NSTS-08278

STS-46 SPACE SHUTTLE MISSION REPORT

October 1992

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

STS-46

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke
LESC/Flight Data Section

Approved by

Don L. McCormack
STS-46 Lead Mission Evaluation Room Manager

David W. Camp
Manager, Flight Data and
Evaluation Office

D. M. Germany
Manager, Orbiter and GFE Projects

Leonard S. Nicholson
Program Manager, Space Shuttle

Prepared by
Lockheed Engineering and Sciences Company
for
Flight Data and Evaluation Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

October 1992

STS-46 Table of Contents

Table of Contents (Concluded)

List of Tables

INTRODUCTION

The STS-46 Space Shuttle Program Mission Report contains a summary of the Orbiter, External Tank (ET), Solid Rocket Booster/Redesigned Solid Rocket Motor (SRB/RSRM), and the Space Shuttle main engine (SSME) subsystem performance during the forty-ninth flight of the Space Shuttle Program, and the twelfth flight of the Orbiter vehicle Atlantis (OV-104). In addition to the Atlantis vehicle, the flight vehicle consisted of an ET, designated ET-48 (LWT-41); three SSME's, which were serial numbers 2032, 2033, and 2027 in positions 1, 2, and 3, respectively; and two SRB's which were designated BI-052. The lightweight/redesigned SRM's that were installed in each SRB were designated 360W025A for the left RSRM and 360L025B for the right RSRM.

The STS-46 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirement, as documented in NSTS 07700, Volume VIII, Appendix E, which states that each major organizational element supporting the Program will report the results of its hardware evaluation and mission performance plus identify all related in-flight anomalies.

The primary objective of this flight was to successfully deploy the European Retrievable Carrier (EURECA) payload and perform the operations of the Tethered Satellite System-1 (TSS-1) and the Evaluation of Oxygen Interaction with Material III/Thermal Energy Management Processes 2A-3 (EOIM-III/TEMP 2A-3). The secondary objectives of this flight were to perform the operations of the IMAX Cargo Bay Camera (ICBC), Consortium for Material Development in Space Complex Autonomous Payload-II and III (CONCAP-II and CONCAP-III), Limited Duration Space Environment Candidate Materials Exposure (LDCE), Pituitary Growth Hormone Cell Function (PHCF), and Ultraviolet Plume Instrumentation (UVPI).

The sequence of events for the STS-46 mission is shown in Table I and the Official Orbiter and GFE Projects Problem Tracking List is shown in Table II. The STS-46 mission was planned as a 7 day plus 2 contingency day mission; however, because of the 24-hour delay in the release of the EURECA satellite, the mission was lengthened to a 8 day plus 2 contingency-day mission with landing at Kennedy Space Center (KSC) on August 8, 1992.

In addition to summarizing subsystem performance, this report also discusses each Orbiter, ET, SSME, SRB, and RSRM in-flight anomaly in the applicable section of the report. Also included in the discussion is a reference to the assigned tracking number as published on the Problem Tracking List. All times are given in Greenwich mean time (G.m.t.) as well as mission elapsed time (MET).

The crew for this forty-ninth Space Shuttle mission was Loren J. Shriver, Col., USAF, Commander; Andrew M. Allen, Major, USAF, Pilot; Claude Nicollier, Ph.D., Mission Specialist 1; Marsha S. Ivins, Mission Specialist 2; Jeffrey A. Hoffman, Ph.D, Mission Specialist 3 and Payload Commander; Franklin Chang-Diaz, Ph.D., Mission Specialist 4; and Franco Malerba, Ph.D., Payload Specialist 1. STS-46 was the third space flight for the Commander, Mission Specialist 3, and Mission Specialist 4. STS-46 was the second space flight for Mission Specialist 2, and the first space flight for the Pilot, Mission Specialist 1, and Payload Specialist 1.

MISSION SUMMARY

The STS-46 vehicle, which weighed 4,516,467 lb, was launched from KSC launch complex 39B at 213:13:56:48.011 G.m.t. (9:56:48 a.m. e.d.t.) on July 31, 1992, after a 48-second hold at T-5 minutes. The ground launch sequencer (GLS) verified the auxiliary power unit (APU) fuel-isolation-valve position at T-5 minutes 25 seconds and at that time the APU 3 fuel isolation valve was still closed. As a result, the GLS held the countdown. The valve was subsequently opened and the countdown was resumed after the short hold. The ascent, on an inclination of 28.45 degrees, was nominal in all respects.

Data analysis revealed a transient problem in the SSME 3 GH_2 flow control valve (FCV). Between 90 and 110 seconds after lift-off, the SSME 3 gaseous hydrogen (GH_2) FCV inlet pressure exhibited erratic pressure cycles up to 60 psi above the baseline pressure of 3100 psia. The valve was not being commanded to cycle at the time. Simultaneous with the pressure increases, the GH_2 disconnect pressure dropped 20 psi, verifying that the pressure cycling was not an erroneous measurement problem. Possible explanations are transient contamination or uncommanded flow control valve poppet motion.

All SSME and RSRM start sequences occurred as expected and launch phase performance was satisfactory in all respects. First stage ascent performance was normal with SRB separation, entry, deceleration, and water impact occurring as anticipated. Both SRB's were successfully recovered. Performance of the SSME's, ET, and main propulsion system (MPS) was also normal, with main engine cutoff (MECO) occurring at approximately 509.4 seconds after lift-off.

The post-ascent gaseous oxygen (GO_2) manifold pressure decay to 0 psi within one minute of main propulsion system (MPS) dump termination violated an Operations and Maintenance Requirements and Specification Document (OMRSD) File IX requirement. This requirement states that the pressure decay will be within 15 scim of the total system leakage measured during the previous ground test. The GO_2 manifold pressure is designed to lock up and then decay slowly throughout the mission, but in this case it tracked the liquid oxygen (LO_2) manifold pressure. With the successful MPS dump and vacuum inerting of the system, this problem did not impact the flight.

No orbital maneuvering subsystem (OMS) 1 maneuver was required. As a result of the 224-second OMS 2 maneuver, the Orbiter was inserted in a 230.5 by 229 nmi. circular orbit.

The remote manipulator system (RMS) checkout was performed at 213:19:45 G.m.t. (00:05:48 MET) with no anomalies noted. The RMS supported the EURECA checkout, overnight park, and deployment.

A number of intermittent data problems occurred with the EURECA payload and the first opportunity for EURECA deployment was passed because of these problems. The EURECA payload was deployed on the first opportunity after a 1-day delay [215:07:06 G.m.t. (01:17:09 MET)]. Communications problems between the EURECA and the Orbiter were determined to be caused by a payload incompatibility with the Orbiter communications. On several occasions while the payload was still on the RMS, the ground stations successfully communicated with the payload. After deployment, the Orbiter separated to 940 ft from the EURECA and remained at that distance one orbit longer than planned, awaiting completion of the payload checkout. Because of the 24-hour delay in the EURECA deployment, the Mission Management Team (MMT) decided to lengthen the mission one day so that all other experiment/payload objectives could be accomplished.

Following the EURECA burn to a higher-altitude orbit, the OMS 3 and OMS 4 maneuvers were performed to lower the Orbiter into a 160 nmi. circular orbit. The 70-second OMS 3 maneuver was initiated at 216:10:54:11 G.m.t. (02:20:57:23 MET) and resulted in a differential velocity (ΔV) of 119 ft/sec. The 70-second OMS 4 maneuver was initiated 45 minutes later at 216:11:39:20 G.m.t. (02:21:42:32 MET) and resulted in a ΔV of 121 ft/sec.

At 216:05:24:23 G.m.t. (02:15:27:35 MET), the waste collection system (WCS) fan separator 1 was turned on and demanded high currents on ac bus 1, a condition that is indicative of a stalled motor. The high demand caused the fan separator circuit breakers to open. The crew then selected fan separator 2, which operated nominally. In an attempt to regain fan separator 1 operation, the fan separator circuit breakers were reset and fan separator 1 was restarted at 216:06:49:06 G.m.t. (02:16:52:18 MET). The fan separator cleared temporarily, but within one minute, stall currents were again observed. The crew was instructed to perform an in-flight maintenance (IFM) procedure to clear fan separator 1 by venting the system overboard through the waste water dump nozzle. As the IFM was being performed, but prior to the dump valve being opened, fan separator 1 cleared and began to operate properly. After approximately 6.5 hours of satisfactory operation, fan separator 1 again appeared to be flooded. As a result, the IFM procedure to clear what was suspected to be a flooded fan separator 1 was performed but was unsuccessful. Fan separator 1 failed to operate following the second IFM procedure and fan separator 2 was selected for the remainder of the mission. A review of waste tank quantity, waste liquid pressure, and dp/dt data during the IFM procedures and other successful attempts to clear fan separator 1 indicate that the fan separator 1 problems may be the result of a mechanical problem and not flooding.

