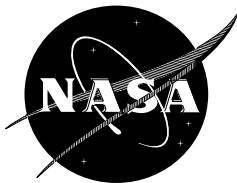


# **STS-130 SPACE SHUTTLE MISSION REPORT**

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September 2010



**National Aeronautics and  
Space Administration**

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

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**STS-130**

**SPACE SHUTTLE MISSION REPORT**

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# STS-130 SPACE SHUTTLE MISSION REPORT

## INTRODUCTION

The Space Transportation System (STS) - 130 Space Shuttle Mission Report presents a discussion of the Orbiter activities on the mission, as well as a summary of the External Tank (ET), the Reusable Solid Rocket Booster (RSRB), the Reusable Solid Rocket Motor (RSRM) and the Space Shuttle Main Engine (SSME) performance during the 130<sup>th</sup> mission of the Space Shuttle Program. The purpose of this mission was to deliver and install the *Tranquility* Node 3 (third connecting module) and the seven-window Cupola to the International Space Station (ISS). The *Tranquility* Node 3 contains life support systems that will enable continued human presence in orbit. The Cupola will provide a windowed robotics viewing station for not only monitoring a variety of ISS operations, but also to study our home planet. Three Extravehicular Activities (EVAs) were performed in support of the installation of the Node 3 and Cupola.

STS-130 was the 17<sup>th</sup> mission since the return to flight following the STS-107 mission, and the 32<sup>nd</sup> mission to the ISS. STS-130 was also the 24<sup>th</sup> flight of the Orbiter 105 vehicle.

The primary objectives of the STS-130 mission were as follows:

1. Deliver, install and activate Node 3 on the Node 1 port Common Berthing Mechanism (CBM).
2. Relocate, install and checkout the Cupola from the Node 3 port CBM to the Node 3 nadir CBM.
3. Transfer and stow critical items.
4. Transfer mandatory quantities of water from Shuttle to the ISS.
5. Install, activate and checkout Water Recovery System (WRS).
6. Perform three EVAs.
7. Transfer Oxygen.
8. Reboost the ISS using the Orbiter Reaction Control System (RCS).

The flight vehicle consisted of the OV-105 Orbiter; the ET, a Super Lightweight Tank (SLWT) designated ET-134; three Block II SSMEs that were designated as serial numbers (S/Ns) 2059, 2061, and 2057 in positions 1, 2 and 3, respectively; and two RSRBs that were designated BI-141. The two RSRMs were designated flight set RSRM-109. The individual RSRMs were S/N 360W109A (left) and S/N 360W109B (right). Launch pad 39A and Mobile Launch Platform (MLP) -2 were used as the platform for launch of the STS-130 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, RSRB, ET, and Integration In-Flight Anomalies

(IFAs) and the 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 six crewmembers that were on the STS-130 flight were George D. Zamka, Colonel, U. S. Marine Corps, Commander; Terry W. Virts, Jr., Colonel, U.S. Air Force, Pilot; Kathryn P. Hire, Captain, U. S. Navy Reserve, Mission Specialist 1; Stephen K. Robinson, PhD, Civilian, NASA, Mission Specialist 2 ; Nicholas J. M. Patrick, PhD., PE, Civilian, NASA, Mission Specialist 3; and Robert L. Behnken, PhD, Lt Colonel, U. S. Air Force, Mission Specialist 4.

STS-130 was the fourth flight for Mission Specialist 2; the second flight for the Commander, Mission Specialist 1, Mission Specialist 3 and Mission Specialist 4; and the first Shuttle flight for the Pilot.



## **MISSION SUMMARY**

All of the International Space Station (ISS) 20A mission objectives were successfully accomplished during this mission. All of the transfers were successfully completed.

### **Pre-Launch**

The first launch attempt on February 7, 2010, was scrubbed because of unfavorable range weather and Return to Launch Site (RTLS) weather.

Prior to the start of tanking for the first launch attempt, the Forward Reaction Control System (FRCS) thruster F1D Tyvek cover was observed to be partially debonded from the thruster and the F3D thruster cover was liberated completely. For the F1D cover, the pocket appeared to be inflating, thus no late release was expected. In the case of the F3D cover, there was no concern with rain having entered the thruster or any rain entering the thruster prior to launch. With this rationale, a waiver was approved for this condition.

During Nitrogen (N<sub>2</sub>) purge activation on the Ice Detector equipment on the 255-ft level of the pad during the first launch attempt, the glass gauge-face failed and distributed-glass fragments to the 235-ft, 195-ft, 135-ft, and Main Launch Platform (MLP) zero-deck levels. The Damage Assessment Team (DAT) assessed a glass impact on the Reinforced Carbon-Carbon (RCC) and tile, and had no damage concerns. The DAT did not assess any glass for lift-off concerns, as the estimated mass was within other accepted pad-debris sources.

### **Flight Day 1**

The STS-130 mission was launched at 039/09:14:07.017 Greenwich Mean Time (GMT) on February 8, 2010.

The Reusable Solid Rocket Booster (RSRB) separation was visible through RSRB separation. A nominal Orbital Maneuvering System (OMS) assist maneuver was performed following RSRB separation. Ignition occurred at 039/09:16:24.5 GMT [00/00:02:17.333 Mission Elapsed Time (MET)], and the maneuver was 134.40 sec in duration.

Main Engine Cutoff (MECO) occurred at 039/09:22:29 GMT (00/00:08:22 MET). The ET separated from the Orbiter at 039/09:22:51 GMT (00/00:08:44 MET).

A nominal OMS-2 maneuver was satisfactorily performed at 039/09:51:48.8 GMT (00/00:31:41.6 MET). The maneuver was 92.8 sec in duration with a Differential Velocity ( $\Delta V$ ) of 142.3 ft/sec. The achieved orbit was 110.0 by 123.8 nmi.

The Payload Bay Doors (PLBDs) were opened at 039/10:46:05 GMT (00/01:31:58 MET). The Ku-Band antenna was deployed at 039/10:55:59 GMT (00/01:41:52 MET), and the self-test was completed with satisfactory results.

The OMS-3 Nominal Correction (NC) 1 maneuver was a two-engine, straight-feed firing performed at 039/12:14:31.1 GMT (00/03:00:24 MET). The firing was 66.2 sec in duration with a  $\Delta V$  of 102.8 ft/sec. The resulting orbit was 111.4 by 180.9 nmi. OMS performance was nominal.

The Shuttle Remote Manipulator System (SRMS) On-Orbit Initialization was completed at 039/12:32 GMT (00/03:18 MET). The SRMS power-on began at 039/13:23 GMT (00/04:09 MET), and checkout was initiated at 039/13:40 GMT (00/04:26 MET). The SRMS was returned to the Pre-Cradle position and powered down at 039/14:54 GMT (00/05:40 MET). During the SRMS Direct-Drive checkout of the wrist-pitch joint, a Motor Drive Amplifier (MDA) Demand-Voltage Build-In Test Equipment (BITE) was annunciated when the command was removed. The crew executed the appropriate malfunction procedure and completed the SRMS checkout with no further anomalies. This anomaly is a known nuisance alarm that has a statistical probability of occurring. The last occurrence of this annunciation was on STS-127 during the Direct Drive Checkout of the Wrist Roll joint.

All Wing Leading Edge (WLE) Impact Detection System (IDS) ascent summary data were successfully downlinked. One data indication on the Starboard wing exceeded the 1-Grms reporting criteria. The magnitude observed was 1.92 Grms on panel 9, which was a low-damage category. During the ascent monitoring, sensor unit 1155 exhibited two off-scale-high data spikes on channel 3 (IFA STS-130-V-02). Channels 1 and 2 of the same sensor recorded nominal G values. After the off-scale high readings on channel 3, all the data collected on the channel was nominal.

The crew was never able to transition the Orbiter Communication Adapter (OCA) downlink rate from 2 Mbps to 48 Mbps (IFA STS-130-V-04). The only impact was a delay in the downlink of digital imagery.

The crew was initially unable to downlink the High-Definition (HD) video (IFA STS-130-V-05). HD video was eventually recovered.

## **Flight Day 2**

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, the Extravehicular Mobility Unit (EMU) checkout, rendezvous tools checkout, and Orbiter Docking System (ODS) ring extension.

The WLE IDS on-orbit monitoring began at approximately 040/02:00 GMT (00/16:46 MET) with Port and Starboard Group 2.

A minor Orbital Maneuvering Engine (OME) Gaseous Nitrogen (GN<sub>2</sub>) system leakage was being monitored. The pressure decay had been observed in this OMS pod on previous flights of OV-105 and did not affect nominal OMS engine usage. Sufficient GN<sub>2</sub> remained in the left supply-tank to support the remaining planned left-OME firings as well as any proposed firings of opportunity. A GN<sub>2</sub> system repressurization was performed to avoid a low-pressure alarm annunciation. In response to concerns that the accumulator pressure could drop below the 299-psia alarm limit during crew sleep periods, a General Purpose Computer (GPC) Memory (GMEM) update was developed to modify the onboard accumulator-pressure Fault Detection and Annunciation (FDA) limit to avoid nuisance alarms. However, the uplink of the GMEM was not required.

The OMS-4 NC2 maneuver was a dual-engine OMS firing that occurred at 040/02:30:02.9 GMT (00/17:15:55 MET) with cutoff at 040/02:31:09.5 GMT (00/17:17:02 MET). The firing time was 66.6 sec with a  $\Delta V$  of 104.2 ft/sec. The resulting orbit was 164.4 by 186.3 nmi. Engine performance was nominal.

The first on-orbit fuel cell purge was a manual purge beginning at 040/03:14 GMT (00/17:59:53 MET).

The SRMS OBSS surveys of the starboard-wing RCC, nose-cap RCC, and port-wing RCC were completed nominally. The maneuver for OBSS grapple started at 040/02:53 GMT (00/17:38:53 MET), with unberthing of the OBSS completed at 040/03:39 GMT (00/18:24:53 MET). The starboard RCC survey began with the flat-field survey at 040/04:26 GMT (00/19:11:53 MET), and was completed at 040/06:24 GMT (00/21:09:53 MET). The nose RCC survey began at 040/06:58 GMT (00/19:55 MET) and was completed at 040/07:31 GMT (00/22:18 MET). The port RCC survey began at 040/07:56 GMT (00/22:40 MET) and was completed at 040/10:09 GMT (01/00:55 MET). The OBSS was berthed and latched at 040/12:20 GMT (01/03:16 MET).

While performing the OBSS Port chine survey on FD 2, the Sensor Package (SP) 1 Intensified Television Video Camera (ITVC) video faded out. The ITVC Automatic Light Control (ALC) configuration was reset, and the port-chine survey was restarted to ensure complete coverage of that region.

The NC3 maneuver was a multi-axis firing using the Primary Reaction Control System (PRCS). Ignition occurred at 040/11:24:04 GMT (01/02:09:57 MET), and the maneuver was 5.3 sec in duration. The  $\Delta V$  was 1.2 ft/sec and the resulting orbit was 164.9 by 186.6 nmi.

The ODS ring extension was completed at 040/11:55:45 GMT (01/02:41:38 MET). No anomalies were noted during the ring extension. The ring extension was performed within the nominal dual-motor drive-time to the initial position of 76.4% ring extension.

The Rendezvous Tools checkout was performed and all systems were nominal. The Trajectory Control Sensor (TCS) was powered on at 040/12:20 GMT (01/03:06 MET) and was powered off at 040/12:30 GMT (01/03:16 MET).

### Flight Day 3

The main activities on FD 3 were rendezvous and docking with the ISS as well as hatch opening, and unberthing and handoff of the OBSS from the Space Station Remote Manipulator System (SSRMS) to the SRMS.

The first waste water dump was initiated at 040/23:27 GMT (01/14:13 MET) and terminated at 040/23:46 GMT (01/14:32 MET). Approximately 62 lb of waste water was dumped at a rate of 1.9%/min.

The Space-to-Space Orbiter Radio (SSOR) was powered ON at 041/00:11:12 GMT (01/14:57:05 MET). SSOR lock-on occurred at about 35,000 ft and the crew checked the audio at 31,000 ft.

The Nominal Height (NH) maneuver was not required. The first maneuver of the day was the OMS-5 NC 4, which was a dual-engine firing. The time of ignition was 041/00:56:14.6 GMT (01/15:42:07 MET) with the cutoff 14.1 sec later. The maneuver had a  $\Delta V$  of 22.3 ft/sec, and the resulting orbit was 177.6 by 187.1 nmi. Engine performance was nominal.

The Nominal Corrective Combination (NCC) maneuver was a -Z axis Reaction Control System (RCS) firing using four primary thrusters. The time of ignition was 041/01:30:44.7 GMT (01/16:16:37 MET). The  $\Delta V$  delivered was 0.15 ft/sec and the resulting orbit was 177.5 by 187.1 nmi.

The Ku-Band antenna was taken to the RADAR mode at 041/01:37:44 GMT (01/16:23:37 MET) and detected the ISS within 16 sec at a range of 141,000 ft. The system began tracking the ISS at 041/01:38:29 GMT (01/16:24:22 MET) at a range of 140,000 ft. The RADAR mode operated as expected and the Communications (COMM) mode was reselected at 041/04:29:28 GMT (01/19:15:21 MET) at a range of 318 ft.

The OMS-6 Terminal Initiation (TI) maneuver was a straight-feed, left OMS engine firing. Ignition was at 041/02:28:25.1 GMT (01/17:14:18 MET) with the cutoff of 8.6 sec later. The  $\Delta V$  delivered was 6.3 ft/sec, and the resulting orbit was 181.2 by 187.2 nmi. Engine performance was nominal.

The RCS Midcourse Correction (MC) 1 maneuver was initiated at 041/02:48:24 GMT (01/17:34:17 MET) and was completed 8.0 sec later. The  $\Delta V$  delivered was 0.2 ft/sec. The Out-of-Plane Null firing was not required. The MC2 maneuver was initiated at 041/03:16:29 GMT (01/18:02:22 MET) and was completed 1.52 sec later. The  $\Delta V$  delivered was 0.4 ft/sec. The MC3 maneuver was performed at 041/03:33:30 GMT (01/18:19:23 MET) and was completed 0.88 sec later. The  $\Delta V$  delivered was 0.2 ft/sec. The MC4 maneuver was initiated at 041/03:43:30 GMT (01/18:29:23 MET). The maneuver was completed 7.52 sec later. The  $\Delta V$  delivered was 1.7 ft/sec.

The TCS was powered ON at 041/03:07:00 GMT (01/17:52:53 MET) at an approximate distance of 25,000 ft and commanded to Acquisition mode 2 min later. The unit began tracking the ISS at 041/03:35:00 GMT (01/18:20:53 MET) at a distance of approximately 4590 ft in the Pulse Laser mode. One minute later, the Pulse Laser handed off to the Continuous-Wave (CW) Laser in High Power.

During the rendezvous activities, the CW Laser exhibited erratic and periodic erroneous Range and R-Dot data (IFA STS-130-V-06). Analysis of the TCS data could not determine a root-cause real-time that would account for the CW failure. The Pulsed Laser's operation did not exhibit the same failure mode and was nominal during its time of operation.

Between 041/03:51 GMT (01/18:39 MET) and the R-Bar Pitch Maneuver (RPM) that occurred at 041/04:03 GMT (01/18:48 MET), the TCS unit switched back and forth between the CW Laser and the Pulsed Laser. Following the RPM, the TCS reacquired the ISS at 041/04:09 GMT (01/18:54 MET) with a distance reading of 660 ft in Pulsed mode. The CW Laser handover occurred within a few seconds, but the TCS unit continued to switch between the two lasers. The CW Laser began to maintain a solid lock on the ISS at 041/04:23 GMT (01/19:10 MET) at a distance of 320 ft. However, the range data began experiencing changes/jumps of up to 30 ft or more and the R-Dot would change/jump from nominal readings to an additional 5 ft/sec. The decision was made to leave the unit as is and proceed with docking operations using the Hand-Held LIDAR (HHL) as the primary sensor with TCS as a backup tool.

The RPM started at 041/04:00:47 GMT (01/18:46:40 MET), and ended at 041/04:09:15 GMT (01/18:55:08 MET). The peak pitch-rate during the maneuver was approximately 0.69 deg/sec. The maximum attitude excursion was in roll and reached approximately 12.2 deg. Performance was nominal. The Twice Orbital Rate V-bar Approach (TORVA) operation began at 041/04:11:54 GMT (01/18:57:47 MET). Performance was nominal.

The ODS power-up sequence was initiated at 041/04:26:10 GMT (01/19:12:03 MET). The Shuttle captured the ISS at 041/05:05:56 GMT (01/19:51:49 MET), and the Post-Contact Thrust (PCT) firing sequence was performed nominally. Ring retraction using dual motors was started at 041/05:15:06 GMT (01/20:00:59 MET). Data indicated the possibility of a stuck damper, which is a known and expected condition. After the initial stuck-damper procedure was performed, the mechanism began oscillating for several minutes. Once damped, the crew began final ring retraction.

At 1 min into final ring retraction, the ring mechanism indicated misalignment. Per procedures, a ring-drive stop command was issued to prevent any further retraction. A ring-retract command was issued again after receiving the ring alignment indication approximately 2 min later. Thirty seconds into the second retraction, the ring alignment indicated misalignment for a second time. At this point, approximately 5 minutes into the misalignment, two of the three petal sensors began to diverge. The docking system experienced a possible gravity-gradient condition for approximately 20 min, at which

time an additional 12 min of damping was required before the final 2 min of ring retraction could be performed prior to closing hooks. It was determined that there were no issues with the hardware performance, and that this condition would not impact the capability to perform undocking.

The ODS hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the Shuttle/ISS interface-seal obtained at 041/05:56:11 GMT (01/20:42:04 MET).

Following ISS capture, the Digital Autopilot (DAP) was moded to Free Drift, and remained in Free Drift through docking completion. The Vernier RCS attitude control was initiated at 041/06:02:43 GMT (01/20:48:36 MET). The Vernier RCS was used to maneuver the stack to the mated Torque Equilibrium Attitude (TEA) attitude at 041/06:11:39 GMT (01/20:57:32 MET), and again for stack-attitude control at 041/06:49:08 GMT (01/21:35:01 MET). ISS took responsibility for attitude control of the stack at 041/07:18:05 GMT (01/22:03:58 MET).

In preparation for the Station-To-Shuttle Power Transfer System (SSPTS) activation, Power Transfer Units (PTUs) -1 and -2 were activated, and Main Bus B and Main Bus C were bus-tied at 041/06:33 GMT (01/21:19 MET). Both PTUs were brought on line at 041/08:10 GMT (01/22:56 MET). All four Orbital Power Converter Units (OPCUs) and both Assembly Power Converter Units (APCUs) were on-line and providing power, which allowed the fuel cell loads to decrease.

Hatch opening took place around 041/08:15 GMT (01/23:10 MET).

The SSRMS unberthed the OBSS at 041/08:55 GMT (01/23:40 MET) and handed-off to the SRMS at 041/09:42 GMT (02/00:28 MET). The SRMS was parked in the Node 3 viewing position.

Condensate collection was initiated, and the first Contingency Water Container- Iodine (CWC-I) was filled at 041/09:21:01 GMT (02/00:06:54 MET) and the second CWC-I was filled at 041/10:05:24 GMT (02/00:51:17 MET).

Two Primary Avionics Software System (PASS) Cabin-Fire Fault Summary messages from the ISS Caution and Warning (C&W) system were annunciated in the Orbiter at 041/12:59:30 GMT (02/03:44:11 MET). Analysis of the events, along with other data-sharing issues between the ISS and the Orbiter, indicated a potential issue with an Orbiter Interface Unit (OIU) (IFA STS-130-N-01).

Following review of the FD 2 and FD 3 RPM imagery, the DAT determined that there are no requirements for a focused inspection. Three items required continued evaluation:

1. A protruding elevon flipper door-to-door sea (IFA STS-130-V-01).
2. A protruding ½-in. ceramic insert between Window 1 and 2 (IFA STS-130-I-003).

3. Failed Room Temperature Vulcanizing (RTV) material on a cracked tile repair immediately aft of Window 1 (IFA STS-130-V-03).

#### **Flight Day 4**

The main activities for FD 4 were preparations for the first EVA, and the replacement and checkout of the Distillation Assembly (DA) in the WRS.

The third CWC-I was filled at 041/23:52:00 GMT (02/14:37:53 MET), the fourth CWC-I was filled at 042/00:22:00 GMT (02/15:07:53 MET) and the fifth was filled at 042/03:39:00 GMT (02/18:24:53 MET).

The left OME GN<sub>2</sub> repressurization was initiated at 042/10:18:18 GMT (03/01:04:11 MET). The pressure was raised from 314 psia to 332 psia.

#### **Flight Day 5**

The main activities on FD 5 were the grappling, unberthing and installation of Node 3 followed by the first EVA.

The first EVA was completed satisfactorily in 6 hr 32 min, and all scheduled tasks were completed. In addition, four get-ahead tasks were also completed.

During the first EVA, the Extravehicular (EV) 1 crewmember's audio in both earphones began to degrade about 4 hr into the EVA (IFA STS-130-V-09). The condition continued through the remainder of the EVA with low audio levels, but a total loss of audio did not occur. After the EVA, a communications test was performed on both the Prime Communications Carrier Assembly (CCA), S/N 1213, and the Backup CCA, S/N 1172. The low audio level was still present in the Prime CCA, while the Backup CCA audio levels were normal.

Node 3 was unberthed using the SSRMS at 043/04:05:17 GMT (03/18:51:10 MET) and was installed on the ISS at approximately 043/06:14:49 GMT (03/21:00:42 MET). Attitude control was performed using ISS Control Moment Gyros (CMGs), with the Orbiter Vernier Reaction Control System (VRCS) ready to assume attitude control should the CMGs become saturated. The CMG momentum peaked at approximately 90.8% of capacity during the maneuver of Node 3 to the Port Hover Position.

The sixth CWC-I was filled at 043/07:31:00 GMT (03/22:16:53 MET), the seventh CWC-I was filled at 043/07:45:00 GMT (03/22:30:53 MET) and the eighth was filled at 043/07:59:00 GMT (03/22:44:53 MET).

The left OME GN<sub>2</sub> repressurization was initiated at 043/11:15:16 GMT (04/02:01:09 MET). The pressure was raised from 315 psia to 332 psia.

At 043/20:22:57 GMT (04/11:08:50 MET), supply water tank A exhibited a water tank quantity dropout from 67.5% to Off-Scale Low (OSL) (-11%) for a duration of 27 sec. This was preceded by a 1-sec quantity dropout from 67.5% to 37%. Water tank quantity dropouts occur on all the supply and waste water tanks in all three Orbiters. The time duration varies and normally lasts from 1 to 2 sec. However, longer duration dropouts have been observed in other flights. The dropout was no impact to the mission.

The DAT completed the review of all the analysis of the three items which required more evaluation and recommended clearing the Orbiter for entry which the Mission Management Team (MMT) accepted.

## **Flight Day 6**

The main activities on FD 6 included vestibule outfitting from Node 1 to Node 3, Node 3 and Cupola hatch opening, aft Intra-Module Ventilation (IMV) cap installation, and preparations for the second EVA.

The first Contingency Water Container (CWC) was filled at 044/01:12 GMT (04/15:57:53 MET).

The second fuel cell purge was performed at 044/10:06 GMT (05/00:51 MET), which was 102 hr from the fuel-cell manual purge.

The left OME GN<sub>2</sub> repressurization was initiated at 044/11:09:38 GMT (05/01:55:31 MET); pressure was raised from 315 psia to 331 psia.

## **Flight Day 7**

The main activities on FD 7 were the second EVA and Tranquility Node 3 activation activities.

The MMT, at the request of the ISS Program, made the decision to add a docked day to the mission.

The second CWC was filled at 045/04:46 GMT (05/19:32 MET).

