NASA-TM-105,475

NSTS - 08207

STS-31 SPACE SHUTTLE MISSION REPORT

May 1990

NASA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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92N17364*# ISSUE 8 PAGE 1241 CATEGORY 16 RPT#: NASA-TM-105475 NAS 1.15:105475 NSTS-08207 90/05/00 24 PAGES UNCLASSIFIED DOCUMENT

UTTL: STS-31 Space Shuttle mission report

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CORP: National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

SAP: Avail: NTIS HC/MF A03

CIO: UNITED STATES

MAJS: /*DISCOVERY (ORBITER)/*HUBBLE SPACE TELESCOPE/*PROTEIN CRYSTAL GROWTH/*SPACE MISSIONS/*SPACE SHUTTLE PAYLOADS/*SPACE SHUTTLES/*SPACE TRANSPORTATION SYSTEM FLIGHTS

MINS: / BOOSTER ROCKET ENGINES/ CAMERAS/ CIRCULAR ORBITS/ EXTERNAL TANKS/ SPACE SHUTTLE BOOSTERS/ SPACE SHUTTLE ORBITERS/ SPACECRAFT CABINS

ABA: Author

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circular orbit having an inclination of 28.45 degrees. The secondary objectives were to perform all operations necessary to support the requirements of the Protein Crystal Growth (PCG), Investigations into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME), Ascent Particle Monitor (APM), IMAX Cargo Bay Camera (ICBC), Air Force Maui Optical Site Calibration Test (AMOS), IMAX Crew Compartment Camera, and Ion Arc payloads. In addition, 12 development test objectives (DTO's) and 10 detailed supplementary objectives (DSO's) were assigned to the flight. The sequence of events for this mission is shown. The significant problems that occurred in the Space Shuttle Orbiter subsystems during the mission are summarized, and the official problem tracking list is presented. In addition, each of the Space Shuttle Orbiter problems is cited in the subsystem discussion.

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STS-31

SPACE SHUTTLE

MISSION REPORT

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INTRODUCTION

The STS-31 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem activities on this thirty-fifth flight of the Space Shuttle and the tenth flight of the Orbiter Vehicle Discovery (OV-103). In addition to the Discovery vehicle, the flight vehicle consisted of an External Tank (ET) (designated as ET-34/LWT-27), three Space Shuttle main engines (SSME's) (serial numbers 2011, 2031, and 2107), and two Solid Rocket Booster (SRB) (designated as BI-037).

The primary objective of the mission was to place the Hubble Space Telescope (HST) into a 330 nmi. circular orbit having an inclination of 28.45 degrees. The secondary objectives were to perform all operations necessary to support the requirements of the Protein Crystal Growth (PCG), Investigations into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME), Ascent Particle Monitor (APM), IMAX Cargo Bay Camera (ICBC), Air Force Maui Optical Site Calibration Test (AMOS), IMAX Crew Compartment Camera, and Ion Arc payloads. In addition, 12 development test objectives (DTO's) and 10 detailed supplementary objectives (DSO's) were assigned to the flight.

The sequence of events for this mission is shown in Table I. The report also summarizes the significant problems that occurred in the Orbiter subsystems during the mission, and the official problem tracking list is presented in Table II. In addition, each of the Orbiter problems is cited in the subsystem discussion within the body of the report.

The crew for this thirty-fifth flight of the Space Shuttle was Loren J. Shriver, Commander; Charles F. Bolden, Pilot; Bruce McCandless, Mission Specialist 1; Steven A. Hawley, Mission Specialist 2; and Kathryn D. Sullivan, Mission Specialist 3. This was the second space flight for the Commander, Pilot, Mission Specialist 1, and Mission Specialist 3, and the third space flight for Mission Specialist 2.

MISSION SUMMARY

The STS-31 mission was scheduled for launch from Complex 39B on April 10, 1990, at 7:47 a.m. c.d.t. The launch countdown proceeded nominally until the auxiliary power units (APU's) were started at T-5 minutes. APU-1 chamber pressure and turbine speed were abnormal at APU start [both conditions are a Launch Commit Criteria (LCC) violation], and the countdown was terminated at T-4 minutes. APU-1 was removed, replaced, and reverified with a hot-fire test on April 18, 1990. The launch was rescheduled for 7:31 a.m. c.d.t. on April 24, 1990.

The launch countdown proceeded nominally for the launch on April 24, 1990. One LCC waiver was approved for the unusual ice/frost formation on the liquid hydrogen 17-inch disconnect. During the final count, the main propulsion subsystem (MPS) liquid oxygen outboard fill and drain valve indicated open. The valve is normally commanded closed by the Ground Launch Sequencer (GLS) at T-48 seconds. The count was held at T-31 seconds, and the valve was manually cycled in accordance with an authorized pre-planned contingency procedure in the LCC. The valve then correctly closed and, following the unplanned hold of 2 minutes 52 seconds, the count was resumed at T-31 seconds and proceeded normally to a successful launch at 114:12:33:50.99 G.m.t. (7:33:50.99 a.m. c.d.t.). Performance of the SRB's, SSME's, ET, and main propulsion system (MPS) was normal with main engine cutoff (MECO) occurring 8 minutes and 31.01 seconds after lift-off, and the Orbiter was placed in an orbit of 330 by 48 nmi. There were no reported anomalies during the launch phase.

A quick-look determination of vehicle propulsion system performance was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) determined for the time period between SRB separation and start of the 3g throttling was 452.2 seconds as compared to a fleet average tag value of 452.66 seconds. The relative velocity of the vehicle reached the adaptive guidance/throttling (AGT) reference value at 15.993 seconds.

Following MECO, during the MPS propellant dump/burn, the left aft reaction control subsystem (RCS) thruster L3A indicated a low chamber pressure and failed off. Propellant injector temperature data indicated the oxidizer valve had failed closed, and the RCS L3A thruster was deselected. Approximately 7 hours later, thruster L3A temperatures indicated an oxidizer leak, and the RCS manifold L3 isolation valve was closed. The manifold remained isolated for the remainder of the mission. This anomaly had no effect on normal mission operations.

The orbital maneuvering subsystem (OMS) -2 maneuver was initiated at 114:13:16:27 G.m.t., and the firing was 5 minutes 4.8 seconds in duration. The differential velocity was 496.7 ft/sec, and the resulting orbit was 330 by 311 nmi. All Orbiter subsystems operated satisfactorily during the maneuver. At 114:19:43:05 G.m.t., a +X RCS circularization maneuver was performed. The 33.5 ft/sec (2 minute 17 second) maneuver placed the Orbiter in a 332 by 331 nmi orbit.

Supply water tank C remained in the 99.8-percent quantity position for 4 hours after launch. Analysis showed that the tank C bellows were stuck, and the bellows were freed using the flash evaporator system (FES) B for a short time to increase the differential pressure across the bellows. Once freed, tank C and D quantities equalized and the bellows performed normally for the remainder of the mission.

When the water spray boiler 2 heater A was turned on at approximately 114:14:45 G.m.t., the vent temperature did not increase. The system responded nominally with heater B. Prior to deorbit, heater A was reactivated, and the temperature increased to the desired level, although at a slower-than-normal rate.