A revised fuel cell purge plan was developed and used during STS-46. The new plan called for purges of all fuel cells at 24 hours MET by ground command. All subsequent purges during the mission were to be performed on 48-hour intervals or whenever a degradation of 0.2 volt was reached by any fuel cell. A final fuel cell purge was to be performed 12 hours prior to the deorbit maneuver to maximize fuel cell performance for entry. Additionally, if any one fuel cell required purging because of performance loss, all three fuel cells were to be purged to maintain a common performance relationship between all fuel cells. As a result of this new procedure for STS-46, five fuel cell purges were performed. In each case, no voltage degradation was observed prior to or voltage gain following the purges.

In preparation for the TSS-1 operations, two orbit-lowering maneuvers were performed to place the Orbiter in a circular 160 nmi. orbit. The TSS-1 boom extension was completed nominally at 217:16:13 G.m.t. (04:02:16 MET). The attempt at 217:17:37 G.m.t. (04:03:40 MET) to separate the second umbilical (U2) was unsuccessful. However, successful separation of the U2 umbilical was attained at 217:20:01 G.m.t. (04:06:04 MET) concurrent with an Orbiter translational pulse that loosened the U2 connection.

The first attempt at satellite deployment occurred at 217:21:21 G.m.t. (04:07:24 MET), but was aborted by the crew when excessive side-to-side movement was observed. After a checkout of the reel and vernier motors, a second attempt was made to deploy the satellite at approximately (217:22:51 G.m.t.) (04:08:54 MET). The deployment was successful and the satellite tether unreeled smoothly to a length of 179 meters (587 feet) when the TSS-1 stopped at 217:23:47 G.m.t. (04:09:50 MET). Because of possible buried winding on the reel, the satellite was reeled in approximately 5 meters, then reeled out at a somewhat higher rate to 256 meters (827 feet) where the satellite stopped. Deployment activities were resumed about 1 1/2 hours later, but the satellite stalled again after 2 minutes at a tether length of 257 meters (830 feet). At this point, the satellite was powered down to survival levels to maintain battery lifetime during a crew rest period. At 218:13:01 G.m.t. (04:23:04 MET), the satellite was again reeled in to a tether length of 224 meters (733 feet) where the tether became jammed and this prevented motion in either direction. A plan was then developed to determine the location of the jam (believed to be in upper or lower tether control mechanism), and then clear the jam. In light of the multiple problems encountered in trying to deploy the tethered satellite, the decision was made to bring the satellite back and dock when the jam was cleared. The plan to accomplish the retrieval of the satellite was initiated at 218:19:51 G.m.t. (05:05:54 MET). The plan included retracting the boom a distance of one panel and the crew visually checking for tether slack inside the boom structure. The crew reported seeing no slack, which indicated that the jam was at the upper tether control mechanism. The boom was then re-extended with the reel brakes engaged. This action cleared the jam and allowed satellite retrieval to begin. The satellite was successfully docked at the top of the boom at 218:22:53 G.m.t. (05:08:56 MET). The boom was retracted and the satellite was secured at 220:00:03 G.m.t. (05:10:06 MET).

At 218:20:13 G.m.t (05:06:16 MET), the cabin pressure was reduced to 10.4 psia in anticipation of a possible TSS-related contingency extravehicular activity (EVA). However, the crew was successful in retrieving the satellite and the EVA was not required. The cabin was repressurized to 14.7 psia at 219:00:54 G.m.t. (05:10:57 MET).

The OMS 5 maneuver was performed at 219:09:39:06 G.m.t. (05:19:42:18 MET) and had a duration of 33 seconds and a ΔV of 59.7 ft/sec. The OMS 6 maneuver was performed at 219:10:23:14 G.m.t. (05:20:26:26 MET) and had a duration of 35 seconds and a ΔV of 64.3 ft/sec. These maneuvers resulted in a 123.8 by 123.4 nmi. circular orbit, which provided the optimum conditions for the Evaluation of Oxygen Interaction with Materials (EOIM) experiment as well as for landing on the first opportunity on flight day 8 at KSC.

The flight control system (FCS) checkout was performed at 220:10:13:00 G.m.t. (06:20:16:12 MET) using APU 2. The APU ran for 4 minutes 52 seconds and all systems were nominal.

During the FCS checkout, a temperature difference of approximately 4.5° C existed between the two temperatures on the left air data probe while in OPS 8. Postflight troubleshooting will be performed to determine whether the problem involves one of the analog/digital converters or one of the temperature transducer circuits.

The reaction control subsystem (RCS) hot-fire was performed at 220:11:00 G.m.t. (06:21:03 MET) and all thrusters operated satisfactorily.

Because of potentially unsatisfactory weather at KSC, the Orbiter was waved off for the first landing opportunity. Weather conditions improved and the decision was made to land at KSC on the second opportunity on flight day 8.

Both payload bay (PLB) doors were closed by 221:09:35:51 G.m.t. (07:19:39:03 MET). The deorbit maneuver was performed at 221:12:17:09 G.m.t. (07:22:20:21 MET). The maneuver was approximately 123 seconds in duration and the ΔV was 224 ft/sec. Entry interface occurred at 221:12:39:53 G.m.t. (07:22:43:05 MET).

Main landing gear touchdown occurred at KSC on concrete runway 33 at 221:13:11:50.3 G.m.t. (07:23:15:03 MET). Nose landing gear touchdown occurred 15 seconds later with wheels stop at 221:13:12:54 G.m.t. (07:23:16:06 MET) (August 8, 1992). The rollout was normal in all respects. The flight duration was 7 days 23 hours 15 minutes 02 seconds. The Orbiter weight at landing was 209,882 lb. The crew completed the required postflight reconfigurations and exited the Orbiter landing area approximately 1.5 hours after landing.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTER/REDESIGNED SOLID ROCKET MOTORS

All SRB systems performed as expected throughout ascent. 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 buildup, 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 performed properly. The SRB prelaunch countdown was normal, and no SRB or RSRM in-flight anomalies have been identified.

No SRB or RSRM Launch Commit Criteria (LCC) violations occurred; however, one Operations and Maintenance Requirements and Specifications Document (OMRSD) violation occurred. During the Orbiter fuel cell activation, the voltage at SRB bus A went to 32.68 Vdc for approximately 30 msec. The OMRSD File II requirement specifies that the voltage be a maximum of 32 Vdc. A waiver was processed to accept the condition based on circuit analysis which verified that 36.7 Vdc would not compromise the integrity of the integrated electronics assembly (IEA), excluding the multiplexer/demultiplexer (MDM). The MDM circuits were verified to be acceptable for flight by the successful completion of the MDM countdown verification test. An OMRSD change is being made to allow a maximum voltage spike of 36.7 Vdc for 200 msec.

Power up and operation of all case, igniter, and field joint heaters were accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the heated ground purge in the SRB aft skirt was not required to maintain the case/nozzle joint and flexible bearing temperatures within the required LCC ranges; however, it was activated at T-15 minutes to inert the aft skirt area of hydrazine.

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 (BSM's) expended and all separation bolts severed properly. Nose cap jettison, frustum separation and nozzle jettison occurred normally on each SRB.

The flight performance of both RSRM's was well within the allowable envelopes and was typical of the performance observed on previous flights. The following table provides the key RSRM parameters from the STS-46 mission.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 81°F		Right motor, 81°F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.97	65.74	66.03	65.61
I-60, 10^6 lbf-sec	175.67	175.77	175.83	174.69
I-AT, 10^6 lbf-sec	296.60	297.28	296.86	295.76
Vacuum Isp, lbf-sec/lbm[a]	268.6	269.2	268.6	267.6
Burn rate, in/sec @ 60 °F at 625 psia	0.3674	0.3661	0.3673	0.3662
Event times, seconds[a]				
Ignition interval	0.232	N/A	0.232	N/A
Web time[a]	109.1	109.4	109.1	109.4
Separation cue, 50 psia	118.8	119.4	118.8	120.0
Action time[a]	120.9	121.9	120.9	122.1
PMBT, °F	81.0	81.0	81.0	81.0
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	3.3	2.8	2.9

Tailoff imbalance	Predicted	Actual
Impulse differential, klbf-sec	N/A	467.0[b]

Notes:

[a] All times are referenced to ignition command time except where noted by the letter a. These items are referenced to lift-off time (Ignition interval).

[b] Impulse imbalance is equal to left motor minus right motor, and was calculated by MSFC.

Both SRB's were successfully separated from the ET at lift-off plus 125.0 seconds. The entry and deceleration sequences were properly performed on both SRB's. RSRM nozzle jettison occurred after frustum separation, and the subsequent parachute deployments were successfully performed. Both SRB's were observed during descent, retrieved after impact, and brought by retrieval ship to Cape Canaveral. The SRB's were brought to KSC where disassembly and refurbishment activities were initiated.

EXTERNAL TANK

All objectives and requirements associated with ET propellant loading and flight operations were met. All electrical equipment and instrumentation performed satisfactorily; however, the liquid hydrogen (LH_2) transducer 3 experienced several stiction-type dropouts during the period of the T-9 minute hold. Readings returned to normal, and the transducer performed as expected during LH_2 pressurization and flight. Also, an interim problem report (IPR) was written against the secondary pressure transducer on the intertank purge pressure upstream of the heater. All ET purge and heater operations were monitored and all performed properly. No LCC or OMRSD violations were identified.