During preparations for the second EVA, the EV 1 crewmember reported that the EMU C&W audio tones could not be heard on Communication Cap Assembly (CCA) S/N 1172. This unit was swapped out with CCA S/N 1192, which operated nominally during the EVA.

The crew successfully completed all tasks in a 5 hr 54 min EVA. The EV 2 crewmember had difficulty removing an ammonia line Quick Disconnect (QD) cap and reported a small stream of ammonia emanating from the QD once the cap was partially removed. Bake-out procedures were successful and no trace of ammonia was detected in the airlock post-EVA.



A CBM Center Disk Cover (CDC) interference with the Cupola secondary structure was evaluated for potential impacts to Cupola relocation.

## **Flight Day 8**

The main activities on FD 8 were the Cupola demating, relocation and installation, and preparation for the relocation of the Pressure Mating Assembly (PMA) 3 on FD 9.

The crew encountered an issue while unbolting the Cupola in preparation for the Cupola relocation. Two bolts appeared to be jammed, but after applying a higher torque, the bolts were successfully removed.

When the cabin N<sub>2</sub> repressurization was initiated at 045/23:43 GMT (06/14:28:53 MET), the Oxygen (O<sub>2</sub>) system regulator was not closed as required in the procedure. As a result, both N<sub>2</sub> and O<sub>2</sub> were flowing into the cabin. The N<sub>2</sub> flowed into the cabin at a nominal rate of approximately 7 lb<sub>m</sub>/hr through the 14.7 psia regulators. However, the O<sub>2</sub> was flowing into the cabin at a rate of 50 lb<sub>m</sub>/hr over approximately 4½ min. This condition resulted in approximately 3.75 lb of O<sub>2</sub> being introduced into the system. The crew was asked to terminate the repressurization. The crew then placed the Pressure Control System (PCS) into the required configuration, and the N<sub>2</sub> repressurization was completed nominally by 046/01:45 GMT (06/16:30:53 MET).

During the N<sub>2</sub> repressurization, the O<sub>2</sub> Power Reactant Storage and Distribution (PRSD) manifold-1 pressure temporarily rose to 975 psia and manifold-2 pressure indicated 950 psia. The increased O<sub>2</sub> demand from the repressurization introduced cold dense cryogenics into the warmer manifolds. The O<sub>2</sub> expanded and caused the pressure rise. This is a well documented occurrence and in-family with previous flights. The O<sub>2</sub> PRSD manifold-pressure relief-valves are specified to crack at 975 psia.

The third CWC was filled at 045/23:52 GMT (06/14:38 MET).

The cabin O<sub>2</sub> repressurization was initiated at 046/10:42 (07/01:27 MET) and terminated at 046/13:26 (07:04:11 MET).

## **Flight Day 9**

The main activities on FD 9 included Cupola vestibule outfitting, PMA 3 relocation, and OIU data-bus troubleshooting with ISS.

The fourth and fifth CWCs were filled at 047/01:37:48 GMT (07/16:22 MET) and 047/02:08:18 GMT (07/16:53 MET), respectively.

The PMA 3 installation took place at approximately 047/02:07 GMT (07/16:53 MET). Three of four latches were used for securing the PMA to the port-facing CBM on Node 3.

Troubleshooting of the OIU-to-ISS data-bus issue was successfully completed at 047/05:23:50 GMT (07/20:09:43 MET). The ISS Node 2 (N2) -2 data bus operated satisfactorily on both channels and the N2-1 data bus continued to operate satisfactorily on Channel A. As a result, the issue has been isolated to a problem on Channel B of the N2-1 data bus.

## **Flight Day 10**

The main activities on FD 10 were the third and final EVA and O<sub>2</sub> transfer.

The only Portable Water Reservoir (PWR) for the mission was filled at 048/06:04 GMT (08/20:50 MET). The sixth CWC was filled at 048/07:11 GMT (08/22:56 MET).

The third and final planned EVA began at 048/02:15:30 GMT (08/17:01:23 MET) and was completed with ingress at 048/08:03:39 GMT (08/22:49:32 MET). The duration of the EVA was 5 hr 48 min. The EVA crew successfully all but one task. The planned task of removing the P1 Flex Hose Radiator Coupler (FHRC) P-clamps was dropped from the end of the EVA due to consumables limitations on the EV1 crewmember.

The crew reported a small Micrometeoroid/Orbital Debris (MM/OD) impact on the side hatch window.

## **Flight Day 11**

The main activities on FD 11 were O<sub>2</sub> transfer and ISS reboost.

The third on-orbit fuel cell purge was initiated at 048/23:52 GMT (09/14:37:53 MET). During the 110-hour purge interval since the second purge, the approximate performance decay was 0.05 Vdc for fuel cell 1, 0.07 Vdc for fuel cell 2, and 0.10 Vdc for fuel cell 3.

The seventh CWC was completed 049/05:57 GMT (09/20:42:53 MET).

The Orbiter executed a VRCS reboost of the Orbiter-ISS mated stack. The handoff to Orbiter control occurred at 049/07:07:04 GMT (09/21:52:57 MET) and the 13-deg maneuver to the reboost-maneuver attitude began at 049/07:09:26 GMT (09/21:55:19 MET). The reboost maneuver began at 049/07:31:07 GMT (09/22:17:00 MET) and the maneuver had a duration of 33 min. The maneuver had a maximum attitude-error excursion of 0.13 deg in roll. The 15-deg maneuver back to the TEA began at 049/08:11:54 GMT (09/22:57:47 MET). The ISS CMG momentum peaked at approximately 50% after handoff to ISS CMG control. The orbit following the reboost maneuver was predicted to be 180.5 by 190.0 nmi.

At 049/07:52:29 GMT (09/22:38:22 MET) the OPCU 1A experienced a fault-isolator shutdown. The established troubleshooting procedures for this known condition were performed and the OPCU 1A was returned to nominal operation in 33 min.

The side-hatch window MM/OD impact reported by the crew on FD10 was assessed and cleared by the Windows Problem Resolution Team (PRT).

## **Flight Day 12**

The main activities of FD 12 were O<sub>2</sub> transfer tear down, rendezvous tools checkout and hatch closure.

A transfer of O<sub>2</sub> to the ISS was completed at 049/23:11 GMT (10/13:56:53 MET). Approximately 25 lb<sub>m</sub> of O<sub>2</sub> were transferred.

The eighth CWC was filled at 049/23:16 GMT (10/14:01 MET).

Starting about 050/04:20 GMT (10/19:05 MET), the Frequency Modulation (FM) -1 transmitter transmitted-power-levels began to fluctuate between 15 and 13.3 watts. This signature continued throughout the remainder of the mission. The specification for the power output is required to be between 10 to 18 watts, and the normal observed power levels are typically a more stable value. The FM-2 Transmitter output was steady. The FM-1 Transmitter continued to support nominal Data Recorder playbacks and video with good quality.

The Rendezvous Tools Checkout was successfully completed. The TCS was powered up at 050/06:23:00 GMT (10/21:08:53 MET) and passed all self-tests. The unit was allowed to remain powered through two long calibration-periods to collect engineering data. During the initial power-up, the unit annunciated an "unrecognized command ignored" message which cleared after two power cycles by the crew. The unit is considered ready for undocking except for the CW laser failure experienced during rendezvous.

The hatch between the ISS and the Orbiter was closed at 050/07:51 GMT (10/22:37 MET), and the vestibule was leak-checked successfully.

The crew reported a new MM/OD impact on window 2. The damage was assessed by the Windows PRT and was determined not to be an issue for entry.

## **Flight Day 13**

The main activities for FD 13 were the undocking, flyaround, separation, and the late inspection of the RCC surfaces.

The Orbiter took attitude control at 050/23:37:13 GMT (11/14:23:06 MET) and the maneuver-to-undock was initiated at 050/23:39:07 GMT (11/14:25:00 MET). The maneuver took approximately 29 min. Separation occurred at 051/00:53:52 GMT (11/15:39:45 MET). The flyaround began at 051/01:15:13 GMT (11/16:01:06 MET) and was completed at 051/02:01:57 GMT (11/16:47:50 MET).

The TCS was powered-on, passed self-test and locked on to the target at approximately 59 ft, which was expected using the pulse laser at short range. The unit continued to operate normally until powered off.

The Ku-Band was taken to RADAR at 051/01:56:05 GMT (11/16:41:58 MET) and locked on to the ISS at an approximate range of 579 ft. The Ku-Band was configured back to COMM at 051/02:33:42 GMT (11/17:19:35 MET) at a range of approximately 8600 ft.

The first RCS separation maneuver was initiated at 051/02:01:55 GMT (11/16:47:48 MET). The maneuver was 5.84 sec in duration and the L1A and R1A thrusters were used.

The second RCS separation maneuver was initiated at 051/02:30:59 GMT (11/17:16:52 MET). The maneuver was 10.8 sec in duration and the L1A and R1A thrusters were used.

Fuel Cell 2 sub-stack 3 failed the Cell Performance Monitoring (CPM) self-test at 051/03:50:29 GMT (11/18:36:22 MET) and continued to fail intermittently (IFA STS-130-V-07). The crew was requested to bus-tie bus B to C. The onboard System Management (SM) alert was inhibited to avoid nuisance alarms for the crew. The Fuel Cell Monitoring System (FCMS) data-takes were reviewed and showed that the FC was operating nominally. The anomaly appeared to be isolated to the CPM system.

A waste water dump was successfully completed at 051/04:08 GMT (11/18:53:53 MET) followed by completion of a condensate CWC dump at 051/04:55 GMT (11/19:40:53 MET).

The crew successfully completed the RCC late inspection survey and downlinked all of the data.

After the crew berthed the OBSS, a cylindrical object was observed floating parallel to the vehicle at 051/11:13 GMT (12/01:59 MET). The object was determined to be of no concern for entry. The crew reported a second object floating away from the Orbiter during FCS checkout. The object was determined to be of no concern for entry.

At approximately 051/11:19 GMT (12/02:05 MET), the crew reported that a MM/OD impact was identified on window 1. Analysis of the photography was completed and the condition was cleared for entry.

## **Flight Day 14**

The main activities for FD 14 were the Flight Control System (FCS) checkout and RCS hot-fire.

The FCS checkout began at 052/00:19:28 GMT (12/15:05:21 MET) and was completed at 052/00:24:52 GMT (12/15:10:45 MET). Auxiliary Power Unit (APU) 1 ran for 5 min 24 sec, and no FCS anomalies were identified.

The RCS hot-fire was initiated at 052/01:15:01 GMT (12/16:00:54 MET) and terminated at 052/01:22:50 GMT (12/16:08:43 MET). All 38 RCS thrusters were fired at least once for at least 0.240 sec per pulse. All thrusters have now been fired. No anomalies occurred.

A supply water dump using the Flash Evaporator System (FES) was initiated at 052/02:20 GMT (12/17:06 MET) and terminated at 052/07:33 GMT (12/22:19 MET). A total of 70 lb of water was dumped.

The RCS procedures for the Maui Analysis of Upper-Atmospheric Injections (MAUI) experiment were initiated at 052/08:02 GMT (12/22:48 MET) and terminated at 052/08:57 GMT (12/23:43 MET). Propellant usage for the four RCS firings was 1% more than expected.

The Ku-Band system was powered down and stowed without issue at 052/09:55 GMT (13/00:41 MET).

The RCC DAT completed the review of all imagery from the late inspection and recommended that the MMT should clear the Orbiter for entry, which was done.

### **Flight Day 15 (Entry and Landing)**

The STS-130 mission was successfully completed with a landing at Kennedy Space Center (KSC), Florida.

Both PLBDs were closed nominally by 052/23:49 GMT (13/14:35 MET) in preparation for landing.

The deorbit maneuver for the first landing opportunity at KSC, an OMS dual-engine straight-feed firing, was performed on orbit 217 at 053/02:14:47 GMT (13/17:00:40 MET) with engine cutoff at 053/02:17:22 GMT (13/17:03:15 MET). The maneuver was 154.4 sec in duration with a  $\Delta V$  of 295.4 ft/sec. The orbit after the deorbit maneuver was 23.3 by 190.3 nmi.

Entry interface occurred at 053/02:48:55 GMT (13/17:34:48 MET).

Immediately after the completion of Terminal Area Energy Management (TAEM), 053/03:14:14 GMT (13/18:00:07 MET), the PLBD Centerline Latches 13-16 System A latch microswitch toggled between on and off for several seconds. The indication ultimately remained off at 053/03:14:34 GMT (13/18:00:27 MET) (IFA STS-130-V-08). This condition did not impact the landing of the Orbiter.

The main landing gear touchdown occurred on KSC runway 15 at 053/03:20:29 GMT (13/17:59:52 MET) on February 21, 2010. The drag chute was deployed at 053/03:20:31 GMT (13/18:16:24 MET). The nose gear touchdown occurred at 053/03:20:36 GMT (13/18:06:29 MET). Drag chute jettison occurred at 053/03:21:07 GMT (13/18:07:00 MET). Wheels stop occurred at 053/03:22:00 GMT (13/18:07:53 MET). The rollout was normal in all respects.

The flight duration was 13 days 18 hr 7 min 53 sec. The last APU was shutdown 21 min 39 sec after landing.

## **PAYLOADS AND EXPERIMENTS**

### **SUMMARY**

All of the International Space Station (ISS) 20A mission objectives were successfully accomplished during this mission. All of the transfers were successfully completed.

### **LAUNCH PACKAGE OVERVIEW**

The ISS 20A launch package consisted of the Node 3 with Cupola. The Node 3, which was named *Tranquility*, is an Italian-built pressurized module and is approximately 23 ft in length and 14.8 ft. in diameter. The Node 3 carried to orbit the Cupola attached to its active Axial Port. In addition, two System/Avionics racks and three Integrated Stowage Platforms (ISPs) were also part of the payload. Node 3 has eight internal rack bays. Node 3 was outfitted on-orbit with key Regenerative Environmental Control and Life Support System (ECLSS) and crew habitability racks including the Air Revitalization System (ARS) rack, the Oxygen Generation System (OGS) rack, Waste and Hygiene Compartment (WHC), Water Recovery System Racks 1 and 2, Total Organic Carbon Analyzer (TOCA), Treadmill-2 also named the Combined Operational Load Bearing External Resistance Treadmill (COLBERT), and Advanced Resistive Exercise Device (ARED).

The Cupola is an Italian-built pressurized module containing a robotic control workstation, which will serve as the primary location for controlling the Space Station Remote Manipulator System (SSRMS). The Cupola has seven windows that will provide a 360-deg panoramic view of Earth, celestial objects and visiting spacecraft. Windows will be used to monitor outside activities including spacewalks, docking operations and external equipment surveys. The Cupola checkout and activation included removal of the Multi-Layer Insulation (MLI) from the windows during the third Extravehicular Activity (EVA) and release of the shutter launch locks.

The Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX), Shuttle Exhaust Ion Turbulence Experiment (SEITE), Ram Burn Observations-2 (RAMBO-2) and Maui Analysis of Upper-Atmospheric Injections (MAUI) were flown as payloads of opportunity.

The ISS non-powered middeck payloads with science conducted during the docked mission on the middeck was the National Lab Pathfinder (NLP) Vaccine-7. For the first time the Commercial Generic Bioprocessing Apparatus (CGBA)-4 was swapped with the CGBA-6.

The powered middeck ISS Program Utilization payloads were General Laboratory Active Cryogenic on ISS Experiment Refrigeration (GLACIER) rear-breather double locker. For ascent, the GLACIER samples were Japan Aerospace Exploration Agency

(JAXA) Nanoskeleton while the return samples were NASA Human Research Program (HRP) Nutrition/Repository/Bisphosphonates Blood and Urine, APEX Cambium, and the JAXA CERISE.

The ascent and descent middeck Short Duration Bioastronautics Investigations (SDBIs) performed during the mission included HRP ISS Sleep Short (SDBI 1634) and ISS Integrated Immune (SDBI 1900).

## **CREW ACTIVITY SUMMARY**

A successful rendezvous and docking to the ISS occurred on Flight Day (FD) 3, February 9, 2010 at 11:06 p.m. Central Standard Time (CST) [01/19:52 Mission Elapsed Time (MET)]. The ISS/Orbiter stack mass on-orbit totaled 1,010,380 lb<sub>m</sub>.

Prior to docking the Orbiter R-bar Pitch Maneuver (RPM) was performed and the ISS crew performed photographic imagery of the Orbiter. Analysis of FD 2 TPS inspection and RPM photographs indicated that a focused inspection was not required. On FD 5, the Space Station Remote Manipulator System (SSRMS) unberthed the Node 3 with Cupola from the Payload Bay (PLB) and successfully berthed Node 3 to the ISS in the Node 1 Port location. On FD 8, the Cupola was relocated from the Node 3 Axial Port to Node 3 Nadir Port with the SSRMS. On FD 9, the Pressurized Mating Adapter (PMA) 3 was relocated from the Node 1 Zenith to the Node 3 Port CBM with the SSRMS. During the docked timeframe, the crew performed three scheduled EVAs, Node 3 and Cupola Intravehicular Activities (IVAs), Public Affairs Office (PAO) events, and middeck/consumables transfer operations.

The ISS reboost was performed by the Orbiter Reaction Control System (RCS) on FD 12 and the Differential Velocity ( $\Delta V$ ) was 3.9 ft/sec, which raised the ISS approximately 1 nmi.

The Cupola Ribbon-Cutting Ceremony was conducted on FD 12 with the Shuttle and ISS crew. The ceremony noted the historical significance of the Cupola and the completion of ISS assembly. Also, the Apollo-Everest Display was transferred from the Shuttle and relocated to the Cupola during the Cupola ribbon-cutting ceremony on FD 12. The plaque contained four Apollo 11 lunar samples and a rock sample from Mt. Everest. The 7.25-in. length by 9.5-in. width by 1.5-in. depth plaque will remain on ISS as a memorial to exploration of Apollo and Mount Everest.

*Endeavour* undocked from the ISS at the beginning of the crew day on FD 13, February 19, 2010 at 6:54 p.m. CST (11/15:40 MET). The ISS flyaround was performed using the High Definition Camera System with live video downlink. On FD 13, the Orbiter Boom Sensor System (OBSS) was used to inspect the port and starboard Wing Leading Edge (WLE) and Nose-cap for Micrometeoroid/Orbital Debris (MM/OD) damage; no damage was discovered. The vehicle was cleared for entry based on the evaluation of the OBSS late inspection data.



The MAUI data-take was attempted on FD 14 at the Air Force Maui Optical and Supercomputing Site (AMOS) ground-site by the Orbiter performing four Primary Reaction Control System (PRCS) firings for 83 sec.

## TRANSFER WEIGHT SUMMARY

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

### TOTAL WEIGHT TRANSFERRED DURING THE MISSION

Parameter	To ISS, lb <sub>m</sub>	From ISS, lb <sub>m</sub>
Cargo Bay	33,382	0
Middeck	1989	1829
<b>Totals</b>	<b>35,371</b>	<b>1829</b>

1. **Water** – A total of 1095 lb<sub>m</sub> was transferred
2. **Oxygen** – Oxygen tank-to-tank transfer was approximately 24 lb<sub>m</sub>.
3. **Nitrogen** – None
4. **Lithium Hydroxide (LiOH)** – A total of 13 used canisters were transferred from the ISS to the Orbiter and 14 new canisters were transferred from the Orbiter to the ISS
5. **Food** – Less than an MLE of food was transferred from the middeck
6. **Power** – The Station-to-Shuttle Power Transfer System (SSPTS) provided 1490.5 kWh to the Orbiter.

## SIGNIFICANT FIRSTS

The significant firsts for the STS-130 mission were as follows:

1. The Node 3 and Cupola were provided by Italy through the European Space Agency (ESA). The two items were the last pressurized elements to be taken to the ISS.
2. Multifunction Electronic Display System Integrated Display Processor software update.
3. Implemented friction stir weld on External Tank (ET) Liquid Oxygen (LO<sub>2</sub>) and Liquid Hydrogen (LH<sub>2</sub>) tank barrel longitudinal wells.
4. Replaced fluorocarbon O-rings and improved resiliency fluorocarbon O-rings in nozzle joint no. 1
5. The Commercial Generic Bioprocessing Apparatus (CGBA) -4 was exchanged with CGBA-6.

## SIGNIFICANT ISS ANOMALIES/PROBLEMS

No significant ISS anomalies occurred during the docked period; however, the following significant problems occurred during docked operations.

The Vozdukh experienced an unexpected shutdown on FD 8. On FD 9 specialists, the crew was asked to verify the Vozdukh Vacuum Valve Group [EBK] 1 valve positions and restart the Vozdukh. During start-up, EBK-1 valves exhibited the same issue of not reaching the expected position, and the Vozdukh was shut down. Troubleshooting confirmed the [EBK] 1 failure, and a replacement activity was completed on FD 10 during a Russian ground-station pass. The Carbon Dioxide (CO<sub>2</sub>) profile returned to the mission predictions.

The Columbus Module data management system failed overnight on FD 12 resulting in loss of non-vital communications with the Columbus module. The ground controllers were still able to see all vital command data except for ammonia detection which the crew was considered prime for detection. Troubleshooting procedures will continue post-undock.

