessful (IFA-STS-129-V-05). The waste dump isolation valve was closed for 60 sec and another attempt to dump was unsuccessful. The dump valve was closed and the dump nozzle heated up to 250 °F and the waste dump valve was re-opened. This attempt also was unsuccessful.

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

Flight Day 12 (331/06:30 - 332/15:00)

The STS-129 mission was successfully completed with a landing at Kennedy Space Center (KSC), Florida.

Both Payload Bay Doors (PLBDs) were closed nominally by 331/11:00:39 GMT (10/15:32:29 MET) in preparation for landing.

The OMS Deorbit maneuver for the first landing opportunity at KSC was a dual-engine straight-feed firing that was performed on orbit 171 at 331/13:37:09.9 GMT (10/18:09:00 MET). The firing was 166.8 sec in duration with a ΔV of 308.6 ft/sec. The orbit after the maneuver was 179.0 by 23.3 nmi.

During the entry, a fire extinguisher mounted on the middeck aft cabin wall came out of its restraint device (IFA STS-129-V-09) and hit the cabin floor causing a dent.

Entry interface occurred at 331/14:12:40 GMT (10/18:44:30 MET).

The main landing gear touchdown occurred at KSC on runway 15 at 331/14:44:21 GMT (10/19:16:11 MET) on November 27, 2009. The drag chute was deployed at 331/14:44:24 GMT (10/19:16:14 MET). The nose gear touchdown occurred at 331/14:44:31 GMT (10/19:16:21 MET). Drag-chute jettison occurred at 331/14:44:51 GMT (10/19:16:41 MET). Wheels-stop occurred at 331/14:45:15 GMT (10/19:17:05 MET). The rollout was normal in all respects.

The flight duration was 10 days 19 hr 17 min 05 sec. The last APU was shutdown 19 min and 18 sec after landing.

Post-Flight

When the ET umbilical Camera Flash Module was opened post-flight, charring was found on the leads of one of the thermostats that control the heaters in the unit (IFA STS-129 V-06). Investigation showed that the leads of the thermostats were not covered by heat-shrink tubing prior to epoxy being applied to the housing. The thermostat lead wore through the epoxy and shorted to the housing.

During the post-flight operations, the Micro-Inspection Team determined that the Pilot (PLT) Multifunction Display Unit (MDU) screen had a small damage site with some

missing glass (IFA STS-129-V-07). The damage was 0.0984 in. wide by 0.122 in. long. In addition, the team believes that a section of the polyester film surrounding the damaged area had also been removed by the impact. Based on the team assessment, the glass fragment was not contained. Preflight inspections of the MDU's did not identify any damage at that time.

PAYLOADS AND EXPERIMENTS

The primary purpose of the mission was to deliver, install, and integrate Express Logistics Carrier (ELC) 1 and 2 on the International Space Station (ISS) deliver prepositioned spare Orbital Replaceable Units (ORUs), and return ISS Expedition 21 crew member Nichole Stott. ELC 1 was installed and activated at the P3 nadir Unpressurized Cargo Carriers Attachment System (UCCAS) and ELC 2 was installed and activated at the S3 outboard Payload Attachment System (PAS). A second major objective of the mission was to perform three scheduled Extravehicular Activities (EVAs) and perform a removal and replacement of the Battery Charger Modules (BCM) 3 and 4. Water and other critical items were also transferred to the ISS on this mission. This mission carried fifteen ORUs; the most ever flown on a Shuttle mission.

Three EVAs were successfully performed resulting in a total of 19 hours, 27 minutes of EVA time on this mission. The crew completed the EVA tasks for ULF 5 and several EVA get-ahead tasks.

LAUNCH PACKAGE OVERVIEW

The ISS Utilization Logistics Flight (ULF) 3 launch package consisted of ELC1, which delivered one Battery Charge/Discharge Unit (BCDU), one Control Moment Gyro (CMG), one Nitrogen Tank Assembly (NTA), one Pump Module (PM), one Ammonia Tank Assembly (ATA), one Plasma Contractor Unit (PCU), one Latching End Effector (LEE), two empty Payload Passive Flight Releasable Attachment Mechanisms (PFRAMs), and one Passive FRAM Adapter Plate (PFAP) for future payload use. The ELC 2 delivered one CMG, one NTA, one PM, one Mobile Transporter/Trailing Umbilical System Reel Assembly (MT/TUS RA), one High Pressure Gas Tank (HPGT), one Cargo Transport Container (CTC), Materials International Space Station Experiments-7 (MISSE-7) attach hardware, one empty PFRAM and one empty payload PFRAM.

The MISSE 7A and 7B Payload Experiment Carriers (PECs) and the S-Band Antenna Support Assembly (SASA) were also integrated on sidewall carriers. The Utilization payloads flown in the middeck for ULF 3 were the General Laboratory Active Cryogenic on ISS Experiment Refrigeration (GLACIER), which was un-powered until Flight Day (FD) 7, a APEX Cambium Advanced Biological Research System (ABRS), National Laboratory Pathfinder (NLP) -cells investigation, transported to space via BioServe's Commercial Generic Bioprocessing Apparatus (CGBA), CERISE (JAXA payload), and the Mouse Drawer System (MDS), returned on ULF 3.

CREW ACTIVITY SUMMARY

On Flight Day (FD) 2, the Orbiter Boom Sensor System (OBSS) survey of the Orbiter's port and starboard Reinforced Carbon-Carbon (RCC) Wing Leading Edge (WLE) panels

and nose cap areas were completed. Data analysis of the R-bar Pitch Maneuver (RPM) imagery along with the FD 2 Laser Dynamic Range Imagery (LDRI), WLE Impact Detection System (WLEIDS), radar, and ground imagery data supported the FD 4 Mission Management Team (MMT) decision that no FD 5 focused inspection was required. The Damage Assessment Team (DAT) subsequently cleared the entire Thermal Protection System (TPS).

On FD 3, the Shuttle captured the ISS at 10:51 am (01/21:23:06 MET). The hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the ring final-position being acquired at approximately 11:08 am (01/21:39:51 MET). Hatch opening took place around 12:30 CST (01/23:02 MET) and the Shuttle crew was welcomed aboard the ISS.

ELC 1 was unberthed from the payload bay with the Shuttle Remote Manipulator System (SRMS) and maneuvered to a handoff position where the Space Station Remote Manipulator System (SSRMS) grappled it. The SRMS ungrappled ELC 1 and was maneuvered to the Singularity Avoidance Position. ELC 1 was then maneuvered with the SSRMS to the Port 3 (P3) truss where it was installed on the P3 Nadir Unpressurized Cargo Carriers Attachment System (UCCAS).

On FD 4, the first Extravehicular Activity (EVA) was successfully completed in 6 hr 37 min. All planned tasks plus one get-ahead task were completed.

On FD 4, preparations continued in Node 1 for the installation of Node 3 during the STS-130 mission by installing equipment in the mid-bay area. The Inter-Module Ventilation (IMV) valve, a new closeout panel and the Node 1 IMV Remote Manual Override (RMO) were installed. In addition, a successful checkout of the IMV Valve was completed.

On FD 5, the flight ULF 3 tasks for the outfitting of Node 1 were completed in preparation for the Node 3 installation.

The Shuttle Remote Manipulator System (SRMS) grappled the ExPRESS Logistics Carrier (ELC) 2 in the Orbiter payload bay in preparation for the second EVA installation on the Starboard 3 truss upper outboard Payload Attach System (PAS).

The Atlantis Commander successfully completed an exchange of the Human Research Facility (HRF) Ultrasound Front End Controller (FEC), the Analog Input Module (AIM), and eight channel boards in the Ultrasound equipment. The crew then partially installed the Ultrasound front panel and activated the HRF. Several tests were completed to assess the operational status of the unit. The Ultrasound equipment is operating nominally.

On FD 6, the second EVA was completed in 6 hr 8 min, and all planned task as well as several get-ahead tasks were completed.

On FD 7, The ISS and Shuttle crews prepared for the third EVA by performing an Extravehicular Activity (EVA) Mobility Unit (EMU) exchange, EVA tool configuration, equipment-lock preparation and reviewing the EVA procedures. This day was a Shuttle off-duty day.

On FD 8, the third and final EVA was successfully completed with all planned tasks and several get-ahead tasks accomplished in 5 hr 42 min. The completed tasks were included installation of the High Pressure Gas Tank (HPGT), the Micro-Meteoroid Orbital Debris (MM/OD) shield was retrieved and the MISSE experiment was installed.

The Urine Processing Assembly (UPA) Distillation Assembly (DA) was removed and packed for return on Atlantis.

On FD 9, The Shuttle Atlantis performed a reboost maneuver of 3.3 ft/sec, which resulted in an ISS altitude increase of approximately 1 nautical mile. The final middeck transfer activities were successfully completed before closing the hatches between the Orbiter and ISS. Following final farewells the crews closed the hatches. Atlantis is scheduled to undock the morning of FD 10.

All Shuttle and Station crew participated in the Change of Command Ceremony to transition ISS CDR responsibilities from Frank DeWinne to Jeff Williams. It was decided to conduct the ceremony earlier than usual to take advantage of the presence of Nicole Stott and the Atlantis crew, and the proximity of Nicole's departure to the 19S departure.

On FD 10, the Orbiter Atlantis successfully undocked from the ISS at 3:53 am CST. This mission delivered over 2000 lb of pressurized cargo and supplies to the ISS. Three very successful Extravehicular Activities (EVAs) were completed and two ExPRESS Logistics Carriers (ELCs) stowage platforms were delivered along with several spares to support ongoing ISS operations. The orbiter completed a fly-around of the ISS, taking photography of the ISS.

On FD 11, two successful dual Orbital Maneuvering System (OMS) engine maneuvers were performed, one for the Department of Defense (DoD) Shuttle Exhaust on Turbulence Experiment (SEITE) and one for the Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) observational payloads of opportunity on FD11. Flight Control System (FCS) checkout and Reaction Control System (RCS) hotfire were performed successfully.

On FD 12, the Atlantis Orbiter landed on the first nominal End-of-Mission (EOM) landing opportunity and landed at the Kennedy Space Center (KSC) on Friday, November 27, 2008 at 8:44 am CST.

TRANSFER WEIGHT SUMMARY

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

TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Parameter	To ISS, Ib _m	From ISS, Ib _m
Cargo Bay	27,468	1,100
Middeck	2,211	2,110
Totals	29,679	3,210

- Water 1389 lb_m (Fourteen Shuttle Contingency Water Containers (CWC's) (one potable CWC and 13 technical CWC's) and 3 Portable Water Reservoirs). In addition, 2 ISS CWC's were filled with condensate and transferred for Russian processing.
- 2. **Oxygen** 40.5 lb_m to repressurize the ISS prior to hatch closure. No tank-to-tank oxygen was transferred.
- 3. **Nitrogen –** 11.0 lb_m of Nitrogen (N_2) transferred to tanks and approximately 77 lb_m of N_2 was used to repressurize the ISS stack.
- 4. Lithium Hydroxide Twelve canisters to ISS and 16 canisters to transferred for Shuttle Return.
- 5. Food 30 half-size Cargo Transfer Bags (CTB's) transferred to ISS

SIGNIFICANT FIRSTS

The significant firsts and records for the STS-129 mission were as follows:

- **1.** First time two ELC's were carried in the payload bay.
- 2. First mission to deliver 15 pre-positioned ORU's to the ISS.
- 3. Last ISS crewmember scheduled to return on the Shuttle.

SIGNIFICANT ISS ANOMALIES

On FD 4 approximately 45 min into the crew-sleep period, a false rapid-decompression alarm was annunciated in the ISS and both the ISS and Orbiter crews were awakened. As part of the emergency-safing procedure, the ISS software shut down all air flow. The shutdown in air flow subsequently triggered a fire alarm in the Columbus module. After verification of nominal pressurization, the ISS crew manually restarted the airflow system. Preliminary indications pointed to the newly installed Mini-Research Module (MRM) -2 as the source of the false rapid decompression. The Shuttle team performed an analysis to determine why a Caution and Warning (C&W) alarm was not annunciated in the Orbiter.

On FD 4 the Water Processing Assembly (WPA) was reactivated at a lower pump speed/flow rate in an attempt to allow continuous processing with the anomalous pressure drop in the process line between the waste water tank and the Mostly Liquid Separator (MLS). Preliminary data from this run indicated the flow rate was lower than expected and a request to increase the pump speed is in work. Ground specialists continue to analyze the data from a continuous run and continue forward plan development to return the WPA to nominal use.

On FD 5 approximately 2 hr into the crew-sleep period, a recurrence of the false rapiddecompression alarm was annunciated in the ISS, and both the ISS and Orbiter crews were awakened. The cause of the false alarms was isolated to a false manual alarm from MRM 2. The MRM 2 manual alarms were inhibited to prevent future occurrences. The Shuttle crew verified that the Orbiter Caution and Warning (C&W) alarm did annunciate. As part of the emergency-safing procedure, the ISS software again shutdown all airflow. Additionally, safing procedures resulted in a re-pressurizing the airlock which was pressurized to 10.2 psi in support of the second EVA camp-out. The repressurization of the airlock resulted in a dp/dt decrease in Orbiter, which triggered an Orbiter master-alarm klaxon.

The ISS Carbon Dioxide Removal Assembly (CDRA) was automatically shut down by the rapid-depressurization alarm. During the subsequent restart attempt, the CDRA blower failed to start. CDRA-blower troubleshooting was performed after the crew was awakened. There was a spare blower on the ISS and removal and replacement requires approximately 2 hr.

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.

	Task	Flight Day Task Completed
	Category 1	
1	Dock Shuttle Flight ULF3 and PMA2 Port and perform mandatory crew safety briefing for all crewmembers.	FD3 √
2	Return E21 FE-2 (17A) crewmember and transfer mandatory crew rotation cargo.	FD3 and FD10√
3	 Complete preparation and check out tasks for 19 Soyuz undocking. a. Complete Soyuz prepacking. b. Perform training/familiarization and vehicle preparation for 19 Soyuz crew return. c. Complete flight plan review. d. Perform transfer tag-up. 	Not required
4	Install, activate, and check out ELC1 to Port (P) 3 Nadir UCCAS.	FD3√

MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS

	Task	Flight Day Task Completed
5	Install, activate, and check out ELC2 to Starboard (S) 3 Upper Outboard Payload Attachment System (PAS).	FD6√
6	Transfer mandatory quantities of water from Orbiter to ISS per Flight ULF3 Transfer Priority List (TPL).	FD9√
7	Transfer and stow critical items per Flight ULF3 TPL.	FD9√
8	Transfer SASA to Z1 location, apply heater and operation power, and connect 1553.	FD4√
9	Install, activate, and check out MISSE PECs 7A and 7B onto ELC2 after ELC2 has been installed on the ISS.	FD8√
10	Remove Node 1 handrail 0111 and replace with NH ₃ line routing bracket.	FD4√
11	Functional Cargo Block (FGB) Local Area Network (LAN) connector Reposition and Micro Meteoroid Orbital Debris (MMOD) shield tie down.	FD4√
12	Mate connector S0 P181 (Node 3 Ch. ¼ Primary Power).	FD4√
13	 Install Node 1 Port bulkhead feed-through and Intra-Module Ventilation (IMV) mod kit in preparation of Node 3 installation. a. Install Node 1 bulkhead feed-through mod kit and perform leak checks (Fuel Cell (FC), wastewater, O₂, N₂, and air revitalization) in preparation for Node 3 installation, if not already performed. b. Install Node 1 IMV reconfiguration mod kit consisting of Node 1 Port Aft IMV valve and wire harnesses, Remote Manual Override (RMO) 	FD5√
	handle and mid-bay closeouts, and perform IMV rigging procedure	500
14	Transfer remaining cargo items per Flight ULF3 TPL.	FD9V
15	Parava and Banloos (PSB) Airlock bettery obstrar modulos (v. 2)	FD3V
10	Transfer and install energy HDCT (O) from ELC2 to ISS Airlock and perform	
17		FDOV
18	Close Node 1 port window flap	Removed
		from IDRD
19	Perform daily ISS payload status checks as required.	FD9√
20	Perform daily middeck activities to support payloads (includes cases where Shuttle crew also performs payloads on the ISS). Items listed below are not in priority order.	FD3-FD9√
	a. Biophosphonates (ISS)	
	b. Reaction self-test (ISS)	
	c. Sleep short	
	d. Integrated Immune	
	e. Spinal	
	I. Steep long (ISS)	
	y. Double cold bay packing and unpacking	
	i Mice Drawer System (MDS)	
	k APEX Cambium/ABRS	
	I. CERISE	
	m. NLP-Cells/CGBA	

