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STS-35 SPACE SHUTTLE MISSION REPORT

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Lyndon B. Johnson Space Center
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STS-35

SPACE SHUTTLE

MISSION REPORT

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INTRODUCTION

The STS-35 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem activities during this thirty-eighth flight of the Space Shuttle and the tenth flight of the Orbiter vehicle Columbia (OV-102). In addition to the Columbia vehicle, the flight vehicle consisted of an External Tank (ET) (designated at ET-35/LWT-28), three Space Shuttle main engines (SSME's) (serial numbers 2024, 2012, and 2028 in positions 1, 2, and 3, respectively), and two Solid Rocket Boosters (SRB's) designated as BI-038.

The primary objectives of this flight were to successfully perform the planned operations of the Ultraviolet Astronomy (Astro-1) payload and the Broad-Band X-Ray Telescope (BBXRT) payload in a 190-nmi. circular orbit which had an inclination of 28.45 degrees.

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 Orbiter subsystem problem is cited in the applicable subsystem discussion within the body of the report.

The crew for this thirty-eighth flight of the Space Shuttle was Vance D. Brand, Commander; Guy S. Gardner, Colonel, USAF, Pilot; Jeffrey A. Hoffman, Ph.D, Mission Specialist 1; John M. Lounge, Mission Specialist 2; Robert A. Parker, Ph.D, Mission Specialist 3; and Samuel T. Durrance, Ph.D, and Ronald A. Parise, Ph.D., Payload Specialists. This was the third Shuttle flight for the Commander and Mission Specialist 2; the second Shuttle flight for the Pilot, Mission Specialist 1, and Mission Specialist 3; and the first Shuttle flight for both payload specialists.

SUMMARY

Prior to this successful launch, the STS-35 mission had been delayed for an extended period because of an unusually high concentration of hydrogen that was detected in the area of the Orbiter/ET disconnect and the Orbiter aft compartment during the propellant loading that was conducted in May 1990. A discussion of the various tanking tests is provided later in this report.

The STS-35 mission was successfully launched on the planned 10-day mission from launch pad 39B at 336:06:49:01.0218 G.m.t. (01:49:01.0218 a.m. e.s.t., December 2, 1990), and all subsystems operated satisfactorily during the ascent phase. Resumption of the countdown after the scheduled T-9 minute hold was delayed because of a possible violation of a range safety launch commit criteria (LCC), which requires a minimum ceiling of 8000 ft for launch area optical coverage and to aid launch-area radar acquisition. Conditions improved, the countdown proceeded and the launch was nominal in all respects with main engine cutoff occurring at 336:06:57:31 G.m.t. A direct insertion trajectory was flown, thus no orbital maneuvering subsystem (OMS-1) maneuver was required or performed.

Examination of data from all elements indicates that all ET and SSME systems, as well as the main propulsion system, operated nominally during the ascent phase, and all launch phase objectives were met. Two anomalies have been identified in the SRB analysis, neither of which impacted the mission. Analysis of vehicle acceleration and preflight propulsion prediction data shows that the average flight-derived engine specific impulse determined for the time period between SRB separation and the start of 3g throttling was 453.4 seconds as compared to the fleet-average tag value of 452.51 seconds.

The dual-engine OMS-2 maneuver was performed as planned at 336:07:29:25.8 G.m.t. The maneuver was 179.6 seconds in duration with a differential velocity of 279.1 ft/sec being imparted to the vehicle. The Orbiter was placed in a 190 by 188 nmi. orbit.

At 336:16:39 G.m.t, the Spacelab data display system (DDS) 1, which was used in conjuction with the Astro 1 and BBXRT payloads, appeared to perform an automatic shutoff. The input current exceeded 1 A for 9 seconds before the shutoff. At the time of the failure, the crew reported a burning odor that went away after the DDS was shut down. Payload operations then continued using DDS 2. At 340:12:08 G.m.t., DDS 2 also experienced an automatic shutdown that was similar to the automatic shutdown on DDS 1 earlier in the mission. The crew also reported a burning odor, although no smoke was detected by the smoke detector. An attempt was made to repower DDS 1. Ac bus power was applied to DDS 1 and the current showed a 0.7 A per phase ramp increase over a period of about 1 1/2 minutes until automatic system shutdown. The crew reported a burning odor believed to be caused by burned electronic components. No further attempts to repower DDS 1 or DDS 2 were made. The DDS failures necessitated ground commanding of the experiments for the remainder of the mission.

At about 337:00:57 G.m.t., the ground controllers reported that the manual pointing control (MPC) mode was toggling among on, standby, and off. The symptom cleared when the MPC SELECT switch was switched from 2 to 1. The problem was caused by a discrepancy between the crew checklist and the actual wiring on the vehicle. This problem did not impact the mission.

The text and graphics system (TAGS) jammed at 336:15:22 G.m.t., and again at 337:12:21 G.m.t. The crew performed the malfunction procedure successfully to restore nominal operation after these two paper jams. At approximately 339:13:15 G.m.t., the crew reported that the TAGS had jammed for the third time this mission. Attempts to repair the TAGS were discontinued, and further messages were uplinked using the teleprinter. This problem did not impact the mission.

The reaction control subsystem (RCS) vernier thruster R5D failed off at 339:19:03:16 G.m.t., because of erratic chamber pressure. Analysis of chamber pressure data from the firing indicated that the low chamber pressure was the result of helium ingestion into the thruster. The thruster was reselected and fired for a series of five longer-than-normal pulses. A decrease in the characteristic roughness of the chamber pressure trace was evident during these firings, and the last two firings were completely normal. The thruster performed nominally for the remainder of the mission, and this problem did not impact the mission.

The waste water dump rates degraded throughout the flight. The dump rate decreased from 1.73 to 1.35 to 1.2 percent/minute for the first three waste water dumps, respectively. A fourth waste water dump, initiated at approximately 342:11:24 G.m.t., showed a dump rate of 1.0 percent/minute during the first dump cycle and for the second dump cycle the rate dropped to 0.26 percent/minute at which time the dump was terminated. A cabin air purge of the waste-water dump line through the contingency cross-tie quick disconnect was initiated using the vacuum wand. The line was purged, and the crew reported observing gray particles coming from the dump nozzle, but a check by the crew showed that air flow at the vacuum wand end appeared negligible after the purge. The data indicate that the dump valve or nozzle area was blocked.

Flight control system (FCS) checkout was completed at 343:04:25:43.02 G.m.t. Auxiliary power unit (APU) 2 operated for 5 minutes 54 seconds and consumed 14 lb of propellant during FCS checkout. The APU 2 gas-generator bed temperature responded slowly, requiring 50 seconds to go off-scale versus 12 to 15 seconds nominally. APU 2 functioned nominally. No water spray cooling was required. The RCS hot-fire test was performed with no anomalies noted.

Because weather forecasts indicated unacceptable conditions at the primary landing site on days 10 through 12 of the mission, a decision was made to end the mission one day earlier than planned.

After completion of all entry preparations including stowage and payload-bay door closure, the OMS deorbit maneuver was performed at 345:04:48:31.1 G.m.t., with a firing duration of 230.9 seconds and a differential velocity of 383.2 ft/sec. Entry interface occurred at 345:05:23:07 G.m.t.