As expected, only the normal ice/frost formations for the July atmospheric 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 LO_2 and LH_2 feedlines and on the pressurization brackets. A small amount of frost was also present along the edge of the LH_2 protuberance air load (PAL) ramps. All of these observations were acceptable and in accordance with NSTS-08303. The Ice/Frost Red Team reported that there were no anomalous thermal protection system (TPS) conditions except for a crack in the foam near the base of the vertical strut similar to those conditions observed on two previous flights.

ET flight performance was excellent. The ET pressurization system functioned properly throughout engine start and flight. The minimum LO_2 ullage pressure experienced during the period of ullage pressure slump was 13.7 psid.

ET separation was confirmed to have occurred properly, and based on main engine cutoff (MECO) time, ET entry and breakup occurred within the predicted footprint. Review and analysis of the ET data revealed no anomalous conditions.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters appeared to be normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time, all LCC were met, and engine start and thrust buildup were normal.

Also, at T-10 seconds, the SSME 1 burn igniter A burn time was 1.3 seconds instead of the nominal 8 to 12 seconds. This shortened burn time could result in potential engine nozzle damage and could impact engine shelf life. As a result, this condition will be evaluated to determine the cause of the shortened burn time.

Preliminary flight data indicate that SSME performance during mainstage, throttling, shutdown, and propellant dump operations was normal. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within specification throughout engine operation. No in-flight anomalies or significant SSME problems have been identified. A quick-look determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. These data showed that the average flight-derived engine specific impulse (Isp) determined for the time period between SRB separation and the start of 3g throttling was 452.3 seconds as compared to the average tag value of 452.47 seconds.

The SSME controllers provided the proper control of the engines throughout powered flight. Engine dynamic data overall compares well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle range safety system (SRSS) closed-loop prelaunch testing was completed as scheduled during the launch countdown. All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at the appropriate times. All SRSS measurements including the signal strength indicated that the system performance was as expected throughout the flight with system signal strength well within system requirements 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 SUBSYSTEM PERFORMANCE

Main Propulsion System

The overall performance of the MPS was excellent. Liquid oxygen and liquid hydrogen loading was performed with no stop-flows or reverts. Cryogenic droplets and larger-than-normal ice buildup around the LH_2 umbilical were noted during the countdown. An unusually high humidity level existed during the countdown, and the conditions were not a constraint to launch. There were no LCC or OMRSD violations.

Throughout the preflight operations, no significant hazardous gas concentrations were detected, and the maximum hydrogen level in the Orbiter aft compartment was 150 ppm, which compares very well with previous data for this vehicle. The MPS helium system performed satisfactorily. The aft compartment helium concentration peaked at 9500 ppm, and the aft compartment oxygen concentration peaked at 177 ppm.

A comparison of the calculated propellant loads at the end of replenish versus the inventory load results in a loading accuracy of +0.021 percent for liquid hydrogen and -0.008 percent for liquid oxygen.

Ascent MPS performance was acceptable. The gaseous oxygen (GO_2) pressurization system performed nominally throughout the entire flight. The GO_2 flow control valves (FCV's) were shimmed to a 77.2-percent flow area for OV-104. The minimum liquid oxygen ullage pressure experienced during the period of ullage pressure slump was 13.7 psid.

Data indicate that the LO_2 and LH_2 pressurization systems performed as planned, and that all net positive suction pressure (NPSP) requirements were met throughout the flight; however, two pressure anomalies were noted. Space Shuttle main engine cutoff (MECO) occurred 509.36 seconds after lift-off.

Data analysis revealed a transient problem in the SSME 3 GH_2 flow control valve (Flight Problem STS-46-V-01). Between 90 and 110 seconds after lift-off, the SSME 3 GH_2 FCV inlet pressure exhibited erratic pressure fluctuations up to 60 psi above the baseline pressure of 3100 psia. The valve was not being commanded to cycle at the time. Simultaneous with the pressure increases, the GH_2 disconnect pressure dropped 20 psi below the normal operating range of 300 psi, verifying that the pressure cycling was not an erroneous measurement problem. This erratic FCV 3 pressure did not affect the LH_2 tank pressure (tank structural and SSME NPSP requirements were met within margin).

Postflight, no leaks were detected on the runway and an x-ray of FCV 3 was not definitive. The valve poppet/sleeve assembly was removed and visually inspected with no anomalous wear or contamination noted. Boroscope inspections of the inlet and outlet flow control valve lines revealed no anomalous conditions or contamination. FCV 3 was rinse sampled and the preliminary results showed no evidence of orifice blockage by major contamination. There were many small (10 to 15 micron metallic particles with the largest being 400 microns. The poppet flange and sleeve conical seat were evaluated for witness marks with some small marks found in the direction of the flow; however, the pattern will be compared with a new poppet before any conclusions will be drawn.

Continued inspection of the FCV 3 piece parts revealed that the poppet springs were intact and there was no structural damage of any piece parts. Significant wear was noted on the poppet seal and sleeve; however, no scenario has been identified that would relate this wear to a pressure anomaly. Investigation into the cause of this anomaly is continuing as this report is written.

The post-ascent GO_2 manifold pressure decay to 0 psi within one minute of MPS dump termination violated an OMRSD File IX requirement. The manifold pressure likewise did not respond to the repressurization during entry. The File IX requirement states that the pressure decay will be within 15 scim of the total system leakage measured during the previous ground test. The GO_2 manifold pressure is designed to lock up and then decay slowly throughout the mission, but in this case it tracked the liquid oxygen manifold pressure (Flight Problem STS-46-V-05). With the successful MPS dump and vacuum inerting of the system, this problem did not impact the flight. Postflight leak checks revealed the reverse seat leakage on the SSME 3 isolation check valve was 176 scim, and the maximum allowable is 100 scim.

Ullage pressures were maintained within the required limits throughout the flight. Feed system performance was nominal. Liquid oxygen and liquid hydrogen propellant conditions were within specified limits during all phases of operation. Propellant dump and vacuum inerting were accomplished satisfactorily.

Reaction Control Subsystem

The RCS performed nominally throughout the mission. In addition to the normal attitude control activities, the RCS aft thrusters were used to perform programmed test inputs (PTI's) in support of development test objective (DTO) 251 during entry. The RCS was interconnected to the OMS for three different periods of time. During the period of interconnection to the left OMS (41.1 hours), 4.91 percent of the OMS propellant was used. During the first period of interconnection to the right OMS (33.4 hours), 3.78 percent of the OMS propellant was used. During a second period of interconnection to the right OMS (5.3 hours) 0.46 percent of OMS fuel was used. In addition to the OMS propellants used during interconnect operations, a total of 5328.4 lb of propellants was consumed by the RCS during the mission.

The RCS was used for a separation burn following the EURECA deployment, and the RCS was also used extensively during the Tethered Satellite System operations.

During the postlanding redundant circuit verification switch test, the left manifold 5 isolation valve indication remained open when the switch was cycled to command the valve closed (Flight Problem STS-46-V-11). The circuit breaker was verified to be closed. The crew cycled the valve three times and no change in the indication was noted. During OMS/RCS safing after KSC personnel received control of the Orbiter, the valve was cycled and all operations were nominal.

Orbital Maneuvering Subsystem

The OMS subsystem operated nominally in the performance of six maneuvers. All six maneuvers were dual engine firings and the cumulative firing time on the OMS was 557.1 seconds. Gaging system performance was nominal on the left and right oxidizer systems and the right fuel system. The left OMS fuel total quantity was biased high and this condition has been observed on previous flights of this pod. Also, the right total quantity anomaly that has been observed on previous flights was noted on this flight. Propellant usage during RCS interconnect operations was 4.91 percent (635.8 lbm) while using the left OMS, and 4.24 percent (549.1 lbm) while using the right OMS. Total OMS propellant usage during the mission was 14,231 lb of oxidizer and 8518 lb of fuel.

A right OMS GN_2 pressure isolation valve open indication was received at 217:03:52 G.m.t. (03:13:55 MET) and remained on (Flight Problem STS-46-V-09). Data review indicates that no valve-open commands were given. The crew verified that the crew compartment switch had not been moved and was in the off position. In addition, if one of the coils was actually energized (to open the valve), the heat from the coil would be expected to increase the GN_2 tank pressure. The GN_2 pressure data showed no increase since the time the open indication was received. About 9 hours later, the isolation valve switch was cycled and the indication returned to normal, showing closed for the closed valve.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed nominally throughout the mission. The vehicle was flown with the four-tank-set configuration. A total of 258.7 lb of hydrogen and 2054 lb of oxygen was supplied. In addition, 118 lb of oxygen was supplied for crew breathing. The mission electrical capability remaining at landing would have supported an additional 67.3 hours of flight at the 15.6-kW level.