A remote manipulator subsystem (RMS) checkout was performed and the end effector camera was used for a survey of the HST. The RMS was successfully used to grapple, unberth, and deploy the HST. All RMS operations were normal and no anomalies were noted during the operations.

Following the successful unberthing of the HST from the Orbiter payload bay, the HST solar array panel number 2 failed to deploy on the first attempt. On the second attempt, the array partially deployed. A third attempt resulted in the array successfully deploying, and the HST was satisfactorily released from the RMS at 115:19:37:51 G.m.t.

The extravehicular activity (EVA) crew members were prepared to support a contingency EVA to manually deploy the HST solar array. After completing the in-suit pre-breathe period, the crew entered the Orbiter airlock. The airlock was depressurized to 5.0 psia in preparation for the EVA, if required. Upon successful deployment of the HST array, the contingency EVA was canceled.

Following HST deployment, two RCS separation maneuvers were performed at 115:19:38:20 G.m.t. and 115:19:58:28 G.m.t. The maneuvers placed the Orbiter in a station-keeping orbit until HST activation was completed and the HST aperture door was successfully opened.

At approximately 116:06:46 G.m.t., the text and graphics system (TAGS) telemetry spontaneously changed to an erroneous "Jam/Empty" condition. The unit stopped responding to advance commands as well as uplink data. Power was cycled to the TAGS, and the unit returned to nominal operations.

At approximately 116:20:12:49 G.m.t., a fuel cell alarm occurred near the end of the fuel cell 2 normal purge sequence. Data review indicated that the fuel cell oxygen flow-rate exceeded the flow-rate alarm limit. Fuel cell 2 purges were inhibited for the remainder of the mission. This action did not significantly affect subsequent performance of the fuel cell, although some degradation of the output voltage was observed.

In-flight troubleshooting was performed on extravehicular mobility unit (EMU) 2 in an effort to determine the cause of a "Power Restart" message anomaly, which occurred on flight day 2. The anomaly could not be reproduced and the decision was made to use the backup unit (EMU 3), should an EVA be required.

At the transition to OPS 8 in preparation for the flight control system (FCS) checkout at approximately 118:08:30 G.m.t., the ground reported that air data transducer assembly (ADTA) 3 was not indicated as being powered up. Normal operation of the ADTA was returned when the circuit breaker was recycled five times on two occasions by the crew.

The FCS checkout was successfully completed at 118:08:43:18.37 G.m.t. APU 2 was shut down after a satisfactory 5 minutes and 37.37 seconds of run-time during which 16 lb of fuel were used. A hot-fire test was successfully performed on all RCS thrusters except those on manifold L3, which remained isolated.

At approximately 118:08:42 G.m.t., the APU 3 fuel pump bypass line temperature began to increase and exceeded the fault detection and annunciation (FDA) limit of 180 °F approximately 12 minutes later. Heater system A was suspected to be failed on, and the crew was instructed to switch to heater system B, after which the temperature returned to normal. The remainder of the APU subsystem heaters were reconfigured from system A to system B at approximately 118:10:04 G.m.t., and the heaters functioned normally.

The crew reported at 118:13:31 G.m.t., that the mid-starboard payload bay floodlight was not functioning. The loss of this light did not impact the mission.

After completion of all final entry preparations, including stowage and payload bay door closure, the OMS deorbit maneuver was performed at 119:12:37:36.05 G.m.t., with a firing duration of 291.0 seconds and a differential velocity of 571.2 ft/sec. Entry interface occurred at 119:13:19:29.28 G.m.t. The entry blackout period did not occur as communications were maintained through the Tracking and Data Relay Satellite (TDRS) network.

Main landing gear touchdown occurred at 119:13:49:56.25 G.m.t., on concrete runway 22 at Edwards Air Force Base, CA. Nose landing gear touchdown followed 10 seconds later with wheels stop at 119:13:50:58.25 G.m.t. The rollout was normal in all respects. The APU's were shut down at 119:14:04:31 G.m.t., and the crew completed their required postflight reconfigurations and egressed the vehicle at 119:14:39:15 G.m.t.

All of the DTO's assigned to the mission were accomplished. DTO 332 (Cabin Growth) was successfully performed by the crew on-orbit. DTO 816 (Gravity Gradient Attitude Control) was successfully accomplished, and the preliminary results indicate that the vehicle reacted essentially the same in the higher orbit flown by STS-31 as in the lower orbits normally flown. DTO 794 (DFRF RF/TLM System Modification Certification) was added on entry day and performed after landing. DTO 519 (Carbon Brake System Evaluation) was performed during landing rollout. All DSO's were accomplished, and the crew reported on several of them during the flight.

LAUNCH SCRUB SUMMARY

On April 10, 1990, an unsuccessful attempt was made to launch the STS-31 mission. The launch was scrubbed at T-4 minutes in the final countdown following an indication of abnormal chamber pressure and turbine speed on APU-1. As a result, APU-1 was removed, replaced, and reverified in a hot-fire test on April 18, 1990, after which the launch was rescheduled for April 24, 1990.

There were no problems with the SSME's, SRB's, solid rocket motors (SRM's) or the ET during this scrubbed launch attempt.

No LCC or Operations and Maintenance Requirements and Specification Document (OMRSD) violations occurred during the scrubbed attempt. The maximum hydrogen concentration that was detected in the Orbiter aft compartment was 180 ppm. The aft compartment helium concentration was unusually high (12,000 ppm) during the initial cryogenics loading. A small leak was found at the 4-inch boot seal and it was repaired between launch attempts. The liquid oxygen outboard fill and drain valve actuator was replaced as it also contributed to high helium concentration in the aft compartment.

Following the scrub, the liquid hydrogen tank ullage pressure transducer 3, which should have been reading 14.9 psia, exhibited erratic indications as low as 12 psia, the minimum reading of the transducer. When the tank was pressurized to 30 psia for draining, the transducer behaved normally. This condition is similar to dropouts noted on four previous flights in which the transducer worked properly once the wiper was moved to a different area of the potentiometer. The transducer operation did not impact the mission.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS/SOLID ROCKET MOTORS

All SRB systems performed as expected throughout ascent. The SRB prelaunch countdown was normal. SRM propulsion performance was well within the required specification limits, and the propellant burn rate for each SRM was normal. SRM thrust differentials during the buildup, steady-state, and tail-off phases were well within specifications. All SRB thrust vector control (TVC) prelaunch conditions and flight performance requirements were met with ample margins. All electrical functions were performed properly. No SRB or SRM LCC or OMRSD violations occurred during the launch countdown.

The SRB flight structural temperature response was as expected. Postflight inspection of the recovered hardware indicated that the SRB thermal protection system (TPS) performed properly during ascent with very little TPS acreage ablation.

Separation subsystem performance was normal with all booster separation motors expended and all separation bolts severed. Nose cap jettison, frustum separation and nozzle jettison occurred normally on each SRB.

The entry and deceleration sequence was properly performed on both SRB's. SRM nozzle jettison occurred at frustum separation, and subsequent parachute deployments were successfully performed.