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

ISS MISSION PRIORITIES COMPLETION STATUS (C	continued)
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	Task	Flight Day Task
		Completed
21	Perform ISS payload research operations tasks.	FD9√
22	Relocate Floating Potential Measurement Unit (FPMU) and Video Stanchion Support Assembly (VSSA) from CP2 to CP6.	FD6√
23	Close Node 2 Zenith window flap.	Task deleted
24	Deploy S3 lower outboard (S3LO) PAS.	FD4√
25	The following Extravehicular Activity (EVA) tasks are deemed to fit within the existing EVA timelines; however, they may be deferred if the EVA is behind schedule. The EVA will not be extended to complete these tasks. a. Route Space-to-Ground Antenna (SGANT) cable	FD4√ FD4√
	 b. Deploy Articulating Portable Foot Restraint (APFR) ingress aides (X2) 	FD6√
	 c. Wireless Video System External Transceiver Assembly (WETA) No. 3 installation at Camera Port 1 (CP1) 	FD6√
	d. S3 upper inboard PAS deploy	FD6√
	 Install Automated Information System (AIS)/Amateur Radio on International Space Station (ARISS) antenna on Columbus 	FD6√
	f. Lubricate JEM RMS LEE snares	FD4√
	g. Lubricate POA LEE snares	FD4√
26	Install Node 1 avionics and fluids mod kit and Node 1 IMV mod kit in preparation for Node 3 installation	FD5√
	 a. Install Node 1 avionics and fluids mod kit cables and hoses, connecting as described: Audio Bus A/Video [to Node 1 Port bulkhead only (J29) Audio Bus B (Connect both ends)] Integrated Station LAN (Connect both ends) 1553 Channel A (Do not connect) 1553 Channel B (Do not connect) Ultrahigh Frequency (UHF) coax (Do not connect) FC water (Connect both ends) Wastewater [Connect to Node 1 Port bulkhead only (J30)] Oxygen [Connect to Node 1 Port bulkhead only (J45)] Nitrogen [Connect to Node 1 Port bulkhead only (J44)] Air Revitalization System (ARS) (Connect both ends) Master Time Line (MTL) supply and return (Connect at Node 1 Port only) 	FD5√
	 b. Node 1 IMV mod kit consisting of the following: 1. Two new duct assemblies (Node 3 supply and return) Two new duct assemblies (Node 3 supply and return) 2. Remove NOD1P1 IMV fan and silencers 3. New NOD1P3 close out panel IMV valve and new RMO at Node 1 Port Aft 4. IMV power and data cables 5. Diffuser covers and caps 	FD5√

ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

	Task	Flight Day Task Completed
27	Reboost the ISS with the Orbiter if mission resources allow and are consistent with ISS trajectory analysis and planning.*	FD9√
28	Perform imagery survey of the ISS exterior during Orbiter fly around after undock, if propellant is available.	FD10√
29	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during ELC1 and ELC2 installation ((ISS Wireless Instrumentation System (IWIS) not required if Microgravity Acceleration Measurement System (MAMS)/Station Acceleration Measurement System (SAMS) available).	FD4, FD6√
30	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during ULF3 Reboost (IWIS required).	FD√
31	Perform SDTO 13005-U, ISS Structural Life Validation and Extension, during ULF3 Orbiter undocking. (IWIS highly desired).	FD10√
32	Activate and check out new Compound Specific Analyzers – Combustion Products (CSA-CP).	
33	Transfer O ₂ from Orbiter to the ISS Airlock HPGTs if consumables permit.	Deferred
34	 If time and ops constraints allow, perform the following Node 1 avionics and fluids mod connections. (These conditions may interfere with EVA operations.): a. 1553 Channel A (Connect J106 and J31) b. 1553 Channel B (Connect J43 and J118) c. Audio Bus A/video [Connect to Node 1 fwd bulkhead (P3) and starboard bulkhead (P78)] d. UHF coax (Connect P120) 	FD5√
35	Perform (Payloads of Opportunity) (not required for docked ops) if propellant is available. a. RAM Burn Observation 2 (RAMBO 2) b. MAUI	
	d. SIMPLEX	FD11√
36	Perform DTO 696, Grab Sample redesign for Shuttle.	\checkmark

ISS MISSION PRIORITIES COMPLETION STATUS (Concluded)

	Task	Flight Day Task Completed
37	Perform program-approved EVA get-ahead tasks. The following EVA get- ahead tasks do not fit in the existing EVA timelines; however, the EVA team will be trained and ready to perform should the opportunity arise. EVA/MOD has the flexibility to select the tasks to be completed based on efficiencies agined in performing the already cabedylod required tasks	FD8√
	 a. Install bootie/grounding sleeves on Mobile Base System (MBS)/MT nadir MBS jumper (2 connectors) 	FD8√
	 b. Release Starboard ATA bolt no. 1 c. Deploy Starboard 3 Lower Inboard jumper d. Connect P1/P3 NH₂ contingency jumper 	FD8√ FD6√ FD8√
	e. Move cheater bar to Z1 toolboxf. Relocate APFRs for future EVAsg. Relocate tool stanchion to APFR	FD8√ FD8√ FD6√
	 h. Retrieve APFR No. 4 and No. 5, remove heat shield IVA, and redeploy i. Connect S1/S3 NH₂ contingency jumper 	APFR 5 only on FD8√ FD8√
	 Install SSRMS LEE A Tip and MBS Capture Latch Assembly (CLA) covers 	FD8√
	 Photograph A/L handrail no. 0537 to document suspect MM/OD impact 	FD4√
	I. Inspect for FOD and photograph Node 2 CBM sealing surface	
38	Russian segment crewmembers. (These activities are considered to not interfere with Shuttle Flight ULF3 objectives):	NOT Reported
	 Complete preliminary Mini Research Module 2 (MRM2) integrations tasks (if not completed in Stage 20S). 	
39	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 apportunity gries.	Not Reported
	 will be trained and ready to perform should the opportunity arise. a. Unpack ULF3 middeck cargo b. Retrieve locking from TEPC detector S/N 1003 ULF3 pre-packed location (added per Chit 7976) 	FD4√

SECONDARY PAYLOADS

General Laboratory Active Cryogenic on ISS Experiment Refrigeration

The GLACIER was powered up on FD 7 in support of the sample transfer on FD 9. No additional information was available at the time of this report.

Mouse Drawer System (MDS)

The Mouse Drawer System (MDS) was transferred to the Shuttle middeck on FD9. No additional information was available at the time of this report.

DEPARTMENT OF DEFENSE PAYLOADS OF OPPORTUNITY

Maui Analysis of Upper-Atmospheric Injections (MAUI)

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

No MAUI observation opportunities occurred during this mission.

Shuttle Exhaust on Turbulence Experiments (SEITE)

On FD 11, a 10-sec dual OMS firing was completed in support of the SEITE payload. The OMS engines were fired in the zenith direction (towards space) to formulate an exhaust cloud that intersected with the Communications/Navigation Outage Forecasting System (C/NOFS) satellite. Specific measurements were taken to depict rocketexhaust models. This firing operation represents the fourth time the DoD and NASA Flight Control Team have worked together to bring two orbiting vehicles to pass close enough to each other that the Shuttle exhaust cloud could be viewed. Experiment results will be made available as soon as the data can be down-linked from the satellite and analyzed by the Principal Investigator (PI).

Shuttle lonospheric Modification with Pulsed Local Exhaust (SIMPLEX)

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

On FD 11 a 10-sec dual OMS firing was completed on FD 11 at 8:08 am CST. The OMS engines were fired in the nadir direction (toward the Earth/ground-site) and the Principal Investigator reported that the Texas Relocatable over the Horizon Radar (ROTHR), Puerto Rican ROTHR, and Arecibo sites successfully collected data during the firing. If this firing event was successful following analysis of the data, the minimum science objectives detailed in the SIMPLEX Payload Integration Plan (PIP) for the Arecibo site will be complete.

Materials on International Space Station Experiment (MISSE-7)

Passive Experiment Containers (PECs) 7A and 7B were installed during the third EVA.

Ram Burn Observation 2 (RAMBO-2)

No observations were made on this flight as the observation satellites were launched close to the STS-129 launch and operational checkout of the satellite systems had not been completed at de-orbit time.

DEVELOPMENT TEST OBJECTIVES

DTO 696 Grab Sample Container (GSC) Redesign for Shuttle

This Development Test Objective (DTO) utilized devices called grab-sample containers to monitor air contaminant levels and the sample was taken on FD 12. Results were not available at the time of this report.

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

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

DTO 805 Crosswind Landing Performance

This DTO of opportunity was not performed during landing due to crosswind conditions.

VEHICLE PERFORMANCE

NATURAL ENVIRONMENTS AND FINAL INSPECTION

Natural Environments

Based on measurements at the 60-ft level of Camera Site 6, the T-0 (instantaneous) surface conditions were as follows:

- 1. Wind speed was 20 knots,
- 2. Wind direction was 347 deg,
- 3. Temperature was 73 °F,
- 4. Humidity was 75%, and
- 5. Ambient pressure was 29.95 in Hg as measured at Camera Site 3.

The I-loads were designed with the Launch (L) -3:35 hr Jimsphere balloon due to a wind change forecasted to occur after the L-4:50 hr Jimsphere. No exceedances of the November 90th percentile database limits were identified for the in-plane or out-of-plane components based on the L-2:20-hr Day-of-Launch I-Load Update (DOLILU) assessment profile. Likewise, there were no wind-shear exceedances. The maximum measured wind velocity was 77.8 ft/sec at 38,000 ft and 322 deg. There were no violations of the in-plane or out-of-plane wind-change redlines from the L-3:35 hr DOLILU I-Load design wind profile to the final assessments based on the L-1:25 hr high-resolution balloon and the 1906 UTC 50 MHz Doppler Radar Wind Profiler (DRWP). The wind change exceeded the boundary over 2400 ft. by less than 1 ft/sec. However, this is not a violation as the exceedance was less than 7500 ft.

The L-1:08 hr Jimsphere balloon was used to clear the roll-maneuver region and was validated with the 1816 UTC False Cape 915 MHz profiler. The maximum measured wind velocity in the roll maneuver region was 20.2 ft/sec at 2200 ft and 9 deg.

Final Inspection

The Final Inspection Team (FIT) observed moderate to heavy condensation over the entire ET. Surface temperatures ranged from 53 to 64 °F. There were no observations noted on the ET TPS acreage, Intertank, or Ice/Frost Ramps. The Liquid Oxygen (LO₂) feed-line brackets were clean, with typical ice/frost formations observed at the bracket-base-to- tank-fitting interface. The bracket at Xt 1871 exhibited an acceptable crack on the inboard strut. Typical ice/frost was noted on the aft interface hardware. Three cracks that were typical with no offset were observed on the vertical strut cable tray -Y side. All observations were acceptable per NSTS documentation.

REUSABLE SOLID ROCKET BOOSTERS

The STS-129 Reusable Solid Rocket Booster (RSRB) identification was BI-140 and the RSRB performed satisfactorily throughout the first stage of the flight. No RSRB-related Interim Problem Reports (IPRs) occurred during the countdown (beginning with the commencement of tanking) and launch. No RSRB Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specifications Document (OMRSD) violations occurred. There was no indication of hold-down stud hang-up based on preliminary analysis.

Both RSRBs were successfully separated from the ET and reports from the recovery area indicate that the deceleration subsystem performed as designed. Recovery ships returned the RSRB's to KSC, and were in good condition.

The inspection observations after the return of the RSRB's to Kennedy Space Center (KSC) were as follows:

- 1. The forward Booster Separation Motors (BSMs) appeared to have functioned nominally, and the frustums had heavy sooting from the BSMs.
- 2. The tilt TVC actuator bracket on the right-hand thruster broke loose from the compliance ring at splash down.
- 3. The left-hand aft skirt had no debonded areas; however, suspect impacts were noted between approximately the 330- and 60-deg area of the booster.

REUSABLE SOLID ROCKET MOTORS

The STS-129 Reusable Solid Rocket Motor (RSRM) set performed within established and predicted nominal limits. No RSRM LCC or 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

Comment [L1]: This does not sound right. Something is missing equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly. Liquid level and Engine Cut-off (ECO) sensors performed as designed.

ET separation was nominal. Since Main Engine Cut-Off (MECO) occurred as expected, entry and breakup was at 36.434 deg South and 158..531 deg West, which was 1.1 nmi uprange of the planned impact location..

When the External Tank (ET) Umbilical Camera Flash Module was opened post-flight, charring was found on the leads on one of the thermostats and the thermostat was shorted as a result (IFA STS-129-V-06). The thermostat controls the heaters in the unit. Investigation showed that the leads of the thermostats were not covered by heat-shrink tubing, prior to applying epoxy to the housing. The thermostat lead wore through the epoxy and shorted to the housing.

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, all LCCs were met, and thrust build up was nominal. Flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown. The High Pressure Oxidizer Turbo Pump (HPOTP) and High Pressure Fuel Turbo Pump (HPFTP) temperatures remained well within specifications throughout engine operation. The commanded Max Q throttle down was a single-step throttle bucket to 72% Rated Power Level (RPL) and Adaptive Guidance Throttle (AGT) was not engaged. Propellant dump operations data appeared normal

Initial review of Advanced Health Monitoring System (AHMS) vibration measurements indicates nominal performance. No Failure Identifiers (FIDs) were reported to the Vehicle Data Table (VDT) from start preparation through propellant dump on all engines. All accelerometer measurements appeared healthy. Detailed vibration data review will occur after recovery of the on-board Modular Auxiliary Data System (MADS) recorder.

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

The Main Propulsion System (MPS) performed nominally throughout the STS-129 mission. No MPS Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specifications Document (OMRSD) violations occurred. No IFAs were identified during the review and analysis of the data.

During the launch countdown while initiating the External Tank/Intertank (ET/IT) purge, the ET/IT venturi inlet pressure remained at 40 psig and should have been greater than 2200 psig. Based on several downstream measurements, this was a confirmed instrumentation problem with the transducer.

The Liquid Hydrogen (LH₂) leak detectors (LD's) 28 and 32 momentarily saw a peak of 7000 ppm at the LH₂ T-0 umbilical cavity during LH₂ replenish. The LCC limit was 40,000 ppm. The Hydrogen Umbilical Mass Spectrometer (HUMS) data corroborated the initial readings. The hazardous gas concentrations were monitored throughout the remainder of the countdown and were acceptable.

The maximum hydrogen concentration level in the Orbiter aft compartment, with the normally elevated system backpressure used for fastfill, was 163.9 ppm (System A was used to determine the maximum concentration). This compares favorably with previous data for this vehicle.

All Liquid Oxygen (LO_2) and LH_2 fill and drain valves performed nominally. The LO_2 and LH_2 Engine Cutoff (ECO) sensors passed all pre-flight checkouts and operated nominally throughout ascent.

The LH_2 pre-pressurization cycle count was 8 cycles; 14 cycles violates 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. The Gaseous Hydrogen (GH_2) system in-flight performance was nominal. Flow control valves cycles were 7 for FCV no. 1, 8 for FCV no. 2, and 5 for FCV no. 3.

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

Hazardous Gas Concentrations

The hazardous gas concentrations at launch are shown in the following table.

HAZARD GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	11830	6800
Hydrogen	170	17
Oxygen	11	10
LD54/55	0	0

Purge, Vent, and Drain System

The Purge, Vent and Drain (PV&D) system performed nominally throughout the mission. Purge flow rates and temperatures and hazardous gas detection system readings were nominal.

During loading an intermittent, cyclical H_2 leak was detected in the LH₂ T-0 cavity via leak detectors 28 and 32. The value went between baseline and a maximum of approximately 7000 ppm as reported by the Hydrogen Umbilical Mass Spectrometer (HUMS). The leak detectors reported 5400 ppm. As a result, inspection and troubleshooting was performed on the Mobile Launch Platform (MLP) hardware post-launch.

The post-landing purge was initiated within approximately 20 min, which was well within the upper aft safety assessments. The final purge was initiated approximately 55 min after touchdown, and this exceeded the 45-min limit. A Data Trend Notice (DTN) was written for this condition KSC Engineering.

Gas Sample Analysis

The redesigned gas sampler system performed nominally and successfully captured all six samples. All measured pressures were within the range of acceptable pressures. A summary of bottle pressure and gas concentration for STS-129 is given in the following table.

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	Right Hand 1	3.14	0.39	3.00	0.03
2	Left Hand 1	1.51	0.37	2.23	0.02
3	Right Hand 2	1.30	0.53	3.35	0.02
4	Left Hand 2	0.79	0.74	3.85	0.07
5	Left Hand 3	0.18	1.33	1.97	0.11
6	Right Hand 3	0.06	1.72	0.78	0.29

SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rate for STS-129, the 31st flight of OV-104, was 1,400 SCIM. The maximum allowable firing leak rate on ascent is 57,000 SCIM. A firing leak rate less than 57,000 SCIM ensures the Orbiter Aft compartment environment did not exceed the Lower Flammability Limit (LFL) for Hydrogen (H₂) during ascent. The actual LFL is a function of the trajectory and will vary slightly from flight to flight. The 57,000 SCIM limit was chosen based on a standardized trajectory and conservatively envelopes the majority of trajectories flown. 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	Right Hand 1	1,400
2	Left Hand 1	520
3	Right Hand 2	480
4	Left Hand 2	1,180
5	Left Hand 3	515
6	Right Hand 3	500

The measured sample bottle pressures indicate the redesigned Orbiter aft fuselage gas sampler system successfully collected all six samples. Hydrogen concentrations were well below the flammability limit in each bottle. The highest estimated leak rate was 1,400 SCIM from right hand bottle no. 1. Concentrations in the remaining five bottles showed a fairly consistent leak rate. The oxygen concentrations were nominal and below the flammability limit. The highest concentration was 3.85% in left hand bottle no. 2. Argon indicates air as the major source of the oxygen in all six bottles and not Orbiter system leakage. The highest helium concentration was 1.72% in right hand bottle no. 3. Due to the low pressure at the time the last bottle acquires its sample and the lack of a diluting atmosphere, the last bottle typically has the most variation in helium concentration.