Fuel Cell Powerplant Subsystem

The performance of the fuel cell powerplant subsystem was excellent throughout the mission. During the 191.3-hour mission, the fuel cells produced 2987 kWh of electrical energy at an average power level of 15.6 kW. In addition, the fuel cells produced 2312.8 lb of water while using 258.7 lb of hydrogen and 2054 lb of oxygen. The average total Orbiter electrical power load was 510 amperes.

A revised fuel cell purge plan was developed for STS-46 and subsequent flights based on the successful results obtained during the STS-50 mission when one of the fuel cells was not purged for over 240 hours and resulted in minimal voltage degradation. The new plan called for purges of all fuel cells at 24 hours MET by ground command. All subsequent purges were to be performed on 48-hour intervals or whenever a degradation of 0.2 volt was reached by any fuel cell. The final fuel cell purge was to be performed 12 hours prior to the deorbit maneuver to maximize fuel cell performance for entry. Additionally, if any one fuel cell required purging because of performance loss, all three fuel cells were to be purged to maintain a common performance relationship between all fuel cells. This procedure was followed for STS-46 and resulted in a total of five fuel cell purges with no anomalies noted. In each case, there was no observed voltage degradation prior to or voltage gain following the purges.

Auxiliary Power Unit Subsystem

The APU subsystem performance during the flight was satisfactory, with three problems noted. The three problems are discussed in the following paragraphs.

During ascent and FCS checkout, the APU 2 gearbox GN_2 pressure and lubrication oil outlet pressure showed erratic traces, and during entry, two repressurizations of the APU 2 gearbox occurred. Three minutes after APU start, when the GN_2 pressure dropped to 5.5 psia, the first repressurization occurred and was followed by increased GN_2 pressure and lubrication oil pressure. However, over the next 30 minutes, the pressures slowly decreased and the second repressurization occurred. During entry operations, no effects were observed on the lubrication oil or bearing temperatures; however, the lubrication oil outlet pressure violated the lower fault detection annunciation (FDA) limit of 25 psia just prior to the second APU 2 repressurization at 221:13:03 G.m.t. (07:23:06 MET). The repressurizations were expected as they also occurred on this APU during the previous flight of this vehicle. Data analysis will be performed to determine the cause of this condition; however, leakage of GN_2 and lubrication oil past the turbine shaft seal is suspected. An in-flight anomaly was assigned to this APU on the previous flight for this same condition.

The APU 1 seal cavity drain pressure decayed from 16 psi to 10 psi over a 30-minute period after APU start during entry. It is suspected that the seal cavity relieved into the APU gearbox. Postflight analysis will be performed to determine the cause of the leak; however, leakage into the gearbox because of a faulty gearbox seal is the suspected cause of the failure. This same condition was noted on the previous flight of this APU and consequently, the reappearance of the condition was not unexpected. This APU (serial no. 312) will be replaced with an improved APU during the Orbiter maintenance down period (OMDP).

Fuel consumption and run time on each APU is provided in the following table.

Flight Phase	APU 1 (S/N 312)		IAPU 2 (S/N 407)		APU 3 (S/N 307)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	20:18	49	20:18	47	20:18	53
FCS checkout			04:52	12		
Entry[a]	73:45	137	56:14	111	56:14	126
Total[a]	94:03	186	81:24	170	76:32	179

[a]The APU's were operated for approximately 15 minutes after landing.

Hydraulics/Water Spray Boiler Subsystem

The performance of the hydraulics/water spray boiler (WSB) subsystem was nominal throughout the flight. The WSB 2 ready indication was lost twice, as expected, prior to APU start because the vent temperature dropped below 130 °F. This condition has been seen on many previous flights, and is now acceptable for APU start.

The WSB 2 GN_2 relief valve failed the in-flight checkout requirement of 30.0 to 33.5 psig by cracking at an indicated pressure of 36.2 psig. This same data signature was noted on STS-44 and STS-45, and the condition is believed to result from an intermittent pressure transducer as indicated by a delayed response followed by an instantaneous pressure drop of 5 psi during the time frame of cracking. Replacement of this transducer is scheduled to occur during the OMDP.

APU 2 was operated for the FCS checkout, and the hydraulics/water spray boiler subsystem performed satisfactorily. APU run time for the checkout was 4 minutes 52 seconds with no hydraulic or lubrication oil cooling required.

Electrical Power Distribution and Control Subsystem

The performance of the electrical power distribution and control (EPD&C) subsystem was nominal throughout the mission. All data analyzed showed nominal voltage and current signatures, and no specified limits were violated. All File IX requirements were satisfied. No discrepancies were noted during the flight.

Environmental Control and Life Support Subsystem

The performance of the atmospheric revitalization system (ARS) was nominal in all respects. The CO_2 partial pressure was maintained below 6.05 mm Hg. Cabin air temperature and relative humidity peaked at 85.5°F and 67.5 percent, respectively. Avionics bays 1, 2, and 3 air outlet temperatures peaked at 105.5°F, 109°F, and 85.2°F, respectively, and the water coldplate temperatures for these three avionics bays peaked at 92.0°F, 92.0°F, and 85.2°F, respectively. All in-flight requirements were met during the successful redundant components check.

The atmospheric revitalization pressure control system performed normally throughout the mission. During the redundant component check, the alternate system was selected and operated properly. The cabin was depressurized to 10.2 psia at 218:20:13 G.m.t. (05:06:16 MET) to support an unscheduled payload contingency EVA that was not performed. The cabin was repressurized to 14.7 psia at 219:00:54 G.m.t. (05:10:57 MET).

The active thermal control system (ATCS) performance was nominal throughout the STS-46 flight. The ATCS flawlessly provided the required cooling to the TSS payload during powered payload operations. The flash evaporator system (FES) was used to perform several water dumps and performed nominally. The radiator coldsoak provided cooling during entry through touchdown plus 12 minutes, after which ammonia systems B and A provided cooling until ground support equipment (GSE) hookup at landing plus 56 minutes.

The supply water and waste management systems performed nominally throughout the mission. At the completion of the mission, all of the associated supply water in-flight requirements had been performed and satisfied.

Supply water was managed through the use of the FES and the overboard dump system. The supply water dump line temperature was maintained between 66 and 89°F throughout the mission with the operation of the line heaters.

Waste water was gathered at about the predicted rate. Three waste water dumps were performed at an average rate of 1.93 percent/minute (3.18 lb/min). The waste water dump line temperature was maintained between 57 and 74°F throughout the mission, while the vacuum vent line temperature was between 58 and 76°F.

Two dumps were performed with the water and waste tanks depressurized to cabin pressure (14.7 psia) in support of DTO 0325 - Waste/Supply Water Dumps. Supply water was dumped at a rate of 0.94 percent/minute (1.55 lb/min), while waste water was dumped at 1.49 percent/minute (2.4 lb/min). Views of the nozzles using an RMS TV camera depicted a normal supply water dump, while evidence of "popcorn" flakes were seen during the waste water dump; however, no icing of the nozzles was observed. This flake condition is the result of gas in the waste water and was expected for the reduced-pressure dump.

The WCS performed adequately throughout the mission. A cabin air leak through the WCS resulted in high pressure control system oxygen flow alarms. Uplinked diagnostic procedures performed by the crew indicated that debris beneath the slide valve assembly was interfering with the proper sealing of the slide valve. The crew operated the commode control handle forward and back approximately 15 times to remove any debris on the slide valve. This procedure cleared the cabin air leak and subsequent operations of this valve were satisfactory.

At 216:05:24:23 G.m.t. (02:15:27:35 MET), the WCS fan separator 1 was turned on and demanded high currents on ac bus 1, a condition that is indicative of a stalled motor. The high demand caused the fan separator circuit breakers to open. Preliminary assessment of the problem indicated that the fan separator was flooded; similar problems were experienced on STS-26 and STS-49. In an attempt to regain fan separator 1 operation, the fan separator circuit breakers were reset and fan separator 1 was restarted at 216:06:49:06 G.m.t. (02:16:52:18 MET). The fan separator cleared temporarily, but within one minute, stall currents were again observed. The crew was instructed to perform an IFM procedure to clear fan separator 1 by venting the system overboard through the waste water dump nozzle. As the IFM was being performed but prior to the dump valve being opened, fan separator 1 cleared and began to operate properly. After approximately 6.5 hours of satisfactory operation, fan separator 1 again appeared to be flooded. As a result, the IFM procedure that was previously used to clear flooded fan separator 1 was performed but was unsuccessful (Flight Problem STS-46-V-06). Fan separator 1 failed to operate following the second IFM procedure and fan separator 2 was selected for the remainder of the mission. A review of waste tank quantity, waste liquid pressure, and dp/dt data during the IFM procedures and other successful attempts to clear fan separator 1 indicate that the fan separator 1 problems were the result of a mechanical problem and not flooding.