Five in-flight anomalies were identified as a result of discrepancies that were observed after the SRB's and SRM's were returned to KSC. These anomalies were:

1. The left SRB aft integrated electronics assembly (IEA) was broken off from the ET attachment (ETA) ring by water impact.

2. The right and left SRB ordnance ring-to-frustum fastener assemblies lost their preload during descent.

3. The range safety system (RSS) crossover bracket on both SRB's was sooted around the P2 connector jam nut.

4. The left SRB aft skirt was missing several areas of aerodynamic moldable shaping material that was lost during descent or at water impact.

5. The right SRM nozzle has a gap of 1.8 inches (maximum) at the 220-degree location of the cowl/outer boot ring bondline.

EXTERNAL TANK

All objectives and requirements associated with the ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation performed satisfactorily. The operation of the ET heaters and purges was monitored and all performed properly. No OMRSD violations were identified.

As expected, only the normal ice/frost formations for the April environment were observed during the countdown. There was no frost or ice on the acreage areas of the ET. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. Frost was also present along the liquid hydrogen proturberance air load (PAL) ramps. All of these observations were acceptable per ice/frost documentation. Camera 163, however, observed more than normal ice on the ET/Orbiter 17-inch liquid hydrogen disconnect. The ice/frost team reported that a thermal protection system (TPS) closeout plug was slightly debonded in one corner of the closeout causing the observed ice on the disconnect. An LCC waiver was approved stating that the ice would have no detrimental effect on the ET or Orbiter.

The ET pressurization system functioned properly throughout engine start and flight. All electrical and instrumentation equipment on the ET performed properly throughout the countdown and flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 17.0 psig. No significant problems have been identified.

The ET tumble system was inactive on this flight. ET separation was confirmed with ET entry and breakup photographically recorded by an Argus aircraft. A violent ET rupture was observed.

SPACE SHUTTLE MAIN ENGINES

All Space Shuttle main engine (SSME) parameters appeared to be normal throughout the prelaunch countdown, comparing very well with prelaunch parameters observed on previous flights.

The engine-ready signal was achieved at the proper time, all LCC were met, and engine start and thrust buildup were normal. Flight data indicate that SSME performance during main stage, throttling, shutdown and propellant dump operations was normal. High pressure oxidizer turbopump and high pressure fuel turbopump temperatures appeared to be well within specification throughout engine operation. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

One SSME in-flight anomaly occurred during the flight. Eight of twelve strain gages (four per engine with two located at the 0-degree position and two located at the 45-degree position), became debonded and data were lost. These strain gages were being flown for the first time to obtain reusability data that would be used in place of additional screening tests during ground operations on the high pressure oxidizer turbopumps. Two engine 1 strain gages, one in each location, provided no useful data, none of the four gages on engine 2 provided useful data, and two of the gages on engine 3, both in the same location, provided no useful data. Evaluation of engine 1 and 3 data is still in progress at this writing. These instrumentation failures had no effect on the flight.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle range safety system (SRSS) closed-loop testing was completed as scheduled during the launch countdown. The SRSS safe and arm (S & A) devices were armed and all system inhibits were turned off at the appropriate times. All SRSS measurements indicated that the system performed as expected throughout the flight. The system signal strength remained well above the specified minimum value of -97 dBM for the duration of the flight.

Prior to SRB separation, the SRB S & A devices were safed, and SRB system power was turned off as planned. The ET system remained active until ET separation from the Orbiter.

ORBITER PERFORMANCE

Main Propulsion System

The overall performance of the main propulsion system (MPS) was excellent. All pretanking purges were properly performed, and loading of liquid oxygen and liquid hydrogen was performed as planned with no stop-flows or reverts. There were no OMRSD violations, but one LCC violation was noted. The automatic closure of the liquid oxygen outboard fill/drain valve failed at T-48 seconds, causing a hold in the final countdown at T-31 seconds until the valve could be closed manually and verified closed. The closure was not accomplished automatically because of a prerequisite control logic discrepancy in the GLS. The count was successfully resumed after a delay of 2 minutes 52 seconds.

Throughout the preflight operations, no significant hazardous gas concentrations were detected, and the maximum hydrogen level in the Orbiter aft compartment was 166 ppm, which is lower than normal when compared with previous data for this vehicle.

The aft compartment helium concentration, which peaked at 12,000 ppm during propellant loading prior to the scrub (Flight Problem STS-31-14), showed a maximum reading of 9500 ppm during loading operations prior to the launch. These higher-than-normal readings were expected because of a small helium purge leak in the liquid hydrogen disconnect. After T-2 hours, when the LCC limit of 10,000 ppm became effective, the helium concentration maximum levels were within limits and at approximately 6000 ppm.

A comparison of the calculated propellant loads at the end of replenish versus the inventory load results in a loading accuracy of -0.02 percent for the liquid hydrogen and -0.01 percent for the liquid oxygen.

Ascent MPS performance appeared to be completely normal. Preliminary data indicate that the liquid oxygen and liquid hydrogen pressurization systems performed as planned.

The gaseous oxygen flow control valves (FCV) remained open during the engine start sequence and the early portion of ascent, and performed normally throughout the remainder of the flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 17.0 psig, which is within the expected band.

Ullage pressures were maintained within the required limits throughout flight. Feed system performance was normal, and the liquid hydrogen and liquid oxygen propellant conditions were within specified limits during all phases of operation. All net positive suction pressure (NPSP) requirements were met. Propellant dump and vacuum inerting were accomplished satisfactorily.

Reaction Control Subsystem

The RCS performed satisfactorily except for the anomalous operation of thruster L3A, which did not affect the successful accomplishment of all mission objectives. A total of 5847 lb of propellant was used during the mission, some of which was consumed during OMS/RCS crossfeed operation.

RCS thruster L3A failed off during the MPS settling burn following ET separation (Flight Problem STS-31-3A). Analysis indicated that the oxidizer valve did not open. About 7 hours later at 114:19:38 G.m.t., the L3A injector temperature and chamber pressure data indicated a freeze/thaw cycle was occurring. Chamber pressure began cycling between 2 psia and 42 psia with corresponding temperature fluctuations (Flight Problem STS-31-3b). The left RCS oxidizer manifold 3 was isolated and the oxidizer manifold pressure decayed rapidly, confirming a leak. The manifold remained isolated for the remainder of the mission.

Orbital Maneuvering Subsystem

The OMS performed in an excellent manner during the two dual-engine maneuvers. The OMS-2 maneuver was the longest OMS-2 firing (306.7 seconds and a differential velocity of 496.7 ft/sec) in the Space Shuttle program. The deorbit maneuver was initiated at 119:12:37:36.05 G.m.t., and lasted 4 minutes

51.0 seconds. The differential velocity of the maneuver was 571.2 ft/sec. Because both firings were long duration, propellant low-level alarms were triggered when the left and right oxidizer quantity indicated below 5 percent.

A total of 23,302 lb of propellant was consumed during the OMS maneuvers and the crossfeed operation with the RCS. These extended firings also resulted in helium tank pressures below the 1500-psi fault detection annunciator (FDA) limit.