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

S/N	Posi- tion	Actual press- ure, torr	Ar, %	Air from Ar, %	He, %	CO, %	CH₄, %	CO _{2,} %	O₂ from air, %	O₂ found, %	H₂, %	H ₂ pyro corrected , %
1142 FLT-1	RH1	162.1	0.17	14.20	0.39	<0.01	<0.01	0.01	2.97	3.00.	0.03	0.03
1139 FLT-1	LH1	78.1	0.09	9.96	0.37	<0.01	0.05	<0.01	2.09	2.23	0.02	0.02
1143 FLT-1	RH2	67.1	0.14	15.20	0.53	<0.01	0.050	0.01	3.19	3.35	0.02	0.02
1140 FLT-1	LH2	41	0.16	17.45	0.74	0.12	0.09	0.01	3.66	3.85	0.13	0.07

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS¹

S/N	Posi- tion	Actual press- ure, torr	Ar, %	Air from Ar, %	He, %	CO, %	CH₄, %	CO _{2,} %	O₂ from air, %	O₂ found, %	H _{2,} %	H ₂ pyro Corrected , %
1141 FLT-1	LH3	9.3	0.09	9.31	1.33	<0.01	<0.01	0.01	1.96	1.97	0.11	0.11
1144 FLT-1	RH3	3.2	0.06	6.85	1.72	0.01	<0.01	0.01	1.44	0.78	0.29	0.29

AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS (Concluded)¹

Note 1: All values are given in percent by volume and the balance in nitrogen

Reaction Control System

The Reaction Control System (RCS) performed satisfactorily throughout the STS-129 mission. No In-Flight Anomalies (IFA's) were identified during the review and analysis of the flight data.

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

Forward RCS Left RCS **Right RCS** Parameter Oxidizer Fuel Oxidizer Fuel Oxidizer Fuel Target, % 82.67 81.53 100.48 100.76 100.48 100.76 Target, lb 1343 832 1523 962 1523 962 Calculated/ 84.71 81.78 100.50 100.66 100.48 100.59 Advertized 1370.6 961.1 1523.0 834.1 1523.3 962.0 PASS WHI^a 4.3907 4.2927 4.4395 4.2756 4.3793 4.2496 BFS WHI[♭] 4.2756 4.3495 4.3793 4.3596 4.3907 4.2927

RCS PROPELLANT LOADING

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 following table.

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1D	4.0	53	28	-1
F2D	4.5	59	23	-1
F4D	4.9	63	20	-2
F3L	7.2	95	14	0
F3F	7.4	98	14	0

TYVEK COVER RELEASE TIMES, VELOCITIES AND ALPHA/BETA ANGLES (Concluded)

Cover	MET (sec)	Velocity (mph)	Alpha (deg)	Beta (deg)
F1F	7.4	98	14	0
F1U	7.9	106	15	0
F2F	8.0	108	15	0
F3U	8.2	110	14	0
F3D	8.2	110	14	0
F2R	8.2	111	14	0
F2U	8.5	115	13	0
F1L	8.7	118	12	0
F4R	8.7	118	12	0

The RCS window-protect firing of the F1U, F2U and F3U thrusters was initiated at 320/19:30:19 GMT [00/00:02:09 Mission Elapsed Time (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 RSRB Booster Separation Motors (BSM's) away from windows during SRB separation.

The ET Separation maneuver was performed at 320/19:36:06 GMT (00/00:08:45 MET) and was a 6.0-sec, 10-thruster translation. ET photography +X was performed at 320/19:37:06 GMT (00/00:08:56 MET) and had a duration of 11.2 sec four thruster translation. The ET Photography Pitch maneuver was performed at 320/19:38:53 GMT (00/00:10:43 MET).

Maneuver/Firing	Engine/ System	Time of Ignition, GMT	∆V, ft/sec	Duration, sec
RCS Window Protect	RCS	320/19:30:19	N/A	2.08
ET Separation	RCS	320/19:36:55	N/A	6
ET Photo +X	RCS	320/19:37:06	N/A	11.2
ET Photo Pitch	RCS	320/19:38:53	N/A	N/A
NC3	RCS	321/22:43:55.9	2.5	11.1
NCC	RCS	322/13:08:17	0.3	N/A
MC1	RCS	322/14:25:57	0.3	1.44
MC2	RCS	322/14:58:44	0.8	3.35
Out of Plane Null	RCS	Not required		
MC3	RCS	322/15:15:41	0.42	1.84
MC4	RCS	322/15:25:41.7	2.01	7.36
RPM	RCS	322/15:52:50	N/A	N/A
TORVA ^a	RCS	322/16:05:25	N/A	N/A
ISS Docking	RCS	322/17:06:00	N/A	N/A

RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	Engine/ System	Time of Ignition, GMT	∆V, ft/sec	Duration, sec
ISS Reboost	RCS	328/10:07:11	2.54	27 min
ISS Undocking	RCS	329/09:53:16	N/A	N/A
ISS Fly Around	RCS	329/10:17:48	N/A	N/A
Separation 1	RCS	329/11:04:29.4	N/A	6.16
Separation 2	RCS	329/11:32:30	N/A	6.48
RCS Hotfire	RCS	330/11:36:02	N/A	
Forward Reaction Control System Dump	RCS	331/13:54:40.9	N/A	30.24

RCS MANEUVERS AND FIRING DATA (Concluded)

Note: ^a TORVA - Twice Orbital Rate Vbar Approach

RCS RESIDUAL PROPELLANTS

Parameter	Mission C Calcu	Derations	PASS Model Calculation ^s		
	%	lb	%	lb	
Forward Oxidizer	5.8	78	5.0	67.9	
Forward Fuel	0.0	0	-0.1	-0.9	
Left Oxidizer	60.0	810	59.6	804.6	
Left Fuel	60.8	517	60.0	510.0	
Right Oxidizer	61.2	826	60.3	814.1	
Right Fuel	60.2	512	59.6	506.6	

Note:

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

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

RCS PROPELLANT CONSUMPTION

Parameter	Oxidizer, Ib	Fuel, Ib	Mixture ratio, Oxidizer/Fuel
Forward RCS	1075.7	696.0	1.55
Left RCS	552.2	345.6	1.60
Right RCS	541.8	348.4	1.56

Prior to docking, the F1F and F2F thrusters were deselected as planned. ISS capture was completed at 322/16:51:14 GMT (01/21:23:04 MET), and the Digital Autopilot (DAP) was moded to Free Drift. Primary thrusters F1L, F3L, F2R, F4R, F1U, F2U, and F3U were then deselected at 322/17:06:14 GMT (01/21:38:04 MET). The attitude control responsibilities between the ISS and the Orbiter are shown in the following table.

Control Responsibility	Event Time, GMT	Comments
	322/16:51:14	DAP FREE/D\RIF
	322/10.51.14	ISS Capture
Orbiter	322/16:51:19	DAP VERN
ISS	322/17:12:19	DAP FREE
Orbiter	322/17:12:27	DAP AUTO – TEA Maneuver
ISS	322/17:17:42	DAP FREE – Set Contraction
Orbiter	322/17:18:06	DAP VERN
ISS	322/17:18:06	DAP FREE
Orbiter	322/17:21:28	DAP AUTO
ISS	322/18:06:01	DAP FREE
Orbiter	328/09:38:58	DAP AUTO - Attitude control
		handover for Reboost
ISS	328/11:18:18	DAP FREE - Post Reboost
		Handover to ISS
Orbiter	329/08:40:35	DAP AUTO - Maneuver to
		Undocking Attitude
		(ALT DAP)
ISS	329/09:33:49	DAP FREE DRIFT – Logic
		Configuration
Orbiter	329/09:35:24	AUTO
ISS	329/09:50:09	FREE - Driver configuration
Orbiter	329/09:50:55	DAP B/ALT/No Low Z
	329/09:53:16	Undocking

CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

The ISS reboost session was started as planned at 328/10:07:11 GMT (07/14:39:01 MET) and lasted the scheduled 27 min. The reboost was performed in Right Orbital Maneuvering System (OMS) interconnect and the RCS performance was nominal. The reboost resulted in an average altitude increase of approximately 1 nmi. The reboost resulted in a final orbit of 180 by 189 nmi, and a ΔV of 2.54 ft/sec, which includes the reboost, attitude hold and associated attitude maneuvers performed after the reboost. The following table shows the thruster operations data for the reboost.

PRIMARY RCS THRUSTER FIRING DATA

Thruster Position	Number of Pulses	Seconds of firing	
F5L	6	1412.32	
F5R	3	1617.96	
L5D	19	888.44	
L5L	1	10.08	
R5D	16	894.0	
R5R	77	77.28	

The maneuver to the undocking attitude was initiated at 329/08:40:35 GMT (08/13:12:25 MET). As part of the undocking preparations, the forward thrusters were reselected at 329/09:11:28 GMT (08/13:43:18 MET), except for F1F and F2F thrusters. Undocking was initiated with a +Z pulse at 329/09:53:16 GMT

(08/14:25:06 MET). The ISS undocking was nominal. The F1F and F2F thrusters were reselected after the undocking was completed. The fly-around (full maneuver) was initiated at 329/10:17:48 GMT (08/14:49:38 MET), and was completed successfully. The Separation 1 maneuver was a 6.16 sec +X firing of L1A and R1A at 329/11:04:29.4 GMT (08/15:34:19.5 MET). Separation 2 was a 6.48-second -X maneuver of F2F and F3F performed at 329/11:32:30 GMT (08/16:04:20 MET).

The RCS hot-fire was initiated at 330/11:36:02 GMT and terminated at 330/11:42:06 GMT (09/16:11:21 MET). All 38 RCS thrusters were fired at least twice for at least 0.240 sec each. No fail-off or fail-leak problems were detected during the hot-fire.

The Forward RCS dump, which used four thrusters, was initiated at 331/13:54:40.9 GMT (10/19:34:41 MET) and lasted 30.24 sec. The dump was nominal and 16.8% (368.9 lb) of propellant was consumed.

The firing data for the vernier thrusters showed a total of 8410 thruster firings for a total firing time of 18,454.96 sec. The firing data for the primary thrusters showed a total of 3,363 firings for a total firing time of 918.32 sec.

Orbital Maneuvering System

The Orbital Maneuvering System (OMS) performed nominally throughout the mission and no IFA's were identified from the review and analysis of the data. There were no deviations from documented OMRSD or LCC violations. All pre-launch operations were nominal for launch. 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-129 mission is shown in the following table.

Vehicle/ equipment	Flight	Orbital Maneuvering Engine (OME)	Ancillary data
Left Pod (LP) 04	31 st	L-OME S/N 108	5 th rebuilt flight - 22 th flight
Right Pod (RP) 01	38 th	R-OME S/N 109	10 th rebuilt flight - 27 th flight

OMS CONFIGURATION

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

OMS MANEUVERS

Maneuver Configuration		Time of ignition,	Firing	∆V, ft/sec/
designation		GMT	time,	interconnec
			sec	t usage, %
Assist	Dual Engine	320/19:30:24.2	84.4	N/A
OMS-2	Dual Engine	320/20:06:25.2	63.7	96.9
OMS-3 (NC1)	Dual Engine	320/23:10:27.0	25.9	39.3
Assist	Dual Engine	320/19:30:24.2	84.4	N/A
OMS-2	Dual Engine	320/20:06:25.2	63.7	96.9
OMS-3 (NC1)	Dual Engine	320/23:10:27.0	25.9	39.3
OMS-4 (NC2)	Right Engine	321/11:38:09.0	10.8	8.0
OMS-5 (NH)	Dual Engine	322/11:50:07.1	89.6	139.0
OMS-6 (NC4)	Dual Engine	322/12:34:16.7	52.6	82.3
OMS-7 (TI)	Left Engine	322/14:05:57.3	11.6	8.7
OMS-8 (SEITE)	Dual Engine	330/09:29:14.2	9.9	17.7
OMS-9 (SIMPLEX)	Dual Engine	330/14:08:46.2	10.1	17.9
OMS-10 (Deorbit)	Dual Engine	331/13:37:10.1	166.8	308.6

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

INTERCONNECT USAGE, %/POUNDS

Parameter	Total, %	Total, pounds
Left OMS	3.791	490.97
Right OMS	4.048	524.25

The propellant usage data are presented in the following table.

PROPELLANT USAGE DATA

Baramatara	Left OM	S pod	Right OMS pod	
Farameters	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, Ibm	7051	4254	7051	4254
Residual, Ibm (aft gage)	493	288	532	374
Residual, Ibm (burn time integration)	644	350	642	290
Residual, Ibm (SODB flow rate)	326	211	276	139

Auxiliary Power Unit System

The Auxiliary Power Unit (APU) system performance was nominal throughout the STS-129 mission.

APU RUN TIMES

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
1 (409)	00:19:10	00:03:42	01:04:32	01:27:24
2 (410)	00:19:16	00:00:00	01:32:12	01:51:28
3 (204)	00:19:26	00:00:00	01:04:43	01:24:09

APU FUEL CONSUMPTION

APU (S/N)	Ascent, Ib	FCS Checkout, Ib	Entry, Ib	Total, Ib
1 (409)	48	12	116	176
2 (410)	51	0	173	224
3 (204)	50	0	131	181

Prior to launch at 320/18:29:03 GMT, a Table Maintenance Block Update (TMBU) was processed to change the APU Fuel Pump Drain Line Pressure 1 Fault Detection and Annunciation (FDA) limit from 25 psia to 40 psia for all three APU systems. This limit is a class 3 Systems Management (SM) alarm in the Backup Flight System) (BFS) (only. Due to several nuisance alarms received by the crew during entry on STS-125, the Problem Resolution Team (PRT) has agreed to perform this TMBU prior to launch on the remaining missions to avoid nuisance alarms and make the FDA limit more meaningful to the current drain system configuration. The 40-psia value corresponds with the minimum burst disc rupture pressure, for the case where a relief valve failure results in vacuum on the outlet side of the burst disc.

During the mission, the APU 1 Gas Generator (GG) injector cooling water tank A heater circuit, did not operate (IFA STS-129-V-10). While the A heater circuit was selected, the water tank temperature slowly decayed and reached a minimum temperature of 46.26 °F. There were no mission or crew impacts associated with the noted anomaly. Analysis showed that there was no threat of water freezing, even if no water tank heater operation was seen during the entire mission. A review of data from previous flights of this vehicle (OV-104) that were between STS-115 and STS-125 showed that this heater circuit may have failed during STS-125. On the previous flights reviewed, excluding STS-125, the water tank heater consistently cycled on at approximately 55 °F while on the 'A' circuit. During STS-125, this heater cycled twice at 55 °F, then the water tank temperature dropped to 52 °F when the nominal heater reconfiguration to the 'B' circuit was successfully performed. At that time, no consideration of a potential 'A' circuit failure was made as it was not noted that the last heater cycle occurred after the reconfiguring to the B-heater circuit.

Hydraulics/Water Spray Boiler System

The Hydraulic/Water Spray Boiler (HYD/WSB) system performance was nominal during all phases of the mission. No IFA's were identified from the review and analysis of the flight data.

The Flight Control System (FCS) checkout was performed with APU/HYD System 1. The HYD/WSB system performance was nominal during the FCS checkout and all parameters were within their expected ranges.

The configuration of all elevon actuator switching valves and the Rudder Speed Brake (RSB) Power Drive Unit (PDU) switching valve were verified to be in the proper positions. Priority valve cracking time was 0.33 sec (specification is less than or equal to 1 sec). The HYD System 1 bootstrap accumulator was 2352 psia prior to APU 1 start and re-seat pressure was 2832 psia (specification is greater than 2675 psia).

HYD systems 1, 2 and 3 priority-valve crack times at APU activation for entry and reseat pressures at APU shutdown were nominal. The priority valve crack time requirement is less than 1 sec and the re-seat pressure requirement is a minimum of 2675 psia. The following table shows the priority valve crack times and reseats pressures.

Priority Valve	Crack Time (< 1 sec)	Reseat Pressure (≥ 2675 psia)
System 1	0.200	2832
System 2	0.180	2736
System 3	0.283	2784

The WSB PGME/H₂O usage during entry is shown in the following table.