## MAJOR ISS MISSION PRIORITIES AND END-OF-MISSION STATUS

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

### ISS MISSION PRIORITIES COMPLETION STATUS

Prior-ity	Task	Flight Day Task Completed
<b>Category 1-Primary Flight Objectives, Mandatory for Flight</b>		
1	Dock Shuttle Flight 20A to Pressurized Mating Adapter (PMA)-2 and perform mandatory crew safety briefing for all crewmembers.	IVA/Imagery √ FD3
2	Perform mandatory water transfers.	IVA √ FD4-FD12
3	Transfer and stow critical items to ISS per 20A TPL.	IVA √ FD3-FD4

### ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
4	Install Node 3 to Node 1 Port CBM using SSRMS. a. Remove Node 3 PCBM contamination covers (8) and inspect Node 3 PCBM. (Imagery) b. Disconnect Node 3 to Orbiter Space Station Power Distribution Unit (SPDU) LTA heater cables. c. Perform high level inspection of Node 1 port CBM (Imagery) d. Remove Node 3 from Orbiter PLB and install on Node 1 port CBM. (Imagery) 1. Perform photo-imagery of Node 3/Port Heat Rejection System (HRS) radiator after Node 3 installation (Robotics) (Imagery) e. Remove and stow P1 (A/L supplementary power) Connect P612 and P602 (Node 3 LTA heater cables) to Node 1 and activate heaters (Note: These are not the same LTA cables used in the Orbiter). (EVA) (Imagery)	√ FD5/EV1           √ FD6
<b>Category 2-Secondary Objectives – Very Highly Desirable</b>		
5	Connect Node 3 internal and external avionics and ammonia jumpers. a. Install 1553 bus terminator (P104) on Node 3 (J104). (EVA) (Imagery) b. Install the P1-FGB and P2-FGB terminators and thermal booties. (EVA) (Imagery) c. Complete Node 1 to Node 3 Vestibule Outfitting (IVA) (Imagery) 1. Remove 4 Node 1 port ACBM controller assemblies. 2. Install 7 wire harnesses (1553 A/station LAN, 1553B, MSS video, MSS BCP, UHF coax, video/audio bus A, audio bus B). 3. Install fuel cell and waste water hose assembly, ARS, MTL supply and return jumpers. d. Complete mating of Node 1 relocation mod kit hoses/wire harnesses (1553A and B, UHF coax, O2 and N2).(IVA) e. Complete routing and mate S0 to Node 3 avionics umbilicals (8 connectors). (EVA) f. Connect/install U.S. Lab to Node 3 ammonia jumpers (4) with thermal shrouds. (EVA) 1. Install EVA gap spanners (Qty 5) to manage jumper routing. 2. Perform photo-imagery of routed jumpers. (Imagery) g. Install (Qty 4) Node 3 trunnion and one keel pin covers. (EVA) (Imagery)	√ FD5, EV1  √ FD5, EV1  √ FD6 √ FD6 (part)  √ FD6  √ FD6  √ FD5, EV1  √ FD7, EV2  √ FD7, EV2

## ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
6	Activate and checkout Node 3. a. Activate Node 3 systems. (IVA) b. Deactivate Node 3 LTA heaters. c. Ingress Node 3. (Imagery) d. Install 1 Portable Fire Extinguisher (PFE) and 2 Portable Breathing Apparatus (PBA) in Node 3. (Imagery) e. Install Node 3 Zenith CBM IMV caps (2). f. Enable emergency lighting power supply (ELPS). g. Install O2 and N2 hose assemblies in Node 1/Node 3 vestibules and purge Node 3 O2 and N2 lines. (Imagery) h. Remove Node 3 starboard NPRVs (2) and replace with Intra Module Ventilation (IMV)s (2). (Imagery) i. Install Node 1/Node 3 IMV vestibule jumpers and silencers (2). (Imagery) j. Remove starboard PPRV and replace with MPEV. (Imagery) k. Install Cap on Aft and Nadir PPRVs. (Imagery) l. Inspect Aft NPRVs. (Imagery)	√ FD7(part) √ FD7 √ FD6 √ FD6  √ FD7  √ FD7(part)  √ FD7  √ FD6
7	Support ISS dual docked operations for the following visiting vehicles if required. a. 20 Soyuz undocking from Multipurpose Research Module 2 (MRM-2). b. 22 Soyuz docking to MRM-2.	N/A for February Launch
8	Relocate the Cupola from Node 3 port CBM and install on Node 3 Nadir CBM. a. Open Node 3 port hatch and install IMV Caps on Internal and External Node 3 Port Aft IMV interface. (Imagery) (IVA) b. Install CBCS in Node 3 nadir CBM. (Imagery) (IVA) c. Open Node 3 Nadir ACBM Center Disk Cover Flap. (Imagery) (EVA) d. Remove Node 1 Port CBM center disk cover and install on Node 3 Port CBM. (Imagery) (IVA) e. Close Node 3 port hatch and depressurize the Cupola. (IVA) f. Release Node 3 nadir ACBM petal restraints. (EVA) g. Perform high level inspection of Node 3 nadir CBM. (SSRMS) (Imagery) (IVA) h. Perform high level inspection of Cupola CBM. (Imagery) (IVA) i. Remove Cupola from Node 3 Port CBM and install on Node 3 nadir CBM. (SSRMS) (Imagery)	√ FD8  √ FD8 √ FD5/EVA1  √ FD6 (part)  √ FD8 √ FD7 √ FD7  √ FD8 √ FD8
9	Install, activate and checkout the Water Recovery System (WRS) Distillation Assembly (DA), Fluids Control and Pump Assembly (FCPA), Water Processor Assembly (WPA) External Filter Assembly (EFA), and Recycle Filter Tank Assembly (RFTA). a. Collect samples (qty. 2) of Waste Water Tank. (IVA) via Chit 8254.	√ FD4-5/IVA
10	Transfer remaining cargo items per Flight 20A TPL. (IVA) a. Install and return Radiation Area Monitors (RAM)s.	√ FD4-12/IVA

## ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
11	Relocate PMA-3 from Node 2 Zenith to Node 3 Port. (SSRMS) (Imagery) a. Perform high level inspection of Node 3 Port CBM. (IVA) (Imagery) b. Perform high level inspection of PMA3 CBM.(IVA) (Imagery) c. c. Perform photo-imagery of PMA3/Port HRS radiator clearance. (SSRMS) (Imagery)	√ FD9
12	Activate and checkout the Cupola. (IVA)(Imagery) a. Pressurize the Cupola and open Node 3 Nadir hatch. b. Remove four Node 3 Nadir ACBM controller assemblies. (Imagery) c. Remove Cupola PCBM MLI and CBCS target. (Imagery) d. Connect Cupola utilities (EPS and avionics jumpers). (Imagery) e. Activate Cupola heaters. f. Connect and fill Node 3/Cupola ITCS lines and configure Node 3 ITCS lines to support Cupola.	√ FD8- 11
<b>Category 3 Flight Objectives – Highly Desirable</b>		
13	Perform daily ISS payload status checks as required. (IVA) a. GLACIER	√
14	The following tasks are deemed to fit within the existing EVA timelines; however, may be deferred if the EVA is behind schedule. The EVA will not be extended to complete these tasks. (EVA)(Imagery) a. Remove Cupola thermal cover. b. Release Cupola shutter launch locks. c. Connect PMA3 heater power (P602/W1103) and (P601/W1301) umbilicals, cap and tie-down additional cables (P608/W1101 and P603/W1201). d. Disconnect Node 3 LTA cable from Node 1 and reconnect the A/L supplementary power (J612 connector) after Node 3 activation. e. Relocate APFR from LAB WIF 4 to STBD A/L toolbox WIF (Required for 19A). f. Remove SPDM ORU Temporary Platform (OTP) and temporary stow on S0 HAB tray in preparation for ULF4. g. Install Video Signal Converter (VSC) Video Fiber Optic Cable, route on FGB/PMA1/Node1/S0 and mate to S0 Video Switching Unit (VSU) connector (preposition for ULF4 Stage). h. Install Node 3 ACS non propulsive vent. i. Install Gap Spanners (3) to provide translation paths between Node 1 and Node 3, U.S. Lab and Node 3, and Node 3 handrails. j. Install Node 3 Worksite Interfaces (3) and remaining EVA On-Orbit Installable Handrails (14).	√ FD10/EVA3 √ FD10/EVA3 √ FD10/EVA3 √ FD10/EVA3 √ FD10/EVA3 √ FD5/EVA1 √ FD10/EVA3 √ FD7/EVA2 √ FD5/EVA1 √ FD7/EVA2 √ FD7/EVA2
15	Perform daily middeck activities to support payloads (including cases where Shuttle crew also performs payload activities on the ISS)	√ IVA

## ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
16	Transfer, install, activate, and checkout the following Node 3 racks. (IVA) (Imagery) a. Advanced Resistive Exercise Device (ARED) from NOD102 to NOD302. b. Air Revitalization System (ARS) from JPM1F3 to NOD3A4.	√ FD 7 √ FD6
17	Perform the following Regenerative ECLSS Rack transfers, installations, activations, and checkouts if time permits. (IVA) (Imagery) a. Water Recovery System (WRS)#1 from LAB1D4 to NOD3D5 b. WRS#2 from LAB1P4 to NOD3D4. 1. Temporarily mount and ground Total Organic Carbon Analyzer (TOCA) to JPM/JLP location if time does not permit transfer to Node 3 during docked operations. c. Waste and Hygiene Compartment (WHC) from LAB1P2 to NOD3F4. 1. Perform Node 3 urine bus fill. 2. Perform Node 3 fuel cell water bus fill and connection to ISS bus in Node 1. d. Oxygen Generation System (OGS) from LAB1P1 to NOD3A5.	IVA Imagery √FD 11 √FD 11  √FD 11  √FD 11
17.5	Perform photo-imagery of the 2A Solar Array Mast. (IVA) (Imagery)	√FD 4 & FD11
18	Remove Integrated Stowage Platforms (ISPs) from Node 3. a. Remove cargo from NOD3D5 ISP and temporarily stow ISP for return on 19A. b. Remove cargo from NOD3D4 ISP and temporarily stow ISP for return on 19A. c. Remove cargo from NOD3F5 ISP.	√ FD7
19	Perform ISS payload research operations tasks.	√ Daily
20	Perform the following Node 3 outfitting tasks. (IVA) (Imagery) a. Open Node 3 starboard ARS manual valve to allow LAB ARS sampling of Node 3. b. Install ITCS sample tools (2) in Node 3 starboard endcone, perform sampling, and return sample for ground assessment. c. Release avionics rack launch restraints, install Knee Brace Attachment Replacements (K-BARs) and Pivot Fittings on Avionics Rack 1. d. Install hyzod covers on the Node 3 starboard hatch external window and Node 3 aft, port, starboard, nadir, zenith and forward hatch internal windows. e. Deploy (1) Station Support Computer (SSC) in Node 3 (including installing hardware and power supply). f. Fill Node 3 to Node 1 MTL lines and configure Node 3 ITCS lines to support Airlock MTL. (Partial completion)	√ FD 6-10

## ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
20 Cont'd	<ul style="list-style-type: none"> <li>g. Remove Node 3 Common Cabin Air Assembly (CCAA) Anti-Vibration Module (AVM) launch brackets (4). (Need post undock pictures to confirm completion of task)</li> <li>h. Remove MTL and LT Pump Package Assemblies Anti-Vibration Module (AVM) launch brackets. (Partial completion)</li> <li>i. Remove closeout panel launch bolts (&gt; 700 bolts) and launch structures.</li> <li>j. Install hatch latch handle guide assemblies (2) on Node 3 starboard and nadir. (Partial completion)</li> <li>k. Install Quick Disconnect (QD) plug on the Node 3 Major Constituent Analyzer (MCA) Vacuum Jumper.</li> </ul>	√ FD 6-10
21	Perform Cupola outfitting tasks. <ul style="list-style-type: none"> <li>a. Install Cupola Audio Terminal Unit (ATU) and Utility Outlet Panel (UOP) (2).</li> <li>b. Configure Cupola Secondary Structure Corner and Curtain Panels (qty 4 each) in the on-orbit configuration. (Interference delayed to stage operations on one panel)</li> </ul>	√ FD10  Began FD 10
22	Transfer O <sub>2</sub> from the Orbiter to the ISS High Pressure Gas Tank (HPGT). 24 lbm transferred	√ FD10-11
23	Perform the following high priority research get-ahead tasks accelerated from the 20A stage. (IVA)	√ Daily
24	Perform ISS Russian Segment tasks.(IVA)	√ Daily
25	Perform ISS RS high priority payload operations. (IVA)	√ Daily
<b>Category 4 Flight Objectives – Desirable</b>		
26	Perform Program-approved EVA get-ahead tasks. The following EVA get-ahead tasks do not fit in the existing EVA timelines; however, the EVA team will be trained and ready to perform should the opportunity arise. EVA/MOD has the flexibility to select the tasks to be completed based on efficiencies gained in performing the already scheduled required tasks. (EVA) <ul style="list-style-type: none"> <li>a. Install gap spanner between ESP2 and Lab (for 19A).</li> <li>b. Relocate APFR#4 Tool Stanchion (TS) from Z1WIF10 to A/L WIF 09.</li> <li>c. Retrieve APFR #4 from Z1WIF10, remove heat shield (IVA), and reinstall on STBD CETA WIF 04. (IVA) (EVA)</li> <li>d. Release S1 Flex Hose Rotary Coupler (FHRC) P-clamps (10/12 P-clamps).</li> <li>e. Release P1 FHRC P-clamps.</li> <li>f. Close P1 Radiator Beam Valve Module (RBVM) Thermal Booties.</li> <li>g. Close Node 2 Zenith CBCS flap</li> </ul>	√FD10/EVA3 √FD10/EVA3  Defer  Defer  Defer Defer √FD10/EVA3
27	Reboost the ISS with the Orbiter if mission resources allow and are consistent with ISS trajectory analysis and planning. (IVA)	√FD11
28	Perform imagery survey of ISS exterior during Orbiter flyaround after undocking. (IVA)	√ FD 12

## ISS MISSION PRIORITIES COMPLETION STATUS (Continued)

Priority.	Task	Flight Day Task Completed
29	Perform payload of opportunity operations to support RAMBO-2, SIMPLEX, MAUI and SEITE. Defer for SIMPLEX, SEITE, and RAMBO-2. FD14 for MAUI. (IVA) (Ground)	√ FD 14
30	<p>Perform Program-approved IVA get-ahead tasks. The following IVA get-ahead tasks do not fit in the existing IVA timelines; however, the increment crew will have the option to perform them should the opportunity arise.</p> <ul style="list-style-type: none"> <li>a. Perform the following additional high priority research get-ahead tasks accelerated from the 20A Stage. <ul style="list-style-type: none"> <li>1. Surface, Water and Air Bio-characterization (SWAB) sampling</li> <li>2. Columbus' Fluid Sciences Laboratory (FSL) handle repair (cargo on 36P).</li> <li>3. Columbus' FSL Video Monitoring Unit (VMU) hardware update (cargo on 36P).</li> </ul> </li> <li>b. Perform Cupola window shutter functional test (Imagery).</li> <li>c. Re-pressurize PMA3.</li> <li>d. Ingress PMA3 and stow cargo.</li> <li>e. Unpack 20A middeck and ISP cargo.</li> <li>f. Temporarily stow NOD3F5 ISP for return on 19A.</li> <li>g. Install JAXA CGSE valve unit. (Imagery)</li> <li>h. Install and checkout the Gateway MAC Address Converter Unit (Imagery)</li> <li>i. Destow and assemble the JEM Airlock Vacuum Pump and Driver. (Imagery) <ul style="list-style-type: none"> <li>1. Check out the JEM airlock.</li> </ul> </li> <li>j. Install Carbon Dioxide Removal Assembly (CDRA) bed in NOD3A4 ARS rack.</li> <li>k. Install soft dummy panel in JPM1F3 rack bay after ARS rack removal.</li> <li>l. Modify and install new Portable Water Dispenser (PWD) Beverage Adapter.</li> <li>m. Remove and replace Major Constituent Analyzer (MCA) in Node 3 ARS rack JPM1A5.</li> <li>n. Relocate Zero Stowage Rack (ZSR) from JPM1A1 to JPM1A5. <ul style="list-style-type: none"> <li>1. Perform ROBOT configuration.</li> </ul> </li> <li>o. Install CBCS in Node 2 nadir CBM (for 19A MPLM).</li> <li>p. Install UOPs at LAB1P5 and LAB1S5.</li> </ul>	<ul style="list-style-type: none"> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">√FD8</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> <li style="text-align: right;">Defer</li> </ul>
31	Relocate the Special Purpose Dexterous Manipulator (SPDM) to the Lab PDGF (19A get ahead that should be completed only if time permits). (Ground)	N/A (removed pre-flight)
32	Perform Station Development Test Objective (SDTO) 13005-U, ISS Structural Life Validation and Extension, during Node 3/Cupola and PMA3 berthing events (ISS Wireless Instrumentation System (IWIS) required). (IVA) (Ground)	√ FD 5, 8, 9



## ISS MISSION PRIORITIES COMPLETION STATUS (Concluded)

Priority.	Task	Flight Day Task Completed
33	Perform Station Development Test Objective (SDTO) 13005-U, ISS Structural Life Validation and Extension, during Shuttle mated reboost, IWIS required. (IVA) (Ground)	√ FD 11
34	Perform SDTO-13005-U, ISS Structural Life Validation and Extension, during 20A Orbiter undocking (IWIS highly desired, but not required) (only if crew time available). (IVA) (Ground)	√ FD 13

## DETAILED TEST OBJECTIVES

### DTO 805 CROSSWIND LANDING PERFORMANCE

The forecasted crosswinds did not meet the criteria of crosswinds greater than 10 knots so the Development Test Objective (DTO) was not attempted during landing.

### DTO 900 SOLID ROCKET BOOSTER THRUST OSCILLATION

Pressure data was recorded with hardware located on the top of the solid rocket motors inside the forward skirt. These data will allow future exploration-initiative engineers to determine the accelerations and loads that are transferred through the structure due to pressure oscillation forces. The data are downloaded after the boosters are recovered.

## DETAILED SUPPLEMENTARY OBJECTIVES

No Detailed Supplementary Objectives (DSOs) were assigned to the STS-130 Mission.

## **VEHICLE PERFORMANCE**

### **LAUNCH DELAY**

The first launch attempt on February 7, 2009, was scrubbed because of unfavorable range weather and Return to Launch Site (RTLIS) weather.

### **NATURAL ENVIRONMENTS**

The T-0 (instantaneous) surface conditions (based on measurements at the 60 foot level of Camera Site 6) were as follows; wind speed was 11 knots, wind direction was 323 deg, temperature was 51 °F, humidity was 73% and ambient pressure was 30.03 inches Hg (pressure measured at Camera Site 3).

The I-loads were designed with the L-3:35 Jimsphere due to a large shear feature near 30,000 ft. Based on the L-2:20 Day-of-Launch I-Load Update (DOLILU) assessment profile, no exceedances of the February 90<sup>th</sup> percentile database limits for the in-plane or out-of-plane components were noted. The maximum measured wind velocity was 243.7 ft/sec at 33,000 ft and 268 deg. There were no wind shear exceedances. However, the maximum shear from this balloon was 98.6% of the design shear. Due to this large shear, a last DOLILU assessment was run using the L-1:25 high resolution balloon. The maximum shear from the L-1:25 balloon was 97.0% of the design shear.

There were no violations of the in-plane or out-of-plane wind change redlines from the L-3:35 DOLILU I-Load design wind profile to the final assessments based on the L-2:20 Jimsphere balloon and the 0845 Universal Time Code (UTC) 50 MHz Doppler Radar Wind Profiler (DRWP).

The L-1:08 Jimsphere balloon was used to clear the roll maneuver region and was validated with the 0746 UTC False Cape 915 MHz profiler. The maximum measured wind velocity in the roll maneuver region was 32 ft/sec at 7400 ft and 288 deg.

### **FINAL INSPECTION**

The entire tank was dry and free of condensate, with frost observed on the Liquid Oxygen (LO<sub>2</sub>) and Liquid Hydrogen (LH<sub>2</sub>) Tank acreage and the Intertank (IT) fasteners. Surface temperatures ranged from 27 °F to 48 °F. Bondline frost was noted on the LO<sub>2</sub> and LH<sub>2</sub> Ice Frost Ramps (IFRs). Typical IT stringer valley cracks were noted. Small frost spots were observed on the LO<sub>2</sub>/IT flange closeout and on the +Y longeron outboard face. The LO<sub>2</sub> Feedline brackets exhibited typical ice/frost formations at the bracket base to tank fitting interface. Light ice-frost was noted on metal/Super Light Ablator (SLA) area of brackets and around the inboard struts. Small frost spots were observed on the aft face of Xt 1377 and Xt 1623 base fitting ramps. Light ice/frost was noted on the aft interface hardware. A typical crack was observed on the vertical strut

cable tray -Y side (8-in. by 0.25-in. with no offset). All observations were acceptable per NSTS documentation.

While on the 255-ft level of the Fixed Service Structure (FSS) conducting the final inspection for the first launch attempt, an Ice Detection Unit used by the Final Inspection Team (FIT) experienced an anomaly that caused the 4-in. by 5-in. by 0.125-in. glass screen to blow outward spreading glass debris. Pieces of glass were scattered to multiple FSS levels as well as the Mobile Launch Platform (MLP). The anomaly resulted in an Interim Problem Report (IPR). The FIT retrieved a portion of the liberated glass prior to the weather-scrubbed launch attempt. A subsequent inspection the following day retrieved additional pieces of glass. The largest retrieved piece of glass was 1.875-in. by 0.375-in. by 0.125-in. and weighed 0.0079 lb<sub>m</sub>. The IPR closure and waiver rationale was based on an assessment that the risk from the retrieved and un-retrieved glass pieces was bound by previously accepted transport analysis of rust particles up to 0.014 lb<sub>m</sub>. The Orbiter Project also presented the results of an analysis that showed that the Orbiter Reinforced Carbon-Carbon (RCC) and Thermal Protection System (TPS) were damage-tolerant to the predicted glass pieces.

## **REUSABLE SOLID ROCKET BOOSTERS**

All Reusable Solid Rocket Booster (RSRB) systems performed as expected during the launch-countdown and ascent of the STS-130 mission. No RSRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred during the launch countdown. Likewise, no RSRB IPRs occurred during the countdown and launch. One In-Flight Anomaly (IFA) was identified and is discussed in a later paragraph.

There was no indication of hold-down stud hang-up based on preliminary analysis.

Both RSRBs successfully separated from the ET and reports from the recovery area indicated that the deceleration subsystem performed as designed. The RSRBs were returned to Kennedy Space Center (KSC) for inspection, disassembly and preparations for refurbishment.

There was one significant first flight/ground process change for the RSRB (gaseous Nitrogen (GN<sub>2</sub>) purge probe and Range Safety System (RSS) cable-foam applications. The change resulted in both improved visual and physical inspection of foam clearance at the probe and cable interface. This action was in response to the STS-129 IFA.

When the SRBs were powered up, the Fuel Isolation Valve (FIV) Closed Position Indicator was reading OFF and it should have read ON (IFA STS-130-B-001). The FIV was cycled about 50 min after SRB Power Up as an attempt to correct the indicator state and perform the Resistance and Frequency BITE test, which was unsuccessful. Later in the countdown, the FIV was cycled and initially the Closed Position Indicator toggled to OFF once and then back to ON where it remained for the rest of the countdown. The Closed Position Indicator performed nominally for Auxiliary Power

Unit (APU) startup and throughout ascent. More detail on this IFA is available in Appendix B.

## **REUSABLE SOLID ROCKET MOTORS**

The STS-130 Reusable Solid Rocket Motor (RSRM) set performed nominally within established and predicted limits.

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 flex bearing temperatures within the required LCC ranges.

No RSRM LCC or OMRSD violations occurred during the launch countdown. No IFAs were identified during lift-off and ascent.

There was one RSRM first-flight design change in which a low-temperature O-ring was used in Nozzle-Joint 1. This same O-ring has been previously flown in RSRM case-field joints since STS-125 and other nozzle-joint locations since STS-126.

## **EXTERNAL TANK**

All External Tank (ET) systems performed as expected during launch countdown and ascent. The ET pre-launch countdown was nominal. No ET LCC or OMRSD violations occurred during the launch countdown. One IFA was identified during lift-off and ascent, and no IPRs were documented during the launch countdown.

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

ET separation was nominal. The impact point of the ET was 37.192 deg South and 159.603 deg West, which was approximately 58 nmi up-range from the predicted impact point.

Post-flight review identified two foam losses on the +Z side of the Intertank NCFI 24-124 Acreage as well as 19 foam losses on the -Z side of the Intertank NCFI 24-124 Acreage. Two of these losses violated the NSTS 60559 Risk Assessment Masses for Void differential pressure in the Intertank (IFA STS-130-T-001). More detail on this IFA is available in Appendix B.

## **SPACE SHUTTLE MAIN ENGINES**

All Space Shuttle Main Engine (SSME) systems performed as expected during the launch countdown, and the ascent performance was typical of previous flights. The SSME pre-launch countdown was nominal. No LCC or OMRSD violations were identified during the pre-launch and lift-off operations.

Engine "Ready" was achieved at the proper time, and thrust build up was nominal. The flight data indicates nominal SSME performance during startup, mainstage, throttling, and shutdown.

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

The commanded Max Q throttle down was a single-step throttle bucket to 74% Rated Power Level (RPL) (Adaptive Guidance Throttle (AGT) was activated).

Propellant dump operations data appeared normal and Main Engine Cutoff (MECO) time was Engine Start + 509 sec.

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

## **SHUTTLE RANGE SAFETY SYSTEM**

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

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

## ORBITER SYSTEMS

### Main Propulsion System

All Main Propulsion System (MPS) systems performed as expected during the STS-130 launch countdown and ascent. All LH<sub>2</sub> and LO<sub>2</sub> loading parameters were nominal. No MPS LCC or OMRSD violations occurred. Also, no MPS related IPRs occurred during the launch countdown.

All LO<sub>2</sub> and LH<sub>2</sub> fill-and-drain valves performed nominally. The LO<sub>2</sub> and LH<sub>2</sub> ECO sensors passed all pre-flight checkouts and operated nominally through ascent.

The LH<sub>2</sub> pre-pressurization cycle count was 11 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 overall Gaseous Hydrogen (GH<sub>2</sub>) system in-flight performance was nominal. All three FCVs performed nominally with 8 cycles on FCV no. 1, 5 cycles on FCV no. 2 and 13 cycles on 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 ET ullage pressure measurements.