Fan separator 2 motor stall currents indicated that fan separator 2 flooded during use at 218:02:29 G.m.t. (04:12:32 MET). After two unsuccessful attempts to clear fan separator 2, the crew was instructed to operate the fan separator motor at the stall condition continuously in an attempt to clear the flooding. After nine minutes at the stall condition, the fan separator cleared and was operated continuously for an additional 2 hours and 45 minutes before being powered off. The waste water liquid line pressure response when fan separator 2 cleared verified that the problem was due to flooding. The crew returned to nominal fan separator 2 operations following the clearing of the flooded condition, and fan separator 2 operated satisfactorily for the remainder of the mission. This type of flooding during use is not unexpected for the low-torque fan separator 2 motor.

Smoke Detection and Fire Suppression Subsystems

The smoke detection subsystem performance was nominal except for the avionics bay 2A smoke detector. Between flight day 1 and 2, the A smoke detector concentration output in avionics bay 2 experienced several drops from a nominal reading of approximately 0 $\mu g/m^3$ to approximately -750 $\mu g/m^3$ (Flight Problem STS-46-V-04). Subsequently, the concentration returned to its nominal reading and remained there for the remainder of the flight. This detector is still considered capable of providing adequate warning in the event of a smoke incident. Use of the fire suppression system was not required.

Airlock Support System

The airlock support system performance was nominal. At 218:20:13 G.m.t (05:06:16 MET), the airlock depressurization valve was used to reduce the cabin pressure to 10.2 psia in anticipation of a possible TSS-related contingency EVA. However, the crew was successful in retrieving the satellite and the EVA was not required. The cabin was repressurized to 14.7 psia at 219:00:54 G.m.t. (05:10:57 MET). Use of the rest of the airlock support components was not required.

Avionics and Software Subsystems

The performance of the integrated guidance, navigation and control subsystem was nominal. Likewise, the star tracker and data processing system (DPS)/flight software performance was nominal. No displays and controls subsystem problems were noted.

The inertial measurement units (IMU's) performed satisfactorily. A bias of 140 μg's was observed on high accuracy inertial navigation system (HAINS) unit 203 during the flight. Normal compensations were uplinked to correct the bias. No other significant biases were observed during the mission.

The operational instrumentation and modular auxiliary data system performance was nominal with two in-flight anomalies noted. The body skin temperature measurement (V09T1026A) operated intermittently for short periods at approximately 213:21:00 G.m.t. (00:07:03 MET) (Flight Problem STS-46-V-02a), and operated satisfactorily for the remainder of the mission. At main landing gear touchdown, the right main gear brake line temperature dropped off-scale low (Flight Problem STS-46-V-2b). Although this sensor is not currently used, it can be used as one of several temperature control sensors for activation of the system 1 hydraulic circulation pump.

The FCS checkout was performed at 220:10:13:00 G.m.t. (06:20:16:12 MET) using APU 2. The APU ran for 4 minutes 52 seconds and all systems were nominal. The FCS was used in support of DTO 251 - Entry Aerodynamic Control Surfaces Test (Alternate Elevon Schedule). However, the automatic elevon schedule was flown instead of the alternate (fixed) elevon schedule. This decision had been made during preflight planning to use the automatic elevon schedule, and the decision resulted from the problems noted during the STS-50 alternate elevon test.

During FCS checkout, a temperature difference of approximately 4.5° C was noted between the two temperatures on the left air data probe while operating in the OPS 8 mode (Flight Problem STS-46-V-12). Temperature data from the two transducers in the left probe are processed by air data transducer assembly (ADTA) 1 and ADTA 3. During STS-46, these data were good during prelaunch operations (OPS 9) as well as during the ADTA self-test performed during FCS checkout (OPS 8). The concern is that the temperatures for a given probe are expected to closely track each other, and therefore, this signature could indicate a transducer or an ADTA electronics problem. Postflight troubleshooting of this condition will be performed during turnaround activities to determine whether the problem involves one of the analog/digital converters or one of the temperature transducer circuits.

Communications and Tracking Subsystem

The communications and tracking subsystem performed in an acceptable manner with a total of four anomalies occurring during the mission.

The flight crew reported at approximately 214:12:30 G.m.t. (00:22:33 MET) that the flight deck speaker was not operating after having operated nominally for several hours (Flight Problem STS-46-V-03). This speaker is one of the redesigned units that was flown for the first time on this vehicle. The circuit breaker was cycled at least five times in an attempt to regain use of the speaker, but the attempts were unsuccessful.

At 216:13:20 G.m.t. (02:23:23 MET), the crew reported that they could not transmit when using channel 1 of wireless crew communications system (WCCS) audio interface unit C (AIU-C) (Flight Problem STS-46-V-07). However, the crew did receive transmissions when using channel 1 of AIU-C. Several crew remote units (CRU's) were tried with channel 1, but no communications were achieved. Other WCCS AIU channels continued to operate correctly.

On a number of occasions during the mission, the crew received the low-voltage warning tone from the CRU's after a couple of hours of use on a fresh battery as well as immediately after a fresh battery was installed (Flight Problem STS-46-V-08). In some cases, the crew were able to continue using a battery for up to 36 hours after first receiving the "low-battery" tone, although the tone did continue throughout the period of time that that battery was used.

As a result of testing, it was confirmed that the video signals from payload bay cameras A, B, C, D, and the RMS elbow camera caused over-modulation of Ku-Band channel 3 (Flight Problem STS-46-V-10). This over-modulation condition resulted in the loss of channel 2 (operations recorder dumps) and channel 1 (real-time data) on some occasions. A test matrix was generated for evaluation of this condition, which included a spectrum analysis. The testing produced nominal results as the problem had cleared prior to the testing and did not repeat for the remainder of the mission.

At 219:17:52 G.m.t. (06:03:55 MET), real-time television of the payload bay was being downlinked via CCTV camera D. The video had a black spot in the center of the picture that appeared to be a burn spot. The camera remained usable for the rest of the mission as this spot only slightly degraded the video from the camera.

The S-band data were lost for a few minutes on many orbits with losses mostly occurring during lower-right antenna operations. The losses have been attributed to RF interference.

Structures and Mechanical Subsystems

All mechanically actuated subsystems performed nominally including the vent doors, ET/Orbiter umbilical doors, payload bay doors, star tracker doors, Ku-Band antenna deployment actuator, and air data probe system. The landing and braking data are shown in the table on the following page.

LANDING AND BRAKING PARAMETERS

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	1865	197.3	~2.0	n/a
Nose gear touchdown	6521	148.1	n/a	3.68

Braking initiation speed	132.2 knots (keas)
Brake-on time	42.2 seconds
Rollout distance	10,860 feet
Rollout time	65.6 seconds
Runway	33 (concrete) at KSC
Orbiter weight at landing	209,882.2 lb

Brake sensor location	Pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	876	Left-hand outboard	24.95
Left-hand inboard 3	840	Left-hand inboard	27.37
Left-hand outboard 2	840	Right-hand inboard	31.17
Left-hand outboard 4	804	Right-hand outboard	26.96
Right-hand inboard 1	1068		
Right-hand inboard 3	1020		
Right-hand outboard 2	972		
Right-hand outboard 4	948		

Tire location	Pressure, psia	Tire temperature, °F	Temperature decal, °F
Left-hand outboard	343.5	63.3	260
Left-hand inboard	344.8	63.3	200
Right-hand inboard	353.2	68.3	200
Right-hand outboard	353.7	68.3	200
Left-hand nose gear	343.0	68.3	N/A
Right-hand nose gear	341.6	68.3	N/A

All brakes were in satisfactory condition with clearance between the brake pucks and the pressure plate. All the bungees fired; all the uplock hooks released; and the nose landing gear axle nuts were in proper alignment. Some hydraulic fluid was visible on the right-hand main landing gear strut and the nose landing gear strut; however, this condition has been noted on previous missions and is not indicative of a problem.

The tires looked to be in excellent condition. There was little scuffing on the four tires with the right tires showing the least scuffing. The scuffing was located on the first rib (from the left) on three of the main tires. The right-hand inboard tire had scuffing on the fourth rib. The spin-up patch on the right-hand inboard tire looked different from that seen previously. The nose gear tires looked good, with the right-hand nose tire having a very discernible spin-up patch.

Aerodynamics, Heating and Thermal Interfaces

Both the ascent and entry aerodynamics were nominal. During entry, the automatic elevon schedule was performed. During the automatic schedule, six PTI's and one manual body flap maneuver were performed.

The ascent and entry heating were nominal and within established limits. The preliminary postflight inspections showed no heating damage. The thermal interfaces remained within limits throughout the countdown and mission with no LCC violations noted.

A portable Shuttle thermal imager was used to measure the surface temperatures of three areas on the Orbiter TPS after landing. These measurements were made in accordance with OMRSD requirements. Twenty-two minutes after landing, the Orbiter nose cap reinforced carbon carbon (RCC) was 194°F; the right RCC panel 17 temperature was 129°F; and the right RCC panel 9 temperature was 139°F.

Thermal Control Subsystem

The thermal control system performed satisfactorily in the maintenance and control of the thermal environment. One anomaly was noted immediately after ascent when the body flap lower skin temperature measurement (V09T1026A) operated erratically (Flight Problem STS-46-V-02a). Later in the mission when data again became available from this sensor, the sensor was operating properly.