WATER SPRAY BOILER TEMPERATURES AND PGME/H₂O USAGE

WSB System	Start Temperature, ⁰F	Steady-State Temperature, ⁰F	PGME/H2O Usage, Ib	
1	259	253	20.6	
2	269	249	42.0	
3	259	253	33.6	

Power Reactant Storage and Distribution System

The OV-104 Power Reactant Storage and Distribution (PRSD) system performance was nominal during STS-129, and no IFA's were identified from the review and analysis of the data. The PRSD system supplied the fuel cells with 2520 lb_m of Oxygen (O₂) and 317 lb_m of Hydrogen (H₂) for the production of 3669 kWh of electrical energy. The average power level for the 259.28-hour mission was 14.2 kW. The PRSD also

provided 210 Ib_m of O_2 to the Orbiter Environmental Control and Life Support System (ECLSS).

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

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, Ib _m
Loaded	101.8	100.9	100.9	101.8	101.8	3961
Launch	100.5	100.1	100.1	100.5	100.5	3918
Landing	40.5	38.3	58.0	10.3	5.0	1188
Hydrogen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, Ib _m
Loaded	102.3	101.5	102.3	103.7	102.8	471.6
Launch	99.3	97.9	99.3	100.6	99.7	457.1
Landing	51.9	54.2	42.2	2.0	1.5	139.7

PRSD TANK QUANTITIES

The Orbiter landed with 1188 lb_m of O₂ and 139.7 lb_m of H₂ remaining in the PRSD system. No oxygen from the Shuttle PRSD was transferred to the ISS. With the reactants remaining at touchdown, a 89-hr mission extension was possible at the 14.2-kW mission-extension average-power-level. A 99-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 12.68 kW.

The reboost maneuver at 328:09:24 GMT (07/13:56 MET) caused Oxygen Tanks 1, 2, 3, and 4 to de-stratify and the associated pressure drop was observed. The oxygen tank 2 pressure was recovered using tank heaters. De-stratification occurs following tank heater operation, a period of no-heater operation with low acceleration, and then acceleration from a maneuver. The tank quantities were in the range where greater pressure drops were observed. This condition is in-family with previous ISS missions.

Fuel Cell System

Fuel Cells

The overall performance of the OV-104 fuel cell system was nominal for STS-129. No IFA's were identified from the review and analysis of the data. The Station-To-Shuttle Power Transfer System (SSPTS) hardware is not on the OV-104 vehicle.

The average electrical power level and load was 14.2 kW and 461 Amperes (A). The fuel cells produced 2838 lb_m of potable water and 3669 kWh of electrical energy from 2520 lb_m of oxygen and 317 lb_m of hydrogen.

Fuel cell operating times, which is the time accumulated on each fuel cell during the pre-launch, on-orbit, and postlanding, were 288:16:37 for fuel cell 1, 287:40:24 for fuel

cell 2, and 286:50:08 for fuel cell 3. The end-of-mission accumulated operating times for these fuel cells are 1517, 1063, 1757 hr, respectively.

The actual fuel cell voltages (200 A load) at the end of the mission were as predicted for fuel cell 1, 0.15 Vdc above predicted for fuel cell 2, and 0.15 Vdc above predicted for fuel cell 3. The voltage margins above the minimum performance curves at 200 A at the end of the mission were 0.90 V above minimum for fuel cell 1, 1.06 V above minimum for fuel cell 2, and 0.90 V above minimum for fuel cell 3.

The prelaunch baseline Cell Performance Monitor (CPM) values for fuel cell 1 were 2, 18, and 14 mV, for fuel cell 2 were 6, 2, and 62 mV, and for fuel cell 3 were 18, 12, and 54 mV. They were established during prelaunch operations approximately 3 hr after the completion of the fuel cell calibration requirement.

The Fuel Cells 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 321:20:43:30 GMT (01/01:15:20 MET); there were no outliers. During the on-orbit FCMS data take, Fuel Cell 2 exhibited "Pin Sharing" on cells 81/82.

During the STS-129 pre-launch activity, the fuel cell 2 H₂ Pump Motor Condition (PMC), measurement indicated noise with no observed bus activity. Kennedy Space Center (KSC) provided rationale for launch acceptance and documented the condition. About 2 hr prior to launch, the PMC noise decreased with corresponding changes in the Alternating Current (AC) 2 bus current, and the fuel cell was approved for launch. Fuel cell 2, H₂ PMC on-orbit measurements were in family with expected indications. Post-flight troubleshooting was performed in the Orbiter Processing Facility (OPF) prior to fuel cell shut-down. AC bus 2 circuit breakers and lighting adjustment dimmers were systematically changed while observing fuel cell 2 H₂ PMC and high-rate bus data. To an extent the condition was re-created; the cause was attributed to AC 2 lighting dimmer adjustments and or circuit breakers opening/closing.

Electrical Power Distribution and Control System

The Electrical Power Distribution and Control (EPDC) system performed nominally during all mission phases of STS-129. The data review and analysis of all available EPDC parameters was completed and no anomalies were identified.

The fuel cell 2 Hydrogen (H₂) Pump Motor Condition (PMC) sensor became erratic during the pre-launch operations. The measurement output ranged from 0.52 to 0.6 Amperes (A) without a corresponding change in AC Bus, and the data spikes were approximately 1 sec in duration. During post flight troubleshooting on the H₂ pump motor, the ground crew was able to induce a very similar noise signature via lighting adjustments. As a result, the H₂ motor and its motor status circuitry were not the cause of the anomaly. The noise is most likely being induced on the bus from the lighting dimmer circuitry similar to what was observed on STS-125.

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 8 min 46 sec, and the avionics hardware was powered for 5 min 38 sec. The system was ready for rendezvous and docking with the ISS.

The application of power for the docking activities was initiated at 322/16:19:17 GMT (01/20:51:07 MET), and the ODS was powered for 58 min 43 sec with power to the avionics hardware for 45 min 28 sec. The initial contact and capture of the ISS occurred at 322/16:51:16 GMT (01/21:23:06 MET). The initial damping was 2 min 45 sec and performance of the "Disable and Release Dampers" procedure was necessary to ensure that any stuck dampers were disengaged.

In preparation for undocking, the ODS was activated at 329/09:26:03 GMT (08/13:57:53 MET). The undocking and separation from the ISS was completed satisfactorily at 329/09:52:06 GMT (08/14:23:52 MET). The ODS was powered for 46 min 41 sec with power to the avionics hardware for 30 min 27 sec for the undocking of the Orbiter.

Life Support Systems

Atmospheric Revitalization and Pressure Control System

The Atmospheric Revitalization and Pressure Control Systems (ARPCS) performed nominally throughout the mission. After hatch closure prior to undocking, the PCS was configured to system 1 and a good checkout was observed in the post-undocking time frame. Following checkout of system 1, the PCS was configured to system 2, which also demonstrated a good checkout in the post-undocking time frame.

Throughout the mission, system 2 Nitrogen (N₂) flow meter exhibited erratic spikes. This is a known condition documented under future trending. The number of spikes observed during this mission (STS-129) was more than the number of spikes observed for the previous missions, STS-122 and STS-125. The increased number of spikes did not have any impact on the mission performance. The master alarm and backup Caution and Warning (C&W) for N₂ systems 1 and 2 will continue to be inhibited to avoid nuisance alarms for missions with this N₂/O₂ panel.

Prior to docking with the ISS, there was one O_2 repressurization performed using direct O_2 flow into the cabin. No Orbiter-to-ISS tank-to-tank O_2 transfers occurred during this mission.

An Orbiter-to-ISS tank-to-tank N_2 transfer was performed, and the final offload to the ISS was approximately 11 lb. Three Orbiter/ISS stack N_2 repressurizations were

performed using the Orbiter PCS. Two N₂ stack repressurizations were performed by opening the payload N₂ valves with restrictors in line that limit the flow to 7 lb/hr for better cabin air mixing. The final N₂ stack repressurization was performed using the 14.7-psi cabin regulator. One O₂ repress was performed through ISS using shuttle O₂ during docked operations.

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

Airlock System

The Airlock Systems performed nominally throughout the mission. All of the scheduled in-flight checkout requirements were satisfied.

Supply and Waste Water System

The Supply and Waste Water System (SWWS) performed nominally throughout the mission and all of the scheduled in-flight checkout requirements were satisfied. The supply water was managed through the use of the Flash Evaporator System (FES), water transfer to the ISS and the dump nozzle.

The Waste Management system performed one successful dump, as a Simultaneous dump, at a nominal average dump rate of 1.7% /min (2.9 lb/min) in the pre-docking period. However, the waste water dumping capability was lost during the second dump performed after docking from the ISS (IFA STS-129-V-05). Approximately 42.4 lb_m was dumped before the dump degraded to an off-nominal rate and the dump valve was closed. A second dump attempt was made after re-heating the nozzle and the dump rate was effectively 0%. The dump nozzle was inspected using the Remote Manipulator System (RMS), and no indication of ice build-up was present at the nozzle surface. After the Waste Water dump anomaly, a nominal condensate Contingency Water Container (CWC) dump was performed by connecting to the cross-tie quick-disconnect which is downstream of the urine filter. This configuration cleared the dump nozzle from the suspect list. A nominal dump from the waste tank was again attempted with no success, and the high capacity urine solids filter became the prime suspect causing the blockage The waste-water dump-line temperature was maintained between 55 °F and 75 °F throughout the mission.

The supply water dump line temperature was maintained between 73 °F and 112 °F throughout the mission. Early in the mission, the supply water dump line cycled between the two thermostats (control and over-temperature). The over-temperature thermostat was controlling. This condition also occurred on STS-125.

A total of fourteen CWCs was filled with supply water and transferred to the ISS, for a total of 1330.1 lb_m. Three PWRs of iodinated water for a total 59.0 lb_m were filled and transferred to the ISS.

Two CWCs were used to collect condensate. The Orbiter condensate CWC was used to collect approximately 43 lb_m of condensate and the ISS condensate CWC was used on the Orbiter to collect approximately 70 lb_m of condensate. Both CWCs were transferred to the ISS for processing. An Orbiter CWC was used to collect 50 lb_m of condensate after the waste-water-dump anomaly.

The four 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 surface defect on the collector bar that causes an intermittent break in potentiometer continuity.

The vacuum vent-line temperature was maintained between 75°F and 52 °F. The thermostat control the heater range is 55 ± 5 to 75 ± 5 °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, and the smoke detection A and B sensor circuits passed.

Use of the Fire Suppression system was not required.

Active Thermal Control System

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

The crew compartment Partial Pressure Carbon Dioxide (PPCO₂) was managed to levels below 5.0 mmHg for a majority of the mission. The PPCO₂ peaked at 5.76 mmHg on FD 8.

For the Air Revitalization Subsystem (ARS) which includes the water loops, no IFAs were observed. During the docked phase of the mission, each of the three instances of false dp/dt rapid depressurization alarms on the International Space Station (ISS) were followed by ISS false-fire alarms. These occurred at the following times:

- 1. 324/01:45 GMT (03/06:17 MET);
- 2. 325/02:56 GMT (04/07:28 MET).
- 3. 328/12:03 GMT (07/16:35 MET);

The rapid dp/dt alarms caused the shutdown of the ISS Intermodular Ventilation (IMV), which then triggered the false-fire alarms. Shortly after each occurrence of the false alarms, the crew removed power from the Orbiter airlock booster-fan temporarily to mitigate booster-fan negative impacts that result from a deadheaded condition. The

source of the false rapid depressurization alarm was a rapid depressurization indication that was generated by a Caution & Warning panel in the Russian Science module. The three rapid depressurization signal originated from the same module

The Ammonia Boiler System (ABS) B primary controller was powered 3 min after the completion of the rollout. Continued ABS operation on system B was for 42 min, until the start of ground-cooling activation. System A activation was not required because Ground Support Equipment (GSE) cooling was initiated.

The ABS tank A and B in-flight leak rate was calculated at approximately $0.02 \text{ lb}_m/\text{day}$ for tank A and $0.02 \text{ lb}_m/\text{day}$ for tank B with the leak rate limit being no-more-than $0.05 \text{ lb}_m/\text{day}$.

Flight Software

The Primary Avionics Software System (PASS) performed satisfactorily during the STS-129 mission.

The PASS moded successfully from Major Mode (MM)101 through MM106, and the Backup Flight System (BFS) maintained tracking during the ascent profile.

Data Processing System Hardware

The data review and analysis of Data Processing System (DPS) parameters have been completed, and the Integrated DPS subsystem performed nominally. There were no additional unexpected DPS hardware internal errors or Fault Summary Messages logged or annunciated during ascent, other than the ones described.

The pre-launch integrated DPS configuration consisted of four PASS G9 General Purpose Computers (GPCs) commanding all four strings and the BFS in OPS 0. Additionally, all MDMs, MMUs, EIUs, MECs, BFCs, ADCs, IDPs, & MDUs (except AFD1) were powered.

At T-20 minutes, the PASS Operations (OPS) 9 to OPS 1 transition occurred and was nominal. Subsequently, the BFS was moded from OPS 0 to OPS 1 and was observed to be tracking all four PASS strings.

During post-insertion, the GPCs were successfully configured to Single G2 (GPC 1), G2FD (GPC 2 and 3), SM2 (GPC 4), and BFS in sleep mode (GPC 5) to support On-Orbit DPS operations.

The GPCs were configured to support Rendezvous and Docking operations. All operations were nominal with no unexpected errors. Post-docking, the GPC set was again contracted to a Single G2 configuration with GPC 1 commanding all strings.

GPC 1 was transitioned to OPS 8 to support Flight Control System (FCS) checkout. After completion, GPC 1 was then transitioned back to OPS 2 to continue nominal onorbit operations. All OPS transitions were nominal and no unexpected errors were observed.

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

Multifunction Electronic Display System

The Multifunction Electronic Display System (MEDS) performed satisfactorily during the mission. During the postflight operations, a small ding (0.984-in. wide by 0.122 in. long in the glass was identified in the PLT Multifunction Display Unit (MDU) 1(IFA STS-129-V-07). A section of the polyester film surrounding the damaged area had also been removed by the impact. Based on the assessment, the glass fragment was not contained. The preflight inspection did not reveal any ding.

During the Crew Sleep Procedures, five violations of SODB Volume I, "MEDS Integrated Display Processor (IDP) Power-On and Power-Off Cycles" occurred. No negative performance resulted from these IDP short power cycles.

Displays and Controls System

The Displays & Controls (D&C) subsystems, including lighting, performed nominally during all phases of STS-129. One In-Flight Anomaly (IFA) was defined and it is discussed in the following paragraph.

During the Payload Bay (PLB) Floodlight powerup on FD 8, the current signature on the Main Bus C (MNC) Mid-Power Controller (MPC) 3 was less than expected for an illuminated floodlight (IFA STS-129-V-03). The failure was isolated to floodlight no. 4. The most probable cause of floodlight failure was a cracked bulb. PLB Floodlight failures due to cracked bulbs are a known failure mode and the most recent failure occurred during STS-125 (Forward Starboard Floodlight). Each PLB Floodlight is independently powered and a failure of one floodlight does not affect the operation of the remaining floodlights. Two remaining PLB Floodlights (Aft Port and Starboard) as well as the Forward Bulkhead Floodlight, and the hand-held spot lights can be used for illumination. The loss of this floodlight did not impact mission operations.

Flight Control System

The Flight Control System (FCS) performed nominally during the preflight, countdown, ascent, orbit, FCS checkout, deorbit preparations, entry, landing and post-landing operations.

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

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

The FCS hardware checkout in the OPS-8 mode performance 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.

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

Air Data Transducer Assembly

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

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 after the elevons are parked during the post-insertion period. All ADTA mode/status words were nominal during the elevon-park operations.

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.

Entry performance was nominal from de-orbit through wheels-stop. All 16 transducers tracked during the pre-probe deployment phase of entry. Air data probes were deployed at approximately Mach 5.0, and deployment timing was within specification at less than 15 sec. ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at about Mach 3.2. No ADTA dilemmas or Redundancy Management (RM) failures occurred during deployment through wheels-stop. Entry data were retrieved and reviewed, and no anomalies were observed.

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 three IMU's. Also, two adjustments of the IMU drift compensation values were made to two of the IMU's.

The Star Tracker (ST) performed nominally throughout the STS-129 mission. No IFAs were identified from the review and analysis of the data.

The –Y ST acquired a navigation-star 639 times during the mission, and the –Y ST also missed a navigation-star 159 times (19.9%) during the mission. Data evaluation showed that one star (no. 28) had 63.5% of the missed stars. Multiple conditions such as bright objects in the field-of-view, or vehicle attitudes, or docking orientation causes the missed stars, and this response in considered normal.

The –Z ST acquired a navigation-star 36 times during the mission and the –Z ST missed a navigation-star 51 times. Further analysis showed that 90.1% of the missed stars occurred during the docking operations. These misses are considered normal as the ST performed normally.

Global Positioning System Navigation

Overall, the Global Positioning System (GPS) operation during STS-129 was nominal. OV-104 is configured with the "1-String GPS" configuration. The GPS was powered at 320/14:25:17 GMT, approximately 5 hr 2 min prior to launch.

During the Entry phase of the mission, the GPS high Figure of Merit (FOM) period is usually encountered in the Plasma region and cleared well before GPS incorporation. The FOM stayed mostly at 1 with two brief jumps to 2 after GPS incorporation. No "Data Invalid" or FOM Chimneys occurred during the critical phase of Entry (below 140,000 ft altitude), where the GPS satellite geometry is less dynamic.