Both the left and right OMS fuel quantity gages indicated erratically. The left fuel total quantity indicated 66 percent during the deorbit maneuver. The gage was noted to be biased high following loading and the bias increased to 14 percent following OMS-2. The right fuel quantity read 22 percent after the deorbit maneuver and should have read 4 percent. The erratic indications will be evaluated during postflight turnaround activities.

The right OMS engine fuel inlet pressure indication (V43P5646C) indicated erratically during entry (Flight Problem STS-31-02d). The erratic behavior lasted between 1 and 2 minutes with the pressure fluctuating between 238 psia and 265 psia.

During postmission operations at Dryden Flight Research Facility, a technician made an incorrect keyboard entry which resulted in a continuous open command to the gaseous nitrogen purge valves and vented the tank to 25 psia. Power was applied for about 55 minutes. The open command was removed by cycling multiplexer/demultiplexer (MDM) flight aft (FA) 1 and FA 2. This operation did not adversely affect the postflight operations.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed normally throughout the mission with no identified anomalies. The vehicle was flown in the three-tank-set configuration. The system provided 1193.7 lb of oxygen and 150 lb of hydrogen for use during the mission by the fuel cells and 40.2 lb of oxygen for use as breathing oxygen). A 90.6-hour extension at the average power level was possible with the reactants remaining at touchdown as the Orbiter landed with 1120 lb of oxygen and 125 lb of hydrogen.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed satisfactorily except for the fuel cell 2 anomaly which did not impact the successful completion of the mission. A total of 1740 kWh of electrical energy and 1344.1 lb of water were produced. The average power level during the mission was 14.4 kW, and the average electrical load was 464 A.

During a fifth automatic purge sequence of fuel cell 2 at 116:20:13 G.m.t., a high oxygen flow rate of 12.0 lb/hr (5.5 lb/hr nominal) was noted (Flight Problem STS-31-06). The purge proceeded nominally for the first 90 seconds when the 7.3 lb/hr increase was noted. After 22 seconds at this high flow rate, purge flow returned to the nominal value for the remaining 8 seconds of the purge. The secondary cues of hydrogen flow and coolant pressure as well as data from earlier purges on this flight showing a similar, but less severe oxygen flow-rate increase, verified that the high-flow condition had occurred. Purges of fuel cells 1 and 3 were normal during this same time period. As a result, purging of fuel cell 2 was discontinued for the remainder of the mission. A small performance loss of about 0.5 V was noted after 66 hours of operation without a purge, but this loss did not impact mission operations.

Auxiliary Power Unit Subsystem

The APU performance was nominal during all phases of the mission, except for heater and instrumentation anomalies. However, during the initial attempt to launch on April 10, 1990, APU 1 showed abnormal chamber pressure and turbine speed immediately after start up while running at normal speed (Flight Problem STS-31-01). The chamber pressure showed plateaus of only 400 psia and turbine speed was at 111 to 113 percent (high speed). The APU was manually switched to high speed for 2 1/2 minutes, and the chamber pressure and turbine speed were nominal. Abnormal chamber pressure and turbine speed returned when normal speed was reselected. Both of these measurements violated their respective LCC, and the launch was scrubbed. Also, the APU 1 exhaust gas temperature (EGT) 2 sensor failed (Flight Problem STS-31-2a), but this latter failure had no effect on the decision to delay the launch. After the decision was made to scrub the launch because of the APU 1 chamber pressure and turbine problem, APU 1 was changed out on the launch pad, and a successful hot-fire test was performed after which the vehicle was declared ready for launch. The following table shows the run time and fuel consumption of each APU during the flight.

Flight phase	APU 1		APU 2		APU 3	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Scrub	5:12	18	5:12	18	5:12	18
APU hot fire	5:02	18				
Ascent	22:12	63	22:12	64	22:12	63
FCS checkout			05:38	16		
Entry	91:45	224	57:51	120	57:51	145
Total[a]	124:11	323	90:53	218	85:15	226

Note a: A total of 14 minutes 35 seconds of APU operation occurred after touchdown.

Two additional EGT sensors (APU 1 EGT 1 and APU 3 EGT 2) failed during entry (Flight Problems STS-31-2c and -2d, respectively). Neither of these failures had any impact on the mission.

During the flight control system checkout, the APU 3A fuel system heaters failed on while APU 2 was operating (Flight Problem STS-31-08). The bypass line temperature exceeded the 180 °F FDA and reached 196 °F at which point heater system 3B was selected. Temperatures returned to the normal range, and heater system 3B operated satisfactorily for the remainder of the mission.

During flight day 3, the APU 1 fuel system A heater thermostat suddenly changed the upper and lower limits and began controlling within an 8 °F band instead of a 24 °F band (Flight Problem STS-31-11). Temperatures on the fuel bypass line, fuel pump, and gas generator valve module also showed the effects of the control band change.

During entry, APU 1 was experiencing low lubrication oil outlet pressures as well as low gearbox pressures, but no limits were exceeded. These pressures had been nominal during ascent.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem performed satisfactorily throughout the mission. Circulation pump pressure drops were minimal (25-psi maximum) during the transition from ground control to OPS 1. Pressure drops of 250 to 400 psia are usually observed during this transition; however, this can be explained by the elevons drift being less than 1 degree and it usually is 3 to 8 degrees at that time.

Water spray boiler spraying for APU cooling began about 30 seconds after MECO. System 1 used approximately 8 lb of water, system 2 used 4 lb, and system 3 used 9 lb. At APU shutdown, all three priority valves locked up within the specification values.

The water spray boiler 2 heater A was operating erratically during prelaunch operations, and the heater apparently failed to respond when power was applied on-orbit (Flight Problem STS-31-05). The B heater worked nominally. During entry, the A heater operated, but the temperature response was slower than normal.

Pyrotechnics Subsystem

The pyrotechnics subsystem operated satisfactorily.

Environmental Control and Life Support Subsystem

Performance of the environmental control and life support subsystem (ECLSS) was satisfactory. The crew reported that the number of lithium hydroxide (LioH) canisters that had been stowed onboard (17) was two short of the number required (19). Modifications were made to the changeout schedule with canisters 1, 2, and 3 being reinstalled. These changes, plus allowing $PPCO_2$ levels to increase to 10 mmHg on the extension days, would have allowed a mission duration of 8 days.

The crew module was depressurized to 10.2 psia for a 72-hour period beginning about 4 hours into the mission. Manual control was utilized to maintain PPO_2 and cabin pressure at the desired levels.

Two FES shutdowns occurred during the mission, but these were expected because of the configuration of the FES midpoint manifold on OV-103. Ammonia boiler activation was not required because the radiator coldsoak cooling lasted until the vehicle GSE cooling was initiated.

The supply water and waste management systems performed satisfactorily with four supply water dumps and one waste water dump being performed. By mission completion, all of the associated in-flight checkout requirements were satisfied.