One File IX requirement was not satisfied during the post-MECO MPS reconfiguration of the SSME Helium (He) E2 A and B regulators. Depending on the order that the engine controllers are shutdown, the decay signature of the He regulators drops suddenly, which is not indicative of a hardware anomaly. Extrapolation of the decay rate of the regulators shows no excessive leakage or blockage in the system. Additionally, post-landing checks of these regulators showed nominal performance.

### Hazardous Gas Concentrations

The aft hazardous gas concentrations during loading were nominal. The following table summarizes the results.

#### HAZARD GAS CONCENTRATIONS AT LAUNCH

Parameter	Peak, ppm	Steady State, ppm
Helium	9000	6500
Hydrogen	181	21
Oxygen	27	10
LD54/55	0	0

## Gas Sample Analysis

The redesigned gas sampler system successfully captured five of the six samples. One measured pressure was below the range of acceptable pressures. A summary of bottle pressure and gas concentration for STS-130 is given in the following table.

### SUMMARY OF BOTTLE PRESSURES AND GAS CONCENTRATION

Bottle No.	Position	Pressure, psia	Helium, %	Measured Oxygen, %	Hydrogen, %
1	RH 1	2.35	0.34	3.23	0.02
2	LH 1	1.64	0.36	3.03	0.03
3	RH 2	1.39	0.60	3.18	0.05
4	LH 2	0.79	0.54	3.67	0.07
5	LH 3	0.18	0.83	2.09	0.26
6	RH 3	0.06	6.10	0.77	0.51

The aft Hydrogen (H<sub>2</sub>) concentration peaked at approximately 182 ppm during fast fill and returned to approximately 21 ppm. The aft Oxygen (O<sub>2</sub>) concentration peaked at approximately 30 ppm during loading and returned to approximately 7 ppm after loading. The Helium concentration peaked at approximately 8,800 ppm during the initial ET loading of LH<sub>2</sub>.

The Ascent Hazard Analysis indicates the maximum hydrogen firing leak rate was 1,250 scim. The maximum allowable firing leak rate on ascent is 57,000 scim. The estimated firing leak rates for all sample bottle data from this flight are summarized in the following table

### HYDROGEN FIRING LEAK RATES

Bottle no.	Position	Hydrogen Firing Leak Rate, scim
1	RH 1	740
2	LH 1	840
3	RH 2	1,250
4	LH 2	1,170
5	LH 3	1,250
6	RH 3	930

The first bottle in the sequence, Right Hand (RH) no. 1, was approximately 40 torr low with a reading of 121.6 torr and the minimum is 161.81 torr. The highest oxygen concentration was 3.67% in the Left Hand (LH) no. 2 bottle. All O<sub>2</sub> concentrations were below the flammability limit. The presence of Argon in the samples indicates air was the source of the O<sub>2</sub>. The highest estimated H<sub>2</sub> system leak was 1,250 scim in RH no. 2 and LH no 3 bottles. All H<sub>2</sub> leak rates were well below the flammability limit. The Helium concentrations were nominal.

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

### **AFT FUSELAGE SAMPLE BOTTLE GAS ANALYSIS**

S/N	Position	Actual pressure, torr	Ar, %	Air from Ar, %	He, %	CO, %	CH <sub>4</sub> , %	CO <sub>2</sub> , %	O <sub>2</sub> from air, %	O <sub>2</sub> found, %	H <sub>2</sub> , %	H <sub>2</sub> pyro corrected, %
1113 FLT-1	RH1	121.6	0.13	13.81	0.34	<0.01	0.01	<DL <sub>a</sub>	2.90	3.23	0.02	0.02
1106 FLT-1	LH1	84.9	0.12	13.28	0.36	<0.01	<0.01	<DL	2.79	3.03	0.03	0.03
1123 FLT-1	RH2	71.7	0.13	13.49	0.60	<0.01	<0.01	<DL	2.83	3.18	0.05	0.05
1109 FLT-1	LH2	41.1	0.14	15.31	0.54	<0.01	<0.01	<DL	3.22	3.67	0.07	0.07
1112 FLT-1	LH3	9.54	0.11	11.35	0.83	<0.01	0.16	<DL	2.38	2.09	0.26	0.26
1146 FLT-1	RH3	3.34	0.02	1.93	6.10	<0.01	0.34	<DL	0.40	0.77	0.51	0.51

Note <sup>a</sup>: DL is detection limit.

### **Purge, Vent, and Drain System**

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

Purge was initiated within 30 min (26 min) of the upper-aft-safety assessments. The purge was initiated approximately 58 min after touchdown, exceeding the 45-min limit. The lateness was due to a delay in completing the Hazardous Gas Detection System (HGDS) checks.

### **Reaction Control System**

The Reaction Control System (RCS) performed all functions nominally as required for successful completion of the mission. No In-Flight Anomalies (IFAs) were identified in the analysis of the flight data.

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



## RCS PROPELLANT LOADING

Parameter	Forward RCS		Left RCS		Right RCS	
	Oxidizer	Fuel	Oxidizer	Fuel	Oxidizer	Fuel
Target, %	67.70	67.41	100.48	100.76	100.48	100.76
Target, pounds	1141.0	712.0	1523.0	962.0	1523.0	962.0
Calculated, %	71.59	68.84	100.69	100.74	100.53	100.76
Advertised, %	1193.5	724.1	1525.8	961.8	1523.7	962.0
PASS WHI <sup>a</sup>	4.3165	4.2369	4.3857	4.2200	4.3799	4.2540
BFS WHI <sup>b</sup>	4.3205	4.2396	4.4112	4.2552	4.4239	4.2655

Notes:

<sup>a</sup> PASS WHI – Primary Avionics Software System Initial Weight of Helium Load

<sup>b</sup> BFS WHI – Backup Flight System Initial Weight of Helium Load

During the prelaunch period, the F3D Tyvek rain cover released and F1D cover leading edge debonded because of high winds prior to the first launch attempt. Since no rain was forecast, the covers were not replaced. All remaining Tyvek covers released at nominal speeds. The 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)
F3D <sup>a</sup>	NA	NA	NA	NA
F3F	4.5	54	22	-6
F2D	5.3	64	19	-5
F4D	5.6	68	19	-5
F1D	7.1	89	18	-4
F1U	7.3	17	93	-4
F1F	7.7	98	17	-4
F2F	8.0	102	16	-4
F2R	8.4	108	16	-3
F1L	8.7	112	16	-3
F4R	8.8	113	16	-3
F3L	9.0	116	15	-3
F3U	10.0	130	15	-2
F2U	10.7	141	14	0

Note: <sup>a</sup> Cover released prelaunch

The following table lists all of the RCS maneuvers performed during the mission.

## RCS MANEUVERS AND FIRING DATA

Maneuver/Firing	Engine/System	Time of Ignition, GMT	$\Delta V$ , ft/sec	Duration, sec
RCS Window Protect	RCS	039/09:16:13	N/A	2.08
ET Separation	RCS	039/09:22:50	N/A	6.0
ET Photo +X	RCS	039/09:23:01	N/A	11.4
ET Photo Pitch	RCS	040/11:24:04	1.2	5.3
NC3	RCS	040/11:24:04	1.2	5.3
NCC	RCS	041/01:30:44.7	0.2	N/A
MC1	RCS	041/02:48:24	0.2	8.0
MC2	RCS	041/03:16:29	0.4	1.52
MC3	RCS	041/03:33:30	0.2	0.88
MC4	RCS	041/03:43:30	1.7	7.52
Reboost	RCS	049/07:31:08	3.9	Approximately 33 min.
Separation 1	RCS +X	051/02:01:55		5.84
Separation 2	RCS +X	051/02:30:59		10.8
RCS Hotfire	RCS	052/01:15:01		
MAUI	RCS	052/08:51:42		13.62
Forward Reaction Control System Dump	RCS	053/02:30:53.3		12.48

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

### CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE

Control Responsibility	Control Start, GMT	Orbiter DAP Mode	Comments
	041/05:05:56	FREE DRIFT	Docking / ISS Capture
Orbiter	041/06:02:43	VERNIER	
ISS	041/06:11:20	FREE	
Orbiter	041/06:11:39	AUTO	TEA Maneuver
ISS	041/06:45:23	FREE	Set Contraction
Orbiter	041/06:49:08	AUTO	
ISS	041/07:18:05	FREE	
Orbiter	049/07:07:03		Attitude control handover for Reboost
ISS	049/09:04:20		Post Reboost Handover to ISS
Orbiter	050/23:37:13	AUTO	Maneuver to Undock attitude
ISS	051/00:34:07	FREE DRIFT	Logic Configuration
Orbiter	051/00:35:58	AUTO	

## CONTROL RESPONSIBILITIES BETWEEN ISS AND SHUTTLE (Concluded)

Control Responsibility	Control Start, GMT	Orbiter DAP Mode	Comments
ISS	051/00:51:57	FREE	Driver configuration
Orbiter	051/00:52:05	DAP B/ALT	No Low Z
ISS	051/00:54:00	Undock	

The reboost firing was performed in RCS Straight Feed and performance was nominal. The reboost resulted in an average altitude increase of approximately 1.2 nmi. This resulted in a final orbit of 180.5 by 190.0 nmi and a Differential Velocity ( $\Delta V$ ) of approximately 3.9 ft/sec, which included the reboost, attitude hold and associated attitude maneuvers post-reboost. The following table shows the number of RCS thruster pulses and the firing time for each thruster.

### REBOOST MANEUVER

Thruster Position	Number of Pulses	Firing Time, sec
F5L	6	1781.20
F5R	3	1978.24
L5D	31	1070.68
L5L	1	28.60
R5D	15	1034.88
R5R	45	132.08

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

### RCS RESIDUAL PROPELLANTS

Parameter	Mission Operations Calculation		PASS Model Calculation <sup>s</sup>	
	%	lb	%	lb
Forward Oxidizer	2.4	32.4	2.9	39.2
Forward Fuel	0.0	0.0	0.3	2.6
Left Oxidizer	44.4	599.4	43.8	591.3
Left Fuel	44.0	374.0	43.8	372.3
Right Oxidizer	41.0	553.5	40.6	548.1
Right Fuel	42.2	358.7	42.3	359.6

Note:

<sup>a</sup> The official JSC Engineering RCS propellant residuals are those listed under the PASS model

Following the RCS Hot Fire, thruster L3D's oxidizer injector temperature did not track fuel injector temperature during post-firing soak backs. This behavior has been observed on this thruster since STS-123. However, following its RCS Hot-Fire pulse during STS-130, the length of this "lagging period" was 6 hrs, which is much longer than

what was previously observed (less than 1 hr). As on the previous flights, the L3D chamber pressure (Pc) response and levels were nominal, indicating nominal valve actuation, and there was no indication of valve leakage. Thus, the problem was an instrumentation indication issue only.

The calculated RCS propellant consumption is shown in the following table.

### **RCS PROPELLANT CONSUMPTION**

<b>Parameter</b>	<b>Oxidizer, lb</b>	<b>Fuel, lb</b>	<b>Mixture ratio, Oxidizer/Fuel</b>
Forward RCS	927.3	582.5	1.59
Left RCS	768.0	484.0	1.59
Right RCS	809.1	496.9	1.63

### **Orbital Maneuvering System**

The Orbital Maneuvering System (OMS) performed satisfactorily and no IFAs were identified during the analysis of the flight data. Three items were identified during the mission and these are discussed in later paragraphs.

The OMS configuration for the STS-130 mission is shown in the following table.

### **OMS CONFIGURATION**

<b>Vehicle/equipment</b>	<b>Flight</b>	<b>Orbital Maneuvering Engine (OME)</b>	<b>Ancillary data</b>
Left Pod (LP) 03	35 <sup>th</sup>	L-OME S/N 107	5 <sup>th</sup> rebuilt flight - 21 <sup>st</sup> flight
Right Pod (RP) 04	31 <sup>st</sup>	R-OME S/N 113	5 <sup>th</sup> rebuilt flight - 8 <sup>th</sup> flight

The OMS maneuvers are shown in the following table.

### **OMS MANEUVERS**

<b>Maneuver designation</b>	<b>Configuration</b>	<b>Time of ignition, GMT</b>	<b>Firing time, sec</b>	<b><math>\Delta V</math>, ft/sec/interconnect usage, %</b>
Assist	Dual Engine	039/09:16:24.6	133.3	N/A
OMS-2	Dual Engine	039/09:51:48.8	92.4	142.2
OMS-3 (NC1)	Dual Engine	039/12:13:24.9	66.2	102.8
OMS-4 (NC2)	Dual Engine	040/02:30:02.9	66.6	104.2
OMS-5 (NC4)	Dual Engine	041/00:56:14.6	14.1	22.3
OMS-6 (TI)	Left Engine	041/02:28:25.1	8.6	6.3
(Deorbit)	Dual Engine	053/02:14:47.2	154.4	295.2

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

### INTERCONNECT USAGE, %/POUNDS

Parameter	Total, %	Total, pounds
Left OMS	0.000	0.000
Right OMS	1.259	163.050

The official propellant residuals are based on using the aft gage residuals for all tanks and are shown in the following table.

### PROPELLANT USAGE DATA

Parameters	Left OMS pod		Right OMS pod	
	Oxidizer	Fuel	Oxidizer	Fuel
Loaded, lbm	7050	4254	7050	4254
Residual, lbm (aft gage)	610	476	610	344
Residual, lbm (burn time integration)	610	325	628	297
Residual, lbm (SODB flow rate)	597	341	579	341

The Left OMS Fuel Totalizer Gage discontinuously dropped from 85% to 46% at 039/09:16:38 GMT, 14 sec into the OMS Assist maneuver. It remained at this value through the remainder of the maneuver and throughout the subsequent OMS-2, OMS-3, OMS-4, OMS-5, and OMS-6 maneuvers. It was not until the deorbit maneuver, when the totalizer updated using the aft gage input (below 30%), that the gage reported nominal values.

A minor Orbital Maneuvering Engine (OME) Gaseous Nitrogen (GN<sub>2</sub>) system leakage was observed. The pressure decay had been observed in this OMS pod on previous flights of OV-105 and did affect nominal OMS engine usage. Sufficient GN<sub>2</sub> remained in the left supply-tank to support the planned left-OME firings as well as any proposed firings of opportunity. A GN<sub>2</sub> system repressurization was performed to avoid a low-pressure alarm annunciation. In response to concerns that the accumulator pressure could drop below the 299-psia alarm limit during crew sleep periods, a General Purpose Computer (GPC) Memory (GMEM) update was developed to modify the onboard accumulator-pressure Fault Detection and Annunciation (FDA) limit to avoid nuisance alarms. However, the uplink of the GMEM was not required.

The Right Oxidizer Low Point Drain Line (LPDL) thermostat on the A-string cycled near the FDA lower limit of 50 °F. The FDA Limit was lowered via Table Maintenance Block Update Table Maintenance Block Update (TMBU) from 50 °F to 40 °F to avoid annunciation of nuisance alarms. However, the measurement did not exceed the original FDA limit while on the A-string (lowest observed temperature was 50.2 °F). During the STS-127 mission, this temperature had a time-varying minimum value (producing a “spoon-shaped” lower bound) at the beginning of the mission which initially cycled below the FDA lower limit of 50 °F and gradually stabilized within FDA limits as

the mission progressed. Similar performance was expected during STS-130, but was not realized. Performance may have improved due to the insulation re-work in the area prompted by the STS-127 heater performance, the warmer Right LPDL thermal environment produced by the STS-130 solar beta angle, or by the combination of these two effects.

### Auxiliary Power Unit System

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

The run times and fuel consumption for the APUs are summarized in the following tables.

#### APU RUN TIMES

APU (S/N)	Ascent, hr:min:sec	FCS Checkout, hr:min:sec	Entry, hr:min:sec	Total time, hr:min:sec
APU 1 (S/N 304)	00:21:39	00:0524	01:06:48	01:33:51
APU 2 (S/N 311)	00:21:54	None	01:33:09	01:55:03
APU 3 (S/N 303)	00:22:11	None	01:07:02	01:29:13

#### APU FUEL CONSUMPTION

APU (S/N)	Ascent, lb	FCS Checkout, lb	Entry, lb	Total, lb
APU 1 (S/N 304)	53	17	145	215
APU 2 (S/N 311)	56	0	196	252
APU 3 S/N 303	56	0	141	197

To avoid possible nuisance alarms, a TMBU was uplinked at 039/18:29:47 GMT (00/09:15:40 MET to change the FDA limit for the APU 3 Fuel Pump Drain Line Temperature 2 from 43 °F to 36 °F. A similar TMBU has been processed on every OV-105 flight starting with STS-118 because the initial APU 3 drain line heater cycle has not occurred until after 43 °F FDA limit has been reached. The minimum temperature reached was 42.191 °F.

Prior to entry at 053/00:46:46 GMT (13/15:32:39 MET), a TMBU was processed to change the APU Fuel Pump Drain Line Pressure FDA limit from 25 psia to 40 psia. This limit is an alarm class-3 Systems Management (SM) alert in the Backup Flight System (BFS) software. This was done as a precaution to avoid nuisance alarms during entry. Due to several nuisance alarms received by the crew during entry on STS-125, the

Problem Resolution Team (PRT) agreed to perform this TMBU on the remaining missions to avoid nuisance alarms and make the FDA limit more meaningful to the current drain system configuration.

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

The performance of the Hydraulics/Water Spray Boiler (HYD/WSB) system was nominal in all respects with no anomalies during the flight.

All three WSB system cores were loaded with approximately 5.0 lb of the additive mixture [53% water (H<sub>2</sub>O); 47% Propylene Glycol Monomethyl Ether (PGME)]. Initial PGME/Water Tank loading for WSBs 1, 2 and 3 were approximately 133.8 lb. Nominal WSB performance was observed on all three systems during the mission. The following tables provide data on WSB performance during ascent and entry

#### **ASCENT WATER SPRAY BOILER LUBRICATION OIL TEMPERATURES**

<b>WSB</b>	<b>Spray Start Temperature, °F</b>	<b>Spray Start Time, GMT</b>	<b>Steady-State Temperature, °F</b>	<b>PGME/H<sub>2</sub>O Usage. lb</b>
System 1	257	039:09:23:22	255	3.4
System 2	257	039:09:24:04	257	3.6
System 3	245	039:09:23:20	249	8.1

#### **ENTRY WATER SPRAY BOILER LUBRICATION OIL TEMPERATURES**

<b>WSB</b>	<b>Spray Start Temperature, °F</b>	<b>Spray Start Time, GMT</b>	<b>Steady-State Temperature, °F</b>	<b>PGME/H<sub>2</sub>O Usage. lb</b>
System 1	255	053:02:43:44	251	33.4
System 2	251	053:02:17:41	251	53.5
System 3	245	053:02:44:05	245	46.6

The Entry PGME/H<sub>2</sub>O usage on WSB 2 exceeded the File IX specification for Entry usage by 3.5 lb (53.5 lbs total usage versus the specification of no greater than 50 lb). A Hydraulics load test was performed after landing during which the APUs ran several minutes longer than typical. A Hydraulics load test is performed every fifth flight of a vehicle. During the Hydraulic loads test, APUs 1 and 3 are typically cycled between Normal Pressure (NORM PRESS) and Low Pressure (LOW PRESS) with APU 2 maintained in the Normal Pressure (NORM PRESS) mode. The additional WSB 2 PGME/H<sub>2</sub>O usage is attributed to the extended WSB cooling of the APU 2 lubrication oil and hydraulic fluid. The extended APU 2 run time in NORM PRESS to perform the loads test resulted in significantly extending the WSB 2 active spray-cooling of the System 2 hydraulic fluid. All WSB 2 operational parameters indicated nominal operation during entry.

## Power Reactant Storage and Distribution System

The OV-105 Power Reactant Storage and Distribution (PRSD) system performance was nominal throughout the mission, and no IFAs were identified during the mission. The PRSD system supplied the fuel cells with 2054 lb<sub>m</sub> of O<sub>2</sub> and 259 lb<sub>m</sub> of H<sub>2</sub> for the production of electrical energy. A 95-hr mission extension was possible at the mission-extension average power level of 9.2 kW with the reactants remaining at touchdown. H<sub>2</sub> Tank 4 and O<sub>2</sub> Tank 4 and 5 were depleted to residual quantities. The total O<sub>2</sub> supplied to the Shuttle/ISS Environmental Control and Life Support System (ECLSS) was 258 lb<sub>m</sub> from PRSD. A 24 lb<sub>m</sub> O<sub>2</sub> tank-to-tank was transfer to ISS was also completed during this flight.

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

### PRSD OXYGEN TANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb <sub>m</sub>
Loaded	100.9	100.1	101.4	101.8	100.9	3945
Off-Loaded	17.0	17.0	17.1	17.5	17.0	3283
Launch	82.5	82.5	82.5	83.0	83.0	3229
Landing	40.5	35.7	29.1	6.3	5.9	918

### PRSD HYDROGENTANK QUANTITIES

Oxygen	Tank 1, %	Tank 2, %	Tank 3, %	Tank 4, %	Tank 5, %	Total Mass, lb <sub>m</sub>
Loading	101.5	101.9	101.0	101.8	100.9	467.2
Launch	96.6	97.5	97.0	97.9	97.0	447.1
Landing	62.1	63.4	71.4	2.4	5.5	188.4

During the third Nitrogen (N<sub>2</sub>) ISS stack re-pressurization, the O<sub>2</sub> PRSD manifold 1 pressure temporarily rose to 974 psia and manifold 2 pressure indicated 950 psia. This was caused by a valve configuration error that resulted in a 50 lbm/hr increase in O<sub>2</sub> demand at about 045/23:48 GMT (06/14:34 MET). The high flow-rate introduced cold dense cryogenic N<sub>2</sub> into the warmer manifolds. The O<sub>2</sub> expanded and caused the pressure rise. The O<sub>2</sub> PRSD manifold pressure relief valves are specified to crack at 975 psia and relieve into O<sub>2</sub> tanks 1 and 2. Both PRSD manifold 1 and 2 data indicated approximately 1 ½ min plateaus at the maximum pressures.



## Fuel Cell System

### Fuel Cells

The overall performance of the OV-105 fuel cell subsystem was nominal and one IFA was identified and will be discussed in a later paragraph. The average electrical power level and load was 9.2 kW and 295 Amperes (A). The fuel cells produced 2313 lb<sub>m</sub> of potable water and 3044 kWh of electrical energy from 2054 lb<sub>m</sub> of oxygen and 259 lb<sub>m</sub> of H<sub>2</sub>.

The actual fuel cell voltages at the end of the mission assuming a 175 A load were 0.16 Volts (V) above the predictions for Fuel Cell 1, 0.10 V above the predictions for Fuel Cell 2, and as predicted for Fuel Cell 3. The voltage margins above the minimum performance curves at 175 A at the end of the mission were 0.94 V above minimum for Fuel Cell 1, 1.1 V above minimum for Fuel Cell 2, and 0.78 V above minimum for Fuel Cell 3. Four fuel cell purges were performed, occurring at approximately 18, 121, 231, and 322 hr MET.

The pre-launch baseline Cell Performance Monitor (CPM) values for fuel cell 1 were 2, 6, and 22 mV, for fuel cell 2 were 36, 14, and 42 mV, and for fuel cell 3 were 14, 18, and 50 mV. These values were established approximately 3 hours after the completion of the Fuel Cell Calibration requirement.

The Fuel Cell Monitoring System (FCMS) was used to monitor individual cell voltages pre-launch, on-orbit, and post-landing. Full-rate on-orbit data was recorded for 12 min beginning at 040:11:19:16 GMT (01/02:05:09 MET), and no outliers were identified. Two additional FCMS data takes were performed on Flight Days 13 and 14, due to the fuel cell 2 sub-stack 3 intermittent self-test failure, which is discussed in the following paragraph.