The GPS state vector was incorporated into both the PASS and BFS in MM304 after performance confirmation with high-speed C-band tracking. This occurred at approximately 150,000 ft altitude, and simultaneously with the call to incorporate

Tactical Air Command And Navigation System (TACAN). The effect was that the PASS and BFS navigation state vector residuals were reduced significantly, as expected.

Communications and Tracking System and Navigation Aids

The communications and tracking system and Navigation Aids (NAVAIDS) performed satisfactorily, and the S-Band 1 system was used for approximately 24 hr. No IFA's were identified from the review and analysis of the data.

Operational Instrumentation/Modular Auxiliary Data System

The Operational Instrumentation (OI) sensors and signal conditioners and the Modular Auxiliary Data System (MADS) performed satisfactorily throughout the mission. No IFA's were identified from the review and analysis of the data. The MADS Pulse Code Modulation (PCM) data from the Solid State Recorder were reviewed after the flight and no problems related to the MADS PCM unit were identified.

Based on telemetry data, the Master Measurement Unit (MMU) System performed nominally during all phases of STS-129 mission. All ascent and entry data from the MMU and recorder were reported satisfactory by the users.

The MADS PCM Built In Test Equipment (BITE) indicated fail at 320/19:54:54 GMT (00.00:26:44 MET) for 16 sec and then continuously from 320/19:55:38 GMT (00/00:27:28 MET). The MADS PCM BITE normally indicates fail when MADS PCM power is removed. However, the command to remove MADS PCM power was not sent until 320/19:58:33 GMT (00/00:30:23 MET). This was after the recorder stopped recording MADS data at 320/19:53:34 GMT (00/00:25:24 MET), and as a result, the MADS PCM ascent data was not affected.

The crew confirmed that on panel A6, the MADS PCM Record (RCD) MODE switch was in the Sample position. In this position, the PCM will power-on the equipment (including the recorder), wait 10 sec, record data for 10 sec, then wait 10 sec to power off the equipment. This sequence is repeated after a 10-min powered-off period. This intermittent sampling would explain why the system indicated a BITE since the system powers off for 10 min. The PCM BITE annunciation is considered an explained condition.

MADS PCM ascent data was recorded on the Solid State Recorder and dumped to the ground. No problems were identified on review of the data.

During entry, the MADS PCM was left powered on for an extended period of time after the Wideband /Aerodynamic Coefficient Identification Package (ACIP) Off command was sent. Operation of the PCM in the sample mode is clearly seen as the MADS PCM powered on and off for two distinct samples before the MADS PCM OFF command was sent.

Mechanical and Hatches System

All of the mechanical and hatches system components operations nominally and no IFAs were identified from the review and analysis of the data. One issue was raised and is discussed in the following paragraph.

During the air data probe deployment, the cockpit switch for the Left-Hand (LH) probe was momentarily moved past the "Deploy" position to the "Deploy/Heat" position, then was immediately moved back to the "Deploy" position. This caused a brief interruption in the motor drive on the LH probe while the switch was between positions. Motor run times were well within limits, and there was no other effect on probe deployment.

Landing and Deceleration System

The Landing System performance at KSC was nominal and no IFA's were identified from the review and analysis of the data and Orbiter hardware. This assessment includes all events from landing gear deployment, main gear touchdown, nose gear touchdown, and drag chute deployment and brake/deceleration through roll-out. It was the second flight of the nose landing gear tires. They were in good condition and performed nominally. The main landing gear tires appeared nominal. The tires had the appearance of tread reinforcement cord materials on areas of the tire's surface, mostly in the area of the spin-up patch. This is a known expected condition characteristic of the new tire design. Post-flight inspection of the drag chute hardware at the Kennedy Space Center (KSC) parachute refurbishment facility indicated that no signs of anomalous conditions for hardware performance exist. The landing parameters table provides a more detailed assessment of system performance.

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	3043.8	0.0	197.4	183.8	1.8	-
Drag Chute Deployment	3978.7	3.11	187.2	173.4		
Drag Chute Disreef	5400.9	8.37	162.9	149.7		
Nose Landing Gear Touchdown	5775.8	9.92	149.5	139.7		-4.4
Brakes On	7493.9	18.40	109.7	100.1		
Drag Chute Jettison	9051.8	30.71	Off-Scale Low	50.9		
Wheels Stop	9643.9	44.99	0.0	0.0		

LANDING PARAMETERS

LANDING PARAMETERS (Concluded)

Parameter		Data					
Brake Initiation Speed, kgs		100.1					
Brake On Time, sec		2	6.59				
Rollout Distance, ft		6	586				
Rollout Time, sec		4	4.99				
Runway Location, Surface and Dec	grees	KSC-33/Concrete					
Orbiter Weight at Landing, Ib		207200.2					
Parameter	Max Pre	kimum Brake essure, psia	Total Brake Energy, Mft/lb				
Left inboard		974.7	13.36				
Left outboard		903.5	11.36				
Right inboard		838.7	11.94				
Right outboard		838.7 12.17					

^aKnots equivalent air speed

Aerothermodynamics, Integrated Heating and Interfaces

Data indicate that the overall Orbiter Thermal Protection System (TPS) was normal. The lower structural temperature data indicated normal entry heating. The recorded structure temperatures are within the flight experience of OV-104. However, the sensor at location B3 (T_{max} = 158.7 °F) experienced the most temperature rise for the OV-104 vehicle ever recorded. From MADS surface thermocouples (T/C), the Boundary Layer Transition (BLT) was asymmetric. The left side of the vehicle experienced the BLT around Mach 12.8 and the right side of the vehicle experienced the BLT around Mach 8.4.

The quick look runway report and post-flight inspection pictures indicated that there were no protruding Ames gap fillers or protruding Arrowhead blanket sleeving identified. Tile damages at the forward window, chine, and left IB elevon areas looked the same as seen on orbit. The frayed gap filler sleeving on the RH OMS pod also looked the same as seen on orbit.

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

Maximum Maximum

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA

Thermal Sensor Location	Temperature, ºF	Temperature Rise, ºF		
Lower fuselage forward center (B1)	129.9	118.8		
Lower fuselage forward left-hand (B2)	169.3	176		
Lower fuselage forward mid left-hand (B3)	158.7	185.7**		
Lower fuselage mid center (B4)	156.1	160.3		
Lower fuselage mid aft center (B5)	174.5	173.6		

Thermal Sensor Location	Maximum Temperature, ⁰F	Maximum Temperature Rise, ºF
Lower fuselage aft center (B6)	193	166.6
Lower Left-wing center (LW)	106.4	143.5
Lower Right wing center (RW)	127.3	128.9
Port side FRCS forward (P1)	122	103.3
Port side fuselage forward center (P2)	77.9	97.3
Port side fuselage forward mid center (P3)	72.7	89.6
Port side fuselage mid aft center (P4)	52.1	74
Port side fuselage aft center (P5)	77.9	71.9
Starboard side FRCS Forward (S1)	161.4	106.7
Starboard side fuselage forward center (S2)	158.7	119.5
Starboard side fuselage forward mid center (S3)	127.3	85.5
Starboard side fuselage mid-aft center (S4)	88.2	66.9
Starboard side fuselage aft center (S5)	106.4	74.9
Left-hand OMS pod side forward (LP)	59.8*	53.8*
Right-hand OMS pod side forward (RP)	72.7	46.3
Lower body flap center	106.4*	82.6*
Right-hand OMS pod side forward	72.7	46.3
Left-hand OMS pod side forward	59.8*	53.8*
Right-hand PLBD forward	54.6*	101.8*
Left-hand PLBD forward	57.2*	114.5*
Right-hand PLBD aft	75.3	104.8
Left-hand PLBD aft	72.7	119.9
Right wing upper center	88.2*	95.0*
Left wing upper center	80.5*	125.1*
Forward RCS center	90.8	69.5
Forward Fuselage upper center	72.7	87

ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA (Concluded)

Notes

* Maximum temperature occurred 30 min after wheel stop.

**. Maximum temperature ever experienced on the OV-104 vehicle.

Thermal Control System

All passive TCS temperatures remained within acceptable limits and all thermal systems performed nominally except as noted in the following paragraphs. No IFA's were identified during the review and analysis of the data.

The APU injector-cooling-water tank heater A exhibited temperatures below its historical cycling range. The tank environment was warm enough that the mission was not impacted. The B heater performed as expected.

The APU 3 drain-line heater exhibited cycling in a lower range than expected. The heater also showed a wider-than-usual cycling range. This heater had a similar signature during the previous STS-125 flight, but the thermostat was repaired during the following flow.

The Main Landing Gear (MLG) port-to-starboard temperature/pressure gradient was historically one of the highest seen at landing. No issues on the tires or gear were noted during rollout.

Thermal Protection System and Post-Landing Assessment

Post-Landing Assessment

The final STS-129 debris-related tile damage numbers are shown in the following table.

Orbiter Surface	Impacts greater than 1 in.	Total impacts
Lower surface	8	58
Upper Surface/Window	2	10
Right OMS pod	3	14
Left OMS pod	1	7
Totals	14	89

SUMMARY OF IMPACT SITES FOR EACH ORBITER SURFACE

The total number of lower surface damage sites was the lowest since the return-toflight.

A post landing walk-down of the runway was performed. No off-nominal flight hardware was found, nor were any debris items.

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.

There was some thruster thermal barrier fraying on the +Y vernier thruster. A small part of the perimeter thermal barrier was lifted and pulled back aft of the -Y forward reaction control system thrusters.

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

The Orbiter nose cap appeared to be in nominal condition, as well as LH and RH RCC panels.

The SSME Dome Mounted Heat Shield (DMHS) blankets all appeared to be in excellent condition, with a very low amount of fraying. Base heat shield tiles appeared to have less than typical damage.

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

Window no. 4 appeared to have the same surface damage that was seen on orbit. Hazing appeared light on all the windows.

Tile and Blanket Flight Assessment

The TPS (Thermal Protection System) Debris Assessment Team (DAT) concluded their ascent imagery reviews. There were only four damage areas in the TPS documented by imagery, and the Leading Edge Subsystem (LESS) team did not have any requests for additional imagery. The TPS was cleared for entry at FD 4 Mission Management Team (MMT) meeting. The Focused Inspection (FI) was not required for STS-129.

On FD 11, the TPS DAT concluded their imagery reviews from the fly-around after undocking. No gross damages were identified.

Reinforced Carbon-Carbon Assessment

The SRMS OBSS surveys of the starboard wing Reinforced Carbon-Carbon (RCC), nose-cap RCC, and port-wing RCC were completed nominally. The maneuver for grappling the OBSS occurred at 321/12:12 GMT (00/16:44 MET), with the unberthing of the OBSS occurring at 321/12:19 GMT (00/16:51 MET). The Starboard RCC surveys began with the Flat Field Survey at 321/13:17 GMT (00/17:49 MET) and was completed at 321/15:08 GMT (00/19:40 MET). The Nose RCC surveys began at 321/15:24 GMT (00/19:56 MET) and was completed at 321/16:00 GMT (00/20:32 MET). The Port RCC survey began at 321/16:22 GMT (00/20:54 MET) and was completed at 321/18:12 GMT (00/22:44 MET). The OBSS was berthed and latched at 321/19:33 GMT (01/00:05 MET).

All Wing Leading Edge (WLE) Impact Detection System (IDS) ascent-summary data was successfully downlinked. Three indications, all on the Starboard (S) side, exceeded the 1 Grms reporting criteria. The largest magnitude observed was 2.46 Grms on panel L6. The WLE IDS on-orbit monitoring began at 321/14:00 GMT (00/18:32 MET) with Port and Starboard Group 2.

The RCC DAT concluded the assessment of the ascent imagery and no gross damages were identified.

The Wing Leading Edge Impact Detection System (WLEIDS) began monitoring at 329/08:30 GMT (08/13:02 MET) and ended at 329/20:00 GMT (08/23:32 MET). No

triggers were reported during this monitoring period, and it was the final WLEIDS onorbit monitoring period.

On FD 10 at 329/14:03 GMT (08/18:34 MET), the OBSS starboard survey was initiated with the maneuver to flat-field position in preparation for the late inspection. The OBSS was berthed at 3 hr 27 min later after the completion of the starboard, nose-cap and port surveys. The RCC DAT conducted their imagery reviews. No gross damages were identified.

On FD 11, the RCC DAT completed the review of all imagery from the late inspection and cleared the Orbiter for entry.

Windows

The window performed their function in an acceptable manner. The results of the final inspection were as follows.

- 1. Window 1 6 Defects and window scrapped [four High Velocity Impacts (HVIs) and two Low Velocity Impacts (LVI).
- 2. Window 2 Zero defects and no stress analysis was required.
- 3. Window 3 Two defects and the window is acceptable for flight (LVI impacts).
- 4. Window 4 Two defects and the window is acceptable for flight (HVI Impacts).
- 5. Window 5 Zero defects and no stress analysis was required.
- 6. Window 6 Three defects and the window was scrapped (HVI Impacts).
- 7. Window 7 Zero defects and no stress analysis was required.
- 8. Window 8 One defect and the window was scrapped (HVI Impact).
- 9. Window 11 Zero defects and no stress analysis was required.

Waste Collection System

The Waste Collection System performed satisfactorily and no IFAs were identified.

EXTRAVEHICULAR ACTIVITY

The three Extravehicular Activities (EVA's) were performed nominally on the International Space Station (ISS) and all planned activities plus numerous get-ahead tasks were completed during the three EVAs, which lasted a total of 18 hr 27 min.

FIRST EXTRAVEHICULAR ACTIVITY

The first EVA was performed on Flight Day (FD) 4 and all planned activities were completed during the 6 hr 37 min EVA.

During the EVA, a spare S-Band Antenna Sub-Assembly (SASA) was installed at Z1 and the J3 (heater power) and J4 (operational power) were connected, the Articulating Portable Foot Restraint (APFR) ingress-aids were installed onto APFRs 3 and 6, the Payload Orbital Replacement Unit (ORU) Accommodation (POA) and Japanese Experiment Module (JEM) Remote Manipulator System (RMS) End Effectors (EE) were lubricated, two Space-to-Ground Antenna (SGANT) cable bundles were installed on Z1 with a Y-jumper connection, the Node 1 Hand Rail (HR) 0111 was removed and an Ammonia HR Bracket was installed in its place, the Node 1 to Functional Cargo Block (FGB) Local Area Network (LAN) cable was wire-tied down parallel along HR 0141, the Node 1 Micrometeoroid/Orbital Debris (MM/OD) shield C2-02 was tied down with 3 long wire ties, and finally Starboard (S) 0 Truss connector P181 was mated to J181 using an adapter and covered with a booty. With additional time available, the crew was able to perform get-ahead tasks on this EVA. The Payload Attachment System (PAS) 3 (nadir/outboard) was deployed, and Airlock HR 0537 suspected sharp edge was photographed.

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 6 and all planned tasks were successfully completed during the 6 hr 8 min EVA.

The Automatic Identification System (AIS) and Amateur Radio on the International Space Station (ARISS) antennas were installed on Columbus, the Floating Potential Measuring Unit (FPMU) was relocated from Camera Port (CP) 2 S1 zenith/outboard) to CP6 (P1 zenith/inboard), the Payload Attachment System (PAS) 2 (zenith/inboard) and 4 (nadir/inboard) were deployed, and finally a Wireless video system External Transceiver Assembly (WETA) was installed at CP1 (S3 aft). With additional time available, the crew was able to perform get-ahead tasks on this EVA. The SGANT connections were cycled to correct a Global Positioning System (GPS) signal issue,

photographs were taken of the Node 2 nadir Common Berthing Mechanism (CBM) starboard/aft sealing surface, the Tool Stanchion from APFR 5 was relocated to APFR 2, APFR 5 was brought inside for the heat shield to be removed, a High Pressure Gas Tank (HPGT) guide post was installed on the Airlock, and two Enhanced Right Angle Drives (ERADs) were brought inside from the Shuttle Payload Bay Tool stowage Assembly (TSA).

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

THIRD EXTRAVEHICULAR ACTIVITY

The third EVA was performed on FD 8 and all planned tasks were successfully completed during the 5 hr 42 min EVA.

APFR 5 was brought back outside, the HPGT 5 was installed on the Airlock, the two MM/OD shields that were removed from the Airlock for the HPGT installation were tied down on the External Stowage Platform (ESP) 2 with two Long Duration Tie Down Tethers (LDTDT), two Materials on the ISS Experiment (MISSE) 7 Passive Experiment Containers (PEC) were installed and deployed on the Expedite the Processing of Experiments to the Space Station (ExPRESS) Logistics Carrier (ELC) 2, the S1 Truss Ammonia Tank Assembly (ATA) bolt 1 was fully released, a cheater bar was stowed in the starboard Z1 toolbox, booties were installed on the two Mobile Base System (MBS) jumpers, camera covers were installed on the Latching End Effector (LEE) A Capture Latch Assembly (CLA) and the MBS Mast Camera Light Pan-and-Tilt Assembly (CLPA), the P1/P3 and S1/S3 Ammonia jumpers were installed with valves open, and APFR 3 was relocated.