Shortly after launch, it was noted that the water supply tanks C and D quantities indicated abnormal values. Normally, within 30 minutes of launch, tanks C and D will equalize to within 3 to 4 percent of each other; however tank C remained at 99.8 percent, while tank D changed from 89.5 to 89.9 percent (Flight Problem STS-31-04). These readings were indicative of a stuck bellows assembly in tank C. In an attempt to provide additional force on the bellows, flash evaporator system B was activated for a few minutes to drain water from tanks C and D. This caused the tank C bellows to regain freedom of movement and normal water supply tank quantities were restored.

The new microbial check valve was flown and tested in accordance with the requirements of DTO 644. Iodine levels were measured and reported to be between 3 and 5 ppm throughout the mission.

The waste collection system (WCS) operation was normal throughout the mission.

Smoke Detection and Fire Suppression Subsystem

The smoke detection and fire suppression subsystem operated satisfactorily.

Airlock Support System

The airlock support system performed nominally when used in preparation for a potential extravehicular activity (EVA). The depress valve was used for cabin and airlock depressurization, and the equalization valve was used for airlock repressurization.

Extravehicular Activity Equipment

Two crew persons prepared for Hubble Space Telescope contingency EVA to the point of depressurizing the airlock to 5 psia. The performance of the suits and EVA equipment was nominal.

The extravehicular 2 (EV2) crew person reported four "power restart" messages on EMU 2 (Flight Problem STS-31-07). Later in-flight troubleshooting did not duplicate the problem and, as a result, EMU 3 was designated to replace EMU 2 should an EVA be required.

Avionics and Software Subsystems

All subsystems of the avionics subsystem operated satisfactorily throughout the mission. The flight control subsystem was used to perform the programmed test inputs (PTI's) during entry when performing DTO 242.

The electrical power distribution and control subsystem operated satisfactorily except that the air data transducer assembly (ADTA) 3 circuit breaker required five actuations on two occasions to obtain power during the FCS checkout (Flight Problem STS-31-12).

The crew reported that the mid-starboard payload bay floodlight flickered and went out when activated prior to payload bay door closure (Flight Problem STS-31-09). Bus current traces confirmed the light problem.

The text and graphics system (TAGS) had three minor problems (heater over-temperature, failure-to-advance paper, and empty/jam indication) during the mission (Flight Problem STS-31-10). In all cases, the problems were cleared by cycling the power switch on the unit, resetting the internal software.

Four instrumentation problems occurred, three of which were exhaust gas temperature measurements on the APU's. The fourth problem concerns the OMS fuel inlet pressure transducer. These problems are discussed in the appropriate subsystem section of this report.

Remote Manipulator System

The remote manipulator system (RMS) performed all required functions concerning deployment and release of the HST in a satisfactory manner. However, the crew noted a higher degree of cross-coupling motion while commanding slow rates with the flight hardware than with ground simulators.

Postflight inspection revealed that the end-effector snare wires were outside their respective grooves by 0.3 to 0.5 inch (Flight Problem STS-31-18). The OMRSD limit is 0.25 inch.

Mechanical Subsystems

All mechanical subsystems performed in a satisfactory manner. The only problem that occurred concerned payload bay door closure when the automatic closure sequence stopped because of a procedural error causing an out-of-configuration message. Door closure was completed using the manual mode. Data review suggests that the starboard aft ready-to-latch switch module indication was slow in appearing. The switch module rigging will be rechecked prior to the next flight.

Performance of the landing/deceleration subsystem was nominal. Landing gear deployment required 6 seconds with all gear down and locked 13 seconds prior to main gear touchdown. The landing of OV-103 occurred on concrete runway 22 at Edwards Air Force Base, CA., with a headwind component of 4 knots and a cross-wind component of 6 knots. Main gear touchdown occurred at 180 knots ground speed 1176 feet past the runway threshold at a sink rate of approximately 3 ft/sec. Nose gear contact occurred 4564 feet from the threshold with a pitch rate of 2.9 deg/sec. Braking was initiated at 119 knots ground speed with an average deceleration rate of 6 feet/second/second with a maximum of 8 feet/second/second. Brake energy absorption was 16.07 million foot-pounds for the left outboard brake, 17.28 million foot-pounds for the left inboard brake, 23.54 million foot-pounds for the right inboard brake, and 21.86 million foot-pounds for the right outboard brake. This was the first landing for the carbon-carbon brakes. The brakes were removed and returned to the vendor for disassembly and inspection. This inspection revealed no brake damage, and the brakes were reassembled for use on a subsequent flight. Postflight analysis of the data revealed no dynamic performance concerns requiring adjustment of the brake anti-skid system.

Prior to the mission, two concerns existed that involved the nose landing gear. First, the tire pressure monitoring system indicated that the left nose tire was leaking at a rate greater than the specified 0.4 psi/day limit. Postflight measurements revealed that the actual rate was 0.21 psi/day, and that the difference between the two nose tires was only 3 psi. The second concern involved the integrity of the nose gear axle housing and bearing retainer nuts. The axle/housing concern (axle contact with the housing causing a brittle spot), will be analyzed. The axle nuts were found to be only slightly out of engagement at the top, and only 1/6 the magnitude observed on other vehicles.

The postlanding inspection of the tires revealed only typical light chevron wear on one rib of the right inboard tire, and minimal wear on the other tires. Tire pressure measurements indicated that all main tire pressures were within 1 psi of each other, indicative of highly repeatable leak rates.

Aerodynamics

Ascent and entry aerodynamic performance was nominal. The alpha was as expected and the control surfaces responded nominally. Eight PTI maneuvers were input to the control surfaces during entry, and all data were collected for postflight analysis.

Thermal Control Subsystem and Aerothermodynamics

The thermal control subsystem (TCS) performed acceptably; however, the water spray boiler 2 vent system A heater apparently failed to respond when enabled for the post-insertion vent bakeout about 2 hours into the flight (Flight Problem STS-31-05). Also, during the FCS checkout on APU 2, the APU 3 fuel line/pump/gas generator valve module (GGVM) system A heater thermostat, which had been cycling erratically, failed on (Flight Problem STS-31-08). The APU 1 fuel pump/GGVM heater system A thermostat set-points suddenly changed at 02:22:00 mission elapsed time as seen in the temperatures on the fuel bypass line, fuel pump, and GGVM (Flight Problem STS-31-11). None of these failures impacted the mission and all are discussed in the subsystem section of the report.

In addition, three APU exhaust gas temperature sensors failed, and these are discussed in the APU subsection of the report.

The aerothermodynamic performance was satisfactory. The acreage heating was nominal based on structural temperature rise data.

Thermal Protection Subsystem

The thermal protection subsystem performance was nominal based on structural temperature responses, tile surface temperature measurements and the postflight inspection. The overall boundary layer transition from laminar to turbulent flow was nominal, occurring between 1110 and 1215 seconds after entry interface. The earlier transition occurred towards the left aft region of the vehicle.

Inspection of the thermal protection subsystem (TPS) indicated that less damage was incurred when compared with the average of previous flights. Debris impact damage was minimal and the base heat shield peppering was less than average. The Orbiter lower surface sustained a total of 33 hits, of which 11 had a major dimension of 1 inch or greater. Based on the severity of the damage as judged from length, depth and amount of tile surface lost, STS-31 was deemed to be better than average. Also, the number of hits that are 1 inch or greater in size is less than average. The lower surface damage sites were distributed essentially equally about the vehicle centerline, with only one of the 33 damage sites located outboard of the main landing gear.