A failure of the central ground computer which processes data from the Tracking and Data Relay Satellite (TDRS) network caused the loss of forward and return communications through the TDRS for approximately 16 minutes during entry.

Main landing gear touchdown occurred at 345:05:54:08 G.m.t. on concrete runway 22 at Edwards Air Force Base, CA. Nose landing gear touchdown occurred approximately 12 seconds later with wheels stop at 345:05:55:07 G.m.t. The rollout was normal in all respects. The three APU's were shut down by 345:06:09:20.5 G.m.t., and the crew completed the required postflight reconfigurations and exited the vehicle at 345:07:40:05 G.m.t.

The Astro-1 payload, consisting of three ultraviolet astronomy experiments (Ultraviolet Imaging Telescope, Wisconsin Ultraviolet Photo-polarimeter, and Hopkins Ultraviolet Telescope), as well as the BBXRT performed well during the STS-35 mission. However, the failure of both Spacelab data display systems required the implementation of a backup procedure whereby the Mission Control Center (MCC) commanded the inertial pointing system to coarse point to the targets. The crew would then use the manual pointing controller to fine-point the instruments. A total of 200 observations of 130 targets was made from the combined payload and this represents about 70 percent of the preflight objectives. In addition, several operations and observations were completed using the three middeck experiments (Air Force Maui Optical Site Calibration Tests, Shuttle Amateur Radio Experiment, and Ultraviolet Plume Instrument).

Ten of the scheduled 13 development test objectives (DTO's) and all of the detailed supplementary objectives (DSO's) were accomplished. DTO 901 (OEX Shuttle Infrared Leeside Temperature Sensing) was not successfully completed because of data collection difficulties. DTO's 517 (Hot Nosewheel Steering Runway Evaluation) and 805 (Crosswind Landing Performance) were not completed during the landing phase because the landing was to be made during darkness and crosswinds were not at the level required by the DTO's.

SUMMARY OF PREVIOUS TANKINGS/TESTS OF STS-35 VEHICLE

On May 29, 1990, during propellant loading operations in preparation for the planned launch of STS-35 on May 30, 1990, a hydrogen leak was detected in the region of the 17-inch disconnect and/or the Orbiter aft compartment. Leak detectors (LD54/LD55) in the vicinity of the disconnect and the aft-fuselage hydrogen-detection system sensed gaseous hydrogen concentration levels that exceeded the maximum allowable limits. As a result of these excessive levels, the launch was scrubbed until the source of the leak could be identified and repaired. Subsequent ambient helium leak tests were performed on the launch pad, but no leak was found. On June 6, 1990, after the completion of engineering analyses, a follow-on tanking test was conducted. The tanking test confirmed the magnitude of the leak and identified the leak source to be in the region of the disconnect. The vehicle was subsequently rolled back to the Vehicle Assembly Building (VAB) where it was demated and all of the hardware that was suspected of leaking was removed and shipped to the contractor at Downey, CA, for detailed testing.

All of the liquid hydrogen interface hardware that could potentially be a leak source was subsequently replaced; the Orbiter side was replaced with the new disconnect hardware from the Orbiter "Endeavour" (OV-105) which is under construction at Palmdale, CA, and the ET side was replaced with a 17-inch disconnect (serial no. 6813) that was supplied by the Orbiter and GFE Projects Office. Several other potential leak sources within the Orbiter aft compartment were also repaired.

A launch countdown for a planned lift-off on September 1, 1990, was initiated on August 29; however, the broad-band X-ray telescope encountered a communications problem that caused the countdown to be terminated prior to the initiation of propellant loading (August 30, 1990). The launch attempt was delayed while the avionics package within the payload was replaced.

On September 5, 1990, all aspects of the launch countdown proceeded without incident until the start of liquid hydrogen fast fill. Shortly after the start of fast fill, sensors located in the Orbiter aft compartment again detected an unacceptable concentration of hydrogen (>6500 ppm compared to an LCC limit of

600 ppm), and the launch attempt was again scrubbed. Approximately 6 hours of isolation tests were conducted after the scrub in an attempt to pinpoint the specific sources of the leaks before the propellants were fully drained from the vehicle. Results of these tests indicated that the following conditions existed:

a. No evidence of hydrogen leakage was found in the area of the 17-inch or 4-inch disconnects;

b. The existing leak was in or near the Orbiter recirculation-pump package inlet and/or the manifold-to-recirculation pump-inlet flange, which is inside the Orbiter aft compartment.

Another recirculation pump package was located, installed and tested. During inspection of the recirculation pump package that was removed, two small nicks were found on the 3-inch sealing surface of pump number 3.

Another suspected area of potential leakage within the aft compartment was at the engine prevalves (PV4, PV5, and PV6). Leak checks and inspections of the engine prevalves were performed. Engine prevalve PV6 was found to have a damaged seal on the detent cover.

The subsequent STS-35 launch attempt on September 17, 1990, failed when the leak detectors sensed aft compartment hydrogen concentration levels in excess of 6700 ppm. Further inspection of the PV6 prevalve revealed that the reinstalled seal on the detent was crushed again. The inspection also revealed scratches on the detent cover seal of the PV5 prevalve.

After this third scrub of STS-35, a special "Leak Team" was formed to locate and fix the leaks. Many leak tests were performed under the direction of this team, and the entire liquid hydrogen system on OV-102 was retorqued. In addition, the detent seals on the PV5 and PV6 valves were again replaced. The repairs were followed by a tanking test on October 30, 1990, that proved that the liquid hydrogen system in the aft compartment of OV-102 did not leak in excess of the LCC limits.

Data from the launch countdown, which subsequently supported the successful flight on December 2, did not show any significant concentration levels of gaseous hydrogen.

VEHICLE PERFORMANCE

The Vehicle Performance section of this report contains a discussion of the operation of each element (SRB's, ET, SSME's, and Orbiter).

SOLID ROCKET BOOSTERS/REDESIGNED SOLID ROCKET MOTORS

All SRB systems performed as expected. The SRB prelaunch countdown was normal, The redesigned solid rocket motor (RSRM) propulsion performance was well within the required specification limits, and the propellant burn rate for each RSRM was normal. RSRM thrust differentials during the build-up, steady state, and tailoff phases were well within specifications. All SRB thrust vector control prelaunch conditions and flight performance requirements were met with ample margins. All electrical functions were performed properly. Also, no SRB LCC, RSRM LCC, or Operations and Maintenance Requirements and Specification Document (OMRSD) violations occurred during the countdown.

Power-up of all igniter and field joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. Ground purges maintained the nozzle-to-case joint and bondline adhesive temperature within the required LCC ranges.

The SRB flight structural temperature response was as expected. Postfight inspection of the recovered hardware indicated that the SRB thermal protection system performed properly during ascent, with very little acreage ablation. Postflight inspection and disassembly revealed an anomaly concerning the RSRM. The virgin carbon cloth phenolic (CCP) on the left RSRM nozzle joint 3 was affected by heat as far back as approximately 1 inch radially past the char line. Soot reached the primary o-ring approximately 12 inches circumferentially in both directions from the 195° location. There was no blow-by erosion or heat effect to the primary o-ring at 195° or any other location. No metal components were heat affected. No flight or static test nozzle joints have exhibited primary o-ring heat effect, erosion, or blow-by. This is the first occurrence of heat-affected virgin CCP in joint 3; however, heat effect has been noted in joint 2 of one flight RSRM and two ground-test RSRM's with no o-ring heat effects. Gas paths and soot in nozzle joints are within the experience base of 26 flights and seven static test nozzles.