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

REMOTE MANIPULATOR SYSTEM AND ORBITER BOOM SENSOR SYSTEM

The Shuttle Remote Manipulator System (SRMS) performed nominally during the STS-129 mission, and no In-Flight Anomalies were identified during the review and analysis of the flight data.

The SRMS on-orbit Initialization began at 320/22:17 GMT [00/02:39 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 320/23:31 GMT (00/04:03 MET) and was completed 28 min later.

On FD 2, the SRMS grappled the Orbiter Boom Sensor System (OBSS) at 321/12:01 GMT (00/16:33 MET) and maneuvered the OBSS to the OBSS Hover Position 19 min later. The Starboard RCC Survey was completed at 321/14:57 GMT (00/19:29 MET). The Nose RCC Survey was completed at 321/16:01 GMT (00/20:33 MET). The Port RCC Survey was completed at 321/17:57 GMT (00/22:29 MET). The OBSS was berthed in the Starboard MPMs at 321/19:33 GMT (01/00:05 MET) and the SRMS grappled the Expedite the Processing of Experiments to Space Station (ExPRESS) Logistics Carrier (ELC) -1 at 01/00:27 MET.

On FD 3, Atlantis rendezvoused and docked with the ISS. The SRMS unberthed the ELC-1 at 322/19:47 GMT (02/00:19 MET) and maneuvered the ELC-1 to the planned Hover position. Following the maneuver to the Hover position, the SRMS maneuvered to the ELC-1 Handoff Position at 322/20:11 GMT (02/00:19 MET). After releasing the ELC-1, the SRMS maneuvered to the Singularity Avoidance Position 23 min later.

On FD 4, the SRMS remained in the Singularity Avoidance Position.

On FD 5, the SRMS maneuvered from the Singularity Avoidance Position to grapple the ELC-2 at 324/11:55 GMT (03/16:27 MET).

On FD 6, the SRMS unberthed the ELC-2 and moved the ELC-2 to the Hover Position at 325/11:34 GMT (04/16:06 MET). Following the maneuver to the Hover position, the SRMS maneuvered the ELC-2 to the Handoff Position 15 min later. After the ELC-2 handoff to the Space Station Remote Manipulator System (SSRMS), the SRMS was maneuvered to the ELC-2 Installation-Viewing position at 325/12:53 GMT (04/17:25 MET). After providing viewing support, the SRMS maneuvered to the Pre-Cradle Position at 325/14:33 GMT (04/19:05 MET).

On FDs 7 through 9, there were no SRMS operations.

On FD 10, after undocking from the ISS, the crew grappled the OBSS at 329/13:29 GMT (08/18:01 MET) and unberthed the OBSS to the Low-Hover position 9 min later. The Starboard RCC Survey began at 329/14:21 GMT (08/18:51 MET) and was completed 59 min later. The Nose Cap Survey began at 329/15:45 GMT (08/18:53 MET) and was completed 30 min later. A waste water dump nozzle inspection was performed just prior to the Port survey at 329/16:44 GMT (08/21:16 MET). The inspection required the pan/tilting of the Laser Dynamic Range Imager (LDRI) sensor to view the nozzle. The Port Survey began at 329/16:58 GMT (08/21:30 MET) and was completed 59 min later. The OBSS was maneuvered to the Low-Hover position at 329/18:14 GMT (08/22:46 MET) and the OBSS, the SRMS maneuvered to the Pre-Cradle position at 329/18:52 GMT (08/23:24 MET) and was cradled 25 min later.

On FD 11, there were no SRMS operations.

WING LEADING EDGE IMPACT DETECTION SYSTEM

ASCENT MONITORING

All requested ascent summary data and 22 half-second windows of raw data were received by 15:50MET with a significant delay caused by a combination of an poor RF and incorrect download command files. The Wing Leading Edge (WLE) analysts' completed the ascent analysis and issued its findings at L+17 hr.

All units triggered and began recording data on Main Engine Ignition within 0.19 sec of each other. The Mission Elapsed Time (MET) was set to 9.20 sec behind Data Elapsed Time (MET = DET - 9.20 sec) for both port and starboard wing units.

A total of three possible impact cases above 1.0 Grms were found on the starboard wing and reported during the flight. The damage likelihood for these indications ranged from less than 1/200 to 1/1000 (Risk Categories I to III). Post-flight analysis of the data found no additional indications above 1.0 Grms.

Automated scanning of the post-flight data acquired from 10 to 500 sec MET revealed a total of 37 possible ascent debris impacts on the wing leading edge (16 on the port and 21 on the starboard wing) ranging from 0.08 to 2.46 Grms.

All reportable ascent indications are listed in following table

Time	Times ^a Location Magr					Magnitude Criteria						Imj	pact ^a	. 7 0	
MET, hr	DET, hr	Wing	RCC	Unit- Channel	Max. Grms	Max. G	Transient	Non-Mission	Spectral	Shock	Damping	Multi-sensor	In-Flight	Post-Flight	Damage Likelihoo Category
98.7	107.9	S	6	1091-J3	2.5	13.8	+	+	+	+	+	+	Р	Р	1
105.3	114.5	S	9	1098-J2	1.9	10.7	+	+	+	+	+	+	Р	Р	III
125.4	134.6	S	12	1114-J3	1.1	3.0	+	0	+	+	+	+	Р	Р	I

SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 GRMS

^a Data analysis findings: P=Possible

^b Assessed from ascent data (I:<1000, II:1/1000-1/500, III:1/500-1/200, IV: 1/200-1/100, V:>1/100

ON-ORBIT MONITORING

MM/OD monitoring began at approximately L+18 hours. For this mission, the WLE IDS recorded 4 triggers, related to 3 events. Together, triggers 1 and 2 satisfied all impact criteria Review of post-flight data revealed no additional on-orbit indications. The following table shows the one Micro-Meteoroid Orbital Debris (MM/OD) impact.

	Time		Locati	Magni tude	Criteria							Imp	act ^a	
	GMT	Wing	RCC	Unit- Channel	Measured Peak, G	Tran-scient	Tran-scient Non Mission Spectral Shock Damping Multi- Sensor Trapped Wave					In-Flight	Post-Flight	
3	321/13:59:17	Р	17	1105-J2	1.50	+	+	+	+	+	+	+	Р	Р

SUSPECTED MM/OD IMPACTS

^a Data analysis findings: P = Possible

CONCLUSIONS

The Wing Leading Edge (WLE) Impact Detection System (IDS) performed well for ascent impact monitoring. During the mission, three ascent impact indications above the 1.0 Grms threshold were reported with damage likelihoods ranging from Category I (less than 1/1000) to III (1/500 to 1/200). Post-flight review of the data found zero additional ascent indications over 1.0 Grms.

One possible MM/OD indication was detected and reported during flight. The indication occurred prior to the early inspection of the port wing. Based on the ascent and on-orbit findings from all systems, including WLE IDS, the Orbiter Project Office (OPO) recommended not performing a focused WLE Reinforced Carbon-Carbon (RCC) inspection. The late mission OBSS survey visually inspected the WLE after Orbiter undocking and prior to entry. No critical damage was found.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government Furnished Equipment (GFE) and Flight Crew Equipment (FCE) operated in an acceptable manner. Six In-Flight Anomalies (IFA's) were identified and are discussed in the following paragraphs.

Following the first Extravehicular Activity (EVA) the EV1 crewmember reported that audio was lost in the left ear, and later the crewmember reported that moisture was in the Communications Cap Assembly (CCA) left-ear section. During the second EVA depressurization, the EV1 crewmember reported faint audio in the CCA during the communications check and did not hear the caution and warning tones when switched to battery power (IFA STS-129-V-02). Prior to the start of Airlock depressurization, the audio was nominal. Just prior to egress, the audio began to dropout and dropouts continued throughout the EVA. In addition, the EV1 crewmember was not able to hear expected EMU caution and warning tones. After the second EVA during the Water Recharge Cycle, and with the Communications activated, a comparison test was performed with other CCA headsets using the EV1 suit. It was determined that the receiver audio level in the prime CCA for EV1 was lower than nominal when compared with the other CCA headsets when installed in the same configuration.

When the crew attempted to configure the Wireless Video System (WVS) V10 to support wireless video operations, the crew reported that the WVS 1 V10 recorder was malfunctioning and destroying tapes (IFA STS-129-V-04). The crew changed the WVS 1 with the monitor 1 V10 recorder and the EVA proceeded as planned.

After the downlink of the Flight Day (FD) 2 survey video was complete, the Orbiter Communications Adapter (OCA) was configured to 48 Mbps downlink, but it did not work (IFA STS-129-S-01). The system was switched to 2 Mbps downlink, which operated successfully, but made the downlink of still images was very slow. On FD 5, the crew was provided troubleshooting steps to recover the 48 Mbps Orbiter Communications Adapter (OCA) output. The crew was able to recover this capability after replacing a cable. This 48 Mbps mode was not planned for use before the late inspection on FD 10.

When the ET umbilical Camera Flash Module was opened post-flight, charring was found on the leads of one of the thermostats that control the heaters in the unit (IFA STS-129 V-06). Investigation showed that the leads of the thermostats were not covered by heat-shrink tubing prior to epoxy being applied to the housing. The thermostat lead wore through the epoxy and shorted to the housing.

On Flight Day (FD) 1, the crew was unable to downlink the High-Definition (HD) video (IFA STS-129-V-11). Troubleshooting information was provided to the crew. The crew replaced the fire-wire cable and the High Definition Television (HDTV) and Taxi lights on

the Multi-Protocol Convertor (MPC).functioned properly. The HDTV downlink after the Orbiter Boom Sensor System (OBSS) operations was attempted and confirmed good. Post-flight testing has been completed. The 4-Pin Female Circuit Cable has intermittent video. There is no signal through the cable for approximately 30 sec and then video appears. This is the first occurrence of this problem. The cable will be downgraded and discarded.

The crew reported that there was no Digital Television (DTV) video on Monitor 2 (IFA STS-129-V-08). Post-flight testing of the cable determined it to be bad.

POST-LAUNCH PAD INSPECTION

Main Launch Platform (MLP) -2, Pad A Fixed Service Structure (FSS), and Pad A apron was conducted on November 16, 2009, from 1623 to 1900 Eastern Standard Time EST. The inspection proceeded relatively quickly while Safing Teams secured the Pad. The entire PAD, FSS and MLP were inspected, and the Solid Rocket Booster (SRB) throat plug material was the only flight hardware found.

The most substantial non-flight hardware issue noted was the Fondue Fyre liberation from the SRB flame trench. There was an approximate 8-ft. by 20-ft section liberated from the west wall and an approximate 5-ft by 8-ft section liberated from the east flame deflector.

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

SRB Hold-down Posts (HDPs) Inspection

HDP no. 1 – The EA934 poured sidewalls were nominal with acceptable minor pitting. The Phenolic shim was nominal with the east corner exhibiting erosion delamination. 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 were nominal with acceptable minor pitting. The southeast sidewall had 4 areas with greater than 1 in. of pitting, which was acceptable. The Phenolic shim was nominal. Both firing lines were missing. Approximately 2-ft of Range Safety System (RSS) cable remained past the HDP door. No galling or chatter marks were noted in the chamfer of the through-hole, and the stud was set down.

HDP no. 3 – This HDP showed nominal indications of erosion on the Room Temperature Vulcanizing (RTV) coating on the blast shield with proper closure. **HDP no. 4** – This HDP showed nominal indications of erosion on the RTV-coating on the 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** - EA934 poured sidewalls were nominal with minor pitting (acceptable*).

The south and east sidewall was approximately 90% delaminated which is an acceptable condition. Phenolic shim was nominal. Both firing lines were missing. No galling or chatter marks were noted in the chamfer of the thru hole, and stud was set down.

HDP no. 7 – This HDP showed nominal indications of erosion on the RTV-coating on the blast shield with proper closure.

HDP no. 8 – This HDP showed nominal indications of erosion on the RTV-coating on the 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 South (S) by 10 deg with no protective tape present. The O-ring was present.

The Right Hand (RH) probe was erect and slightly bent to the Southeast (SE) by 10 deg, with no protective tape present. The O-ring was present.

RSRB T-0 (Lift-Off) Ground Carrier Assemblies (GCAs) Inspection

The LH SRB T-0 GCAs appeared to be in nominal condition with proper demating.

- 1. Several connector housings had broken sidewalls.
- 2. The 3J1 and 4J1 pin and sockets were raised higher than nominal.
- 3. All four frangible bolt halves were present.

The RH SRB T-0 GCAs appeared to be in nominal condition with proper demating.

- 1. Several connector housings had broken sidewalls.
- 2. The 3J1 and 4J1 pin and sockets were raised higher than nominal.
- 3. All four frangible bolt halves were present.

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

Both TSMs appeared to be undamaged, and both bonnets appeared to have closed properly.

MLP Deck Inspection

- 1. MLP deck was in nominal condition.
- 2. Typical blast erosion was observed in and around the SRB flame holes.
- 3. The -Y Orbiter Work Platform (OWP) Access Platform had structural damage to a support member.

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

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

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

- 1. GH_2 vent line latched on the eighth tooth (of eight) on the latching mechanism.
- 2. The vent line had a South bias in positioning. The North gimbal strut was between the two ratchet pawls. The team has not seen this condition in the past. The GN_2 vent line had a nominal arresting cycle. The inspection of the GUCP left- and right-hand pivot assemblies indicated a nominal separation. The

flexible-hose cable restraints were tangled on the RH static lanyard pull-off bracket.

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

GOX Vent Arm (255-ft level) Inspection

- 1. The Gaseous Oxygen (GOX) vent arm and hood appeared undamaged.
- 2. The LH side flexible duct aluminized blanket was damaged.
- 3. The hood windows and purge ducts appeared to be in nominal condition and the latch mechanism locked properly.
- 4. The Northeast seal access door pip pin was not installed.

PAD Facility Inspection

- 1. Pad A appeared to be in very good condition and exceptionally clean.
- 2. Apparent impact marks were present under the MLP deck and were possibly from Fondue Fyre.

North SRB Flame Trench Inspection

- 1. The SRB flame trench experienced off-nominal erosion with Fondue Fyre.
- 2. The West Wall damage appeared to be 8-ft wide by 20-ft high.
- 3. The East flame deflector damage appeared to be 5-ft wide by 8-ft high.

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 East and West Pad Surface areas.
- 3. A plastic electrical cap and Operational Intercommunication System (OIS) connector cap was found on the pad surface.
- 4. Two pieces of rust-scale were found (6 sq in and 2 sq in) and 6-in. piece of wire was found on the East side of the pad surface.
- 5. Two pressure-regulator heads were found on the FSS Tower side of the West pad surface.
- 6. A pressure gage assembly was found on the pad surface near truck 1 at the RSS eye-wash station.
- 7. Two KC fittings and a knurled knob were found adjacent to the elevator tower on side 1.

- 8. A Do-Not-Operate tag was found on the 135-ft level.
 9. Three in² of rust scale, a wire or welding rod 6-in. were found on the 175-ft level.

PRELAUNCH AND LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS

The analysis of the photography from prelaunch, launch and on-orbit enabled the Orbiter vehicle to be cleared for entry and landing.

VEHICLE OBSERVATIONS

Multiple External Tank (ET) Thermal Protection System (TPS) foam losses were identified on the –Z Intertank. These are:

- 1. Multiple areas of foam loss at approximate XT-1050 in the +Y,-Z quadrant of the Intertank.
- 2. A divot was located in second valley of the +Y of –Z Aerovent.
- 3. A divot was identified at approximately 191 deg.
- 4. A divot was observed at approximately 154 deg.
- 5. A divot was observed at approximately 166 deg.
- 6. ET TPS foam loss was observed inboard of the LH₂ cable tray at Xt 1851 and the release time was indeterminate.
- A possible foam loss on the –Z sidewall of the adjacent stringer (S17-6) -Y of the ETCA. Portion of the loss was observed to liberate during the GH₂ vent arm retraction at 0.461 Mission Elapsed Time (MET).
- 8. Photography showed a ET Thermal Protection System (TPS) loss from the inboard starboard Bipod closeout that was released at 170.2 MET.
- 9. The photography showed a ET TPS loss from the LH₂ Ice Frost Ramp (IFR) extension at approximately Xt 1593 and it was released at 325 sec MET.
- 10. Photography showed two possible missing ET TPS divots from the upper portion of the LH₂ flange closeout at the -Y thrust panel between ribs R-18 and R-22. The time of the losses were observed at 384.7 sec MET.
- 11. Photography showed a probable missing piece of ET TPS at approximately Xt 1377 on the outboard side of the LO_2 feedline and inboard of the pressure line, which was released at 430.5 sec.

At approximately 100 sec MET debris that possibly impacts the Orbiter forward fuselage, was observed.

At 126 sec MET, possible Orbiter tile damage was observed on the port inboard elevon during Reusable Solid Rocket Booster separation.