Aerothermodynamics

The acreage heating was nominal throughout entry with no excessive temperatures noted.

Thermal Protection Subsystem

The TPS performance was nominal, based on structural temperature response and some tile surface temperature measurements. The overall boundary layer transition from laminar to turbulent flow was symmetric, occurring 1250 seconds after entry interface.

The Orbiter TPS sustained a total of 236 hits, of which 22 had a major dimension of one inch or greater. The total number of Orbiter TPS debris hits was higher than average; however, the number of hits having a major dimension greater than one inch was less than average. This total does not include the numerous hits on the base heat shield that have been attributed to SSME vibration/acoustics and exhaust plume recirculation. A comparison of these numbers to statistics from 33 previous missions of similar configuration indicates that the total number of hits is greater than average, and the number of hits one inch or larger in diameter is average.

The Orbiter lower surface sustained a total of 186 hits, of which 11 had a major dimension of one inch or greater. Seventy-one hits, two of which had a major dimension of one inch or greater, were clustered aft and inboard of the LH2 ET/Orbiter (left-hand) umbilical. Similar clusters have been observed on previous flights and are probably caused by ice and debris that is shed from the umbilical during ascent. A tile outboard of the right-hand nose landing gear door exhibited a pin hole with inclusion. Further assessment of the hole/inclusion will be performed and a sample taken, if required.

Postflight inspections of reinforced carbon carbon (RCC) parts identified some small pits in the outer surface of some panels and tee-seals from about panel 6 to 18 on the lower surface of both wings. Similar pits were noted on STS-50. These damage sites can be generally characterized as very small pits or pinholes from which a glassy substance has bubbled on to the surface. The pits are estimated to be in the range of 1 to 10 mils in diameter with an unknown depth, but contained within the silicon carbide coating layer of the leading edge structural system. Although it cannot be verified at this time, the cause of the pitting condition appears to be a combination of material characteristics and flight conditions (temperature and pressure). In addition to the pits, a reduction in the Type A surface sealant on the lower surface was noticeable. These conditions are not considered to be a safety-of-flight issue, but the conditions will continue to be evaluated after the next flight of OV-104 and OV-102.

The nose landing gear door thermal barrier had two torn patches. Numerous tears, frays, and protrusions occurred on the sleeving of the main landing gear door thermal barriers. These barriers are to be replaced with the redesigned, mechanically attached thermal barriers. The redesigned, mechanically attached ET door thermal barriers performed well and showed no signs of degradation or subsurface flow. Degraded outer mold line repairs existed on tiles at both elevon-elevon gap locations.

No TPS damage was attributed to material from the wheels, tires, or brakes.

All ET/Orbiter separation ordnance devices appeared to have functioned properly. No flight hardware was found on the runway below the umbilicals when the ET doors were opened.

Damage to the base heatshield tiles was typical. The SSME 1 dome-mounted heat shield closeout blanket was torn at the 6 o'clock position. The blanket on SSME 2 was frayed from the 2 o'clock to 3 o'clock position. There was no apparent damage to the SSME 1 nozzle insulation from the hydrogen igniter anomaly during SSME ignition.

Orbiter windows 3 and 4 exhibited moderate hazing with a few streaks. Hazing on the other windows was less than usual. Window 5 sustained an impact and will be removed and replaced. Laboratory analysis will be performed on samples taken from windows 1 through 8 and window 11. Six damage sites were noted on the perimeter tiles around window 3. The impact sites were only surface coating losses or were no more than 1/4 inch deep. This damage may have been caused by the room temperature vulcanizing (RTV) used to bond the paper covers to the forward RCS nozzles or by exhaust products from the SRB booster separation motors.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

All government furnished equipment/flight crew equipment operated nominally throughout the mission.

REMOTE MANIPULATOR SYSTEM

The RMS accomplished its mission objectives with full system performance and with no RMS anomalies during the total uncradled operational time of 2 days 6 hours 43 minutes.

Prior to the EURECA deployment operations, the RMS was uncradled for 1 1/4 hours for RMS checkout. All checkout signatures were nominal.

EURECA was scheduled for deployment with the RMS within 18 hours of launch. Because of the payload/Orbiter communications problems, EURECA release was delayed 24 hours from the planned release time. The RMS grappled the payload approximately 11 1/2 hours into the mission with unberthing occurring about 1 hour later. At the lower hover position above the payload bay, the Orbiter payload data interleaver first lost communications with the EURECA satellite. Deployment maneuvers continued to the release position where EURECA solar arrays and the antenna were deployed. Payload-communications troubleshooting continued until a decision was made to park the RMS and satellite for a crew sleep period.

About 36 hours into the mission,the RMS/EURECA was returned to the release position and the satellite was released at 215:07:07 G.m.t. (01:17:10 MET). As planned preflight, the RMS was left in a poise-for-capture position for 6 hours in preparation for a contingency EURECA retrieval. Rather than cradling the RMS, the wrist camera was moved to a position to view a scientific experiment near the TSS-1 support base until the wrist camera was needed to view the water dump nozzle during a scheduled performance of DTO 325. The RMS was cradled at 216:07:41 G.m.t. (02:17:44 MET) after the final use of the wrist camera for close-in viewing of the TSS in its support structure.

CARGO INTEGRATION

All integration hardware performed nominally, and no cargo integration out-of-limit conditions were noted during the flight.

PAYLOADS

EUROPEAN RETRIEVABLE CARRIER

The EURECA encountered extensive communications problems with the Orbiter (Atlantis), and consequently, the release of the satellite was delayed approximately 24 hours. The EURECA was successfully released from Atlantis at

215:07:07 G.m.t. (01:17:10 MET). After the planned 6-hour period of station keeping with the Atlantis, the EURECA initiated the first orbital transfer maneuver (OTM). Approximately seven minutes into the burn, it was terminated because of attitude errors which were later determined to be invalid values in the low attitude conical Earth sensor (LACES) calibration data table. Corrected values were uplinked and the remaining burn time (approximately 14 minutes) was successfully completed at 5:27 a.m. c.d.t. on August 6, 1992. The OTM-2 burn was successfully performed at 4:26 a.m. c.d.t. on August 7, 1992, and the EURECA was inserted in a circular orbit at an altitude of 270 nmi. At the end of the STS-46 mission, the EURECA payloads were being activated and the satellite systems were operating nominally.

TETHERED SATELLITE SYSTEM

As a result of the one-day delay in the deployment of the EURECA satellite, TSS-1 operations were also delayed one day. The Orbiter performed two orbit-lowering maneuvers to place the Orbiter in a circular 160 nmi. orbit.

The TSS-1 boom extension was nominal with completion occurring at 217:16:13 G.m.t. (04:02:16 MET). The subsequent attempt at 217:17:37 G.m.t. (04:03:40 MET) to separate the second umbilical (U2) was unsuccessful. However, successful separation of the U2 umbilical was attained at 217:20:01 G.m.t. (04:06:04 MET) concurrent with an Orbiter translational pulse that loosened the U2 connection.

The first attempt at satellite deployment occurred at 217:21:21 G.m.t. (04:07:24 MET), but was aborted by the crew when excessive side-to-side movement was observed. After a checkout of the reel and vernier motors, a second attempt was made to deploy the satellite at approximately (217:22:51 G.m.t.) (04:08:54 MET). The deployment was successful and the satellite tether unreeled smoothly to a length of 179 meters (587 feet) when the TSS-1 stopped at 217:23:47 G.m.t. (04:09:50 MET). Because of possible buried winding on the reel, the satellite was reeled in approximately 5 meters, then reeled out at a somewhat higher rate to 256 meters (827 feet) where the satellite stopped. Deployment activities were resumed about 1 1/2 hours later, but the satellite stalled again after 2 minutes at a tether length of 257 meters (830 feet). At this point, the satellite was powered down to survival levels to maintain battery lifetime during a crew rest period. At 218:13:01 G.m.t. (04:23:04 MET), the satellite was again reeled in to a tether length of 224 meters (733 feet) where the tether became jammed which prevented motion in either direction. A plan was then developed to determine the location of the jam (believed to be in upper or lower tether control mechanism), and then clear the jam. In light of the multiple problems encountered in trying to deploy the tethered satellite, the decision was made to bring the satellite back and dock when the jam was cleared. The plan to accomplish the retrieval of the satellite was initiated at 218:19:51 G.m.t. (05:05:54 MET). The plan included retracting the boom a distance of one panel and having the crew visually check for tether slack inside the boom structure. The crew reported seeing no slack, which indicated that the jam was at the upper tether control mechanism. The boom was then re-extended with the reel brakes engaged. This action cleared the jam and allowed satellite retrieval to begin. The satellite was successfully docked at the top of the boom at 218:22:53 G.m.t. (05:08:56 MET). The boom was retracted and the satellite was secured at 220:00:03 G.m.t. (05:10:06 MET).