During the fuel cell 2 CPM self-test at 051/03:44:46 GMT (11/18:30:41 MET), the differential voltage indication for fuel cell 2, sub-stack 3 went to an Off-Scale High (OSH) reading of 500 mV from a nominal value of approximately 24 mV (IFA STS-130-V-07). The nominal CPM self-test reading is 50 mV. There were four additional occurrences with the fuel cell 2 CPM self-test indicating nominal reading at 051/05:11:46 GMT (11/19:57:39 MET). The SM limit sensing for this parameter was inhibited onboard to prevent nuisance alarms.

The fuel cell 2 CPM was declared to be suspect. As a back-up to the CPM, a Main B to Main C bus-tie was implemented, as well as a daily FCMS data take to monitor relative fuel cell performance. Two FCMS data takes were performed in addition to the scheduled FCMS data taken prior to landing. The bus-tie was broken prior to entry.

## **Station-to-Shuttle Power Transfer System Operation**

The Station-to-Shuttle Power Transfer System (SSPTS) performed nominally and supplied 1490 kWh to the Shuttle for the period of 229.5 hr while docked to the ISS. When combined, the Orbiter average electrical power level was 13.73 kW for the mission duration.

In preparation for the SSPTS activation, Power Transfer Units (PTUs) -1 and -2 were activated, and Main Bus B and Main Bus C were bus-tied at 041/06:33:00 GMT (01/21:18:53 MET). Both PTUs were brought on line at 041/08:10:00 GMT (01/22:55:53 MET). All four Orbital Power Converter Units (OPCUs) and both Assembly Power Converter Units (APCUs) were on-line and providing power, which allowed the fuel cell loads to decrease.

The SSPTS OPCU 1A had a “fault isolation” shut-down at 049/07:52:29 GMT (09/22:38:22 MET). The SSPTS had been deactivated while some racks were being installed on the ISS and the event occurred during reactivation. This is similar to the occurrence on STS-119. The malfunction procedure designated for this type of occurrence was performed and recovered the function. The “fault isolation” shut-down was due to a known characteristic discovered during qualification testing and was accepted due to the infrequent occurrence and relatively simple recovery procedure.

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

The Electrical Power Distribution and Control (EPDC) system performed nominally during all mission phases. No IFAs were identified during the review and analysis of the flight data. The SSPTS PTU performance for the mission was flawless.

## **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 Flight Day (FD) 2 and the ODS was activated for 9 min 33 sec, and the avionics hardware was powered for 5 min 58 sec. The system was ready for rendezvous and docking with the ISS.

The ODS power-up sequence was initiated at 041/04:26:10 GMT (01/19:12:03 MET). The Shuttle captured the ISS at 041/05:05:56 GMT (01/19:51:49 MET), and the Post-Contact Thrust (PCT) firing sequence was performed nominally. Ring retraction using dual motors was started at 041/05:15:06 GMT (01/20:00:59 MET). Data indicated the possibility of a stuck damper, which is a known and expected condition. After the initial stuck-damper procedure (ring-in) was performed, the mechanism began oscillating with a small deviation for several minutes. Once damped, the crew began final ring retraction.

At 1 min into final ring retraction, at approximately 48% linear advance, the ring mechanism indicated misalignment (light went off). Per procedures, a ring-drive stop command was issued to prevent any further retraction. A ring-retract command was issued again after receiving the ring alignment indication approximately 2 min later. Thirty seconds into the second retraction, the ring alignment indicated misalignment for a second time. At this point, approximately 5 min into the misalignment, two of the three petal sensors began to diverge, which indicates a 28% misalignment. The docking system experienced a possible gravity-gradient condition for approximately 20 min, at which time an additional 12 min of damping was required before the final 2 min of ring retraction could be performed prior to hooks-closing. It was determined that there were no issues with the hardware performance, and that this condition would not impact the capability to perform undocking.

The ODS hooks were driven closed nominally and final ring extension was performed, releasing the capture latches with the Shuttle/ISS interface-seal obtained at 041/05:56:11 GMT (01/20:42:04 MET).

In preparation for undocking, the ODS was activated at 051/00:11:58 GMT (011/14:57:51 MET). The undocking and separation from the ISS was completed satisfactorily at 051/00:53:52 GMT (011/15:39:43 MET). The ODS was operational for 56 min 52 sec for the undocking of the Orbiter.

## **Life Support Systems**

### **Atmospheric Revitalization Pressure Control System**

The Atmospheric Revitalization Pressure Control System (ARPCS) performed nominally throughout the mission and no IFAs were identified during the review and analysis of the flight data.

An Orbiter-to-ISS tank-to-tank O<sub>2</sub> transfer was performed, the final offload to ISS was approximately 24 lb<sub>m</sub>. No Orbiter-to-ISS tank-to-tank N<sub>2</sub> transfers performed during this mission. Four N<sub>2</sub> Orbiter/ISS stack repressurizations were performed using the Orbiter PCS. These repressurizations were performed by opening the payload N<sub>2</sub> valves with restrictors in the line, thus limiting the N<sub>2</sub> flow to 7 lb<sub>m</sub>/hr for better cabin air mixing.

During the third N<sub>2</sub> repressurization, a valve configuring error occurred that resulted in O<sub>2</sub> flowing into the cabin at approximately 50 lb<sub>m</sub>/hr along with the expected approximately 7 lb<sub>m</sub>/hr N<sub>2</sub> flow. The O<sub>2</sub> flowed into the cabin for approximately 4.5 min prior to the valves being reconfigured to terminate the O<sub>2</sub> flow. Prior to docking with ISS, there was one O<sub>2</sub> repressurization performed using direct O<sub>2</sub> flow into the cabin. Two O<sub>2</sub> repressurizations were performed to the ISS using shuttle O<sub>2</sub> during docked operations.

## **Airlock System**

The Airlock (A/L) systems performed nominally throughout the mission.

All of the scheduled in-flight checkout requirements were satisfied with the exception of the A/L lower bulkhead internal temperature. External airlock structural heater did not cycle using Main Bus A or Main Bus B power. During this mission, as well as during STS-127, the environment did not get cold enough for this heater to activate while on Main Bus A, with the lowest temperature reaching approximately 63 °F. The heater cycle range requirement is 40-85 °F. While on Main Bus B power, the temperature reading reached a minimum of approximately 61 °F and was near to activation, but entry heating warm-up prevented activation.

## **Supply and Waste Water System**

The Supply Water and Waste Management System (SWWMS) performed nominally throughout the mission. The supply water was managed through the use of the Flash Evaporator System (FES) and water transfer to the ISS. No water dump was performed through the nozzle. The supply-water dump-line temperature was maintained between 75 °F and 95 °F throughout the mission.

At 043/20:22:57 GMT (04/11:08:50 MET), supply water tank A exhibited a water tank quantity dropout from 67.5% to Off-Scale Low (OSL) (-11%) for a duration of 27 sec. This was preceded by a 1-sec quantity dropout from 67.5% to 37%. Water tank quantity dropouts occur on all the supply and waste water tanks in all three Orbiters. The time duration varies and normally lasts from 1 to 2 sec. However, longer duration dropouts have been observed in other flights. The dropout was no impact to the mission.

The Waste Management Compartment (WMC) system performed two successful dumps at a nominal average dump rate of 2.0 %/min (3.3 lb<sub>m</sub>/min). One of the dumps was performed in the pre-docking period and the second one was performed after undocking. The wastewater dump line temperature was maintained between 53 °F and 77 °F throughout the mission.

Eight Contingency Water Containers (CWCs) and eight CWC-Iodine were filled with supply water and transferred to the ISS, for a total of 753.5 lb<sub>m</sub> and 321.8 lb<sub>m</sub> respectively. One Payload Water Reservoir (PWR) of iodinated water for a total 20.2 lb<sub>m</sub> was filled and transferred to ISS.

One Orbiter condensate CWC was used to collect approximately 77 lb<sub>m</sub> of condensate. An ISS condensate CWC was used on the Orbiter to collect additional condensate. Both CWCs were transferred to the ISS for processing.

The quantity sensors in the supply water tanks A, B, C and D exhibited quantity dropouts throughout the mission. Such dropouts have been experienced in previous flights and the problem was caused by either contamination on the collector bar and/or

surface defect on the collector bar. This condition causes an intermittent break in continuity across the potentiometer. These dropouts are understood problems.

The vacuum vent line temperature was maintained between 80°F and 57 °F. The thermostat control range for the heater is  $55 \pm 5$  to  $75 \pm 5$  °F.

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

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

Use of the Fire Suppression system was not required.

### **Active Thermal Control System**

The Active Thermal Control System (ATCS) performed nominally throughout the mission. No IFAs were identified in the review and analysis of the flight data.

No pre-evaporative cooling was observed prior to the GPC activation of the Flash Evaporator System (FES) during ascent. All hardware performed nominally during ascent.

It was noted during this flight that the aft mid-body FES water feedline heater A was dithering. Dithering is a phenomenon whereby the controlling thermostat gets into a rapid-cycling mode such that the heater is on and off long enough to allow the appearance of constant mid-band temperature. This mode of operation is not detrimental to the operating system, and should the thermostats useful cycle life be expended causing failure, the system A or B heater can be reactivated.

The Ammonia Boiler System (ABS) tank A and B in-flight leak rate was calculated to be approximately 0.02 lb<sub>m</sub>/day for tank A and 0.01 lb<sub>m</sub>/day for tank B with the leak rate being no more than 0.05 lb<sub>m</sub>/day.

The partial pressure of Carbon Dioxide (ppCO<sub>2</sub>) controlled-level ranged from 1.3 to 5.0 millimeters of Mercury (mmHg) versus the flight rule maximum limit at 5.0 mmHg. There was no crew report of any CO<sub>2</sub> symptom.

### **Flight Software**

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

Two PASS Cabin-Fire Fault Summary messages from the ISS C&W system were annunciated in the Orbiter at 041/12:59:30 GMT (02/03:44:11 MET). Analysis of the

events, along with other data-sharing issues between the ISS and the Orbiter, indicated a potential issue with an OIU (IFA STS-130-N-01).

### **Data Processing System Hardware**

The Data Processing System (DPS) hardware performed satisfactorily and the data review and analysis of DPS parameters identified no IFAs.

### **Multifunction Electronic Display System**

The Multifunction Electronic Display System (MEDS) performed satisfactorily and no IFAs were identified during the review and analysis of the data.

### **Displays and Controls System**

The Display and Controls (D&C) system performed satisfactorily throughout the mission and no IFAs were identified from the analysis of the data and debriefing with the crew members.

### **Flight Control System**

The Flight Controls System (FCS) performed nominally during all phases of the mission, and no IFAs were identified during the review and analysis of the flight data.

At all times, the SRB Thrust Vector Controller (TVC), MPS TVC, and aerosurface actuators were positioned as commanded with normal driver currents, secondary differential pressures, and elevon primary differential pressures. The rate outputs of the four Orbiter rate gyro assemblies (ORGAs) and four SRB Rate Gyro Assemblies (SRGAs) tracked one another normally, and there were no spin motor rotation detector (SMRD) dropouts. The outputs of the four Accelerometer Assemblies (AAs) also tracked one another normally. Reaction jet driver (RJD) operation was also normal with no thruster failures or other anomalies noted. Device driver unit (DDU) and controller operations were nominal as well. Both the rotational hand controller (RHC) and the transitional hand controller (THC) were used and exhibited normal channel tracking. Likewise, the FCS temperatures were also nominal throughout the mission.

### **Air Data Transducer Assembly**

The Air Data Transducer Assemblies (ADTAs) performed nominally throughout the mission and no IFAs were identified from the review and analysis of the data.

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

During entry, the air data probes were deployed at approximately Mach 5.0, and deployment timing was within specification at less than 15 sec. The ADTA data were incorporated into Guidance, Navigation, and Control (GN&C) at about Mach 3.2. No ADTA dilemmas or Redundancy Management (RM) failures occurred through wheels stop.

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

The Inertial Measurement Unit (IMU) system performed satisfactorily throughout the STS-130 mission. No IFAs were identified during the review of data and analysis. During the flight, one adjustment of the on-board IMU accelerometer compensations was performed, and three adjustments of the IMU drift compensation values.

The Star Tracker (ST) operated nominally. The -Y ST acquired a navigation-star 1519 times during the mission. The -Y ST missed a navigation-star 202 times, and this condition is considered nominal based the various Orbiter operations during all of the phases of the mission. The -Z ST acquired a navigation-star 51 times during the mission, and missed a navigation-star 22 times. Of the 22 missed navigation-stars, 21 of the stars were lost during docking and undocking operations, which is nominal.

### **Global Positioning System Navigation**

Overall, Global Positioning System (GPS) performed nominally throughout the mission and no IFAs were identified during the review and analysis of the data

All three GPS strings were powered prior to launch. During the power-up sequence, the Miniaturized Airborne GPS Receiver (MAGR) receivers were powered prior to the GPS Input/Output (I/O) being activated. This sequence is now standard for day of launch power up and eliminates any potential time-out errors which could have been generated by the GPCs polling unpowered MAGR receivers.

Power was turned off for GPS no.1 and GPS no. 3 as part of the Group B Powerdown. These two receivers were powered again just before the Flight Control Systems (FCS) Checkout (C/O) the day before landing. Upon power up, both systems downloaded the daily encryption key and transitioned to Precise Positioning Service (PPS) mode at the expected times. GPS no. 2 remained ON and in PPS mode during the entire mission.

During Entry, the GPS high Figure of Merit (FOM) period, usually encountered in the plasma region, cleared before GPS incorporation into the PASS. No Data-Invalid or FOM Chimneys occurred during the critical phase of Entry, below 140,000 ft altitude, where the GPS satellite geometry is less dynamic.

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

The Communications and Tracking systems performed satisfactorily and no IFAs were identified during the review and analysis of the data. Likewise, the Navigation Aids (NAVAIDS) performed satisfactorily.

The Ku-Band antenna was taken to the RADAR mode at 041/01:37:44 GMT (01/16:23:37 MET) and detected the ISS within 16 sec at a range of 141,000 ft. The system began tracking the ISS at 041/01:38:29 GMT (01/16:24:22 MET) at a range of 140,000 ft. The RADAR mode operated as expected and the Communications (COMM) mode was reselected at 041/04:29:28 GMT (01/19:15:21 MET) at a range of 318 ft.

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

The Operational Instrumentation (OI) and Modular Auxiliary Data System (MADS) performed nominally, and no IFAs were identified during the review and analysis of the data.

The MADS ascent data was recorded on the Solid State Recorder (SSR) and dumped to the ground. Data from the MADS recorder was dumped and reviewed. No issues were identified.

### **Mechanical and Hatches System**

All mechanical and hatch systems performed satisfactorily during the mission. However, one IFA occurred during entry and is discussed in the following paragraph.

At 053/03:14:14 GMT (13:18:00:07 MET), approximately 6 min prior to touchdown, the system B latch indication was lost on the Payload Bay Door centerline latch actuator for latches 13-16 (IFA STS-130-V-08). The system A-latch indication was not lost. The Payload Bay Doors had been closed and latched nominally at approximately 4 hr prior to touchdown.

### **Landing and Deceleration System**

The Landing System performance at KSC was nominal and no IFAs were identified during the review and analysis of the data.

The landing parameters for the STS-130 mission are shown in the following table.



## LANDING PARAMETERS

Parameter	From threshold, ft	Time from MLG touchdown, sec	Speed, keas <sup>a</sup>	Speed, kgs	Sink rate, ft/sec	Pitch rate, deg/sec
Main Landing gear touchdown	2719.1	N/A	191.1	188.9	-1.69	
Drag Chute Deployment	3770.6	3.312	180.8	177.9		
Drag Chute Disreef	5209.3	8.44	158.3	157.2		
Nose Landing Gear Touchdown	5209.3	8.44	158.3	157.2		-5.4
Brakes On	7966.0	21.787	98.0	96.2		
Drag Chute Jettison	10105	39.985	OSL <sup>b</sup>	55.6		
Parameter	From threshold, ft	Time from MLG touchdown, sec	Speed, keas <sup>a</sup>	Speed, kgs	Sink rate, ft/sec	Pitch rate, deg/sec
Wheels Stop	13217.2	94.240	0.0	0.0		
Parameter			Data			
Brake Initiation Speed, keas			98.0			
Brake On Time, sec			21.787			
Rollout Distance, ft			10498.1			
Rollout Time, sec			94.24			
Runway Location, Surface and Degrees			KSC Concrete 15			
Orbiter Weight at Landing, lb			201121.0			
Parameter		Maximum Brake Pressure, psia		Total Brake Energy, Mft/lb		
Left inboard		696.0		6.43		
Left outboard		624.0		5.11		
Right inboard		768.0		6.16		
Right outboard		648.0		3.66		

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

<sup>b</sup>Off-scale low

### Aerothermodynamics, Integrated Heating and Interfaces

The lower structural temperature data indicated normal entry heating. The recorded structure temperatures were within the flight experience of OV-105 vehicle. The MADS surface thermocouples, Boundary Layer Transition (BLT) was symmetric and occurred around Mach 5.6 or 1333 sec after Entry Interface (EI) based on the pre-flight End-of – Mission (EOM) trajectory.

The runway report and post-flight inspection pictures indicated that the protruding ceramic insert on the window no. 2 carrier panel remained in the same condition as was seen on orbit. The cracked tile corner on the forward canopy also was still present, and the protruding elevon flipper door seal seen on-orbit was in the same condition.

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

### ENTRY MAXIMUM TEMPERATURE AND MAXIMUM TEMPERATURE RISE DATA

Thermal Sensor Location	Maximum Temperature, °F	Maximum Temperature Rise, °F
Lower fuselage forward center (B1)	135.1	118.9
Lower fuselage forward left-hand (B2)	193	169.2
Lower fuselage forward mid left-hand (B3)	164	158
Lower fuselage mid center (B4)	137.7	134.3
Lower fuselage mid aft center (B5)	174.5	163.5
Lower fuselage aft center (B6)	177.2	145.7
Left-wing center (LW)	127.3	126.4
Right wing center (RW)	114.2	126
Port side FRCS forward (P1)	145.6	106.4
Port side fuselage forward center (P2)	119.4	93
Port side fuselage forward mid center (P3)	98.6	79.9
Port side fuselage mid aft center (P4)	83	51.5
Port side fuselage aft center (P5)	85.6	54.1
Starboard side FRCS Forward (S1)	132.5	111.2
Starboard side fuselage forward center (S2)	101.2	118.1
Starboard side fuselage forward mid center (S3)	88.2	74.6
Starboard side fuselage mid-aft center (S4)	57.2 <sup>a</sup>	56.3 <sup>a</sup>
Starboard side fuselage aft center (S5)	70.1	61.6
Left-hand OMS pod side forward (LP)	88.2	72
Right-hand OMS pod side forward (RP)	62.4 <sup>a</sup>	53.8 <sup>a</sup>
Lower body flap center	106.4 <sup>a</sup>	77.4 <sup>a</sup>
Right-Hand OMS Pod Side Forward	62.4 <sup>a</sup>	53.8 <sup>a</sup>
Left-Hand OMS Pod Side Forward	88.2	72
Right-hand PLBD forward	59.8 <sup>a</sup>	79.2 <sup>a</sup>
Left-hand PLBD forward	59.8 <sup>a</sup>	64.0 <sup>a</sup>
Right-hand PLBD aft	75.3	89.6
Left-hand PLBD aft	83	87.2
Right wing upper center	77.9 <sup>a</sup>	92.2 <sup>a</sup>
Left wing upper center	85.6 <sup>a</sup>	54.1 <sup>a</sup>
Forward RCS forward center	90.8	61.8
Forward fuselage upper center	67.5	64.1

**Notes**

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

### Thermal Control System

The Passive Thermal Control systems performed nominally, and no IFAs were identified during the review and analysis of the data. All heater systems performed normally.

The starboard low-point drain-line FDA was changed from 50°F to 40 °F due to cycling near the lower FDA limit. The APU 3 drain-line temperature was lowered from 45 °F to 36 °F to prevent nuisance alarms. The L3D oxidizer injector temperature was tracking low when compared with the fuel injector temperature immediately after the RCS hotfire.

The Thermal team participated in the TPS damage assessment by providing EI initial conditions for the forward overhead canopy, a location near window no. 2, and the damaged area around the port elevon flipper door.

### **Thermal Protection System and Post-Landing Assessment**

#### **Post-Landing Assessment**

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

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

<b>Orbiter Surface</b>	<b>Impacts greater than 1 in.</b>	<b>Total impacts</b>
Lower surface	9	46
Upper Surface/Window	0	11
Right OMS pod	2	5
Left OMS pod	1	2
<b>Totals</b>	<b>12</b>	<b>64</b>

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

The overall performance of the Thermal Protection System (TPS) was satisfactory and two IFAs were identified in the review and analysis of the imagery.

Following review of the FD 2 and FD 3 RPM imagery, the DAT determined that there are no requirements for a focused inspection. Three items that required continued evaluation were:

1. A protruding elevon flipper door-to-door seal (IFA STS-130-V-01).
2. A protruding ½-in. ceramic insert between Window 1 and 2 (IFA STS-130-V-03).
3. Failed the Room Temperature Vulcanizing (RTV) on a cracked tile repair immediately aft of Window 1 (IFA STS-130-V-03).

The DAT completed the review of all the analysis of the three items which required more evaluation and recommended clearing the Orbiter for entry.

#### **RCC Flight Assessment**

The Reinforced Carbon-Carbon (RCC) performed satisfactorily.

The SRMS OBSS surveys of the starboard-wing RCC, nose-cap RCC, and port-wing RCC were completed nominally. The maneuver for OBSS grapple started at 040/02:53 GMT (00/17:38:53 MET), with unberthing of the OBSS completed at 040/03:39 GMT (00/18:24:53 MET). The starboard RCC survey began with the flat-field survey at 040/04:26 GMT (00/19:11:53 MET), and was completed at 040/06:24 GMT (00/21:09:53 MET). The nose RCC survey began at 040/06:58 GMT (00/19:55 MET) and was completed at 040/07:31 GMT (00/22:18 MET). The port RCC survey began at 040/07:56 GMT (00/22:40 MET) and was completed at 040/10:09 GMT (01/00:55 MET).

On FD 13, after undocking, the crew maneuvered the OBSS to the flat-field position at 051/05:25 GMT (11/29:11 MET) to start the Late Inspection of Endeavour's TPS. The starboard RCC survey began at 051/06:05 GMT (11/20:51 MET) and was completed at 051/06:58 GMT (11/21:44 MET). The Nose Cap Survey began at 051/07:26 GMT (11/22:12 MET) and was completed at 051/07:57 GMT (11/22:43 MET). The port survey began at 051/08:21 GMT (11/23:07 MET) and was completed at 051/09:12 GMT (11/23:58 MET).

The On FD 14, the RCC DAT completed the review of all imagery from the late inspection and recommended that the MMT should clear the Orbiter for entry, which was done.

### **Windows**

The post-flight inspection of the Orbiter Windows showed numerous hypervelocity impacts that resulted in six windows being scrapped. The condition of each window follows.

1. Window W1 had 5 defects and the window was scrapped.
2. Window W2 had 4 defects and the window was scrapped.
3. Window W3 had 2 defects and the window was declared acceptable for flight.
4. Window W4 had 2 defects and the window was declared acceptable for flight.
5. Window W5 had no defects and the window inspection was complete and ready for rollout.
6. Window W6 had 8 defects and the window was scrapped.
7. Window W7 had 3 defects and the window was scrapped.
8. Window W8 had 1 defect and the window was scrapped.
9. Window W11 had 1 defect and the window was scrapped.

### **Waste Collection System**

The Waste Collection System performed nominally throughout the mission.

## **EXTRAVEHICULAR ACTIVITY**

Three Extravehicular Activities (EVAs) were performed nominally by Crewmembers Robert Behnken (EV1) and Nicholas Patrick (EV2) on the International Space Station (ISS) during the STS-130/20A mission. All planned activities plus numerous get-ahead tasks were completed during the three EVAs, which lasted a total of 18 hr 14 min.

### **FIRST EXTRAVEHICULAR ACTIVITY**

The first EVA was performed on Flight Day (FD) 5 and all planned activities were completed during the 6 hr 32 min EVA.