Separation subsystem performance was normal for the SRB's with all booster separation motors expended and all separation bolts severed. Separation of the SRB occurred 126 seconds after lift-off, about 1.7 seconds later than planned and all recovery systems performed as designed, except the right SRB main parachutes did not disconnect at water impact. The three main parachutes were found draped over the booster and required disconnection before removal. Troubleshooting of the parachute release circuitry isolated the failure to a wide-band signal conditioner in that circuit. Both SRB's were recovered and returned to Kennedy Space Center for disassembly and refurbishment.

EXTERNAL TANK

All objectives and requirements associated with the ET propellant loading and flight operations were met. The operation of the ET heaters and purges was monitored and all performed satisfactorily. The Ice/Frost "Red Team" reported that no anomalous thermal protection system conditions existed on the ET, except that a two-foot long by 1/4-inch wide vertical crack existed in the intertank thermal protection system material. This crack started at the liquid hydrogen-tank intertank interface and ran in a valley of the intertank stringer below the ground umbilical carrier plate, near the -Y thrust panel. KSC documentation had dispositioned this crack as acceptable for flight in the as-is condition. No LCC or OMRSD violations were identified.

As expected, only the normal ice/frost formations for the December environment were observed during the countdown. No ice or frost existed on the acreage areas of the ET. Normal quantities of ice and frost were present on the liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. Frost was also present on the liquid hydrogen protruding air load (PAL) ramps. All of the ice and frost observations were acceptable in accordance with Space Shuttle documentation.

ET flight performance was excellent. All electrical and instrumentation equipment functioned properly throughout the countdown and flight. The ET pressurization system functioned properly throughout engine start and flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 14.7 psid.

The ET tumble system was inactive for this flight. ET separation was nominal, the ET did not tumble, and the ET entry and breakup occurred within the predicted footprint.

No significant problems were identified; however, one in-flight anomaly was identified after the flight when the photographs of the ET, taken by the crew, revealed 10 circular divots on the intertank-to-hydrogen flange. The largest six divots were 8 to 10 inches in diameter. This anomaly did not impact flight operations.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters were normal throughout the prelaunch countdown, comparing well with prelaunch parameters observed during previous flights. Engine-ready was achieved at the proper time, no LCC violations were present, and engine start and thrust build-up were normal.

Preliminary flight data indicate that the SSME performance during mainstage, throttling, shutdown and propellant dump operations was normal. All three engines started and operated normally. High pressure oxidizer turbopump and high pressure fuel turbopump temperatures appeared to be well within specification throughout the period of 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 routinely, and no in-flight anomalies or other problems have been identified.

SHUTTLE RANGE SAFETY SYSTEM

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 above the specified minimum of -97 dBm throughout powered flight.

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

ORBITER SUBSYSTEMS

Main Propulsion System

The overall performance of the main propulsion system (MPS) was excellent. Liquid hydrogen loading was performed as planned with no stop-flows or reverts. However, one stop-flow/revert occurred during liquid oxygen chilldown when a 350 A surge shut down a Government furnished equipment (GFE) liquid oxygen pump (A126). An alternate pump (A127) was activated with a resultant delay of 49 minutes in the loading operations. No OMRSD violations occurred during the loading operations.

Throughout the preflight operations, no significant hydrogen hazardous gas concentrations were detected with the maximum hydrogen level in the Orbiter aft compartment being 140 ppm. This level was significantly lower than normally experienced with the Columbia vehicle.

During replenish, the aft compartment helium reading reached 16,200 ppm, which exceeded the LCC limit of 10,000 ppm. A leak was isolated to the aft compartment hazardous gas detection system sample line disconnect, which ingested T-0 umbilical helium purge gas. Therefore, no helium leak actually existed within the aft compartment.

A comparison of the calculated propellant loads versus the inventory loads at the end of replenish results in a loading accuracy of -0.041 percent for liquid hydrogen and -0.049 percent for liquid oxygen.

Ascent MPS performance was completely normal. Data indicate that the liquid oxygen and hydrogen pressurization systems performed as planned and that all net positive suction pressure requirements were met throughout the powered flight phase.

The gaseous oxygen flow control valves were shimmed to a high position of 93 percent and a low position of 55 percent open as the step one fixed orifice program was flown for the second time. The gaseous oxygen pressurization system performed normally throughout the flight, with a minimum liquid oxygen ullage pressure during the period of the ullage pressure slump being 14.7 psid.

Out-of-specification valve response times were noted for the liquid oxygen outboard and liquid hydrogen inboard and outboard fill and drain valves at vacuum-inert initiation. The OMRSD identifies the minimum opening response time as 2.9 seconds for each valve. The quick valve response times (2.75, 2.49, and 2.81 seconds) are a result of the deletion of the manual anti-slam procedure. The valves are certified under slam-operation conditions. Fast opening times are frequently encountered at vacuum inert initiation. The OMRSD will be modified to reflect new minimum response times. The quick response times are not considered an in-flight anomaly.

Propellant dump and vacuum inerting were accomplished satisfactorily. Postflight evaluation revealed three failed measurements which are all attributed to a faulty hardware interface module card. These failures were minor in nature and had no impact on the flight or countdown operations.

Reaction Control Subsystem

The performance of the reaction control subsystem (RCS) was nominal with two anomalies noted. During entry, the RCS was also used to support DTO 242, which is an entry aerodynamic control surface test. A total of 4820 lb of propellant was used by the RCS engines, including that burned during the forward RCS dump burn and that supplied from the OMS during crossfeed operations. The Orbital Maneuvering Subsystem section discusses the amount of OMS fuel consumed by the RCS during interconnect operations.

At 337:22:39 G.m.t., it was noted that the left RCS drain panel A-string heaters did not cycle on at the thermostat set point (59 °F) (Flight Problem STS-35-04). The temperature while operating on the A heaters went as low a 52 °F (within 3 °F of fault-detection-annunciator limit) before switchover to the B heaters. The B heaters functioned normally. Much of the mission was flown on the A heaters to conserve power. Solar heating maintained the temperatures within acceptable limits. The lowest temperature noted while operating on the A heaters was approximately 47 °F for the fuel and 50 °F for the oxidizer.

During flight day 3 activities, vernier thruster R5D failed off (Flight Problem STS-35-20). Analysis of the chamber pressure traces indicated that helium ingestion had occurred. The thruster was reselected and hot fired until no trace of gas could be seen (five pulses). Analysis is continuing to determine the source of the helium.