Other damage noted during the inspection was a 2 1/2-inch by 1-inch tile coating loss on the right-hand rudder speedbrake trailing edge, a broken and loosely attached 2-inch by 3-inch tile corner in the -Y star tracker cavity, a 4-inch by 1/2-inch layer of insulation peeled back forward of window 2, and two damaged tiles on the perimeter of window 5.

Overall, all reusable carbon-carbon parts looked good. The nose landing gear door thermal barrier had minor fraying around patches. A forward Nicalon patch was detached. The forward RCS thermal barrier was in excellent condition, although a right-side thruster thermal barrier had a minor fray. The right main landing gear door thermal barrier had a small fray in the forward outboard section. The left main landing gear door thermal barrier had a 6-inch frayed patch. The right ET door thermal barrier showed evidence of two small flow paths. An elevon cove left-hand outboard carrier panel had a large gap. The elevon-elevon gap tiles appeared in excellent condition with no breached gap fillers or slumped tiles. The newly designed engine-mounted heat shield thermal curtain on engine 1 was in excellent condition. The SSME 2 blanket had a tear between 2:30 and 3:00 o'clock. The upper body flap, where the right-hand thrusters impinge, had two tiles with large areas of coating missing.

The postflight inspection also revealed that seal material was missing from the trailing edge of elevon flipper doors 5 and 6 (Flight Problem STS-31-15). The material was found in the upper elevon cove area. The retainer hardware on right-hand flipper doors 5, 6, 12, and 13 was found to be installed backwards. The retainer hardware on some doors on the other vehicles was also found to be installed backwards, and these conditions have been corrected.

Inspection of the windows show window 3 to be heavily hazed with streaks, window 2 moderately hazed with streaks, and window 4 moderately hazed. A laboratory analysis of the samples taken from each window will be performed.

The Shuttle thermal imager was used to record the kinetic surface temperatures of several areas. At 9 minutes after landing, the nosecap reusable carbon carbon (RCC) temperature was 197 °F; and 12 minutes after landing, the left wing RCC panels 9 and 17 both measured 84 °F.

FLIGHT CREW EQUIPMENT AND GOVERNMENT FURNISHED EQUIPMENT

The EV2 crewman reported four "power restart" messages on EMU 2 (Flight Problem STS-31-07). Later in-flight troubleshooting failed to duplicate the problem, and EMU 3 was designated to replace EMU 2 should EVA operations be required.

The crewman optical alignment sight (COAS) readings from the +X position on flight day 4 and 5 had a difference of 0.6 degree (Flight Problem STS-31-13). Calibrations from the -Z position were nominal.

The galley water dispenser dispensed less than the requested amount throughout the mission (Flight Problem STS-31-16). Initially the amount of under-dispense was consistent, but as the mission progressed, the amount became erratic.

The crew reported that a 70-mm Hasselblad camera jammed, but the condition was cleared by a crewman with no further impact to the mission.

The Orbiter aft fuselage gas sampler system gas sample bottles experienced a significant amount of air leakage into the bottles (Flight Problem STS-31-17). Five of the six bottles had more than 70 percent air in the sample, which resulted in the loss of data. It is normal to leak air into the bottles during the flight; however, this amount of leakage in more than three bottles is abnormal. One bottle, serial number 1319, retained the aft compartment sample and provided a good data point with a level of 2.91 percent hydrogen (corrected for pyrotechnic combustion products in the sample). This is the highest hydrogen reading for OV-103 since STS 51-L, but it is still in the safe region and well below the lower flammability limit curve. This sample was taken on the left side of the vehicle at approximately 102 seconds after lift-off.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

A total of 21 of the 23 video tapes recorded during launch were reviewed with no anomalies identified. Cloud cover and exposure problems with the video hampered analysis and possible detection of debris or any anomalous conditions. Also, 70 films of launch were reviewed in addition to the Castglance film of SRB descent and recovery operations. No vehicle anomalies were identified in any of the launch films or video.

Data from six landing video cameras and NASA Select were reviewed following landing. No anomalies were noted. Five 16-mm documentary, one 16-mm engineering and two 35-mm engineering cameras recorded photographic data which have been reviewed. Data from these cameras was marginal because of the late change from landing on runway 23 to runway 22.

A test was run using a Sony Mavica still camera to capture brake inspection and other events of interest. Still video was acquired and sent to JSC in near-real-time for analysis by photographic personnel.

HUBBLE SPACE TELESCOPE

The Hubble Space Telescope (HST) was deployed on revolution 20 following a nominal grapple and unberthing by the RMS. Prior to the release of HST, one of the HST solar arrays (SA) failed to unfurl, but preplanned contingency procedures were implemented and the SA was deployed successfully. All of the HST deployable appendages [SA, high-gain antenna (HGA), and aperture door (AD)] were deployed prior to releasing the HST from the RMS.

A series of minor anomalies have occurred during the HST orbital verification, including a malfunctioning HGA, unplanned AD closures, and some minor pointing problems. The Space Telescope Operations Control Center has successfully resolved all of these problems, and the HST checkout is continuing on schedule.

On May 20, 1990, the wide field/planetary camera shutter was opened, and the HST experienced "first light" when a photograph was taken of the open star cluster IC 2602 in the constellation Carina. Preliminary evaluation of the HST photographs indicate that, even though the telescope is still not precisely focused, the quality of the images is far superior to that produced by the best ground-based telescopes. Once the HST instruments have cooled to the design temperatures (should require about 3 to 6 months), the HST should begin returning images that are orders of magnitude better than can be obtained using ground-based instruments.

TABLE I.- STS-31 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	114:12:26:10.80
	APU-2 GG chamber pressure	114:12:26:11.65
	APU-3 GG chamber pressure	114:12:26:12.33
SRB HPU activation	LH HPU system A start command	114:12:33:23.17
	LH HPU system B start command	114:12:33:23.33
	RH HPU system A start command	114:12:33:23.49
	RH HPU system B start command	114:12:33:23:65
Main propulsion system start	Engine 3 start command accepted	114:12:33:44:420
	Engine 2 start command accepted	114:12:33:44.563
	Engine 1 start command accepted	114:12:33:44.657
SRB ignition command (lift-off)	SRB ignition command to SRB	114:12:33:50.99
Throttle up to 104 percent thrust	Engine 3 command accepted	114:12:33:54.940
	Engine 2 command accepted	114:12:33:54.963
	Engine 1 command accepted	114:12:33:54.937
Throttle down to 97 percent thrust	Engine 3 command accepted	114:12:34:09.021
	Engine 2 command accepted	114:12:34:09.044
	Engine 1 command accepted	114:12:34:09.018
Throttle down to 67 percent thrust	Engine 3 command accepted	114:12:34:19.101
	Engine 2 command accepted	114:12:34:19.124
	Engine 1 command accepted	114:12:34:19.098
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	114:12:34:43.0
Throttle up to 104 percent thrust	Engine 3 command accepted	114:12:34:50.143
	Engine 2 command accepted	114:12:34:50.165
	Engine 1 command accepted	114:12:34:50.139
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	114:12:35:51.55
	RH SRM chamber pressure mid-range select	114:12:35:50.63
End SRM action	LH SRM chamber pressure mid-range select	114:12:35:53.705
	RH SRM chamber pressure mid-range select	114:12:35:53.585
SRB separation command	SRB separation command flag	114:12:35:56
SRB physical separation	SRB physical separation	
	LH APU A turbine speed LOS*	114:12:35:56.75
	LH APU B turbine speed LOS*	114:12:35:56.71
	RH APU A turbine speed LOS*	114:12:35:56.79
	RH APU B turbine speed LOS*	114:12:35:56.75
Throttle down for 3g acceleration	Engine 3 command accepted	114:12:41:19.602
	Engine 2 command accepted	114:12:41:19.616
	Engine 1 command accepted	114:12:41:19.591
3g acceleration	Total load factor	114:12:41:20.0
MECO	MECO command flag	114:12:42:21.0
	MECO confirm flag	114:12:42:23.0
ET separation	ET separation command flag	114:12:42:39.0