The initial tasks performed during the EVA were performed in the Shuttle Cargo Bay to prepare Node3/Cupola for unberthing and installation on the International Space Station (ISS). The Orbiter Launch-To-Activation (LTA) cables were de-mated from Node 3 and stowed in Tool Stowage Assembly (TSA). The Node 3 Passive Common Berthing Mechanism (CBM) protective covers were removed and CBM seal inspections were completed. A Bus Terminator (BT) and a Functional Energy Block (FGB) Terminator were also installed on Node 3.

During the robotic operations of removing Node 3 from the Orbiter Payload Bay (PLB) and berthing Node 3 on the Node 1 Port, the EVA crewmembers repositioned an Ammonia (NH<sub>3</sub>) line-jumper bag and a NH<sub>3</sub> Multilayer Insulation (MLI) bag on the U.S. Laboratory. The EVA crewmembers then completed the removal the Orbital Replacement Unit (ORU) and Tool Platform (OTP) from the Special Purpose Dexterous Manipulator (SPDM) and tied it down on Starboard (S) Zero (0) habitation tray for stowage to make room on the SPDM for the Enhanced OTP being delivered on STS-132.

The EVA crewmembers then translated to Node 3 that had completed being installed on Node 1. The crewmembers installed a gap-spanner between the U.S. Laboratory Handrails 0231 (Forward) and 0232 (Forward) and another gap-spanner between the Node 1 Handrail 0106 (Zenith) to Node 3 Handrail 0673 (Zenith). They also performed a Gap Spanner clean up task to remove tape that was added to the Node 3 ground-installed gap-spanner buckles. The final gap-spanner task was a get-ahead task to relocate the gap-spanner on the U.S. Lab Handrail 0208 (Starboard) to Node 1 Handrail 0112 (Port).

Node 3 activation tasks were then completed by the EVA crewmembers to include installation of the Node 3 LTA avionics cables were installed (Channels 1/2 and 3/4) and removal of 11 avionic dust caps and two long pieces of MLI from Node 3.

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

## **SECOND EXTRAVEHICULAR ACTIVITY**

The EVA crew successfully completed the second EVA on FD 7, and all planned activities were completed during the 5 hr 54 min EVA.

The planned tasks for the second EVA crewmembers were focused on the Node 3 activation and outfitting. The EVA crewmembers installed four NH<sub>3</sub> lines, NH<sub>3</sub> line MLI and gap-spanners to restrain the NH<sub>3</sub> lines in place to ensure that the ISS Node 1 Zenith CBM would be cleared for the future Permanent Multipurpose Module (PMM) installation. All NH<sub>3</sub>-line Quick Disconnect (QD) thermal booties were installed and the Loop A QD bails were actuated to enable ammonia flow between the U. S. Laboratory and Node 3. The Node 3 Nadir CBM pedals were open and the CBM seals were inspected and the seals were cleared for cleanliness. The Node 3 Non-Propulsive Vent (NPV) was installed. All four Node 3 Trunnions and Keel pin covers were installed to provide thermal protection. Eight handrails were installed on Node 3.

The EVA glove inspections and post-EVA photographs indicated no glove damage had been incurred during EVA 2.

## **THIRD EXTRAVEHICULAR ACTIVITY**

On FD 9, the crew performed the third EVA and all planned activities were completed during the 5 hr 48 min EVA.

The EVA crewmembers opened the U.S. Laboratory Loop-B QD valves to enable a secondary path for the ammonia flow between the U.S. Laboratory and Node 3. Also, the crew installed thermal booties on the QDs.

The ammonia-line MLI management was completed by attaching wire ties between the MLI and the U.S. Laboratory at two handrail locations. The Pressurized Mating Adapter no. 3 (PMA 3) heater cables and data cable were installed onto Node 3 on the port axial cone. One of the two Node 3 LTA cable connections was removed from Node 1, and the Airlock secondary power cable was re-connected back to the original location.

The EVA crewmembers removed the Cupola MLI and released the window shutter launch-lock bolts on all seven window shutters. The Worksite Interfaces (WIFs) were installed on Node 3. The NH<sub>3</sub> Line MLI Photogrammetry was performed on the U.S. Laboratory to document clearances for the future berthing of the PMM. Six more Node 3 Handrails were installed at the preflight planned locations.

A Video Signal Converter (VSC) cable was installed between S0 and the FGB; the S0 side of the cables was mated to the S0 panel. The Node 2 Zenith CBM Berthing Camera System (CBCS) flap was closed.

Get ahead tasks completed included the gap-spanner installation between the External Stowage Platform no. 2 (ESP-2) Handrail 8013 (Port) and US Lab Handrail 0293 (Aft)

and the Articulating Portable Foot Restraint (APFR) no. 3 relocation from Lab WIF 4 to Starboard Airlock Toolbox WIF.

The planned task of removing the P1 FHRC (Flex Hose Radiator Coupler) P-Clamps was dropped from the end of EVA 3 due to consumable limitations on the EV1 crewmember.

EVA glove inspections and post-EVA photographs indicated no glove damage on EV1's gloves and a non-critical peeling of the Room Temperature Vulcanizing (RTV) pad on EV2's left glove thumb.

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

The Shuttle Remote Manipulator System (SRMS) performed satisfactorily, and no In-Flight Anomalies (IFAs) were identified during the review and analysis of the data.

The Flight Day (FD) 1 SRMS On-orbit Initialization began at 039/12:24 Greenwich Mean Time (GMT) [00/03:09:53 Mission Elapsed Time (MET)]. The port and starboard Manipulator Positioning Mechanisms (MPMs) were deployed and the SRMS shoulder brace was released. The SRMS checkout began at 039/13:40 GMT (00/04:26 MET) and was completed 1 hr 15 min later. During the Direct Drive Checkout, the Wrist Pitch joint Servo Power Amplifier (SPA) annunciated a Motor Drive Amplifier (MDA) demand voltage Built-In Test Equipment (BITE) as the direct drive command was removed. This is a known nuisance BITE, which was cleared by power-cycling the SRMS.

On FD 2, the SRMS grappled the Orbiter Boom Sensor System (OBSS) at 040/03:19 GMT (00/18:04 MET) and maneuvered the OBSS to the OBSS Hover Position at 040/03:38 GMT (00/18:14 MET). The starboard Reinforced Carbon-Carbon (RCC) survey began at 040/05:10 GMT (00/19:56 MET) and was completed at 040/06:24 GMT (00/21:10 MET). The nose RCC survey began at 040/07:00 GMT (00/21:46 MET) and was completed at 040/07:31 GMT (00/22:17 MET). The port RCC survey began at 040/07:55 GMT (00/22:41 MET) and was completed at 040/09:53 GMT (01/00:39 MET). The OBSS was berthed in the starboard MPMs at 040/11:03 GMT (01/01:49 MET) and the SRMS was maneuvered to the Pre-cradle Position 17 min later. The SRMS OBSS surveys of the starboard wing RCC, nose cap RCC, and port wing RCC were completed nominally.

On FD 3, *Endeavour* rendezvoused and docked with the International Space Station (ISS). The SRMS maneuvered to the OBSS Handoff Pre-grapple Position at 041/08:35 GMT (01/23:21 MET). The Space Station Remote Manipulator System (SSRMS) then grappled and unberthed the OBSS and moved the OBSS to the Handoff Position. The SRMS grappled the OBSS at 041/09:41 GMT (02/00:27 MET). After the SSRMS released the OBSS, the SRMS was maneuvered to the Node 3 Installation Viewing Position at 041/10:25 GMT (02/01:11 MET).

During the period between FD 4 through 10, the SRMS and OBSS remained at the Node 3 Installation Viewing Position.

On FD 11, the SRMS maneuvered from the Node 3 Installation Viewing Position to the Undocking Position at 049/00:49 GMT (09/15:35 MET).

On FD 12, no SRMS operations were performed.

On FD 13, after undocking, the crew maneuvered the OBSS to the Flat Field Position at 051/05:25 GMT (11/29:11 MET) to start the Late Inspection of *Endeavour's* TPS. The



starboard RCC survey began at 051/06:05 GMT (11/20:51 MET) and was completed at 051/06:58 GMT (11/21:44 MET). The nose cap survey began at 051/07:26 GMT (11/22:12 MET) and was completed at 051/07:57 GMT (11/22:43 MET). The port survey began at 051/08:21 GMT (11/23:07 MET) and was completed at 051/09:12 GMT (11/23:58 MET). The OBSS was maneuvered to the hover-position at 051/09:34 GMT (12/00:54 MET) and berthed at 051/10:18 GMT (12/01:04 MET). After releasing the OBSS, the SRMS maneuvered to the Pre-cradle Position at 051/10:45 GMT (12/01:54 MET).

On FD 14, the SRMS was cradled at 051/23:25 GMT (12/14:11 MET) and latched 4 min later. The stowing of the port and starboard MPMS was completed at 051/23:36 GMT (12/14:22 MET).

## WING LEADING EDGE IMPACT DETECTION SYSTEM

### ASCENT MONITORING

All units triggered and began recording data on Main Engine Ignition within 0.15 seconds of each other. The Mission Elapsed Time (MET) was set to 9.21 sec behind Data Elapsed Time (DET) (MET = DET – 9.21sec) for both port and starboard wing units. Only one possible impact case above 1.0 Grms was found on the starboard wing and reported during the flight. Post-flight analysis of the data did not find any additional indications above 1.0 Grms. All reportable ascent indications are listed in following table.

#### SUSPECTED ASCENT DEBRIS IMPACTS ABOVE 1.0 GRMS

Times <sup>a</sup>		Location			Magnitude		Criteria				Impact <sup>b</sup>	
MET, hr	DET, hr	Wing	RCC	Unit Channel	Max. Grms	Max. G	Transient	Local	Spectral	Shock	In-Flt	Post-Flt
110.2	119.4	Stbd	9	1178-J2	1.92	10.7	+	+	+	+	P	P

<sup>a</sup>Adjusted to correct for known differences between the onboard laptop and actual GMT times.

<sup>b</sup>P = Probable

### ORBIT MONITORING

Continuous on-orbit monitoring of each Reinforced Carbon-Carbon (RCC) panel was not possible because of sensor-unit battery-life limitations. Each wing was monitored with two groups of sensors consisting of 10 and 11 units.

During the planned Group 2 Sensor Micrometeoroid/Orbital Debris (MM/OD) monitoring [098/16:15:00 Greenwich Mean Time (GMT) to 099/11:15:00 GMT] with the Wing Leading Edge (WLE) Impact Detection system (IDS), Starboard wing sensor unit S/N 1041 acquired a trigger on its third channel (upper 6/7 RCC panel interface location) and failed to force trigger the other 10 sensor units via RF as the system was programmed (IFA STS-130-V-02).

The WIS GFE team verified the sensor unit 1041 and the other sensors in its group were properly programmed by reviewing the programming commands and result files. This was the first time a unit has triggered and all of the sensors in its group have failed to force trigger.

For this mission, 11 on-orbit triggers were recorded, which related to 5 separate events. One of these events included 4 triggers, each of which satisfied all impact criteria. These 4 triggers were reported as one probable MM/OD impact indication. Review of the post-flight data did not reveal any additional on-orbit indications. The peak trigger from the probable MM/OD indication is shown in the following table.

## SUSPECTED MM/OD IMPACTS

GMT	Location			Magnitude	Criteria					Impact <sup>b</sup>	
	Wing	RCC	Unit-Channel	Measured G Peak	Transient	Non-Mission	Spectral	Shock	Damp-ing	In-Flt	Post-Flt
040/02:28:03	Stbd	6	1162-J3	1.92	+	+	+	+	+	P	P

<sup>a</sup>Adjusted to correct for known differences between the onboard laptop and actual GMT times.

<sup>b</sup>P = Probable

## ASCENT DATA ANOMALIES

Two ascent data anomalies (data spikes) were found during the mission. These were similar to a data anomaly seen during STS-123, which was also flown by OV-105 and occurring around the same MET. The ascent data anomalies are shown in the following table.

## ASCENT DATA ANOMALIES

MET	DET	Location			Magnitude		Criteria					Impact <sup>b</sup>	
		Wing	RCC	Unit-Channel	Max Grms	Max G	Transient	Non-Mission	Spectral	Shock	Multi-Sensor	In-Flt	Post-Flt
12.0	2.8	Port	5/6L	1155-J3	492	993	+	-	-	-	-	P	P
13.4	4.2	Port	5/6L	1155-J3	480	993	+	-	-	-	-	P	P

<sup>a</sup>P = Probable

## CONCLUSIONS

The WLE IDS system performed well for ascent impact monitoring. During the mission, one ascent impact indication above the 1.0 Grms threshold was reported with a damage likelihood of Category I (<1/1000). Post-flight review of the data did not find any additional ascent indications over 1.0 Grms.

One probable MM/OD indication was detected and reported during flight. Based on the ascent and on-orbit findings from all systems, including WLE IDS, the Orbiter Project Office (OPO) recommended that no focused WLE RCC inspection was required. The late mission Orbiter Boom Sensor System (OBSS) survey visually inspected the WLE after the Orbiter undocked and prior to entry. No critical damage was found.

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

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

The TCS was powered ON at 41/03:07:00 GMT [01/17:52:53 Mission Elapsed Time (MET)] at an approximate distance of 25,000 ft and commanded to Acquisition mode 2 min later. The unit began tracking the International Space Station (ISS) at 041/03:35:00 GMT (01/18:20:53 MET) at a distance of approximately 4590 ft in the Pulse Laser mode. One minute later, the Pulsed Laser handed off to the Continuous-Wave (CW) Laser in High Power.

During the rendezvous activities, the CW Laser exhibited erratic and periodic erroneous Range and R-Dot data (IFA STS-130-V-06). Analysis of the TCS data could not determine a root-cause real-time that would account for the CW failure. The Pulsed Laser's operation did not exhibit the same failure mode and was nominal during its time of operation.

During the first EVA, the EV1 crewmember's audio in both earphones began to degrade about 4 hr into the EVA (IFA STS-130-V-09). The condition continued through the remainder of the EVA with low audio levels, but a total loss of audio did not occur. A communications test was performed on both the Prime Communications Carrier Assembly (CCA), S/N 1172, and the Backup CCA, S/N 1192, after the EVA. The low audio level was still present in the Prime CCA, while the Backup CCA audio levels were normal.

During preparations for the second EVA, the EV1 crewmember reported that the Extravehicular Mobility Unit (EMU) C&W audio tones could not be heard on CCA S/N 1172. This unit was swapped out with CCA S/N 1192, which operated nominally during the EVA.

During the planned Group 2 Sensor Micrometeoroid/Orbital Debris (MM/OD) monitoring (098/16:15:00 GMT to 099/11:15:00 GMT) with the Wing Leading Edge (WLE), Impact Detection system (IDS), Starboard wing sensor unit S/N 1041 acquired a trigger on its third channel (upper 6/7 RCC panel interface location) and failed to force trigger the other 10 sensor units via RF as the system was programmed to do (IFA STS-130-V-04).

The WIS GFE team verified that sensor unit 1041 and the other sensors in its group were properly programmed by reviewing the programming commands and result files. This was the first time a unit has triggered and all of the sensors in its group have failed to force trigger.

## **POST-LAUNCH PAD INSPECTION**

The post-launch inspection of the Main Launch Platform (MLP) -2, Pad A Fixed Service Structure (FSS), and Pad A apron/infield/flame trench was conducted on February 8, 2010, from 5:45 a. m. to 7:45 a.m. Eastern Standard Time (EST). The inspection proceeded relatively quickly while the Safing Teams secured the Pad. The entire Pad, FSS and MLP were inspected. The only flight hardware found was some Reusable Solid Rocket Booster (RSRB) throat plug material.

Orbiter lift-off lateral acceleration data indicated a maximum of 0.10g. Hold-down Post (HDP) stud hang-ups are typically noted with lateral accelerations above 0.19g.

## **SRB HOLD-DOWN POSTS INSPECTION**

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

**HDP no. 2** – The EA934 poured sidewalls were nominal with minor acceptable pitting. The Phenolic shim was nominal. Both firing lines were missing. Approximately 1.5 ft. of Range Safety System (RSS) cable remained past the tie-off point. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down. A small metal irregularity was detected at the lip of the through-hole at the 200-deg from the North location.

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

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

**HDP No. 5** – The EA934 poured sidewalls were nominal with minor acceptable pitting. The Phenolic shim was nominal. Approximately 6 in. of the firing-line cables were intact. No galling or chatter marks were noted in the chamfer of the through-hole and the stud was set down.

**HDP No. 6** – The EA934 poured sidewalls were nominal with minor acceptable 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. 7** – The HDP showed nominal indications of erosion on the RTV-coated blast shield with proper closure.

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

## **GASEOUS NITROGEN PURGE LINES INSPECTION**

The Left-Hand (LH) Gaseous Nitrogen (GN<sub>2</sub>) probe was erect and slightly bent Southeast. Protective tape was present with no exposed braiding and the O-ring was present.

The Right Hand (RH) probe was erect and slightly bent West. The protective tape was present with no exposed braiding, and the O-ring was not present.

## **RSRB T-0 (LIFT-OFF) GROUND CARRIER ASSEMBLIES INSPECTION**

1. The LH RSRB T-0 Ground Carrier Assemblies (GCA) appeared to be in nominal condition with proper demate.
  - a. Several connector housings had broken sidewalls.
  - b. The 3J1 and 4J1 pin and sockets were raised higher than nominal.
  - c. All four frangible bolt halves were present.
2. The RH RSRB T-0 GCAs appeared to be in nominal condition with proper demate.
  - a. Several connector housings had broken sidewalls.
  - b. The 3J1 and 4J1 pin and sockets were raised higher than nominal.
  - c. All four frangible bolt halves were present.

## **LIQUID OXYGEN AND LIQUID HYDROGEN TAIL SERVICE MASTS INSPECTION**

Both the Liquid Oxygen (LO<sub>2</sub>) and Liquid Hydrogen (LH<sub>2</sub>) Tail Service Masts (TSMs) appeared to be undamaged and both bonnets appeared to have closed properly.

## **MAIN LAUNCH PLATFORM DECK INSPECTION**

The MLP deck was in nominal condition. Typical blast erosion was observed in and around the RSRB flame holes. Both TSM North targets were missing. Both North Camera targets were missing. The East-side rain bird target was missing.

## **ORBITER ACCESS ARM (195-FT LEVEL) INSPECTION**

The Orbiter Access Arm (OAA) was retracted and secured with no apparent damage. All slide-wire baskets remained secured at 195' Level with no evidence of damage.

## **GASEOUS HYDROGEN VENT LINE GROUND UMBILICAL CARRIER PLATE (215-FT LEVEL) INSPECTION**

The Gaseous Hydrogen (GH<sub>2</sub>) vent line latched on the eighth tooth (of eight) on the latching mechanism. The vent line had a south bias in positioning. The north gimbal strut was between the two ratchet pawls. The GH<sub>2</sub> vent line had a nominal arresting cycle as noted on the previous launch. The inspection of the Ground Umbilical Carrier Plate (GUCP) LH and RH pivot assemblies indicated a nominal separation. The External Tank (ET) GUCP 7-inch GH<sub>2</sub> Quick-Disconnect (QD) probe was accessible for inspection and appeared to be undamaged. Both the QD probe sealing surface and the poppet valve assembly were in good condition. The ET GUCP exhibited less than

typical blast damage and the pyrotechnic-bolt fired nominally. Both the 4 ft and 24 ft vacuum-jacketed braids were minimal scorching.

### **GASEOUS OXYGEN VENT ARM (255-FT LEVEL) INSPECTION**

The Gaseous Oxygen (GOX) vent arm and hood appeared undamaged. The hood-windows and purge ducts appeared to be in nominal condition and the latch mechanism was locked properly.

### **LAUNCH PAD FACILITY INSPECTION**

Launch Pad A appeared to be in very good condition and exceptionally clean.

### **NORTH RSRB FLAME-TRENCH INSPECTION**

The North RSRB flame-trench had small pieces of Fondue Fyre material liberated consistent with the skim-coat repair done to the trench surfaces. No large sections of Fondue Fyre were liberated.

### **DEBRIS ITEMS FOUND**

1. Minor pieces of RSRB throat plug material were found on the Launch-Pad surface.
2. Small pieces of Fondue Fyre were found on both East and West Launch-Pad surface area.
3. A small piece of rust-scale was found on the 175-ft level.
4. The ET Intertank-Access swinging gate was found on the launch-pad surface west of the elevator banks.
5. A KC fitting was found on the West-side of the launch-pad apron.
6. The Pad Terminal Connection Room (PTCR) access door was damaged.
7. A small writing pen was found on West-side of the flame trench on the pad surface.
8. A metal pin approximately 4.5 in. long that had one end threaded was found.
9. Two small bolts, one stainless, were found 150 ft South of the elevators.
10. Two welding rods were found, one at the 255-ft level and one on the pad surface.
11. A small glass fragment was found on the 255-ft level.
12. An Oxygen analyzer box latch was missing and one latch was loose at the 215-ft level.
13. A broken light bulb was within a fixture on the 175-ft level.

# **LAUNCH PHOTOGRAPHY AND TELEVISION ANALYSIS**

## **VEHICLE OBSERVATIONS**

The launch photography provided data for the evaluation by the Debris Assessment Team to determine the condition of the Thermal Protection System (TPS).

At minus 2.592 sec Mission Elapsed Time (MET), a piece of debris was observed between Space Shuttle Main Engine (SSME) no. 2 and the body flap.

At approximately 41 sec MET, debris appeared to impact the Orbiter fuselage forward of the starboard Main Landing Gear Door (MLGD). The debris was observed falling aft between the Orbiter and External Tank (ET). There was possible impact with the Orbiter fuselage. However, the debris spray is observed in only one frame with no indication of origin.

At 48.248 sec MET, debris was observed above the port wing and it appeared to impact the Orbiter near the elevon cove. The debris first appeared near the Orbiter left Reaction Control System (RCS).

At approximately 101 sec MET, a possible debris impact near the starboard MLGD appeared in a single frame near the forward edge of the starboard MLGD. After the debris passed through the camera Field-of-View, a light spot appeared to be on the Orbiter surface that was not previously present. This light-color area could have indicated an impact event, or it is possible that it may have been an imagery artifact.

At 119.3 sec MET, a single piece of ET TPS was observed to release from the +Z Intertank stringer inboard of the Liquid Oxygen (LO<sub>2</sub>) feedline (forward of the starboard bipod) and fell aft. The review of the video indicates no impact to the Orbiter.

At approximately 123 sec MET, debris was observed traveling aft between the Orbiter and the ET. A possible debris impact to the Orbiter forward lower surface was indicated by the potential debris spray.

At approximately 125 sec MET, debris was observed to be falling aft and the debris appeared to impact the Orbiter starboard fuselage edge. The debris was from the forward end of the stack and it broke into several smaller pieces, which is an indication of possible impact, although no impact was observed. No visible vehicle damage was noted.

At approximately 129 sec MET, an unidentified light-colored object was detected near the LH RSRB Nose Cap after RSRB separation. This film was from the Right Hand (RH) RSRB ET observation camera, which monitored the Left Hand (LH) RSRB following the separation events. In the first frame that the object is seen at 128.412 sec MET, it appears to be near the far/backside of the LH RSRB. The object appears to be



tumbling based on object shape/movement and the object does not appear to be stationary.

At 485.6 sec MET, multiple pieces of debris were observed on the port side of the vehicle, first seen near the Orbiter port fuselage. Possible impact to the Orbiter fuselage observed.

During ascent, an ET TPS loss was observed on the +Z Intertank stringer inboard of the LO<sub>2</sub> feedline.

During ascent, a missing piece of ET TPS was noted on the intertank stringer S 1-1.

During ascent, a missing piece of ET TPS was noted on the port side of the intertank at approximately Xt 987.

During ascent, a missing piece of ET TPS was observed at approximately Xt 993 forward of the starboard bipod.