At 170.2 sec MET, a single piece of debris was first observed near the starboard bipod spindle and travelled aft. The debris appears to impact the Liquid Oxygen (LO_2) feedline as indicated by a change of direction. The debris then appeared to travel toward the Orbiter fuselage, possibly impacting the Orbiter.

At 384.7 sec MET, multiple pieces of debris were observed outboard of the port bipod. The debris appeared to travel aft, then over the port wing out of the field-of-view. No contact with the Orbiter vehicle was observed.

At 430.5 sec MET, debris was observed liberating from the aft section of the External Tank (ET). The debris appears to have liberated outboard of the LO_2 feedline. The debris appears to impact the Orbiter fuselage, as noted by a change in debris trajectory

LAUNCH PAD OBSERVATIONS

At -4.569 sec MET, debris appeared to emerge from RH flame hole.

At -3.400 sec MET, debris was first observed near the LH₂ Tail Service Mast (TSM), and the debris travelled toward and appeared to impact the Orbiter aft fuselage sidewall. The impact was indicated by the change in direction of the debris. The Debris Assessment Team (DAT) cleared this area for entry using on-orbit inspection imagery.

At 0.333 sec MET, the Right Hand (RH) aft skirt foam was observed to crack near the GN_2 purge line.

At 0.429 sec MET, debris liberates from the RH RSRB aft skirt cavity near HDP M1 DCS.

At 0.982 sec MET, debris was observed releasing from the Hold-Down Post (HDP) M1 Debris Containment System stud hole.

At 0.05 to 0.009 sec MET, debris liberates from near Hold-Down Post (HDP) M5 Debris Containment System (DCS).

At 2.122 sec MET, the Gaseous Hydrogen (GH_2) vent arm was captured off center, however, the arm was latched securely.

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APPENDIX A STS-129 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-1 Gas Generator Chamber Pressure	320/19:23:20.136
	APU-2 Gas Generator Chamber Pressure	320/19:23:21.070
	APU-3 Gas Generator Chamber Pressure	320/19:23:22.053
SRB HPU Activation	LH HPU System A Start Command	320/19:27:42.045
	LH HPU System B Start Command	320/19:27:42.205
	RH HPU System A Start Command	320/19:27:42.365
	RH HPU System B Start Command	320/19:27:42.525
Main Engine Start	SSME-3 Start Command Accepted	320/19:28:03.424
	SSME-2 Start Command Accepted	320/19:28:03.544
	SSME-1 Start Command Accepted	320/19:28:03.678
SRB Ignition	SRB Ignition Command	320/19:28:09.985
Throttle Up 104.5 Percent	SSME-1 Command Accepted	320/19:28:13.915
	SSME-2 Command Accepted	320/19:28:13.920
	SSME-3 Command Accepted	320/19:28:13.920
Throttle Down to 72 Percent	SSME-1 Command Accepted	320/19:28:42.875
	SSME-2 Command Accepted	320/19:28:42.881
	SSME-3 Command Accepted	320/19:28:42.881
Throttle Up to 104.5 Percent	SSME-1 Command Accepted	320/19:29:03.676
	SSME-2 Command Accepted	320/19:29:03.681
	SSME-3 Command Accepted	320/19:29:03.682
Maximum Dynamic Pressure (Max Q)	Derived Ascent Dynamic Pressure	320/19:29:13
Both SRMs at 50 psi	LH SRM Chamber Pressure	320/19:30:08.905
	RH SRM Chamber Pressure	320/19:30:09.185
End SRM Action	LH SRM Chamber Pressure	320/19:30:10.185
	RH SRM Chamber Pressure	320/19:30:10.385
SRB Separation Command	SRB Separation Command Flag	320/19:30:13
SRB Physical Separation	LH APU A Turbine Loss of Signal	320/19:30:13.948
	RH APU B Turbine Loss of Signal	320/19:30:13.948
	LH APU B Turbine Loss of Signal	320/19:30:13.988
	RH APU A Turbine Loss of Signal	320/19:30:13.988
OMS Assist Ignition	R Engine Bipropellant Valve Position	320/19:30:24.2
	L Engine Bipropellant Valve Position	320/19:30:24.2
OMS Assist Cutoff	R Engine Bipropellant Valve Position	320/19:31:48.8
THE WE DE COO	L Engine Bipropellant Valve Position	320/19:31:48.8
I hrottle Down for 3g	SSME-1 Command Accepted	320/19:35:32.963
	SSME-2 Command Accepted	320/19:35:32.967
	SSIVE-3 Command Accepted	220/19:55:52.972
3G Acceleration	Polar Load Factor (g)	320/19:30:13.2
for Cutoff	SSME-1 Command Accepted	320/19:30:28.004
Ior Cuton	SSIME-3 Command Accepted	320/19:30:28.008
	SSME-2 Command Accepted	320/19.30.20.014
SSME Shutdown	SSME-1 Command Accepted	320/19:36:34.324
	SSME-3 Command Accepted	320/19:36:34.328
Main English Outs# (MEOO)	SSIVIE-2 Command Accepted	520/19:36:34.334
IVIAIN ENGINE CUTOTT (MECO)		320/19:36:34
ET Concretion	T Separation Command Flor	320/19:30:33
	EI Separation Command Flag	320/19:30:30

APPENDIX A STS-129 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Deactivation	APU-1 Gas Generator Chamber Pressure	320/19:42:27.116
	APU-2 Gas Generator Chamber Pressure	320/19:42:34.690
	APU-3 Gas Generator Chamber Pressure	320/19:42:46.113
OMS 1 Ignition	L Engine Bipropellant Valve Position	Not Required
	R Engine Bipropellant Valve Position	
OMS 1 Cutoff	L Engine Bipropellant Valve Position	Not Required
	R Engine Bipropellant Valve Position	
OMS 2 Ignition	R Engine Bipropellant Valve Position	320/20:06:25.2
	L Engine Bipropellant Valve Position	320/20:06:25.2
OMS 2 Cutoff	R Engine Bipropellant Valve Position	320/20:07:29.0
	L Engine Bipropellant Valve Position	320/20:07:29.2
Payload Bay Doors	Right Payload Bay Door Open 1	320/21:11:01
Open	Left Payload Bay Door Open 1	320/21:12:19
OMS 3 Ignition	L Engine Bipropellant Valve Position	320/23:10:27.0
	R Engine Bipropellant Valve Position	320/23:10:27.1
OMS 3 Cutoff	L Engine Bipropellant Valve Position	320/23:10:53.2
	R Engine Bipropellant Valve Position	320/23:10:53.3
OMS 4 Ignition	L Engine Bipropellant Valve Position	
	R Engine Bipropellant Valve Position	321/11:38:09.5
OMS 4 Cutoff	L Engine Bipropellant Valve Position	
0110 FL W	R Engine Bipropellant Valve Position	321/11:38:20.5
OMS 5 Ignition	L Engine Bipropellant Valve Position	322/11:50:07.0
0140 5 0 1 11	R Engine Bipropellant Valve Position	322/11:50:07.1
OMS 5 Cutoff	L Engine Bipropellant Valve Position	322/11:51:36.8
0.00	R Engine Bipropellant Valve Position	322/11:51:36.9
OMS 6 Ignition	L Engine Bipropellant Valve Position	322/12:34:16.6
	R Engine Bipropellant Valve Position	322/12:34:16.7
OMS 6 Cutoff	L Engine Bipropellant Valve Position	322/12:35:09.4
OMS 7 Lenities	R Engine Bipropellant Valve Position	322/12:35:09.5
OMS / Ignition	L Engine Bipropellant Valve Position	322/14:05:57.2
OMS 7 Cutoff	K Engine Bipropellant Valve Position	222/14:06:00.0
OMS / Cutoff	L Engine Bipropellant Valve Position	322/14:06:09.0
Docking	Conture	222/16:51:17
Docking		322/10:51:17
Undocking		329/09:53:02
OMS 8 Ignition	R Engine Bipropellant Valve Position	330/09:29:14.1
	L Engine Bipropellant Valve Position	330/09:29:14.2
OMS 8 Cutoff	L Engine Bipropellant Valve Position	330/09:29:24.4
Flight Original Original	R Engine Bipropellant Valve Position	330/09:29:24.5
Flight Control System	APU-1 Gas Generator Chamber Pressure	330/10:50:50.746
ADULA Otam	ADULA Ora Ora sector Obreshan Decourse	000/40-54-00 500
APU 1 Stop	APU-1 Gas Generator Chamber Pressure	330/10:54:29.566
OMS 9 Ignition	K Engine Bipropellant Valve Position	330/14:08:46.1
	L Engine Bipropellant Valve Position	330/14:08:46.2
OMS 9 Cutoff	R Engine Bipropellant Valve Position	330/14:08:56.5
Deviced Dev: Dr	L Engine Bipropellant Valve Position	330/14:08:56.6
Payload Bay Door	Lett Payload Bay Door Close	331/10:56:45
CIOSE	Right Payload Bay door Close	331/10:59:40

APPENDIX A STS-129 MISSION EVENTS

EVENT	DESCRIPTION	ACTUAL GMT
APU Activation	APU-2 Gas Generator Chamber Pressure 331/13:32:	
	APU-1 Gas Generator Chamber Pressure	331/13:59:48.276
	APU-3 Gas Generator Chamber Pressure	331/13:59:49.673
Deorbit Maneuver	L Engine Bipropellant Valve Position	331/13:37:10.1
Ignition	R Engine Bipropellant Valve Position	331/13:37:10.2
Deorbit Maneuver	L Engine Bipropellant Valve Position	331/13:39:57.0
Cutoff	R Engine Bipropellant Valve Position	331/13:39:57.1
Entry Interface	Orbital Altitude Referenced to Ellipsoid	331/14:12:40.0
Blackout End	Data Locked (High Sample Rate)	No Blackout
Terminal Area Energy	Major Mode Code (305)	331/14:37:51
Management (TAEM)		
Main Landing Gear	Main Landing Gear Left Hand Tire Pressure	331/14:44:21
Contact	Main Landing Gear Right Hand Tire Pressure	331/14:44:21
Main Landing Gear	Main Landing Gear Right-Hand Weight on Wheels	331/14:44:21
Weight on Wheels	Main Landing Gear Left Hand Weight on Wheels	331/14:44:21
Drag Chute	Drag Chute Deploy 1 CP Volts	331/14:44:23.7
Deployment		
Nose Landing Gear	Nose Landing Gear Left Hand Tire Pressure 1	331/14:44:31
Contact		
Nose Landing Gear	Nose Landing Gear Weight on Wheels	331/14:44:31
Weight on Wheels		
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	331/14:44:51.3
Wheels Stop	Velocity with respect to Runway	331/14:45:15
APU Deactivation	APU-1 Gas Generator Chamber Pressure	331/15:04:19.306
	APU-2 Gas Generator Chamber Pressure	331/15:04:24.480
	APU-3 Gas Generator Chamber Pressure	331/15:24:24.783

INTRODUCTION

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-129 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

IFA Number	Title	Comments
STS-129-V-02	EV1 CCA Loss of Audio	During the Flight Day (FD) 4 first Extravehicular Activity (EVA) at approximately 323/20:30:12 Greenwich Mean Time (GMT) [03/01:02:02 Mission Elapsed Time (MET)], the EV1 crewmember reported a loss of Communications Cap Assembly (CCA) headset audio in his right earphone. Audio was still being received in the left earphone. Shortly thereafter, EV1 crewmember reported that no audio was being received in either earphone. Subsequently, the EV2 crewmember adjusted the volume control for EV1 and audio was restored temporarily. A communications check was performed in the airlock after the EVA at approximately 323/20:55:22 GMT (03/01:27:12 MET) and good Communications was reported for both EV1 and EV2. Later the EV1crewmember reported that moisture was in the Communications Cap Assembly (CCA) left-ear section. The headset was allowed to dry and the moisture barrier earphone diaphragms were replaced by the crew prior to the second EVA. During the second EVA depressurization, the EV1 crewmember again reported faint audio during the Communications check and did not here the caution and warning test tones when switched to battery power. It was confirmed that the volume control was at the maximum position, but voice could only hear at a faint level. The SSER radio was switched to an alternate string but Communications were not significantly improved. The EV1 crewmember completed the EVA in that condition. After the second EVA during the Water Re-charge Cycle, and with Comm activated, a comparison test was performed with other CCA headsets using the EV1 suit. It was determined that the receiver audio level in the prime CCA/CCEM for EV1 was lower than nominal when compared with the other CCA headsets when installed in the same configuration. Post-flight Plan: Standard destowing of the suspect CCA/CCEM, and return to JSC for ground processing, testing, troubleshooting and repair as need. Troubleshooting indicated that a combination of moisture and damaged receiver lead to the problem.
STS-129-V-03	Mid Starboard Payload Bay (PLB) Floodlight Failed	During the P{LB floodlight powerup on FD8, the current signature on Main C Bus (MNC) Mid-Power Controller (MPC) 3 was less than expected for an illuminated floodlight, and the Aft-Port or Mid- Starboard Floodlight was considered suspect. The crew was asked to troubleshoot the floodlight by placing the power switch to off. As a result, the Mid-Starboard Floodlight no.4 is considered failed and a bootie was placed on the power switch to prevent further operation of Floodlight no. 4. The failure of Floodlight no. 4 is of no impact to mission success or crew safety. Multiple losses of Payload Bay Floodlights could cause the crew to utilize an alternative method (hand-held spot light) to verify the configuration of the latches during Payload Bay Door closure operations. The most probable cause of Floodlight no. 4 failure is a cracked bulb. Post-Flight Plan: The floodlight was inspected during the post-flight processing and a cracked bulb was found. The floodlight was removed and replaced and the Payload bay lighting test was successfully completed.

IFA Number	Title	Comments
STS-129-V-04	Wireless Video System (WVS) 1 V10 eating Tapes	When attempting to configure the Wireless Video System (WVS) 1 V10 to support wireless video operations on FD4, the crew reported the WVS 1 V10 recorder was malfunctioning and eating tapes. The crew exchanged the WVS 1 V10 with the hardware was returned to JSC and checkout. Troubleshooting revealed tape feed mechanism Monitor 2 V10 and proceeded with EVA operations. Post-flight Plan: The DSR-V10 Digital Recorder Assembly had a build up dirt during years of use causing the pinch roller to stick to the tape and causing the tape to not spool correctly. The V10 recorder has been cleaned and all V10 units are tested prior to each flight. Multiple V10 units are flown on every flight and V10 units can be swapped around based on priority.
STS-129-V-05	Waste Dump Stopped Prematurely	The waste water dump initiated after undocking at 329/12:07:38 GMT (08/16:39:28 MET), exhibited a nominal waste dump rate (approximately 2.0 %/min) until 329/12:19:36 GMT (08/16:51:26 MET) when the waste dump rate degraded to approximately 0.3 %/min. The waste dump was terminated by closing the dump valve and the nozzle was reheated to approximately 258 °F. The dump valve was then opened at 329/12:35:34 GMT (08/17:07:24 MET) for continuation of the dumping operation. The observed dump rate continued off-nominally at near 0 %/min and the waste dump nozzle to 305 ° F. There was no indication of ice on the nozzle bake-out signature. In addition, an RMS port survey of the waste dump nozzle indicated no ice buildup. On FD 11, the condensate Contingency Water Container (CWC) was successfully dumped through the waste-water dump nozzle, which exonerated the waste-dump nozzle as the cause of the failure to complete the waste water dump. A waste water tank dump was attempted through the High Capacity Filter using the conventional dump configuration, and it was unsuccessful. The dump valve was closed for 60 sec and another attempt to dump was unsuccessful. The dump valve was closed and the dump nozzle heated up to 250 °F and the waste dump valve was re-opened. This attempt also was unsuccessful. Post-flight Plans : Sampling urine from the waste tank, and having it analyzed. In addition, the filter will be removed (and replaced) and sent out for disassembly and inspection. Inspection indicated excessive build-up of urine solids as the cause of the blockage. Following those actions, KSC performed a biocide and citric acid flush of the waste system and replaced the filter per the Operations Maintenance Requirements and Specification Document (OMRSD).
STS-129-V-06	External Tank (ET)	When the flash module was opened post-flight, charring was found on the leads of one of the
	Umbilical Camera Flash	thermostats that control the heaters in the unit. Investigation showed that the leads of the
	Module Thermostat	thermostats were not covered by heat-shrink tubing, prior to applying epoxy to the housing. The thermostat lead wore through the epoxy and shorted to the housing.