Orbital Maneuvering Subsystem

The performance of the OMS was very satisfactory with no anomalies noted. Two OMS maneuvers were performed (OMS-2 and deorbit), with a total firing duration of 410.5 seconds and a differential velocity of 662.3 ft/sec. A total of 11,013 lb of oxidizer and 6521 lb of fuel was used from the OMS tanks of which over 7 percent was used by the RCS during interconnect operations. The ongoing problem of the right aft gauge going off-scale high and causing discrepant aft and total readings recurred, but the discrepant readings did not affect mission operations.

The OMS oxidizer high-point bleed line (aft) system A and B heater thermostats were intermittently cycling and dithering. The A thermostat cycled between 56 °F and 95 °F, and the B thermostat cycled between 57 °F and 77 °F. The A thermostat dithered between 61 °F and 65 °F, and the B thermostat dithered at a steady 62 °F. These conditions did not impact mission operations, as dithering thermostats are not considered failed. Also, both systems have an over-temperature thermostat in series for redundancy; therefore, no action will be taken until the Orbiter undergoes major modifications after its next flight. Following the deorbit maneuver, the oxidizer low-level warning indicated about 4.5 percent remaining, which was slightly below estimates. Evaluation showed this condition to be within normal tolerances because of the inaccuracies in the amount of oxidizer used during interconnect operations with the RCS.

Power Reactant Storage and Distribution Subsystem

The performance of the power reactant storage and distribution (PRSD) subsystem was nominal, with no anomalous operation noted. The Orbiter was configured with five cryogenic tank sets for this long-duration mission. A total of 2679 lb of oxygen and 321 lb of hydrogen was consumed during the mission, with 130 lb of oxygen consumed by the crew included in that total. Reactants remaining at touchdown were adequate to support a mission extension of 72 hours.

At 341:06:40 G.m.t., PRSD oxygen tank 5 quantity dropped below 8 percent. The tank heater was turned off 2 hours 10 minutes later, at which time the quantity had dropped to 6 percent. The Shuttle Operational Data Book states a constraint that requires that any individual oxygen tank heaters be turned off when quantity in that tank reaches 8 percent to avoid overpressurizing the tank. This condition did not impact the mission.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem operations were nominal, meeting all electrical requirements for the 9-day scientific mission. The total energy produced during the 214-hour mission was 3606 kWh with the average power level at 16.8 kW. A total of 2870 lb of water was the by-product of this power generation which consumed 2549 lb of oxygen and 321 lb of hydrogen. The average total Orbiter electrical power was 16.8 kW and 540 A. The three fuel cells each operated in excess of 256 hours in support of the STS-35 mission.

At the end of a manual purge of fuel cell 3, the water relief nozzle and relief line heaters were deactivated. A fault message alerted the crew to reactivate the heaters, thereby preventing catastrophic damage to the fuel cells, should the primary or secondary water path become blocked or if freeze-up of the water relief had taken place.

The fuel cell 3 hydrogen flow meter continued to read off-scale high as on previous missions.

Auxiliary Power Unit Subsystem

The APU subsystem performance was satisfactory with one anomaly identified during the mission, and that anomaly did not impact mission operations. The following table shows the cumulative run time and fuel consumption of each APU during the mission.

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
Ascent	18:11	45	18:12	48	18:12	51
FCS checkout			5:54	14		
Entry	01:25:46	159	59:09	121	59:09	124
Total [a]	01:43:57	204	01:23:15	183	01:17:21	175

Note:
[a] A total of 15 minutes 11 seconds of APU operation occurred after landing.

The APU 2 gas-generator bed temperature (V46T0222A) exhibited a slow response when the APU was started for FCS checkout, requiring about 50 seconds to reach 500 °F (off-scale high) instead of the nominal 12 to 14 seconds (Flight Problem STS-35-11a). This anomaly did not affect the mission. The gas generator injector stem temperature reacted nominally during the startup, and no anomalous conditions were noted in the gas generator chamber pressure. This APU was removed during turnaround activities, as previously planned, and troubleshooting will be performed.

Three other problems were noted during the mission and their significance did not warrant the declaration of an anomaly. The APU 2 lubrication oil outlet pressure was higher than normal during ascent, FCS checkout, and entry, averaging 90 to 100 psia instead of 40 to 50 psia. This is indicative of wax in the lubrication oil system that results when hydrazine mixes with lubrication oil. The pressures returned to normal during each period when the lubrication outlet temperature reached 200 to 225 °F. Also, APU 2 fuel tank isolation valve B experienced transient open indications when the valve was actually closed. This was a known condition and had been accepted to fly as is prior to the flight. Additionally, the APU 2 injector temperature was biased approximately 50 °F higher than the gas generator bed temperature at 336:14:00 G.m.t. The two temperatures should be approximately the same. The same condition occurred on the last flight of this vehicle, and the thermal junction was replaced following the STS-32 mission. This problem did not impact the mission.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler (WSB) subsystem operated satisfactorily throughout the mission and one anomaly was identified. Additionally, two minor problems were also noted. During prelaunch operations, all three WSB "OK" indications were continuously present. No LCC violations were observed.

WSB spraying for APU 2 lubrication oil cooling began about 2 minutes after main engine cutoff (MECO), as was expected. WSB spraying for APU 2 cooling was not required because the lubrication oil temperature never exceeded 250 °F. High gearbox oil pressure on APU 2 (40 to 50 psid from APU 1 and APU 3) during the prelaunch period indicated wax/crystal contamination due to hydrazine leakage into the gearbox. The wax/crystal condition resulted in lower lubrication oil temperatures on APU 2 during ascent and probable contamination of WSB 2 (Flight Problem STS-35-19). WSB spraying for APU 3 lubrication oil cooling was not evident until about 12 minutes after lift-off when the lubrication oil temperature had reached 277 °F. Analysis showed that the lubrication oil temperature had exceeded the maximum WSB specification of 275 °F for 7 seconds. During entry, WSB 3 experienced a minor over-cooling of the lubrication oil. Analysis to determine the cause of these conditions continues.

Pyrotechnics Subsystem

The pyrotechnics subsystem operated nominally throughout the mission.

Environmental Control and Life Support Subsystem

The atmospheric revitalization system performed nominally throughout the mission. After the failure of data display system 2 created a burning odor in the cabin, the combustible products analyzer (CPA) was unstowed and high levels of carbon monoxide were detected in the cabin. The carbon monoxide absorber cartridge (lithium hydroxide canister filled with platinum and charcoal) was installed in the cabin loop for 4 hours after which the carbon monoxide levels should have been reduced below Shuttle maximum allowable concentration (SMAC); however, the CPA failed to record a decrease in carbon monoxide. The CPA was purged with pure oxygen and still showed a carbon monoxide concentration; therefore, analysis showed that the CPA-measured levels of carbon monoxide were invalid.

During the redundant component checkout, a small amount of water was reported around humidity separator B just after switching to A. The water was allowed to evaporate and humidity separator A performed nominally for the rest of the mission. Based on the increased quantity in the waste water tank and no visual inspection of the separator, the humidity separators could not be verified to have carried over water. This condition may have been caused by condensation or residual water from humidity separator B after shutdown. This free water did not impact the mission, and the humidity separators performance will be verified during normal turnaround activities. The pressure control system hardware parameters all remained within nominal ranges throughout the mission.