* = loss of signal

TABLE I.- CONTINUED

Event	Description	Actual time, G.m.t.
OMS-1 ignition	Left engine bi-prop valve position	None required/ Direct insertion
APU deactivation	APU-1 GG chamber pressure	114:12:48:22.43
	APU-2 GG chamber pressure	114:12:48:23.58
	APU-3 GG chamber pressure	114:12:48:24.77
OMS-2 ignition	Left engine bi-prop valve position	114:13:16:26.9
	Right engine bi-prop valve position	114:13:16:27.0
OMS-2 cutoff	Left engine bi-prop valve position	114:13:21:31.7
	Right engine bi-prop valve position	114:13:21:31.8
Hubble Space Telescope release	Voice call	115:19:37:51.0
RCS separation 1 burn	L1A jet driver	115:19:38:20.0
RCS separation 2 burn	F2F jet driver	115:19:58:28.0
Flight control system checkout		
APU start	APU-2 GG chamber pressure	118:08:37:40.60
APU stop	APU-2 GG chamber pressure	118:08:43:18.37
APU activation for entry	APU-1 GG chamber pressure	119:12:32:45.29
	APU-2 GG chamber pressure	119:13:06:40.14
	APU-3 GG chamber pressure	119:13:06:40.83
Deorbit maneuver ignition	Left engine bi-prop valve position	119:12:37:36.05
	Right engine bi-prop valve position	119:12:37:36.05
Deorbit maneuver cutoff	Left engine bi-prop valve position	119:12:42:27.05
	Right engine bi-prop valve position	119:12:42:26.85
Entry interface (400k)	Current orbital altitude above reference ellipsoid	119:13:19:29.28
Blackout end	Data locked at high sample rate	No blackout because of TDRS
Terminal area energy management	Major mode change (305)	119:13:43:36.25
Main landing gear weight on wheels	LH MLG weight on wheels	119:13:49:56.25
	RH MLG weight on wheels	119:13:49:56.26
Nose landing gear weight on wheels	NLG WT on Wheels -1	119:13:50:08.25
Wheels stop	Velocity with respect to runway	119:13:50:58.25
APU deactivation	APU-1 GG chamber pressure	119:14:04:30.33
	APU-2 GG chamber pressure	119:14:04:30.96
	APU-3 GG chamber pressure	119:14:04:31.65

TABLE II.- STS-31 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-31-01	APU 1 Chamber Pressure and Turbine Speed Abnormal SCRUB ATTEMPT	100:12:42 G.m.t. PR-APU-3-10-0208 CAR 31RF01	At activation, APU 1 ran at high speed while normal speed was selected. APU 1 was removed and replaced on the launch pad, and a hot-fire was completed on the replaced unit. Chipped seat found on pulse control valve of removed unit.
STS-31-02	Instrumentation a) APU 1 EGT 2 Failed SCRUB ATTEMPT	a)100:12:42 G.m.t. PR APU-3-10-0209 IM 31RF02	EGT 2 failed to respond at APU activation. Transducer removed and replaced between launch attempts.
	b) APU 1 EGT 1 Failed	b)119:13:33 G.m.t. IM31RF10 PR APU-3-11-0212	EGT 1 failed during entry. Transducer will be removed and replaced at KSC during turnaround.
	c) APU 3 EGT 2 Failed	c)119:13:35 G.m.t. IM31RF11 PR APU-3-11-0212	EGT 2 failed during entry. Transducer will be removed and replaced at KSC during turnaround.
	d) Right OMS Engine Fuel Inlet Pressure Erratic (V43P5646C)	d)119:13:45 G.m.t. IM31RF13 IPR 41V-0015	Five minutes before landing, fuel inlet pressure oscillated without corresponding change in ullage pressure. Troubleshooting at KSC
STS-31-03	RCS Thruster L3A Problems a) Thruster L3A Failed Off	a) 114:12:44 G.m.t. CAR 31RF06	a) Thruster L3A failed off during +X burn for post-MECO MPS dump. Oxidizer injector valve did not open.
	b) Oxidizer Leak	b) 114:19:38 G.m.t. CAR31RF06 PR LP04-0700264	b) Oxidizer leak detector dropped from 90 °F to 21 °F and stabilized. Approximately 45 minutes later, chamber pressure began cycling between 2 psia and 42 psia with corresponding temperature fluctuations. Manifold 3 was closed and oxidizer manifold pressure decayed rapidly, confirming the leak. Thruster was removed on May 3 and shipped to vendor. Thruster hole covered for ferry flight.
STS-31-04	Supply Water Tank Bellows Stuck	114:13:51 G.m.t. IM31RF04 IPR 41V-0014	During prelaunch operations, tank D normally drains into tank C. On-orbit, tank C and D failed to equalize quantities as normally occurs. Some water was drained from Tank C and D by using FES B which freed up tank C bellows. Will require tank C bellows test at KSC.
STS-31-05	Water Spray Boiler 2 Vent Heater A Showed No Response	114:15:55 G.m.t. IM31RF05	After operating erratically during prelaunch operations, WSB 2A heater failed to respond when power was reapplied on-orbit. Heater 2B worked nominally. Will require heater and controller checkout at KSC. No ferry impact. Heater A worked during entry, but increased temperature at slower than normal rate. Insulation resistance checks to be performed at KSC.
STS-31-06	Fuel Cell 2 Oxygen Flow Rate High During Purge	116:20:13 G.m.t. CAR 31RF07 IPR 41-V-0004	Oxygen flow rate experienced a 22-second high flow excursion reaching a maximum of 12.0 lb/hr during purge. Flow rates returned to normal after the excursion. No further in-flight purges were performed on fuel cell 2. Fuel cell 2 will be removed and replaced at KSC.