During ascent, an ET TPS Loss was observed at approximately Xt 993 forward of the starboard bipod

During ascent, ET TPS Losses were identified on the -Z Intertank area.

## **LAUNCH PAD OBSERVATIONS**

At 2.790 sec MET, an object, possibly an attachment pin, was observed bouncing on top of the elephant hide inside the Liquid Hydrogen (LH<sub>2</sub>) Tail Service Mast (TSM) after door closure.

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## **APPENDIX A** **STS-130 MISSION EVENTS**

<b>EVENT</b>	<b>DESCRIPTION</b>	<b>ACTUAL GMT</b>
APU Activation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	039/09:09:17.809 039/09:09:19.173 039/09:09:20.366
SRB HPU Activation	LH HPU System A Start Command LH HPU System B Start Command RH HPU System A Start Command RH HPU System B Start Command	039/09:13:39.107 039/09:13:39.317 039/09:13:39.377 039/09:13:39.547
Main Engine Start	SSME-3 Start Command Accepted SSME-2 Start Command Accepted SSME-1 Start Command Accepted	039/09:14:00.468 039/09:14:00.577 039/09:14:00.700
SRB Ignition	SRB Ignition Command	039/09:14:07.017
Throttle Up 104.5 Percent	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039/09:14:11.185 039/09:14:11.194 039/09:14:11.196
Throttle Down to 74 Percent	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039/09:14:44.945 039/09:14:44.955 039/09:14:44.957
Throttle Up to 104.5 Percent	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039/09:14:58.385 039/09:14:58.395 039/09:14:58.397
Maximum Dynamic Pressure (Max Q)	Derived Ascent Dynamic Pressure	039:09:15:11
Both SRMs at 50 psi	LH SRM Chamber Pressure RH SRM Chamber Pressure	039:09:16:08.977 039:09:16:09.897
End SRM Action	LH SRM Chamber Pressure RH SRM Chamber Pressure	039:09:16:11.717 039:09:16:12.017
SRB Separation Command	SRB Separation Command Flag	039:09:16:14
SRB Physical Separation	LH APU A Turbine Loss of Signal LH APU B Turbine Loss of Signal RH APU A Turbine Loss of Signal RH APU B Turbine Loss of Signal	039:09:16:14.257 039:09:16:14.297 039:09:16:14.297 039:09:16:14.337
OMS Assist Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	039:09:16:24.5 039:09:16:24.6
OMS Assist Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	039:09:18:37.9 039:09:18:37.9
Throttle Down for 3g	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039:09:21:27.509 039:09:21:27.524 039:09:21:27.529
3G Acceleration	Total Load Factor (g)	039:09:22:15.4
Throttle down to 67 percent for Cutoff	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039:09:22:22.229 039:09:22:22.246 039:09:22:22.250
SSME Shutdown	SSME-3 Command Accepted SSME-2 Command Accepted SSME-1 Command Accepted	039:09:22:28.470 039:09:22:28.486 039:09:22:28.490
Main Engine Cutoff (MECO)	MECO Command Flag MECO Confirmed Flag	039:09:22:29 039:09:22:30
ET Separation	ET Separation Command Flag	039:09:22:51

## **APPENDIX A**

### **STS-130 MISSION EVENTS**

<b>EVENT</b>	<b>DESCRIPTION</b>	<b>ACTUAL GMT</b>
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	039:09:30:53.779 039:09:31:10.963 039:09:31:30.116
OMS 1 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	Not Required
OMS 1 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	Not Required
OMS 2 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	039:09:51:48.8 039:09:51:48.0
OMS 2 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	039:09:53:21.9 039:09:53:22.0
Payload Bay Doors Open	Right Payload Bay Door Open 1 Left Payload Bay Door Open 1	039:10:44:44 039:10:46:05
OMS 3 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	039:12:13:24.9 039:12:13:24.9
OMS 3 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	039:12:14:31.3 039:12:14:31.5
OMS 4 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	040:02:30:02.9 040:02:30:02.9
OMS 4 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	040:02:31:09.7 040:02:31:09.9
OMS 5 Ignition	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	041:00:56:14.5 041:00:56:14.7
OMS 5 Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	041:00:56:28.9 041:00:56:29.1
OMS 6 Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	041:02:28:25.1
OMS 6 Cutoff	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	041:02:28:33.9
Docking	Capture	041:05:05:56
Undocking	Undocking Complete	051:00:53:52
Flight Control System Checkout – APU 1 Start	APU-1 Gas Generator Chamber Pressure	052:00:19:27.479
APU 1 Stop	APU-1 Gas Generator Chamber Pressure	052:00:24:48.399
Payload Bay Door Close	Left Payload Bay Door Close Right Payload Bay door Close	052:23:40:28 052:23:44:25
APU Activation	APU-2 Gas Generator Chamber Pressure APU-1 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	053:02:09:49.353 053:02:36:02.179 053:02:36:04.366
Deorbit Maneuver Ignition	L Engine Bipropellant Valve Position R Engine Bipropellant Valve Position	053:02:14:47.2 053:02:14:47.2
Deorbit Maneuver Cutoff	R Engine Bipropellant Valve Position L Engine Bipropellant Valve Position	053:02:17:22.0 053:02:17:22.2
Entry Interface	Orbital Altitude Referenced to Ellipsoid	053:02:48:55
Blackout End	Data Locked (High Sample Rate)	NO BLACKOUT
Terminal Area Energy Management (TAEM)	Major Mode Code (305)	053:03:14:00
Main Landing Gear Contact	Main Landing Gear Left Hand Tire Pressure Main Landing Gear Right Hand Tire Pressure	053:03:20:29 053:03:20:29

**APPENDIX A**  
**STS-130 MISSION EVENTS**

<b>EVENT</b>	<b>DESCRIPTION</b>	<b>ACTUAL,GMT</b>
Main Landing Gear Weight on Wheels	Main Landing Gear Right-Hand Weight on Wheels Main Landing Gear Left Hand Weight on Wheels	053:03:20:29 053:03:20:29
Drag Chute Deployment	Drag Chute Deploy 1 CP Volts	053:03:20:31.1
Nose Landing Gear Contact	Nose Landing Gear Left Hand Tire Pressure 1	053:03:20:36
Nose Landing Gear Weight on Wheels	Nose Landing Gear Weight on Wheels	053:03:20:36
Drag Chute Jettison	Drag Chute Jettison 2 CP Volts	053:03:21:06.8
Wheels Stop	Velocity with respect to Runway	053:03:22:00
APU Deactivation	APU-1 Gas Generator Chamber Pressure APU-2 Gas Generator Chamber Pressure APU-3 Gas Generator Chamber Pressure	053:03:42:48.249 053:03:42:56.053 053:03:43:04.836

## **APPENDIX B**

### **STS-130 IN-FLIGHT ANOMALIES**

#### **INTRODUCTION**

This appendix contains listings and discussions of each of the In-Flight Anomalies (IFAs) that were identified for the STS-130 mission.

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

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### ORBITER ANOMALIES

IFA Number	Title	Comments
STS-130-V-01	Elevon Flipper Door-to-Door Seal Protruding	<p>The left-hand outboard elevon flipper door sliding seal between doors 12 and 13 was deformed, and this resulted in a 2.4-in. high by 3-in. wide protuberance and 0.5-in. wide by 1.7-in. long leak-path into the elevon cove. The seal was bent up the full width of the seal from the leading edge to the first attaching fastener. A half-inch clearance remained between the bent seal and the trailing edge seal during full-up elevon deflections. The Debris Assessment Team (DAT) thermal assessment showed no issues for internal or external components. The bent seal was not expected to liberate and in the unlikely event that it did liberate, the low energy impact would be limited to the elevon.</p> <p><b>Post-flight:</b> Post-flight inspection showed no change to the seal condition or any evidence of thermal degradation. Engineering inspection/evaluation to determine the root cause was performed. Both the door seal and trailing edge seal were removed and routed to the NASA Shuttle Logistics Depot (NSLD) for failure analysis. Both seals will be replaced.</p>
STS-130-V-02	WLEIDS Sensor SN 1155 Off Scale High During Ascent	<p>During the ascent monitoring with the Wing Leading Edge Impact Detection System (WLE IDS), sensor unit 1155 experienced two off-scale-high data spikes on channel 3 (lower RCC 5/6 panel interface on the Port wing). The off-nominal data peaks were recorded during the following times and G peak values:</p> <ol style="list-style-type: none"> <li>1. 039/09:14:09.8 GMT; 2.78 seconds MET – 867G, 492 Grms (G peak is clipped).</li> <li>2. 039/09:14:11.2 GMT; 4.20 seconds MET – 867G, 480 Grms (G peak is clipped).</li> </ol> <p>Channels 1 and 2 of the same sensor recorded nominal G values during those times. Following the off-scale-high readings on Channel 3, all the data collected on that the channel was nominal. Although the root cause is still unknown, this issue could be a result of a loose accelerometer that allows for more oscillation providing an off-nominal high G value or due to a charge amplifier issue within the data recorder for channel 3 providing an incorrect offset/gain.</p> <p><b>Post-flight:</b> The sensor was removed and replaced. The discrepant sensor was shipped back to JSC for further troubleshooting.</p>

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### ORBITER ANOMALIES

IFA Number	Title	Comments
STS-130-V-03	TPS Anomalies	<p>Three Thermal Protection System (TPS) items were identified in-flight and one identified post-flight, which exceeded pre-defined screening criteria and were entered into the TPS Inspection Imagery Management System (TIIMS) database. All 3 in-flight items were cleared using standard procedures/tools. No focused inspection was required based on the data available from Flight Day (FD) 3 R-bar Pitch Maneuver (RPM) images and FD 2 inspections.</p> <ol style="list-style-type: none"> <li>1. The Inconel strip between the flipper doors was Protruding (IFA STS-130-V-01).</li> <li>2. A ceramic insert was protruding from the window no. 2 carrier panel (IFA STS-130-I-003).  <b>Post-Flight:</b> The ceramic insert remained in place with no change in height. Post-landing, however, it was easily removed. Inspection of insert cavity showed interference between plug and C/P fastener head. The Reusable Surface Insulation (RSI) plugs in both inserts were removed and reinstalled with the plug bottoming out before it was flush with the insert/Outer Mold Line (OML) indicating hard contact and potential pre-loading of insert bondline. The braided string that is used to prevent plug from backing out of insert showed evidence of fraying at the bottom of the plug. Post-landing inspection also found a ceramic insert/plug protruding from the outboard lower carrier panel on Window 5. Review of on-orbit imagery showed that the insert was protruding prior to vehicle entry.</li> <li>3. A new crack adjacent to a previous Room Temperature Vulcanizing (RTV) repair was suspected.  <b>Post-Flight:</b> Post-flight inspection indicated that the cracked section remained in place with no observed offset. Adjacent to the RTV repair, some missing coating was observed along with a very slight crack.</li> </ol>

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### ORBITER ANOMALIES

IFA Number	Title	Comments
STS-130-V-03 (Continued)	TPS Anomalies	<p>4. Felt Reusable Surface Insulation (FRSI) plug was identified as liberating at T-2.592 Mission Elapsed Time (MET) between the Space Shuttle Main Engine (SSME) no. 2 and the body flap. The RPM inspection did not give any details as the location from which the FRSI plug was liberated due to shadowing in the aft of the vehicle.</p> <p><b>Post-flight:</b> During the post-flight TPS runway inspection, a FRSI plug was identified as missing from the dome heat shield of engine #2. Review of processing documents points to the most likely cause of the liberation being installation of a plug whose diameter was insufficient to provide adequate resistance coupled with failure to perform a pull test. The plug will be replaced and a pull test performed.</p>
STS-130-V-04	OCA 48 Mbps Not Available	<p>The transition from Orbiter Communications Adapter (OCA) 2MB Downlink (channel 2) to OCA 48MB (Channel 3) resulted in a failure on Flight Day (FD) 1. The OCA downlink configuration was returned to the original 2MB Configuration and the MUX BYPASS was returned back to ACT and turned off. At 42/00:35 GMT, further troubleshooting was performed for OCA 48MB. During the troubleshooting procedure, the ground saw that DTV data was being shipped to the ground when the MUX was supposed to be configured for OCA 48MB. The crew confirmed that the MUX BYPASS switch was properly configured in the BYPFR position (OCA). MCC was receiving DTV data packets, indicating that a relay in the MUX could be stuck in the ACT position (DTV). A power cycle of the MUX was no joy. The OCA downlink was returned to the original 2MB configuration and the MUX BYPASS switch was returned to ACT. The Lack of 48 Mbps High Rate increased the time required for the downlink of inspection imagery from IDC, LCS, and digital cameras.</p> <p><b>Post-Flight:</b> Ground troubleshooting has isolated the problem to a defective MUX bypass switch. The MUX has been removed and replaced. The removed unit was routed to JSC for additional troubleshooting.</p>



## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### ORBITER ANOMALIES

IFA Number	Title	Comments
STS-130-V-05	HDTV Downlink Issues	<p>On Flight Day (FD) 1, the crew attempted to downlink the ET hand-held high definition video. The Multi Protocol Converter (MPC) HDV and TAXI LEDs were not illuminated indicating no HD video from the HDV camcorder to the MPC. The DTV cables were swapped with the spare shorter cable, resulting in HDV and TAXI LEDs illuminating. Still no HD video downlink on Downlink Data Multiplexer (MUX) channel 2. The Multiplexer (MUX) Channel 2 status LEDs indicated a bad fiber-optic connection between the MPC and MUX CH 2. The crew swapped out the MPC to MUX 3 meter ST-to-ST Optical cable with a shorter 1 meter ST-to-ST Optical cable. After the optical cable swap, the MUX LED status lights still indicated a bad fiber-optic connection. HD downlink was moved to channel 1 of the MUX and still had no HD downlink. On FD 4, the crew performed the “MUX MPC troubleshooting” procedure, and were able to downlink live HD video via the MUX Channel 2 input. Later on FD 4, a playback was attempted in the same configuration with intermittent, then no HD video. On FD 5, the crew attempted another HD video playback via MUX Channel 2 but was unsuccessful. The HD Optical cable was moved to MUX channel 1 and the on-board hardware configuration was verified. This resulted in a successful HD playback on MUX channel 1. On FD7, FD8, FD9, and FD10, HD Video playback was successful. On FD 11, the crew swapped out the 1 meter ST-to-ST Optical cable with the primary and longer 3 meter ST-to-ST Optical cable to support the FD 14 PAO event. The Crew reported good MUX status LEDs on channel 1. Later on FD 11 the crew performed a successful HD downlink.</p> <p><b>Post-flight:</b> The MUX was removed and replaced, and returned to JSC for further troubleshooting.</p>

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### ORBITER ANOMALIES

IFA Number	Title	Comments
STS-130-V-06	TCS Erratic Data During Rendezvous	<p>During approach, Trajectory Control Sensor (TCS) did not operate as expected. The TCS did not transition from the Pulsed to the Continuous Wave (CW) laser mode as expected at approximately 1000 feet. Instead the TCS remained with the Pulsed laser and had occasional instances of switching to the CW laser. During the R-Bar Pitch Maneuver (RPM) (range is approximately 600 feet), the CW laser data became ratty but usable. The raw Rdot values were fluctuating between 0.7 and 5 ft/sec, with the filter smoothing the data enough to be usable.</p> <p>The Pulsed laser was overridden by the crew on the V-bar (range approximately 250 ft). The CW laser performance on the V-bar was no better than the earlier Pulse laser performance, showing jumps in position, rapid changes in Rdot and frequent navigation-initializations. No further troubleshooting was performed.</p> <p>In discussions with the Rendezvous Proximity Operators Program (RPOP) personnel, the TCS personnel requested the overriding of the Pulsed laser during the Twice Orbital R-Bar Approach (TORVA). This would force the CW to remain operational and permit the TCS personnel to assess the performance before reaching the positive V-bar. The TCS was able to assess that the CW laser was not operating correctly with jumps in range and range rate data, without overriding the Pulsed laser. Prior to reaching the positive V-bar, TCS requested overriding the CW laser. This would permit a valid Pulsed laser to continue to support the rendezvous mission operation. The RPOP filtering would have presented valid data to the crew until the Pulsed receiver would become saturated at approximately 65 ft. Other Tools for Rendezvous and Docking (TRAD) tools would support the rendezvous and docking portion of the mission. This request was not implemented.</p> <p><b>Post-Flight:</b> TCS S/N 1007 was removed and replaced with TCS S/N 1010, and returned to JSC for further troubleshooting.</p>

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES  
ORBITER ANOMALIES**

IFA Number	Title	Comments
STS-130-V-07	FC2 Substack 3 CPM Intermittent Self-test Fail	<p>Fuel Cell (FC) 2 received a failed intermittent self-test (3-5 times). The Cell Performance Monitor (CPM) reported a voltage difference between substacks. Fuel Cell Monitoring System (FCMS) data looked good. The Main B to Main C bus tie was put in place per Flight Rules. A Table Maintenance Block Update (TMBU) was sent to inhibit the alarm. The data pointed to a healthy fuel cell. The Bus tie was broken for entry.</p> <p><b>Post-flight:</b> The failed CPM was replaced by the vendor. Retest of the new installation was completed and demonstrated satisfactory operation.</p>

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES  
ORBITER ANOMALIES**

IFA Number	Title	Comments
STS-130-V-08	PLBD Centerline Actuator System A Latch Indication Lost	<p>At 013/18:00:07 MET (immediately after Terminal Area Energy Management (TAEM), the Payload Bay Door (PLBD) Centerline Latch 13-16 Latch A Microswitch toggled between ON and OFF for several seconds. The indication ultimately remained OFF starting at 013/18:00:27 MET. No impact to the mission. The system 'B' latch indication remained on, indicating the 4 latch gang was still in the latched position.</p> <p><b>Post-flight:</b> Prior to PLBD opening, troubleshooting isolated the failure to the actuator. Also, a second issue was that in the unlatch direction, the noise at latches 13-16 was noticeably louder than that at latches 1-4. A command signal test (no power to motor) showed that the Latch A limit switch OFF indication was not inhibiting motor-1. With power applied, motor-1 was driven to latch with Latch A ON indication received after approximately 0.1 sec. Additional motor-1 cycles showed nominal Latch A indications. The PLBDs were then opened and the latch cycled again with no anomalous conditions related to the anomaly. Cycling of the latch 13-16 Power Drive Unit (PDU) with the latches unloaded [doors open] while monitoring a data recorder was performed. There were no obvious indications of a problem. Prior to cycling the latches with doors closed, the latches were cycled again with the doors open and that time the issue did recur. In addition, it appeared that the second limit switch was having similar issues. The problem with both limit switches and the noise continued during troubleshooting with the doors closed as well. The conclusion of the Problem Resolution Team (PRT) was that there was an increase in load in the aft region of the PLBDs. The PLBD bulb-seal compression measurements along the centerline were taken. Additional borescope inspections of the expansion joints were performed and the results are in engineering review. The PRT took this issue to the OPO on 3/24/2010 with a recommendation to fly the PDU as-is, and the OPO concurred with the recommendation.</p>

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STS-130 IN-FLIGHT ANOMALIES  
ORBITER ANOMALIES**

IFA Number	Title	Comments
STS-130-V-09	EV1 CCA SN 1213 Volume Low During EVA 1	<p>During the first Extravehicular Activity (EVA), the EV1 crewmember's earphone/receive audio in both earphones began to degrade approximately 4 hr into the EVA. The EV1 crewmember increased the volume on the Displays and Controls Module (DCM) from 4 to 6. The EVA was continued with low audio levels; not total loss of audio. Prior to entering the Airlock at the end of the EVA, the EV1 crewmember switched from PRI to ALT with no change in audio level. After the EVA, the ear cups were inspected for visible moisture with none found. The MBEDs seals were inspected; seals looked intact. A communication. check was performed in both hard-line and PRI using the Prime Communication Carrier Assembly (CCA) and the Backup (BU) CCA. The B/U had nominal audio with the Prime still exhibiting the same reduced audio level.</p> <p><b>Post-Flight:</b> The Prime CCA (S/N 1213) failed ground testing. Further troubleshooting is in work.</p>

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### REUSABLE SOLID ROCKET BOOSTER ANOMALIES

IFA Number	Title	Comments
STS-130-B-001	System A TVC FIV Position Indicator Toggled Twice During the Launch Countdown	<p>When the SRBs were powered up, the Fuel Isolation Valve (FIV) Closed Position Indicator was reading OFF and it should have read ON. The FIV was cycled about 50 min after SRB Power Up as an attempt to correct the indicator state and perform the Resistance and Frequency BITE test. The FIV was opened for 18 sec. During this time, the Closed Position Indicator remained in the OFF state and when the valve was closed, the indicator switched to ON. Five seconds after the valve was cycled, the indicator toggled from ON to OFF three times and remained in the OFF state. A waiver was taken due to the inability to perform the Left-Hand (LH) Rock Resistance and Frequency BITE test (the Closed Position Indicator was in an incorrect state). All four FIVs were cycled per normal countdown operations for the Resistance and Frequency BITE tests. During the FIV cycle, the LH Rock remained in the OFF state but once the valve was closed, the Closed Position Indicator went back to ON. Ten minutes later, the Closed Position Indicator toggled to the OFF state twice then remained in the ON state. To satisfy the OMRSD and not write the waiver, a Resistance and Frequency BITE test was performed on LH Rock. The BITE test was successful. The LH Rock FIV had to be cycled again per normal countdown operations, and the Closed Position Indicator performed nominally. Thirty minutes after the FIV was cycled, the Closed Position Indicator toggled to the OFF state once then back to ON where it remained during the rest of launch countdown. Thirty minutes after the FIV was cycled, the Closed Position Indicator toggled to the OFF state once then back to ON where it remained during the rest of launch countdown. The Closed Position Indicator performed nominally for APU startup and through ascent. This condition occurred on both the first and second launch attempts.</p> <p><b>Post-flight Activity:</b> The Rock and Tilt installed cables will be tested for continuity from the IEA to the FIV prior to disassembly. Additionally, the FIV position indicators will be monitored for a period of time while still installed in the aft skirt. The Rock and Tilt installed cables will be tested for continuity from the IEA to the FIV during Postflight (prior to disassembly). The investigation is continuing as the cause has not been identified.</p>

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES**

**REUSABLE SOLID ROCKET MOTOR ANOMALIES**

No Reusable Solid Rocket Motor anomalies were identified during the STS-130 mission.

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES**

**SPACE SHUTTLE MAIN ENGINE ANOMALIES**

No Space Shuttle Main Engine anomalies were identified during the STS-130 mission



**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES**

**EXTERNAL TANK ANOMALIES**

IFA Number	Title	Comments
STS-130-T-001	Post-Flight Review Identified 2 Foam Losses on +Z Side Intertank Acreage and 19 Foam Losses on -Z Side of the Intertank	Post-flight review identified two (2) foam losses on the +Z side of the Intertank NCFI 24-124 Acreage as well as 19 foam losses on the -Z side of the Intertank NCFI 24-124 Acreage. Two of these losses violate the NSTS 60559 Risk Assessment Masses for Void differential pressure in the Intertank; 0.004 lb <sub>m</sub> for less than or greater than 135 sec and 0.015 lb <sub>m</sub> for greater than 135 sec. Loss 1 had an estimated mass of 0.023 lb <sub>m</sub> . Time of Loss 1 was estimated at approximately 119 sec. Loss 2 had an estimated mass of 0.052 lb <sub>m</sub> . Time of Loss 2 was estimated at approximately 485 seconds and was a multiple-piece liberation. The Failure Mode attributed to these Intertank Acreage losses are not specifically covered in NSTS 60559. The most probable contributor to these Intertank Acreage losses as determined by the Intertank Loss Team was poor surface adhesion most likely due to surface contamination prior to foam application.