All active thermal control system components operated nominally during the mission. The flash evaporator system (FES) was used to perform all supply water dumps as required by the payload. Proper payload cooling was provided for the on-orbit operation, and radiator cooling did not require the deployment of the radiators. The freon coolant loop 1 flowrate was degraded as predicted prior to flight, a condition that did not affect the flight.

A flash evaporator system (FES) supply water dump was completed satisfactorily. At the beginning of the dump, which lasted approximately 11 hours, the tank quantity was approximately 92.5 percent. At the end of the dump, the tank quantity was approximately 4.3 percent. The FES dump ensured that at the end of flight day 9, a total of 620 lb of water would be available for cooling during entry.

The supply water management system performed nominally throughout the mission. Supply water was managed by dumping water through the flash evaporator system. However, the waste water system dump performance was not fully satisfactory. The waste water system collected water satisfactorily and at a rate 26 percent greater than the level nominally predicted. Three successful water dumps were performed, but the dump rate continually degraded from 1.73 percent per minute to 1.12 percent per minute. During the fourth waste water dump, the dump rate continued to degrade and reached a level as low as 0.26 percent per minute, when the dump was stopped to prevent icing of the dump nozzle. A cabin air purge of the line was unsuccessful. Following the purge, an attempt was made to clear the waste water dump line and nozzle using the in-flight maintenance (IFM) hose, which was connected to the 30-psi nitrogen source from the pressure control system and the contingency water cross-tie waste quick disconnect (QD), but the line and nozzle became completely blocked (Flight Problem STS-35-05). As a result, the contingency water collection bag was filled with waste water and the waste water tank quantity was reduced to 10.4 percent at approximately 6 days and 9 hours elapsed time. Again at approximately 7 day 9 hours elapsed time, the waste water was transferred from the tank to 15 female urine absorption systems (UAS's). This transfer gained enough ullage in the waste tank to allow the crew to return to using the waste collection system for a nominal 10-day end-of-mission. Another attempt was made with nitrogen from the 30-psi source to clear the line, and little or no flow was obtained. Additional contingency methods of transferring waste water were available, if the mission had been extended for one day.

The waste collection system performed nominally throughout the mission. In accordance with Development Test Objective (DTO) 329, the improved waste collection system that was flown for the first time was evaluated. The crew reported that the system worked well.

Smoke Detection and Fire Suppression

The smoke detection system operated nominally and the fire suppression system was not required. Burning-wire type odors from the payload data display systems were reported by the crew on three occasions; however, no detectable thermal degradation products were indicated by the smoke detection subsystem.

Airlock Support System

The airlock support system was not used as no extravehicular activities were required or performed. The airlock was used for stowage during the mission.

Avionics and Software Subsystem

The performance of the integrated guidance, navigation and control subsystem was nominal throughout the mission with no anomalies identified. The FCS was used to perform DTO 242, an entry aerodynamic control surfaces test, which was completed with nominal FCS performance.

All three inertial measurement units (IMU's) performed nominally during the prelaunch, ascent, on-orbit, and entry phases of the mission. The star trackers performed nominally; however, the -Z star tracker exhibited a self-test failure on the first two attempts after power up because of star position errors of 1.10 degree in the horizontal position and 0.07 degree in the vertical position (Flight Problem STS-35-10). These errors were only observed on the first two software passes. Numerous subsequent self-tests were performed with nominal results.

The performance of the data processing system/flight software was satisfactory. One data entry unit keyboard channel miscompare was noted at landing and the data are being analyzed to determine the cause of this condition. At 336:16:41 G.m.t., the aft data display unit 3 (DDU 3) was commanded on for the -Z crew optical alignment sight (COAS) calibration, and the downlinked status of the three power supplies showed the status of power supply B as off while the status of power supplies A and C indicated on. Cycling the aft flight controller power switch cleared the failure indication. This problem did not impact the mission.

Data analysis showed that the electrical power distribution and control subsystem performed nominally throughout the mission with nominal voltages and current signatures, and no specification limits violated. One potential electrical problem concerning the pilot's seat was noted during prelaunch operations (Flight Problem STS-35-23). The seat would not move downward when commanded, and the initial analysis indicates a stuck switch problem rather than a switch failure.

The displays and controls subsystem performed nominally.

Communications and Tracking Subsystem

The communications and tracking subsystem performance was acceptable with eight anomalies and one problem identified, none of which caused a significant impact on the mission. The text and graphics system (TAGS) malfunctioned three times between 337:12:20 and 339:13:14 G.m.t. (Flight Problem STS-35-02). Despite the implementation of a 45-minute minimum warm-up time after the second jam, the crew reported that the TAGS had jammed a third time. While the crew was performing the malfunction procedure, the modified forceps tool that was fabricated for use on TAGS paper jams was broken (Flight Problem STS-35-03). No workarounds appeared to be feasible, and attempts to repair the TAGS were discontinued. These problem did not impact the mission.

The Ku-band system also failed a self-test. This deployed assembly (serial number 106) has a history of self-test failures; however, system performance was not affected and the condition did not impact the mission.

At approximately 336:18:00 G.m.t., the crew reported that two headsets and one crew remote unit were inoperative (Flight Problem STS-35-06). Additional headsets were available, and consequently, these failures did not impact the mission.

Three closed-circuit television (CCTV) cameras exhibited failure conditions during the mission. The crew reported that CCTV camera B had no picture and ground commands to this camera produced the same results (Flight Problem STS-35-7a). Camera B was turned off for the remainder of the mission. CCTV camera C showed a convex black area at the top of the screen, a concave black area at the bottom of the screen, and a black-and-white picture in the center (Flight Problem STS-35-7b). Cycling power did not clear this problem that was apparently caused by a sticking color wheel. CCTV camera D had an intermittent problem in that when powered up, only "snow" appeared on the screen (Flight Problem STS-35-7c). The camera was powered up later in the mission and operated properly.

The S-band upper left antenna was linked to many of the S-band Tracking and Data Relay Satellite (TDRS) forward link dropouts (Flight Problem STS-35-13). The S-band reflected power changed with time (from 1 to 5 watts) during a pass using the upper left antenna. Numerous bad forward link passes coincided with the use of the upper left antenna. Performance of the lower right S-band antenna was also erratic. These problems did not impact the mission. Also, the downlink on air-to-ground 2 was noisy during most of the mission (Flight Problem STS-35-15). The noise disappeared when operating on network signal processor (NSP) 1 and was only present when operating on NSP 2.

Operational Instrumentation Subsystem

The operational instrumentation (OI) subsystem performed satisfactorily with three minor anomalies. Data could not be dumped from track 2 of the operations (OPS) recorder 1 (Flight Problem STS-35-01). Data were lost from 337:09:24 to 337:09:35 G.m.t., and track 2 was not used for the remainder of the mission. Also, data from track 5 of OPS recorder 2 were degraded when dumped in both directions (Flight Problem STS-35-08). Data were also not recorded on this track for the remainder of the mission.

At 339:19:18 G.m.t., the payload recorder dumps at 4:1 and 2:1 were degraded (Flight Problem STS-35-09). As the mission progressed, data dumped at 1:1 were also degraded. All three of these recorders have the same manufacturer and have been in use since 1983 or 1984. The symptoms observed are indicative of the early stages of head wear as opposed to tape life.