The primary data set required that the satellite be deployed a minimum distance of 10 km. The maximum deployed distance was 257 meters, and the predicted 45 volts electromagnetic flux (EMF) and 15 mA were developed. However, this level of induced voltage was insufficient to excite the physical process for the Category I or II objectives. The Category III objectives accomplished included studies of electron beam propagation, beam-gas cloud interactions, and Shuttle glow. More data than planned for this limited deployment were obtained for these investigations. Also, as a result of the unplanned stops at a distance of less than 1 km, a number of unplanned observations were made that will enhance the understanding of electrodynamic tethers in space. Dynamic observations included the damping of longitudinal modes, libration control via the Orbiter, and tether string modes.

EVALUATION OF OXYGEN INTERACTION WITH MATERIALS III/ THERMAL ENERGY MANAGEMENT PROCESSES 2A-3

After completion of the TSS-1 activities, two OMS maneuvers were performed to lower the orbital altitude of the Orbiter into a circular orbit at 124 nmi. The Evaluation of Oxygen Interaction with Materials III (EOIM III) operated for the full 40-hour requirement for material sample exposure to the atomic oxygen flux at the 124-nmi. altitude. Another part of the experiment lost a portion of one of the five 8-hour cycles due to a momentary main power outage; however, the science loss was minimal. The TEMP 2A-3 payload operated flawlessly throughout the mission and obtained 126 percent of the planned data takes.

IMAX CARGO BAY CAMERA

The IMAX Cargo Bay Camera (ICBC) successfully exposed all 10 minutes 25 seconds of film. The ICBC completed nine flight-unique scenes which included EURECA prerelease and postrelease, TSS-1 flyaway, and TSS reeling out and reeling in. Additionally, nine Earth observation scenes were captured on film including typhoon Janis, the Windward Islands, Java, the Sahara Desert, Madagascar, Brazil, the Andes mountains, Tuamoto Archipelago, and Indonesia through Australia.

CONSORTIUM FOR MATERIAL DEVELOPMENT IN SPACE COMPLEX AUTONOMOUS PAYLOAD-II

The Consortium for Material Development in Space Complex Autonomous Payload-II (CONCAP-II) successfully operated on flight days 7 and 8. Early in the cycle, some uncertainty about the status of the motorized door assembly existed; however, this was resolved and 10 hours of data were gathered (100 percent of their requirement).

CONSORTIUM FOR MATERIAL DEVELOPMENT IN SPACE COMPLEX AUTONOMOUS PAYLOAD-III

The Consortium for Material Development in Space Complex Autonomous Payload-III (CONCAP-III) acceleration measurement system operated nominally throughout the flight. The second objective of this payload could only be met with the TSS satellite deployed to a significantly greater distance than the satellite was able to attain. Therefore, this second objective was not met.

LIMITED DURATION SPACE ENVIRONMENT CANDIDATE MATERIAL EXPOSURE

The Limited Duration Space Environment Candidate Material Exposure (LDCE) operated nominally and the entire 40-hour material samples exposure time was obtained.

PITUITARY GROWTH HORMONE CELL FUNCTION

The Pituitary Growth Hormone Cell Function (PHCF) payload required a prelaunch change of the experiment sample because of bacterial contamination. Temperature ranges were adjusted early in the flight and total science recovery was anticipated. The PHCF payload experienced no anomalies during the flight.

ULTRAVIOLET PLUME INSTRUMENT

There were no opportunities for Ultraviolet Plume Instrument (UVPI) observations during this flight.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

A total of eight DTO's and 10 detailed supplementary objectives (DSO's) were assigned to the STS-46 flight. Of these, six DTO's and all 10 DSO's were accomplished. A discussion of each DTO and DSO is contained in the following paragraphs.

DEVELOPMENT TEST OBJECTIVES

In addition to the six DTO's that were accomplished, the crew provided two photographs of the ET after separation. These photographs are normally scheduled under DTO 312; however, this DTO was not scheduled for STS-46. The photographs were very good and the unexpected data will be analyzed.

The status of the assigned DTO's is contained in the following paragraphs.

DTO 251 - Entry Aerodynamic Control Surfaces Test - This DTO was to be performed using an alternate (fixed) elevon schedule; however, this use of this schedule was canceled because of problems encountered on STS-50. As a result, this DTO was accomplished using the automatic elevon schedule.

DTO 307D - Entry Structural Capability - Data were gathered for this DTO during entry. The data have been given to the sponsor for analysis.

DTO 325 - Waste/Supply Water Dumps - Two dumps were performed with the supply water and waste tanks depressurized to cabin pressure (14.7 psia) in support of test 3 of this DTO. Supply water was dumped at a rate of 0.94 percent/minute (1.55 lb/min), while waste water was dumped at 1.49 percent/minute (2.4 lb/min). Views of the nozzles using an RMS TV camera depicted a normal supply water dump, while evidence of "popcorn" flakes were seen during the waste water dump; however, no icing of the nozzles was observed. This flake condition is the result of gas in the waste water and was expected for the reduced-pressure dump.

DTO 656 - Payload and General Purpose Computer Single Event Upset Monitoring - The Payload and General Support Computer (PGSC) Single Event Upset Monitoring DTO was conducted on flight days 1, 2, and 3. The data have been given to the sponsor for evaluation.

DTO 663 - Acoustical Noise Dosimeter - Data were gathered on flight days 1, 2, 4, 6, and 7 and all runs were complete except for flight day 1. The data have been given to the sponsor for evaluation.

DTO 666 - Modify ECLSS Supply Air Ducting to Provide Chilled Air to Suited Crew Members - This DTO was performed; however, the crew indicated that without proper venting from the suit, this modification does not relieve the conditions for which it was developed.

DTO 700-2 - Laser Range and Range Rate Device - The laser range and range rate device was used during TSS-1 deployment operations with no apparent anomalies. The sponsor has received the data for evaluation.

DTO 805 - Crosswind Landing Performance - The crosswind landing performance DTO was a DTO of opportunity for Edwards Air Force Base; however, the landing was at Kennedy Space Center and the DTO was not performed.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 484 - Assessment of Circadian Shifting in Astronauts by Bright Lights - This DSO was a preflight and postflight testing DSO with no in-flight test requirements. The DSO was completed and the results have been given to the sponsor for evaluation.

DSO 603 - Orthostatic Function During Entry, Landing, and Egress - This DSO, using the 603 B protocol, was performed during deorbit preparations, entry, landing, and egress from the Orbiter. The data have been given to the sponsor for evaluation.

DSO 604 - Visual Vestibular Integration as a Function of Adaption - This DSO was performed on flight day 2, and the data have been given to the experiment sponsor for evaluation.

DSO 613 - Changes in Endocrine Regulation of Orthostatic Tolerance Following Space Flight - This DSO was performed during preflight and postflight operations and had no in-flight requirements. The data are being evaluated by the sponsor.

DSO 614 - Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion - This DSO was performed during preflight and postflight operations and had no in-flight requirements. The data are being evaluated by the sponsor.

DSO 618 - Effects of Intense Exercise During Space Flight on Aerobic Capacity and Orthostatic Function - This DSO was performed on flight days 1, 3, and 7. This DSO was flown with two subjects: one active and one control. Data have been given to the sponsor for evaluation.

DSO 802 - Educational Activities (Objective 1) - This DSO was completed on flight day 2. The data are being used to prepare videos for educational use.

DSO 901 - Documentary Television - This DSO was accomplished throughout the flight as videos were made of various activities. The videos have been given to the sponsor for evaluation.

DSO 902 - Documentary Motion Picture Photography - This DSO was accomplished throughout the flight as motion pictures were taken of various activities. The film is being evaluated by the sponsor.

DSO 903 - Documentary Still Photography - This DSO was accomplished at the crew discretion throughout the mission. The film is being evaluated by the sponsor.

PHOTOGRAPHIC AND TELEVISION ANALYSES

LAUNCH DATA ANALYSIS

On launch day, 22 of the 23 expected videos were received and screened. Items of interest included observation of a bolt hang-up on holddown post M-7 on the left SRB. Camera E-11 showed the condition with the visible extent of the bolt hang up measured at 13.11 inches when the bolt appeared to be at maximum extension.

A second item was the discolorations noted in the SSME 1 and 2 Mach diamonds both before lift-off and after the roll maneuver. This condition is under review by both JSC and MSFC personnel.

The final item noted was the appearance of possible excessive vibration of the SSME 2 engine bell at engine start-up. An engineering review is underway to determine if the motion observed was excessive.

ON-ORBIT DATA ANALYSIS

On-orbit photographic data analysis has consisted of evaluating the two photographs of the ET after separation, and the videos of the satellite operations. The DTO (312) that requires photographs of the ET was not planned for this mission; however, Mission Specialist 3 provided a bonus to the DTO sponsor by taking two photographs. The photographs were taken about 21 minutes after lift-off, and as a result, the ET image is much smaller than observed previously. Photographic enhancement techniques were used in an effort to obtain additional information from the photographs.

LANDING DATA ANALYSIS

Nine landing videos were made and received three hours after landing for evaluation. No anomalous events were detected on any of the landing videos.