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES**

**SYSTEM ENGINEERING AND INTEGRATION ANOMALIES**

IFA Number	Title	Comments
STS-130-I-001	Unexpected Debris/Expected Debris Exceeding Mass Allowable Prior to Pad Clearance (Liftoff Debris).	STS-130 experienced unexpected debris and expected debris exceeding the mass allowable prior to pad clearance. Post-flight investigation identified several areas for improvement. This IIFA was closed at the SICB on March 9, 2010, based on the following rationale: Risk assessment indicates that given the proposed mitigations, observed debris poses no appreciable increase in risk. Lift-off debris risk is currently characterized as infrequent, catastrophic due to significant limitations in controls and significant uncertainties in analysis. Expected Lift-off debris risk is classified as infrequent catastrophic in IDBR-01 cause AD. Unexpected lift-off debris from KSC Facilities/GSE is transferred from IDBR-01 cause AJ to LL-0077, which is classified as infrequent catastrophic. Debris release was mitigated for identified potential sources of critical debris by performing repairs and adding inspections for system-level components. Ongoing mitigations include Foreign Object Damage (FOD) awareness, attrition-based removal of hardware, routine inspections and monitoring for facility corrosion.
STS-130-I-002	ET TPS Loss From The Intertank	Mission imagery identified the loss of Thermal Protection System (TPS) on multiple areas of the Intertank, with one instance that occurred during the Aerodynamic Sensitive Transport Time (ASTT) and exceeded the mass allowable. The associated hazard report is IDBR-01 Cause G. Based on post-flight analysis of procedures and pull-test data, combined with the ongoing analysis of this issue since STS-127, the loss mechanism for this debris release is attributed to poor surface adhesion that is most likely due to surface contamination prior to foam application. Although a tile Probabilistic Risk Assessment (PRA) was unable to be developed using the current tile-damage models, the team accepted the risk of this type of debris event considering the unlikely combination of specific events that must take place for the debris to cause critical damage. Due to uncertainties in this assessment and the inability to quantify a tile PRA, the risk remains "infrequent/catastrophic" in IDBR-01.

**APPENDIX B  
STS-130 IN-FLIGHT ANOMALIES**

IFA Number	Title	Comments
STS-130-I-003	Ceramic Insert Protruding Near Window No. 2	<p>During on-orbit inspections, a ceramic insert was found protruding approximately 0.4-in. from a tile below window no. 2. The protrusion was cleared for entry without removal based on the low potential for liberation (with positive margin for impact areas) and no thermal heating concerns. The insert did not liberate during entry and it was easily removed post-landing. If released during flight, this insert would be considered unexpected debris per IDBR-01. Post-flight inspections found another insert protruding approximately 0.1-in. on the same tile on the other side of the Orbiter (adjacent to window no. 5). Post-flight analysis indicates that the most probable causes of protruding inserts are:</p> <ol style="list-style-type: none"> <li>1. Voids in the ceramic adhesive between the insert and the tile, and</li> <li>2. Interference between the plug and the fastener.</li> </ol> <p>These two causes can be resolved via preflight inspection and will be for future flights.</p>

**APPENDIX B**  
**STS-130 IN-FLIGHT ANOMALIES**

**FLIGHT SOFTWARE ANOMALIES**

No Flight Software anomalies were identified during the STS-130 mission.

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### FLIGHT OPERATIONS AND INTEGRATION ANOMALIES

IFA Number	Title	Comments
STS-130-N-001	Orbiter Interface Unit (OIU) to ISS Data Bus Interface Errors	<p>During the initial configuration of the OIU to communicate with the GNC Multiplexer Demultiplexer (MDM) on OIU bus 3 at 41/07:05 GMT, a transient loss of communication occurred between the GNC MDM and the OIU. The loss of Communication (COMM) was evident by a flag set in the OIU indicating it had lost COMM with the GNC MDM. The GNC MDM responded by switching to bus channel B which is a known and expected event. Normally, this would not have been an issue as the OIU and GNC would have re-established COMM on channel B. However, COMM was not re-established. Ten seconds later, the channel was switched back to A (the GNC MDM will not allow it to switch bus channels more often than every 10 sec). During the 10 sec period, the OIU failed to re-establish COMM with the GNC MDM, timed out, reset it's frame counter, and began using its internal clock instead of that provided by the GNC MDM. So, even though COMM was re-established on channel A, the OIU and GNC were not synchronized. This out-of-synchronization condition eventually led to ISS fire alarms falsely being reported on the Orbiter (41/12:59:30 and 41/13:00:20 GMT) and anomalous ISS ground data being received through OIU (41/17:20 GMT). Once the OIU and GNC MDM were synchronized via a ground command (41/21:26 GMT), data were reported good. Troubleshooting then centered on isolating the source of the failure of bus channel B (ISS bus ORB-N2-1, OIU bus 3). On Flight Day (FD) 5, the bus channel was taken to B again and both the OIU and the Aft Flight Deck (AFD) Portable Computer System (PCS) dropped off the bus. Since those two items are on separate paths on the bus, assuming a single-point failure, this ruled out the OIU and the AFD PCS as failure modes.</p> <p><b>Post-Flight:</b> Inspection of the 'X' connectors was performed. Silver oxide was found on the pins. A sample was routed to the NASA materials laboratory for analysis. Testing of the Orbiter Docking System (ODS) connectors/wiring was performed with no issues noted. There will be no further in-vehicle troubleshooting.</p>

## APPENDIX B STS-130 IN-FLIGHT ANOMALIES

### MOD ANOMALIES

IFA Number	Title	Comments
STS-130-D-001	Incorrect TAL Runway Surface in Flight Rule	<p>Flight Rule A4-111 defines acceptability conditions for Orbiter End-of-Mission (EOM) or intact abort runways. For STS-130 (and numerous previous flights) the Zaragoza (ZZA) runway was listed in the Flight Rule as having a grooved surface, making it acceptable for Orbiter landings if there is visible moisture on the runway. On launch day for STS-130, the flight control team received eyewitness reports indicating that the runway at ZZA is not grooved. This was followed two days later by photographic evidence proving the ZZA runway is in fact not grooved, and therefore unacceptable for Orbiter landings if there is visible moisture on the surface. The incorrect Zaragoza runway surface description in Flight Rule A4-111 could have resulted in an unsafe Orbiter abort landing situation.</p> <p><b>Cause:</b> The root cause was that inadequate information was available at the time of the analysis to document the ZZA runway grooved or not grooved surface configuration.</p> <p><b>Corrective actions:</b> MOD has re-confirmed the grooved or ungrooved surface configuration of all EOM and Intact Abort runways listed in Flight Rule A4-111. Overall process changes are not planned at this time because no additional EOM or Intact Abort runways are planned to be Space Shuttle Program approved before the end of the Shuttle Program. A change to Flight Rule A4-111 was approved by the JPRCB on 3/22/2010 to correctly list the Zaragoza runway surface as ungrooved, for STS-131 and subsequent flights. IFA is closed for STS-131 and subsequent flights.</p>

## **APPENDIX C**

### **DOCUMENT SOURCES**

#### **MER DAILY REPORTS**

The following STS-130 MER Daily Reports by Michael D. Wright, Lead MER Manager:

- Launch and First Daily Report, dated February 8, 2010
- Second Daily Report, dated February 9, 2010
- Third Daily Report, dated February 10, 2010
- Fourth Daily Report, dated February 11, 2010
- Fifth Daily Report, dated February 12, 2010
- Sixth Daily Report, dated February 13, 2010
- Seventh Daily Report, dated February 14, 2010
- Eighth Daily Report, dated February 15, 2010
- Ninth Daily Report, dated February 16, 2010
- Tenth Daily Report, dated February 17, 2010
- Eleventh Daily Report, dated February 18, 2010
- Twelfth Daily Report, dated February 19, 2010
- Thirteenth Daily Report, dated February 20, 2010
- Fourteenth Daily Report, dated February 21, 2010
- Landing Plus 2 Hour Report, dated February 22, 2010
- Mission Summary Report, dated February 26, 2010

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

- STS-130 Lift-Off Event Time, Dino Diluigi, USA-Huntsville, February 8, 2010
- STS-130 RSRM Flash Report, Robert Zahl, ATK Systems, February 8, 2010
- STS-130 HOSC Console Flash Report, Dino Diluigi, USA-Huntsville, February 8, 2010
- STS-130 In-Flight Anomalies, David W. Morr, USA-Huntsville, June 8, 2010

#### **ORBITER REPORTS**

- STS-130 Communications and Tracking Report, Martha M. May, Boeing-Houston, March 11, 2010
- STS-130 Shuttle Remote Manipulator System, N. Doshewnek, MDA-Houston, March 4, 2010
- STS-130 HYD/WSB System Report, Charles A. Ritrivi, Boeing-Houston, March 17, 2010
- STS-130 Main Propulsion System Report, Trina A. Martingano, Boeing-Houston, March 16, 2010
- STS-130 Mechanical Systems Data Review, Jeff Goodmark, Boeing-Houston, March 26, 2010
- STS-130 Auxiliary Power Unit System, Christopher N. Adi, Boeing-Houston, March 12, 2010
- STS-130 OI/MADS Sensors, Signal Conditioners and Fuel Cell Monitoring System, Dwight A. Favors, Boeing-Houston, March 1, 2010
- STS-130 OI/MADS MUX and Timing Report, Bruce S. Woods, Boeing-Houston, March 12, 2010
- STS-130 Data Processing System Integrated Report, James T. Westergard, Boeing-Houston, March 23, 2010
- STS-130 EPDC Mission Report, William D. Peterson, Boeing-Houston, March 12, 2010
- STS-130 ATCS and ARS Post-Flight Mission Report, Carmelo S. Asuncion, Boeing-Houston, March 12, 2010
- STS-130 Wing Leading Edge Impact Detection System, Jennifer C. Hodge, Boeing-Houston, March 22, 2010
- STS-130 Life Support System Report (ARPCS and Airlock Systems), Erich L. Bass, Boeing-Houston, March 11, 2010
- STS-130 Orbiter Docking System Summary, Robert E. Davis, NASA-JSC, March 12, 2010
- STS-130 OMS Report, James M. Garza, Boeing-Houston, March 12, 2010

STS-130 RCS Mission Report, James M. Garza, Boeing-Houston, March 12, 2010  
STS-130 Final Aeroheating Report, Dennis C. Chao, Boeing-Houston, March 29, 2010  
STS-130 Fuel Cells Mission Report, Johnny D. Wong, Boeing-Houston, March 12, 2010  
STS-130 Power Reactant Storage and Distribution, Johnny D. Wong, Boeing-Houston, March 12, 2010  
STS-130 Global Positioning System Report, Heip M. Gui, Boeing-Houston, March 12, 2010  
STS-130 Thermal Control System Summary, Kent K. Rowley, Boeing-Houston, March 10, 2010  
STS-130 Flight Control System and ADTA Mission Report, Howard Damoff, Boeing-KSC, March 1, 2010  
STS-130 Final Mission Events List, Vernon C. Hill, ESCG-Houston, February 21, 2010  
STS-130 SE&I In-Flight Anomalies, R. Morehead, NASA-JSC, June 22, 2010  
STS-130 Windows Report, Orlando Torres, Boeing-KSC, March 12, 2010  
STS-130 Display and Controls, Quoc P. Ngo, Boeing-Houston, March 12, 2010  
STS-130 Purge, Vent and Drain Report, C. C. Heinol, Boeing-Houston, March 12, 2010  
STS-130 ADS – GCILC Mission Report, Arnold A. Arrington, Boeing-KSC, March 12, 2010  
STS-130 Mechanical Systems, Link Salvador, Boeing-Houston, March 12, 2010  
STS-130 Landing and Deceleration Quick Look Report, C. C. Heinol, Boeing-Houston, March 12, 2010

#### **OTHER REPORTS**

STS-130 CSR Final Report, Shelby J. Lawson, NASA-JSC, April 12, 2010  
STS-130 Final Landing Debris Runway Report, Jennifer G. Morgan, NASA-KSC, February 25, 2010  
STS-130 Final Debris Maps, Jennifer G. Morgan, NASA-KSC, February 24, 2010  
STS-130 Pre-EVA No. 1 Data, Jeff Outlaw, Hamilton Sundstrand, February 11, 2010  
STS-130 Post-Extravehicular Activity Report for EVA 1, Samuel D. Hower, Hamilton Sunstrand, February 12, 2010  
STS-130 Pre-EVA No. 2 Data, Brian Peavey, Hamilton Sundstrand, February 13, 2010  
STS-130 Post-Extravehicular Activity Report for EVA 2, Jennifer Johnson, Hamilton Sunstrand, February 14, 2010  
STS-130 EVA no. 3 Ingress and Post-EVA Report, Forrest L. Despain, Hamilton Sunstrand, February 17, 2010  
STS-130 Final Extravehicular Activity Report, David A. Foltz, NASA-JSC, April 1, 2010  
STS-130 Post-Launch Walkdown Report, Jeffrey S. Thon, NASA-KSC, March 23, 2010  
STS-130 Descent Postflight Summary, Barbara C. Schill, USA-Houston, March 19, 2010  
STS-130 prop30 Mass Properties Report, Barbara C. Schill, USA-Houston, March 19, 2010  
STS-130 Imagery Reports, Imagery Integration Group, NASA-JSC, February 8 through February 13, 2010  
STS-130 Ascent Hazard Analysis Final Report, C. C. Heinol, Boeing-Houston, March 22, 2010  
STS-130 Flight Software Anomalies, J. A. Currie, NASA-JSC, May 4, 2010  
STS-130 MOD Anomalies, Gregory A. Lange, NASA-JSCV, May 10, 2010  
STS-130 FO&I Anomalies, Raymond Serna, NASA-JSC, May 4, 2010



## APPENDIX D

### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

Acronym/ Abbreviation	Explanation
A	Ampere
AA	Accelerometer Assemblies
ABS	Ammonia Boiler System
ADTA	Air Data Transducer Assembly
AGT	Adaptive Guidance Throttling
AHMS	Advanced Health Monitoring System
A/L	Airlock
ALC	Automatic Light Control
AMOS	Air Force Maui Optical Supercomputing Site
APCA	Aft Power Control Assembly
APCU	Assembly Power Converter Unit
APFR	Articulating Portable Foot Restraint
APU	Auxiliary Power Unit
ARED	Advanced Resistive Exercise Device
ARPCS	Atmospheric Revitalization Pressure Control System
ARS	Air Vitalization Rack
ATCS	Active Thermal Control System
BITE	Build-In Test Equipment
BFS	Backup Flight System
BFS WHI	Backup Flight System Initial Weight of Helium Load
BLT	Boundary Layer Transition
BT	Bus Terminator
C&W	Caution and Warning
CBCS	CBM Berthing Camera System
CBM	Common Berthing Mechanism
CCA	Communications Carrier Assembly
CDC	Center Disk Cover
CERISE	<i>Caenorhabditis</i> and Protein Phosphorylation in Space Environment
CDT	Central Daylight Time
CGBA	Commercial Generic Bioprocessing Apparatus
CMG	Control Moment Gyro
C/O	Checkout
CO <sub>2</sub>	Carbon Dioxide
COLBERT	Combined Operational Load Bearing External Resistance Treadmill
COMM	Communications
CPM	Cell Performance Monitor

## APPENDIX D

### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
CST	Central Standard Time
CW	Continuous Wave
CWC	Contingency Water Container
CWCI	Contingency Water Container Iodine
DA	Distillation Assembly
D & C	Display and Control
DAP	Digital Autopilot
DAT	Debris Assessment Team
DDU	Data Display Unit
DET	Data Elapsed Time
DOLILU	Day of Launch I Load Update
DPS	Data Processing System
DSO	Detailed Supplementary Objective
DTO	Development Test Objective
DRWP	Doppler Radar Wind Profiler
$\Delta V$	Differential Velocity
ECLSS	Environmental Control and Life Support System
ECO	Engine Cut-off
EDT	Eastern Daylight Time
EI	Entry Interface
EMU	Extravehicular Mobility Unit
EO	External Tank/Orbiter
EOM	End-of-Mission
EPDC	Electrical Power Distribution and Control
ESA	European Space Agency
ESP	External Stowage Platform
EST	Eastern Standard Time
ET	External Tank
EV	Extravehicular (Crewmember)
EVA	Extravehicular Activity
FC	Fuel Cell
FCE	Flight Crew Equipment
FCMS	Fuel Cell Monitoring System
FCS	Flight Control System
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection Annunciation
FES	Flash Evaporator System

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
FGB	Fixed Grapple Bar
FHRC	Flexible Hose Radiator Coupler
FID	Failure Identifier
FIT	Final Inspection Team
FIV	Fuel Isolation Valve
FM	Frequency Modulation
FOM	Figure of Merit
FOV	Field of View
FRCS	Forward Reaction Control System
FSE	Flight Support Equipment
FSS	Fixed Service Structure/Flight Support System
FSW	Flight Software
g/G	Gravity
GCA	Ground Carrier Assembly
GFE	Government Furnished Equipment
GHe	Gaseous Helium
GH <sub>2</sub>	Gaseous Hydrogen
GLACIER	General Laboratory Active Cryogenics ISS Experiment Refrigeration
GMEM	GPC Memory
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GN <sub>2</sub>	Gaseous Nitrogen
GO <sub>2</sub> /GOX	Gaseous Oxygen
GPC	General Purpose Computer
GPS	Global Positioning System
Grms	Gravity root mean square
GUCP	Ground Umbilical Carrier Plate
H <sub>2</sub>	Hydrogen
H <sub>2</sub> O	Water
HD	High Definition
HDP	Holddown Post
HGDS	Hazardous Gas Detection System
He	Helium
HHL	Hand-Held LIDAR
HPFTP	High Pressure Fuel Turbopump
HPOTP	High Pressure Oxidizer Turbopump
HRP	Human Research Program

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
HTV	H II Transfer Vehicle
HYD	Hydraulic
IBA	Inspection Boom Assembly
IDS	Impact Detection System
IFA	In-Flight Anomaly
IFR	Ice Frost Ramp
IMU	Inertial Measurement Unit
IMV	Intra-Module Ventilation
I/O	Input/Output
IPR	Interim Problem Report
IVA	Intravehicular Activity
ISP	Integrated Stowage Platform
ISS	International Space Station
IT	Intertank
ITVC	Intensified Television Video Camera
JAXA	Japanese Aerospace Exploration Agency
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LH	Left Hand
LH <sub>2</sub>	Liquid Hydrogen
LiOH	Lithium Hydroxide Carrier
LO <sub>2</sub>	Liquid Oxygen
LPDL	Low Pressure Drain Line
LTA	Launch-to-Activation
MAGR	Miniature Air-to-Ground Receiver
MAUI	Maui Analysis of Upper Atmospheric Modification
MADS	Modular Auxiliary Data System
MC	Midcourse Correction
MCC	Mission Control Center
MDA	Motor Drive Amplifier
MECO	Main Engine Cutoff
MEDS	Multifunction Electronics Display System
MET	Mission Elapsed Time
MLGD	Main Landing Gear Door
MLI	Multi-Layer Insulation

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
MLP	Main Launch Platform
MLS	Microwave Landing System
MM/OD	MicroMeteoroid/Orbital Debris
MMT	Mission Management Team
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
N <sub>2</sub>	Nitrogen
N2	Node 2
NASA	National Aeronautics and Space Administration
NAVAID	Navigation Aids
NC	Nominal Correction
NCC	Nominal Correction Combination
NGT	No Greater Than
NH	Nominal Height
NH <sub>3</sub>	Ammonia
NLP Vaccine-7	National Laboratory Pathfinder Vaccine-7
NPV	Non-Propulsive Vent
0	Zero
O <sub>2</sub>	Oxygen
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter
ODS	Orbiter Docking System
OGS	Oxygen Generation System (Rack)
OI	Operational Instrumentation/Operational Increment (Software)
OIU	Orbiter Interface Unit
OME	Orbital Maneuvering Engine
OMRSD	Operational Maintenance and Requirements Specification Document
OMS	Orbital Maneuvering System
OPCU	Orbiter Power Converter Unit
ORGA	Orbiter Rate Gyro Assembly
ORU	Orbital Replacement Unit
OSH	Off-Scale High
OSL	Off-Scale Low
OPO	Orbiter Project Office

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
OTP	Orbit Tool Platform
P	Port
PAO	Public Affairs Office
PASS	Primary Avionics Software System
PASS WHI	PASS With Initial Helium Load
PCS	Pressure Control System
PCT	Post-Contact Thrust
PGME	Propylene Glycol Monomethyl Ether
PGSC	Payload General Support Computer
PLB	Payload Bay
PLBD	Payload Bay Door
PMA	Pressurized Mating Adapter
ppm	parts per million
PRCS	Primary Reaction Control System
PRSD	Power Reactant Storage and Distribution System
PRT	Problem Resolution Team
PTCR	Pad Terminal Connection Room
PTU	Power Transfer Unit
PV&D	Purge, Vent and Drain
PWR	Payload Water Reservoir
QD	Quick Disconnect
RAMBO	Ram Burn Observations
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RH	Right Hand
RHC	Rotational Hand Controller
RJD	Reaction Jet Driver
RM	Redundancy Management
RPL	Rated Power Level
RPM	R-Bar Pitch Maneuver
RSRB	Reusable Solid Rocket Booster
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System
RTLS	Return to Launch Site
RTV	Room Temperature Vulcanizing (material)
S	Starboard
S&A	Safe and Arm

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
SDBI	Short Duration Bioastronautics Investigations
SDFS	Smoke Detection and Fire Suppression
SDTO	Station Development Test Objective
SE&I	Systems Engineering and Integration
SEITE	Shuttle Engine Ion Turbulence Experiment
SIMPLEX	Shuttle Ionospheric Modification with Pulsed Firings
SLA	Super Light Ablator
SLWT	Super Lightweight Tank
SM	System Management
SMRD	Spin Motor Rotation Detector
S/N	Serial Number
SP	Sensor Package
SPA	Servo Power Amplifier
SPDM	Special Purpose Dexterous Manipulator
SRGA	SRB Rate Gyro Assembly
SRMS	Shuttle Remote Manipulator System
SRSS	Shuttle Range Safety System
SSME	Space Shuttle Main Engine
SSOR	Space-to-Space Orbiter Radio
SSP	Space Shuttle Program
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
ST	Star Tracker
STS	Space Transportation System
SWMMS	Supply Water and Waste Management System
TAEM	Terminal Area Energy Management
TCS	Thermal Control System/Trajectory Control Sensor
TEA	Torque Equilibrium Maneuver
THC	Translation Hand Controller
TI	Terminal Phase Initiation/Transfer Initiation
TMBU	Table Maintenance Block Update
TOCA	Total Organic Carbon Analyzer
TORVA	Twice Orbital Rate V-Bar Approach
TPS	Thermal Protection System
TSA	Tool Storage Assembly
TSM	Tail Service Mast
TVC	Thrust Vector Controller

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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<b>Acronym/ Abbreviation</b>	<b>Explanation</b>
UTC	Universal Time Code
VDT	Vehicle Data Table
VRCS	Vernier Reaction Control System
VSC	Video Signal Conditioner
WHC	Waste and Hygiene Compartment
WIF	Worksite Interface
WLE	Wing Leading Edge
WLE IDS	Wing Leading Edge Impact Detection System
WMC	Waste Management Compartment
WRS	Water Recovery System
WSB	Water Spray Boiler



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### STS-130 ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

<u>Unit of Measure</u>	<u>Explanation</u>
°F	degree Fahrenheit
deg	degree
deg/sec	degree per second
ft	feet
ft/sec	feet per second
Grms	gravity root mean square
hr	hour
In.	inch
keas	knots estimated air speed
kgs	knots ground speed
kW	Kilowatt
kWh	Kilowatt hour
lb	pound
lb <sub>m</sub> /lbm	pound mass
lb/min	pound per minute
lbm/hr	pound per hour
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 <sub>2</sub>	partial pressure carbon dioxide
psia	pound per square inch absolute
scim	standard cubic inch per minute
sec	second
V	Volt
Vdc	Volt direct current