TABLE II.- STS-31 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-31-07	EMU 2 "Power Restart" Messages (GFE)	115:20:25 G.m.t.	EV2 crew person reported four "power restart" messages during EVA preparation. In-flight troubleshooting failed to reproduce the problem. Troubleshooting will be performed at the JSC FEPC. Unit removed at DFRF and shipped to JSC for troubleshooting.
STS-31-08	APU 3 Pump Bypass Heater A Failed On	118:08:41 G.m.t. PR APU3-11-0214 CAR31RF08	During FCS checkout, APU 3 fuel pump bypass temperature ramped up to approximately 196 °F, tripping FDA alarm. Reconfigured to heater B and temperatures returned to normal. Ferry in heater B position. Remove and replace APU at KSC due to turbine wheel life constraint.
STS-31-09	Mid-Starboard Payload Bay Floodlight Went Out	118:13:31 G.m.t. IM31RF09 IPR 41V-0016	Crew reported that light flickered and went out when activated. Confirmed light problem with bus current traces. Standard troubleshooting and remove and replace at KSC.
STS-31-10	TAGS unit not responding to Advance Commands; also Invalid Telemetry	IPR 41V-0006	Troubleshooting will take place in the vehicle.
STS-31-11	APU 1 Fuel Pump/GGVM Heater System A Thermostat Set Point Change	117:08:00 G.m.t. CAR31RF12 PR APU-3-11-0213	APU 1 fuel bypass line temperature (V46T0128A) indicated thermostat controlling within 8 °F bank (115 °F to 112 °F) instead of normal 24 °F band. Suspect thermostat contamination from vibration of bimetallic disk. Precursor of hard failure. Remove and replace A thermostat at KSC.
STS-31-12	Air Data Transducer Assembly (ADTA) 3 Circuit Breaker Contamination	118:08:30 G.m.t. IM31RF14 PR DDC-3-11-0054	During FCS checkout, ADTA 3 was bypassed on transition to OPS 8 and showed no power. Crew cycled circuit breaker five times with no success. An additional five cycles were required to restore power. Since Flight Rule and OMRSD limits of five cycles to restore power through a circuit breaker were exceeded and ADTA is a Criticality 1 function, removal and replacement of circuit breaker is required.
STS-31-13	Plus X COAS Misalignment	118:19:25 G.m.t. IM31RF16	Calibration difference of 0.6 degree between flight day 4 and 5 measurements.
STS-31-14	Aft Helium Concentration High SCRUB ATTEMPT	Prelaunch IM31RF15 PR MPS-3-10-0777	Helium concentration reached 12,000 ppm, then decreased to 8,000 ppm prior to T-2 hours LCC effectivity (LCC maximum = 10,000 ppm). The pin hole leak in 4-inch interconnect boot was resealed with RTV between launch attempts.

TABLE II.- STS-31 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-31-15	Missing Seal Material From Trailing Edge of Elevon Flipper Doors 5 and 6	Postflight PR STR-3-11-3204 (Missing Seal) PR STR-3-11-3205 (Retainer Backward) TPS STR-3-11-462 (Cavity inspection) IM31RF17	Missing seal material found in upper elevon cove area. Retainer hardware on right-hand flipper doors 5, 6, 12, and 13 found to be installed backwards. KSC to inspect doors 5 and 6 cavities for over-temperature. OV-104 inspection shows left-hand door 2 seal retainer backwards. Inspection of OV-102 is complete, with retainers on right-hand doors 4 and 6 backwards. Rework completed.
STS-31-16	Galley Water Underdispense (GFE)	Mission Duration	Crew reported galley dispensed less water than requested with the amount of underdispense becoming erratic as the mission progressed. KSC removed galley and shipped to JSC FEPC for troubleshooting.
STS-31-17	Five of Six Aft Fuselage Gas Sampler Bottles Leaked	Postflight	All six bottles fired during ascent, however, five subsequently leaked air back into the bottle. KSC troubleshooting in progress
STS-31-18	RMS End Effector Snare Wires Approximately 1/2 inch Out of Grooves	Postflight PR-RMS-3-11-0016	Postflight inspection showed snare wires 0.3 to 0.5 inch outside their grooves. OMRSD limit is 0.25 inch.

NASA Headquarters
QP/B. Greenly
QP/R. Perry
QT/M. Greenfield
LB-4/G. L. Roth
MA/R. L. Crippen
MO/R. Nygren
MOJ/C. Perry
ML/W. Hamby
MES/N. Frandsen

Goddard Space Flt Ctr
300/R. L. Bauman
700/J. R. Busse
710/T. E. Huber
730/E. I. Powers
730.1/J. P. Young
400/D. W. Harris
400/P. T. Burr
410/J. Barrowman (6)
302/W. F. Bangs
313/R. Marriott

KSC
NWSI-D/Respository (25)
MK/B. H. Shaw

MSFC
CN22D/Respository (30)
EP51/J. Redus (5)
EL74/P. Hoag (5)
FA51/S. P. Sauchier
JA01/J. A. Downey
SA12/O. E. Henson

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Rockwell-Downey
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Rockwell-Houston
RS12/A. Coutret (10)
RS12/L. A. Jared
ZC01/D. McCormack
R16G/D. Huss
R16G/R. Pechacek

JSC
AA/A. Cohen
AC/D. A. Nebrig
AC5/J. W. Young
AP3/J. E. Riley (4)
AP4/B. L. Dean (3)
BL/W. L. Draper
BY4/History Office (2)
CA/D. R. Puddy
CA4/R. Filler
CB/D. Brandenstein (5)
CB/K. Colgan
CB/L. Shriver (5)
DA/Library
DA2/T. W. Holloway
DA3/S. G. Bales
DA3/R. K. Holkan
DA8/R. Legler
DA8/Library
DF/J. Knight
DF/D. Nelson
DF7/P. Cerna
DF72/Q. Carelock
DG/J. A. Wegener
DH4/R. D. Snyder
DH411/E. B. Pippert
DH4/J. F. Whitely
DH45/M. LeBlanc
DG47/Sim Sup's
DM/J. C. Harpold
DM/C. F. Deiterich
EA/H. O. Pohl
EC/W. E. Ellis
EC/F. H. Samonski
EC3/D. F. Hughes
EC2/M. Rodriguez
EC4/L. O. Casey
EC3/E. Winkler
EC6/J. W. McBarron (5)
EC3/D. M. Hoy
EG3/R. Barton
EE/J. Griffin
EE2/H. A. Vang
EE3/A. Steiner
EE3/P. Shack
EE3/T. W. Early
EE6/L. Leonard
EE6/R. Nuss
EE7/O. L. Schmidt
EE7/J. C. Dallas
EK/I. Burtzlaff
ET5/J. A. Lawrence
EG/K. J. Cox
EG2/L. B. McWhorter
EG4/J. E. Yeo
EK5/W. N. Trahan
EP/C. A. Vaughn
EP2/H. J. Brasseaux
EP2/L. Jenkins
EP5/C. R. Gibson
EP5/N. Faget
ER/W. W. Guy
ES/D. C. Wade
ES/W. G. McMullen (2)
ES3/C. R. Ortiz
ES3/L. D. Palmer
ES3/Y. C. Chang
ES3/P. Serna
ES6/C. W. Norris (2)
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