IFA Number	Title	Comments
STS-129-V-07	Multifunction Display Unit (MDU) Pilot (PLT) 1 Screen Glass Damage	The Micro Inspection Team evaluated the PLT1 MDU screen glass and determined that there was a small ding with some missing glass that measured approximately 0.0984-in. wide by 0.122-in. long. In addition, the inspection also indicated the possibility of a section of the polyester film surrounding the damaged area had also been removed by the impact. If their assessment is correct, the glass fragment was likely not contained. KSC inspected the MDU just prior to Orbiter Processing Facility (OPF) rollout, and again during preflight cleaning prior to the start of the STS-129 countdown, and did not note any damage at those times. Therefore, it is believed that this condition occurred during flight. If this is the case, it is possible that the Atlantis and/or ISS crews may have been exposed to this tiny glass fragment during the STS-129 mission, or that it may still be on the vehicle, potentially exposing the next crew. The MDU was removed and replaced. Inspection by the vendor found no shattered glass fragments and no breach of the protective polyester film. Damaged area appears to be surface contamination.
STS-129-V-08	Cables	The crew reported no video on Monitor 2. Post-flight: Post-flight testing determined that the cable was bad.
STS-129-V-09	Fire Extinguisher Dislodged from Wall Holder	During the STS-129 entry, a fire extinguisher mounted on the middeck aft cabin wall came out of its restraint device and hit the cabin floor causing a dent. Structures Division accepted a Problem Report (PR) for the two dings in the floor caused by the falling middeck aft fire extinguisher. The larger ding is 1.49-in. by 1.38-in.with a depth of 0.103-in. The Structures personnel are currently assessing the condition if it can be flown as-is or repair is required. We also have taken a FCS PR (FCS-4-32-0781) on the fire extinguisher to document that it fell out of the bracket during deorbit and will verify it's not damaged (it's not) and if it is usable for another flight Post-flight: Evaluation of the extinguisher verified that it is still usable, but will be put at the end of the line for usage per Houston as seven other flight ones exist for use. Forward Plan: Drawings are being updated to clarify the installation procedure, and the installation procedure is also being updated. Also, verification of proper Extinguisher installation with closeout photographs.

IFA Number	Title	Comments
STS-129-V-10	Auxiliary Power Unit (APU) Water Tank Heater A Did Not Operate at Expected Temperature	On Flight Day (FD) 5, the heater telemetry for the APU injector water cooling tank, which is common to all three APUs, did not cycle on as expected at the controlling thermostat 55 °F On set-point seen on previous flights. The heater is monitored by temperature sensor (APU H ₂ O Tank Temperature) and is controlled by a thermostat. The temperature slowly decreased from 55 °F on FD5 to 49 ° F on FD7 where it stabilized. Should the heater not operate for the remainder of the mission, no threat of water freezing exists. The nominal heater reconfiguration to the redundant B circuit is scheduled to be performed after undocking from the ISS on Wed, FD10. No change to nominal crew action or procedures is required. The out of family heater system performance had no impact on mission operations; however, it is reason to perform a post flight inspection and checkout of the installation. The APU injector water cooling system is a contingency system only and is not required for nominal system operation. It is available if a cooled hot restart of an APU is required and the system is criticality 1 for aborts. Water cooling has never been used on a shuttle mission. Post-flight Plan: An inspection of the APU injector water cooling system water-tank installation was conducted during postflight ground processing to investigate possible problems with the thermostat, the insulation, and/or the temperature sensor, any of which could be a cause or a contributing cause. The post-flight testing showed the thermostat was failed and thermostat was removed and replaced.
STS-129-V-11	HD Video Downlink Unsuccessful	On FD01, the crew was unable to downlink the High-Definition (HD) video from the G1 camcorder to Multi-Protocol Converter (MPC). Troubleshooting information was provided to the crew, the crew replaced the firewire cable and the HDTV and Taxi lights lit on the MPC. The HD downlink after Orbiter Boom Sensor System (OBSS) Operations was attempted and confirmed good. Post-flight status: Testing was completed. The 4-Pin Female Cable had intermittent video. No signal appears from the cable for approximately 30 sec after which video appears. This is the first occurrence of this problem. Post-flight status: The cable was downgraded and discarded.

SOLID ROCKET BOOSTER ANOMALIES

IFA Number	Title	Comments
STS-128B-001	Right-Hand Solid Rocket Booster (SRB) aft skirt foam on the out- board side of Holddown Post M2 near the GN ₂ Purge Line observed to crack during lift-off.	The area where the crack occurred is obscured by SRB exhaust early in lift-off. The crack first became visible at 0.333 sec Mission Elapsed Time (MET). While the crack is visible in camera E008 imagery, the length of the crack appears to remain the same; however, the width of the crack appears to increase to 1.7 in. at 0.432 sec MET and then decreases to a stable width of approximately 0.75 in. The cracked foam was not observed to liberate from the camera E008 imagery. The cracked foam was verified to be intact up to -66 sec MET from cameras E0052, E225, and E207. After 66 sec MET, the imagery resolution is insufficient to verify the aft skirt foam condition. Analysis by the MSFC and JSC Image Analysis Teams (IAT's) was performed using imagery from numerous cameras and High Definitions TV views. The MSFC analysis is discussed in the previous paragraph. The JSC analysis reported that the area where the cracked foam was observed appears to be intact until approximately 66 sec MET before the image resolution begins to decline. The MSFC IAT analysis indicated the crack to be 30 in. long and 1.7 in. wide. The JSC IAT analysis indicated the processes and concluded that all of the foam materials properties were within engineering specification. The probable cause was foam adhering to the GN ₂ purge probe.

REUSABLE SOLID ROCKET MOTOR ANOMALIES

No RSRM were identified during the STS-129 Mission.

SPACE SHUTTLE MAIN ENGINE ANOMALIES

. No SSME anomalies were identified from the STS-129 data and analysis.

EXTERNAL TANK ANOMALIES

IFA Number	Title	Comments
STS-128-T-001	Post-flight review identified foam losses on the Z side of the Intertank Acreage.	The External Tank (ET) -133 imagery evaluation identified foam losses on the ?Z side of the Intertank (IT) acreage. This anomaly was deferred and is closed.

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-129-I-001	Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Lift-off Debris)	STS-129 went to the infrequent catastrophic. Debris release has been mitigated for identified potential sources of critical debris by performing repairs. At the System Integration Control Board (SICB), SR4655 provided rationale for closure of and adding inspections for system-level components (e.g. MLP FIREXSTS-129-I-001. The recommendation was accepted and the IIFA was closed. The nozzles around the Space Shuttle Main Engine (SSME) Exhaust Hole; ETVAS cooling spray nozzles and following is a summary of the rationale for closure: plumbing; OIS electrical connector Dust Caps; and GVA hood knurled fasteners. Ongoing mitigations include Foreign Object Damage (FOD) awareness. Attrition-based Risk Assessment indicates that given the proposed mitigations, observed removal of hardware, routine inspections and monitoring for facility debris poses no appreciable increase in risk. Lift-off debris risk is corrosion.
STS-129-I-002	Single Transient SRB Input/Output (I/O) Error at Liftoff	During STS-129 liftoff, an Solid Rocket Booster (SRB) Input/Output (I/O) error occurred on Multiplexer/Demultiplexer (MDM) LL2 (one of the two left SRB MDMs) via Launch Data Bus (LDB) 2. Following the single transient error, the SRB I/O operated nominally through SRB separation. The transaction is a request for non-critical data from MDM LL2 made by the General Purpose Computer (GPC) across LDB2. The SRB data from the transaction is not used by the Flight Software (FSW), but is only for down-list. Subsequent investigation during STS-129 found that the characteristics of this anomaly, a single transient I/O error, would be caused by the coincident timing of the disconnect of T-0 umbilical removing electrical power from the Data Bus Isolation Amplifier (DBIA) causing a short, less than 28 microseconds, noise burst on the Launch Data Bus (LDB) 2. If the noise burst collides with a simultaneous transmission on the bus, an I/O error is recorded. Telemetry indicates the I/O error occurred during the removal of power from the DBIA. There is no effect on Flight Control or other flight systems, as the data is not used by the GPCs.

SYSTEM ENGINEERING AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-129-I-003	ET TPS Losses on -Z Intertank	The Crew hand-held camera imagery for ET-133 (STS-129) revealed eight Thermal Protection System (TPS) losses on the -Z side of the External Tank (ET) Intertank (IT). The timing of release was indeterminate since ascent imagery of the -Z side of the ET was limited. All of the losses were located outside of the critical-debris zone, and therefore, did not pose a threat to the Orbiter. The integrated concern centers on the potential for debris to liberate with the same failure mode on the +Z side, as observed on ET-131 (STS-127), and strike the Orbiter causing significant damage. The failure mode appears to be similar to that of the IT TPS losses observed on ET-131 (STS-127). The failure mode for ET-131 was most likely poor TPS bond adhesion, as indicated by the STS-127 imagery, which showed multiple losses extending to the substrate. Since the losses for STS-129 were located only on the -Z side, only the crew hand-held imagery was available to conduct an analysis for the presence of substrate at the loss sites. Therefore, due to the limited resolution of the available imagery, it could not be determined conclusively that the losses extended to substrate, but these types of losses could not be ruled out. However, the ET-133 (STS-129) losses were similar to those on ET-131 (STS-127) in that they also appeared to correlate with the location of the Michoud Assembly Facility (MAF) platforms used to clean the IT. The correlation was particularly noticeable for both ET-131 and ET-133 on the -Z side at the Xt-1057 platform level. For ET-134/STS-130, 58 bond adhesion tests were conducted on +Z side of the ET-134 IT. A total of 24 were located in areas of high-debris risk to the Orbiter. Another 24 were spread out in the area between the high-risk zones. The final 10 additional bond adhesion tests were performed on the +Z side at the Xt-1057 level. Only one test failed to meet the success criteria. However, a retest in an adjacent area passed. These test results give some indication that there may be no gross TPS bond adhe

FLIGHT SOFTWARE ANOMALIES

IFA Number	Title	Comments
STS-129-S-001	OCA 48 Mbps Downlink Not Functional	Prior to Pre-sleep on FD2, the crew configured the onboard Orbiter Communications Adapter (OCA) for 48 Mbps downlink (through the High Definition Television (DTV) Multiplexer (MUX). The Mission Control Center (MCC) did not see any 48 Mbps data in the building. The crew then acknowledged DTV-MUX switch was misconfigured. The crew reconfigured the DTV-MUX properly and repeated the setup for 48 Mbps (as per nominal procedure) and still no joy on 48 Mbps downlink. White Sands only saw clock (no data) on carrier. Based on the White Sands data, the OCA cable was probably bad at this point but not yet realized. The crew was instructed to reboot the OCA router, but still no joy after reboot. The crew was asked to reconfigure the onboard OCA transmit rate back to the nominal 2 Mbps and this was successful. The OCA remained in the 2 Mbps at that time On FD5, The OCA was configured for 48 Mbps. During a test with the ground, White Sands reported seeing clock but no data on the downlink carrier. The crew rebooted the onboard router, but the results on the downlink did not change. The crew then performed an external loopback test on the Clock (P3 and Data (P4) legs of the OCA interface cable. The loopback test failed. The crew installed the backup interface cable and performed a loopback test on the P3 and P4 legs of the new cable. This loopback test was successful. The crew then connected the P3 and P4 cables to the MUX and OCA and 48 Mbps data was successfully received on the ground OCA Router. The backup interface cable will remain in place for the remainder of the flight. The use of OCA 48 Mbps after the late inspection will remain in the plan. This anomaly was originally designated as STS-129-V- 01; post-flight Plan: Plan is for early destowing of the cable, followed by nominal processing.

FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

No Flight Operations and Integration Anomalies were identified.

MOD ANOMALIES

STS-129-D-001High Pressure Gas Tank (HPGT) Unexpected Release from EXPRESS Logistics Carrier (ELC-2).The third Extravehicular Activity (EVA) nominal procedures call handed off from the ELC-2 to the Space Station Remote Manip the EVA crewmembers. During the HPGT release from ELC-2, before it was securely controlled by both EVA crewmembers. T assuming that the HPGT would be held in place by the final set configuration on the ELC. Post-flight it was determined that the the fifth latch only works when the HPGT is mated to the Interna Airlock and not to the ELC. This condition was not known by th Directorate (MOD), and therefore the procedure was written inc Final Closure: MOD conducted an internal error chain analysi HPGT/ELC hardware interface configuration was not known. A investigated why the MOD Anomaly Report was not reported at Anomaly (IFA immediately post-landing. These investigations o of January 2010. Findings were briefed to MOD and steps hav further recurrences. The following corrective actions have beer 1. The DX/MOD Flight Readiness Review (FRR) process include reporting of hardware configuration; 2. An EVA Flight/Increment Lead Work Instruction has be to be used for generating procedures; 3. An Operational Replacement Unit (ORU) Readiness Di developed to better document ORU hardware; and, 4. An EVA Assessment Team (EVAAT) Work Instruction I december to EVAAT werearce.	Illed for the HPGT to be ipulator System (SSRMS) by 2, the HPGT came loose The procedure was written et of latches (out of five) ne "locked" configuration of national Space Station (ISS) the Mission Operations ncorrectly. sis to determine why the Additionally, MOD as an Operation In=Flight s were completed by the end ave been taken to ensure no en established: s has been updated to been written noting resources Dashboard process has been

APPENDIX C

DOCUMENT SOURCES

MER DAILY REPORTS

The following STS-129 MER Daily Reports by Michael D. Wright, Lead MER Manager: Ascent and First Daily Report, dated November 16, 2009 Second Daily Report, dated November 17, 2009 Third Daily Report, dated November 18, 2009 Fourth Daily Report, dated November 19, 2009 Fifth Daily Report, dated November 20, 2009 Sixth Daily Report, dated November 21, 2009 Seventh Daily Report, dated November 22, 2009 Eighth Daily Report, dated November 23, 2009 Ninth Daily Report, dated November 24, 2009 Tenth Daily Report, dated November 25, 2009 Eleventh Daily Report, dated November 26, 2009 Twelfth Daily Report, dated November 27, 2009 Landing Plus 2 Hour Report, dated November 27, 2009 Mission Summary Report, dated December 1, 2009

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- STS-129 OMS Report, Donald E. Varanauski, Boeing-Houston, December 18, 2009 STS-129 RCS Report, Donald E. Varanauski, Boeing-Houston, December 18, 2009
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STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/	MEACONE
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 RCS	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
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
CO ₂	Carbon Dioxide
COLBERT	Combined Operational Load Bearing External Resistance Treadmill
COMM	Communications
CPM	Cell Performance Monitor
CTB	Crew Transfer Bag
CWC	Contingency Water Container
CWCI	Contingency Water Container Iodine
D & C	Display and Control
DAP	Digital Autopilot

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
DAT	Debris Assessment Team
DCQ	Deck Crew Quarters
DDU	Data Display Unit
DET	Data Elapsed Time
DMHS	Dome Mounted Heat Shield
DOD	Department of Defense
DOLILU	Day of Launch I Load Update
DPS	Data Processing System
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
FES	Flash Evaporator System
FGB	Fixed Grapple Bar
FID	Failure Identifier
FIR	Fluids Integration Rack

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
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
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
HIV	H II Transfer Vehicle
HYD	Hydraulic
IAI	Image Assessment Leam
IBA	Inspection Boom Assembly
	Impact Detection System
	Individual Equipment Liner Kit
	In-Fiight Anomaly
	Inertial inteasurement Unit
124	integrated Stowage Platform

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
ІТ	Intertank
IVA	Intravehicular Activity
ISP	Specific Impulse
ISS	International Space Station
JAXA	Japanese Aerospace Exploration Agency
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
LIOH	Lithium Hydroxide
LMC	Lightweight Mission Peculiar Equipment Support Structure Carrier
LMG	Left Main Gear
LO ₂	Liquid Oxygen
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
MFE	Mid-Frequency Executive
MISSE	Materials International Space Station Experiment
MLG	Main Landing Gear
MLI	Multi-Layer Insulation
MLP	Main Launch Platform

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
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
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 Vacinne-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
Р	Port
PAO	Public Affairs Office
PAS	Payload Attachment System
PASS	Primary Avionics Software System
PASS WHI	PASS With Initial Helium Load

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
PCM	Pulse Code Modulation
OPO	Orbiter Project Office
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
PPCO ₂	Partial Pressure Carbon Dioxide
PRCS	Primary Reaction Control System
PRSD	Power Reactant Storage and Distribution System
PRT	Problem Resolution Team
PV&D	Purge, Vent and Drain
PWR	Payload Water Reservoir
QD	Quick Disconnect
R&R	Remove and Replace
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RGA	Rate Gyro Assembly
RH	Right Hand
RHC	Rotational Hand Controller
RJD	Reaction Jet Driver
RM	Redundancy Management
RMS	Remote Manipulator System
RNS	Relative Navigation System
RP	Right Pod
	Remote Power Controller Module
RPL	Rated Power Level
RSRB	Reusable Solid Rocket Booster
RSP	Resupply Stowage Platform
KOK	Resupply Stowage Racks
KOKIVI	Reusable Solid Rocket Motor
	K-Bar Mich Maneuver
K2R	Rudder Speed Brake

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
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 Gryo Assembly
SRMS	Shuttle Remote Manipulator System
SRSS	Shuttle Range Safety System
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSPIS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
SI	
SIP	Space Test Program
515	Space Transportation System
SW	Southwest
	Supply water and waste Management System
	See COLBERT
	Tactical All Navigation System
	Condensor Evit Temperature
	Thermal Control System/Trajectory Control Sensor
	Treaking and Date Balay Satellite
	Translation Hand Controller
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STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
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

STS-129 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Unit of Measure	Explanation
°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