Structures and Mechanical Subsystems

The structures and mechanical functions were nominal during the mission. The right-hand aft separation hole plugger did not fully extend (Flight Problem STS-35-21). One of the two boosters was jammed between the plugger and the rim of the hole. The other booster was missing.

The right-hand stop bolt on the ET forward structural attachment assembly was bent (Flight Problem STS-35-22). This deformation was similar in magnitude to the deformation observed on STS-38.

The landing and deceleration subsystem performance was nominal with main gear touchdown occurring at 345:05:54:08 G.m.t., at a ground speed of 207.9 knots. Sink rate at main gear touchdown was approximately 1.0 ft/sec. The nose landing gear touchdown occurred at 345:05:54:20 G.m.t., at a ground of 169.5 knots and a pitch rate of 3.40 deg/sec. Braking was initiated 11.6 seconds later at a ground speed of 134.5 knots with wheels stop occurring 34.3 seconds after brake initiation. Rollout distance was 10,447 feet. Brake energies were 32.41 million ft-lb for the left-hand outboard wheel, 31.04 million ft-lb for the left-hand inboard wheel, 29.70 million ft-lb for the right-hand inboard wheel, and 32.53 million ft-lb for the right-hand outboard wheel. The vehicle weight at landing was 225,329.2 lb.

Aerodynamics

The entry aerodynamics were nominal with the control surfaces responding as expected. Also, the angle of attack was as expected. DTO 242 (part 3) was performed during entry. This DTO required eight programmed test inputs (PTI's) including one manual body flap maneuver. Initial analysis indicates that all maneuvers appeared to be nominal.

Thermal Control Subsystem

The thermal control (heater) subsystem operated nominally except for the left RCS drain panel system A heater, which operated nominally for only one cycle (Flight Problem STS-35-04). Orbiter structural and component temperatures were maintained within acceptable limits throughout the flight. The temperature of the Viton window seals is estimated to have been no colder than -45 °F. In addition, eight dithering thermostats were identified during the mission. None of these require replacement prior to the next flight. Also, the left OMS oxidizer high-point bleed line system A and B heater control thermostats exhibited periods of nominal cycling as well as periods of dithering.

Thermal Interfaces and Aerothermodynamics

The prelaunch thermal interfaces temperatures were all within design limits. Also, the ET/Orbiter umbilical cavity electronic connector temperatures were nominal. Preliminary analysis indicates that ascent heating was nominal and that all Orbiter/SSME hydraulic interface temperatures were within interface control documentation limits.

The aerothermodynamics during entry were satisfactory with acreage heating nominal. The local heating was nominal based on postflight inspection results.

Thermal Protection Subsystem

The thermal protection subsystem (TPS) performance was nominal based on structural temperature responses and some tile surface temperature measurements. The overall boundary layer transition from laminar flow to turbulent flow was nominal, occurring between 1210 and 1215 seconds after entry interface.

The postflight inspection revealed the TPS to be in good to excellent condition with minimal impact damage, but with two large surface-damage areas evident in the right-hand chine. The Orbiter TPS sustained a total of 147 hits, of which 17 had a major dimension of 1-inch or greater. This total does not include the 100 hits on the base heat shield. The lower surface had 132 hits, of which 15 had a major dimension of 1-inch or greater. A comparison of these numbers to statistics from 24 previous flights of similar configuration indicates the total number of hits on the lower surface was average. A cluster of 45 hits (six larger than 1 inch) occurred just aft and inboard of the liquid hydrogen ET/Orbiter umbilical opening.

Overall, all reusable carbon carbon (RCC) parts appeared nominal. The OV-102 chin panel recorded its first flight. Inspection of the panel revealed surface bubbling of the "A" enhancement coating applied on the RCC surface. The chin panel is acceptable for flight in the as-is condition. The nose landing gear door TPS was in good condition with only one loose patch on the Nicalon sacrificial thermal barrier and small breaches on both sides. Indications of potential flow paths and blanket damage were evident under the forward ET forward attach RCC. The left-hand main landing gear door forward outboard tile and adjacent structure tile had significant edge damage. Breaching of the outboard and aft thermal barrier was evident on both doors. The ET door thermal barriers were in good condition. The elevon cove TPS was in good condition with no evidence of outgassing or gap filler damage. The elevon-elevon gap tiles were in good condition, with no breached gap fillers. There was missing coating and tile material on the right-hand wing tip, aft of RCC panel 22. Overall, the upper surface TPS and OMS pods were nominal, with typical upper wing surface white-tile damage. One of these sites exhibited significant thermal erosion (approximately 3/4 inch in depth) and melting of the adjacent tile coating material.

The largest lower surface damage site was located on the right-hand chine, affected four tiles, and had a maximum depth of 1/4 inch.

No TPS damage was attributed to material from the wheels, tires, or brakes. Material loss from the main landing gear tires was average for a concrete runway landing.

Damage to the base heat shield tiles was less than average (approximately 100 sites). The body flap upper surface tiles suffered more damage than usual with several damage sites exhibiting significant depth. All three main engine closeout blankets had localized areas of peeled, frayed, and/or missing material.

During the postflight inspection, a piece of environmental seal material, approximately 24 inches long, was observed hanging from the expansion joint between the first and second sections of the right-hand payload bay door (Flight Problem STS-35-16).

An impact crater, about 0.15 inch in diameter, was found in window 1 (Flight Problem STS-35-18). Orbiter windows 3 and 4 were moderately hazed with minor streaking, and windows 2 and 5 were lightly hazed.

FLIGHT CREW EQUIPMENT

All flight crew equipment functioned nominally, except the TAGS unjamming tool. The middeck locker-sized manual trash compactor was evaluated for DTO 634. The crew used the trash compactor daily and stated that the device worked very well.

While the crew was attempting to remove a paper jam from the TAGS, the modified forceps tool that was designed to be used for paper removal broke (Flight Problem STS-35-03). The crew reported that a weld spot at the head of the tool had failed and that the jaws were separated from the shaft. The crew was unsuccessful in an attempt at reattaching the head to the shaft using the crimp tool from the pin kit.

At 349:09:52 G.m.t., while using the personal hygiene station hose assembly as a contingency in-flight maintenance hose to flow waste water, the crew reported that the hose became clogged and would not flow water. The crew stated that "gray flakes" were in the water. The valve and possibly the quick disconnect were contaminated and clogged.

During prelaunch adjustment of the pilot's seat, the astronaut support personnel reported that the seat could not be adjusted downward (Flight Problem STS-35-23). The seat was acceptable for flight because no downward movement was anticipated during dynamic flight, and the crew could manually adjust the seat while on orbit, if necessary.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

On launch day, 25 videos were screened, and no anomalies were noted. Cloud coverage did obstruct the view of the vehicle from several of the tracking cameras. Review of over 60 films was also completed and no anomalies were noted. Because of the night launch, no Castglance film of the SRB recovery was made. In some cases, exposure problems resulting from the night launch and cloud cover hampered analysis and detection of possible debris or anomalies.

The crew also took eight pictures of the ET after separation. Analysis of these pictures is continuing.

Video and films of landing on runway 22 at Edwards Air Force Base were also reviewed, but because of the night landing, the quality of the pictures was not up to the level seen on day landings. No anomalies were noted in any of these landing videos or films.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

Thirteen development test objectives (DTO's) were planned for this mission. Ten of these DTO's were accomplished; two DTO's were not attempted because the initial conditions were not correct, and data collection problems prevented the completion of a third DTO. The status of each DTO at the time of publication is presented in the following subparagraphs.

DTO 236 - Ascent Wing Aerodynamic Distributed Loads - The data were successfully collected for this DTO and are being analyzed by the sponsor.

DTO 242 - Entry Aerodynamic Control Surfaces Test - All eight programmed test inputs (PTI's) were successfully completed. The data are being analyzed by the sponsor.

DTO 301 - Ascent Structural Capability - The data were successfully collected and are being analyzed by the sponsor.

DTO 307 - Entry Structural Capability - The data were successfully collected and are being analyzed by the sponsor.

DTO 312 - ET Thermal Protection System Performance - This DTO was successfully accomplished. Preliminary analysis of the ET photography taken by the crew after ET separation reveals several white and black burn scars caused by SRB separation. A number of divots and gouges were also detected. Digital classification of the images is in work and will be included in the final report for this DTO.

DTO 329 - Improved Waste Collection System Evaluation - The improved waste collection system (IWCS) performed well as reported by the crew. The IWCS final report is now in final preparation.

DTO 517 - Hot Nosewheel Steering - This DTO was not performed because it was planned to be performed under daylight conditions.

DTO 634 - In-Flight Trash Collection - The trash collector was used frequently during the mission with excellent results. The final report on this DTO is in preparation.

DTO 805 - Crosswind Landing Performance - This DTO was not performed because of the low crosswinds that were present at the time of landing.

DTO 901 - Orbiter Experiment Shuttle Infrared Leeside Temperature Sensing - This DTO was not successfully completed because of data collection problems.

DTO 902 - Orbiter Experiment Shuttle Upper-Atmosphere Mass Spectrometer - Data were collected and are being analyzed. The final report on this DTO will be published in March 1991.

DTO 903 - Orbiter Experiment Shuttle Entry Air Data Sensor - The data were collected for this DTO and are being analyzed.

DTO 911 - Orbiter Experiment Aerothermodynamic Instrumentation Package - The data were collected for this DTO and are being analyzed.

DETAILED SUPPLEMENTARY OBJECTIVES

A total of 11 detailed supplementary objectives (DSO's) were planned for this mission. Data were collected on all 11 DSO's and are currently being analyzed by the investigators.

TABLE I.- STS-35 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	336:06:44:13.66
	APU-2 GG chamber pressure	336:06:44:14.45
	APU-3 GG chamber pressure	336:06:44:15.31
SRB HPU activation	LH HPU system A start command	336:06:48:33.21
	LH HPU system B start command	336:06:48:33.37
	RH HPU system A start command	336:06:48:33.53
	RH HPU system B start command	336:06:48:33.69
Main propulsion System start	Engine 3 start command accepted	336:06:48:54.455
	Engine 2 start command accepted	336:06:48:54.575
	Engine 1 start command accepted	336:06:48:54.695
SRB ignition command (lift-off)	SRB ignition command to SRB	336:06:49:01.0218
Throttle up to 104 percent thrust	Engine 3 command accepted	336:06:49:04.992
	Engine 2 command accepted	336:06:49:04.976
	Engine 1 command accepted	336:06:49:04.969
Throttle down to 71 percent thrust	Engine 3 command accepted	336:06:49:27.713
	Engine 2 command accepted	336:06:49:27.696
	Engine 1 command accepted	336:06:49:27.689
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	336:06:49:51
Throttle up to 104 percent thrust	Engine 3 command accepted	336:06:50:04.195
	Engine 2 command accepted	336:06:50:04.177
	Engine 1 command accepted	336:06:50:04.170
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	336:06:51:01.26
	RH SRM chamber pressure mid-range select	336:06:51:01.46
End SRM action	LH SRM chamber pressure mid-range select	336:06:51:03.85
	RH SRM chamber pressure mid-range select	336:06:51:03.97
SRB separation command	SRB separation command flag	336:06:51:07
SRB physical separation	SRB physical separation	
	LH APU A turbine speed LOS*	336:06:51:06.78
	LH APU B turbine speed LOS*	336:06:51:06.78
	RH APU A turbine speed LOS*	336:06:51:06.78
	RH APU B turbine speed LOS*	336:06:51:06.78
Throttle down for 3g acceleration	Engine 3 command accepted	336:06:56:33.457
	Engine 2 command accepted	336:06:56:33.458
	Engine 1 command accepted	336:06:56:33.460
3g acceleration	Total load factor	336:06:56:34
MECO	MECO command flag	336:06:57:33
	MECO confirm flag	336:06:57:33
ET separation	ET separation command flag	336:06:57:51
OMS-1 ignition	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown

* = loss of signal

TABLE I.- CONTINUED

Event	Description	Actual time, G.m.t.
OMS-1 cutoff	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
APU deactivation	APU-1 GG chamber pressure	336:07:02:25.38
	APU-2 GG chamber pressure	336:07:02:26.63
	APU-3 GG chamber pressure	336:07:02:27.09
OMS-2 ignition	Left engine bi-prop valve position	336:07:29:25.8
	Right engine bi-prop valve position	336:07:29:25.9
OMS-2 cutoff	Left engine bi-prop valve position	336:07:32:25.4
	Right engine bi-prop valve position	336:07:32:25.2
Flight control system checkout		
APU start	APU-2 GG chamber pressure	343:04:19:49.33
APU stop	APU-2 GG chamber pressure	343:04:25:43.02
APU activation for entry	APU-1 GG chamber pressure	345:04:43:32.57
	APU-2 GG chamber pressure	345:05:10:10.98
	APU-3 GG chamber pressure	345:05:10:11.75
Deorbit maneuver ignition	Left engine bi-prop valve position	345:04:48:31.1
	Right engine bi-prop valve position	345:04:48:31.0
Deorbit maneuver cutoff	Left engine bi-prop valve position	345:04:52:21.9
	Right engine bi-prop valve position	345:04:52:22.0
Entry interface (400k)	Current orbital altitude above reference ellipsoid	345:05:23:07
Blackout	Data locked at high sample rate	No blackout because of TDRS
Terminal area energy management	Major mode change (305)	345:05:47:56
Main landing gear contact	LH MLG tire pressure	345:05:54:08
	RH MLG tire pressure	345:05:54:08
Main landing gear weight on wheels	LH MLG weight on wheels	345:05:54:10
	RH MLG weight on wheels	345:05:54:09
Nose landing gear	NLG tire pressure	345:05:54:20
Nose landing gear weight on wheels	NLG WT on Wheels -1	345:05:54:21
Wheels stop	Velocity with respect to runway	345:05:55:07
APU deactivation	APU-1 GG chamber pressure	345:06:09:18.36
	APU-2 GG chamber pressure	345:06:09:19.78
	APU-3 GG chamber pressure	345:06:09:20.57

Note: Numerous data dropouts occurred, resulting in ranges being given for measurements.

TABLE II.- STS-35 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-35-01	OPS Recorder 1 Track 2 Problem	337:11:34 G.m.t. FIAR-BFCE-029-F022 PR-INS-2-11-0669	OPS recorder 1 track 2 unable to dump data. Loss of dump data from 337:09:24 G.m.t. to 337:09:35 G.m.t. No operational impact on mission. Track 2 was not used for the remainder of the mission. Recorder was removed at DFRC.
STS-35-02	TAGS Paper Jam	337:12:20:26 G.m.t. PR COMM-0159	TAGS jammed during first page of an uplink sequence. Additional jam occurred at 339:13:14 G.m.t., while page 3 of a message sequence was passing through the OHC developer. During troubleshooting, the TAGS unjamming tool also malfunctioned (STS-35-03).
STS-35-03	TAGS Unjamming Tool Broken (GFE)	339:13:29 G.m.t. FIAR-BFCE-213-F006	TAGS unjamming tool broke while attempting to clear a jammed piece of paper. The weld spot by the gripper teeth broke.
STS-35-04	Left RCS Drain Panel Heater A Not On At Normal Temperature	337:22:39 G.m.t. IM36RF02 IPR 40V-0004	The left RCS drain panel temperature sensors, V42T2304A and V42T2305A, indicated that the heater did not cycle at the expected 59°F on the left pod A heaters. The temperature on the A heater went down to 52 °F, which was within 3 °F of the fault detection annunciator limit, before switching to the B heater.
STS-35-05	Waste Water Dump Degradation	339:12:30 G.m.t. IM35RF03 IPR 40V-0004	Waste water dump data shows a gradual degradation of the waste water dump rate. Line completely blocked on fourth water dump. Waste tank was off-loaded to CWC and UCD's/UAS's. The 30 psia nitrogen purge failed to remove blockage. Chit prepared to troubleshoot and repair at KSC.
STS-35-06	Two headsets inoperative and one crew remote unit (CRU) failed	336:18:00 G.m.t. FIAR BFCE 029-F024 FIAR BFCE 029-F025 FIAR BFCE 029-F026	The crew reported that two (2) headsets were inoperative. One is physically broken, and the others will not transmit. Also, one CRU would not transmit.
STS-35-07	CCTV Problems: a) CCTV Camera B Failed (GFE)	340:13:23 G.m.t. FIAR BFCE 029-F029	a) Crew reported that camera B had no picture. Further commanding from the ground indicated the same result. Remove and replace camera.
	b) CCTV Camera C Color Wheel Sticking	341:22:06 G.m.t. FIAR BFCE 029-F030	b) Upon activation, camera C image showed a convex black area on top, concave black area on bottom, and black and white picture in center. Cycling power did not clear the problem. Transient anomaly. Remove and replace camera.
	c) Camera D - Intermittent Power Up/Commanding Problem	344:03:16 G.m.t. FIAR BFCE 029-F031	c) Camera D was powered up and only "snow" appeared on the monitor. Later, camera D was powered back up and worked fine. Analysis of downlink video revealed camera D was phase shifting throughout the entire mission. This failure was the result of a large phase shift. No testing required. Remove and replace camera D.

TABLE II.- STS-35 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-35-08	OPS Recorder 2 Track 5 Degraded Quality	340:08:01 G.m.t. PR INS 2-11-0670 FIAR BFCE 029-F028	Dump of OPS recorder 2 track 5 was degraded when dumped in either direction. Removed at DFRC.
STS-35-09	Payload Recorder Track 5 Degraded Quality	339:19:18 G.m.t. PR INS 2-11-0671 FIAR BFCE 029-F027	Initial payload recorder dump at 4:1 and 2:1 were degraded. Recorder continued to degrade during the mission, with 1:1 dumps also affected. Removed at DFRC.
STS-35-10	-Z Star Tracker Failed First Two Self-Tests	336:08:51 G.m.t. IM35RF04 IPR 40V-0012	-Z Star tracker failed first two self-tests, but passed all subsequent self-tests. Star tracker operated nominally throughout the mission. Possible warmup issue.
STS-35-11	APU 2 Gas Generator Bed Temperature Responded Slowly	343:04:20 G.m.t. IM35RF05	During APU 2 start for FCS checkout, the gas generator bed temperature reading lagged behind nominal by 20 seconds. APU operated nominally. Remove and Replace APU 2.
STS-35-12	Integrated in STS-35-07b		
STS-35-13	Upper Left S-band Antenna Performing Poorly	342:01:30 G.m.t. IM35RF06 IPR 40V-0013	Unexplained forward link dropouts have occurred while on upper left antenna. Reflective power has fluctuated between 1 and 5 watts during these dropouts. KSC troubleshooting plan in place.
STS-35-14	Integrated in STS-35-07c		
STS-35-15	Noise on Air-to-Ground 2	Mission Duration	Downlink on air-to-ground 2 was noisy during most of the mission. While on NSP 1, no noise was present. Possibly an NSP 2 problem.
STS-35-16	Payload Bay Door Environmental Seal Debond	Found during postflight PR STR 2-11-2705	A 24-inch piece of the environmental seal between panels 1 and 2 on the right payload bay door was found loose on top of payload bay door.
STS-35-17	WSB 3A Operation Abnormal During Ascent and Entry	Ascent and Entry	During ascent, spray cooling did not initiate until APU 3 lubrication oil return temperature reached 280 °F (should be no greater than 250 °F). During entry, slight overcooling occurred. Hot oil flush required.
STS-35-18	Window W-1 Has A 0.15-inch Diameter Chip	Postflight Inspection PR STR 2-11-2703	Postlanding inspection revealed an impact 0.15-inch in diameter and approximately 0.005-inch depth. "Spider webbing" type cracks were emanating from the impact point. Noted by crew on flight day 6. Believed to have occurred in the atmosphere. Window will be removed and replaced.
STS-35-19	WSB 2 Subjected to Abnormally Large Quantities of Wax	Ascent and Entry	During ascent and entry, large amounts of wax were noted in the APU 2 lubrication oil system. APU 2 will be removed and replaced; however, WSB 2 requires a hot-oil flush.

TABLE II.- STS-35 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-35-20	RCS Vernier Thruster R5D Failed Off	339:19:03 G.m.t.	Redundancy Management (RM) deselected thruster R5D because of low chamber pressure. The data indicate the presence of helium in the crossfeed line. Similar to failure seen of STS-9 (STS-09-14).
STS-35-21	Right-Hand Aft Separation Hole Plugger did not fully extend	Found postflight PR PYR 2-11-0091	The hole plugger did not complete its stroke, One of the two boosters was jammed in between the plugger and the rim of the hole. The other booster was missing.
STS-35-22	Right-Hand Stop Bolt Bent on ET Forward Structural Attachment Assembly	Postflight Inspection PR PYR 2-11-0092	Similar in magnitude to the deformation seen after STS-38 scrub.
STS-35-23	Pilot Seat Down Limit Switch Failure	Prelaunch Deferred PR FRCS-A0031	Pilot seat failed to allow the seat motor to drive down. Down limt switch removed and replaced during the STS-35 OPF flow as a result of STS-32-27. Troubleshooting planned.

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