TABLE I.- STS-46 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	213:13:51:58.44
	APU-2 GG chamber pressure	213:13:51:59.39
	APU-3 GG chamber pressure	213:13:52:00.17
SRB HPU activation	LH HPU system A start command	213:13:56:21.02
	LH HPU system B start command	
	RH HPU system A start command	213:13:56:21.46
	RH HPU system B start command	
Main propulsion System start	Engine 3 start command accepted	213:13:56:41.44
	Engine 2 start command accepted	213:13:56:41.53
	Engine 1 start command accepted	213:13:56:41.65
SRB ignition command (lift-off)	SRB ignition command to SRB	213:13:56:48.011
Throttle up to 104 percent thrust	Engine 3 command accepted	213:13:56:52.00
	Engine 1 command accepted	213:13:56:52.01
	Engine 2 command accepted	213:13:56:52.02
Throttle down to 82 percent thrust	Engine 3 command accepted	213:13:57:11.84
	Engine 1 command accepted	213:13:57:11.85
	Engine 2 command accepted	213:13:57:11.86
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	213:13:57:38
Throttle down to 67 percent thrust	Engine 3 command accepted	213:13:57:39.52
	Engine 1 command accepted	213:13:57:39.53
	Engine 2 command accepted	213:13:57:39.54
Throttle up to 104 percent thrust	Engine 3 command accepted	213:13:57:46.88
	Engine 1 command accepted	213:13:57:46.89
	Engine 2 command accepted	213:13:57:46.90
Both SRM's chamber pressure at 50 psi	RH SRM chamber pressure mid-range select	213:13:58:47.25
	LH SRM chamber pressure mid-range select	213:13:58:48.09
End SRM action	RH SRM chamber pressure mid-range select	213:13:58:50.29
	LH SRM chamber pressure mid-range select	213:13:58:50.31
SRB separation command	SRB separation command flag	213:13:58:53
SRB physical separation	LH rate APU A turbine speed LOS	213:13:58:53.49
	RH rate APU A turbine speed LOS	213:13:58:53.49
Throttle down for 3g acceleration	Engine 3 command accepted	213:14:04:18.24
	Engine 1 command accepted	213:14:04:18.26
	Engine 2 command accepted	213:14:04:18.26
3g acceleration	Total load factor	213:14:04:19.1
MECO	Command flag	213:14:05:16
	Confirm flag	213:14:05:17
Engine Shutdown	Engine 3 command accept	213:14:05:17.41
	Engine 1 command accept	213:14:05:17.42
	Engine 2 command accept	213:14:05:17.42
ET separation	ET separation command flag	213:14:05:35

TABLE I.- STS-46 SEQUENCE OF EVENTS (Continued)

Event	Description	Actual time, G.m.t.
OMS-1 ignition	Left engine bi-prop valve position	Not performed - direct insertion trajectory flown
	Right engine bi-prop valve position	
OMS-1 cutoff	Left engine bi-prop valve position	
	Right engine bi-prop valve position	
APU deactivation	APU-1 GG chamber pressure	213:14:12:15.17
	APU-2 GG chamber pressure	213:14:12:16.73
	APU-3 GG chamber pressure	213:14:12:17.63
OMS-2 ignition	Right engine bi-prop valve position	213:14:38:11.4
	Left engine bi-prop valve position	213:14:38:11.6
OMS-2 cutoff	Left engine bi-prop valve position	213:14:41:54.4
	Right engine bi-prop valve position	213:14:41:54.6
Payload bay door open	PLBD right open 1	213:15:34:00
	PLBD left open 1	213:15:35:19
EURECA release	Voice call	215:07:07
OMS-3 ignition	Left engine bi-prop valve position	216:10:54:13.3
	Right engine bi-prop valve position	216:10:54:13.3
OMS-3 cutoff	Left engine bi-prop valve position	216:10:55:23.0
	Right engine bi-prop valve position	216:10:55:23.0
OMS-4 ignition	Left engine bi-prop valve position	216:11:39:21.8
	Right engine bi-prop valve position	216:11:39:21.8
OMS-4 cutoff	Right engine bi-prop valve position	216:11:40:32.2
	Leftight engine bi-prop valve position	216:11:40:32.4
TSS deploy	Voice call	217:22:50:47
TSS retrieve	Voice call	218:22:52:47
OMS-5 ignition	Left engine bi-prop valve position	219:09:39:06.6
	Right engine bi-prop valve position	219:09:39:06.6

TABLE I.- STS-46 SEQUENCE OF EVENTS (Concluded)

Event	Description	Actual time, G.m.t.
OMS-5 cutoff	Left engine bi-prop valve position	219:09:39:40.6
	Right engine bi-prop valve position	219:09:39:40.6
OMS-6 ignition	Right engine bi-prop valve position	219:10:23:14.8
	Left engine bi-prop valve position	219:10:23:14.9
OMS-6 cutoff	Right engine bi-prop valve position	219:10:23:51.2
	Left engine bi-prop valve position	219:10:23:51.4
Flight control system checkout		
APU start	APU-3 GG chamber pressure	220:10:13:00.25
APU stop	APU-3 GG chamber pressure	220:10:17:51.95
Payload bay door close	PLBD left close 1	221:09:33:59
	PLBD right close 1	221:09:35:52
APU activation for entry	APU-1 GG chamber pressure	221:12:12:26.50
	APU-2 GG chamber pressure	221:12:29:58.51
	APU-3 GG chamber pressure	221:12:29:59.46
Deorbit maneuver ignition	Left engine bi-prop valve position	221:12:17:09.9
	Right engine bi-prop valve position	221:12:17:10.0
Deorbit maneuver cutoff	Right engine bi-prop valve position	221:12:19:13.4
	Left engine bi-prop valve position	221:12:19:13.7
Entry interface (400K)	Current orbital altitude above reference ellipsoid	221:12:39:53
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	221:13:05:22
Main landing gear contact	LH MLG tire pressure	221:13:11:50
	RH MLG tire pressure	221:13:11:50
Main landing gear weight on wheels	LH MLG weight on wheels	221:13:11:51
	RH MLG weight on wheels	221:13:11:51
Nose landing gear contact	NLG tire pressure	221:13:12:05
Nose landing gear weight on wheels	NLG WT on Wheels -1	221:13:12:05
Wheels stop	Velocity with respect to runway	221:13:12:56
APU deactivation	APU-1 GG chamber pressure	221:13:26:11.05
	APU-2 GG chamber pressure	221:13:26:11.89
	APU-3 GG chamber pressure	221:13:26:13.31

TABLE II.- STS-46 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-46-V-01	Main Engine 3 Hydrogen Flow Control Pressure Anomaly	213:13:58 G.m.t. IM46RF01 IPR TBD-0002	Between lift-off plus 90 and 110 seconds, main engine 3 gaseous hydrogen outlet pressure (V41P1360A) exhibited erratic pressure fluctuations up to 70 psi above the baseline pressure of 3100 psia. Simultaneously, the gaseous hydrogen disconnect pressure (V41P1490A) dropped 20 psia. A troubleshooting plan was developed and has been in work since August 14. A chit was not required. No leaks were detected on the runway. An X-ray of FCV 3 was not definitive. The vendor removed the poppet/sleeve assembly and no visible contamination was found.
STS-46-V-02	a) Body Flap Lower Skin Temperature Transducer Erratic (V09T1026A) b) Right Main Landing Gear Temperature Dropped Off-Scale Low (V58T0192A)	213:21:00 G.m.t. IM46RF02 IPR-TBD-0010 221:13:12 G.m.t.	The body flap skin temperature transducer (V09T1026A) exhibited erratic temperature drops. The measurement went off-scale low (-200 °F) several times. At main landing gear touchdown, the right main gear brake line return temperature (V58T0192A) dropped off-scale-low. Although not currently being used, this sensor can be used as one of several temperature control sensors for activation of the system 1 hydraulic circulation pump.
STS-46-V-03	Flight Deck Speaker Inoperable	214:12:30 G.m.t. PR COM-4-13-0124	The flight deck speaker was reported to be inoperable. This is the first flight of this particular unit and first use of the newly designed speaker on OV-104. The circuit breaker was cycled five times without success. KSC: Removed and replaced unit on 8/13 and shipped to JSC for troubleshooting.
STS-46-V-04	Avionics Bay 2A Smoke Detector Negative Excursions	214:20:32 G.m.t. IM46RF03	Smoke concentration sensor V62G0608A exhibited several sporadic drops to -700 $\mu g/m^3$. KSC: Perform self-test on unit prior to vehicle going to Palmdale. A chit is not required.
STS-46-V-05	GO_2 Manifold Pressure Decay	213:14:10 G.m.t. IM46RF06 PR MPS-4-13-0928	The gaseous oxygen disconnect pressure (V41P1590A) decayed to zero within a minute of MPS dump termination. The gaseous oxygen manifold pressure should decay slowly throughout the flight. Instead, its pressure tracked that of the liquid oxygen manifold. This performance failed File IX requirement DV41AYO.210. With a successful dump and vacuum inert, this problem did not impact the flight. Troubleshooting plan which includes normal OMRSD tests was developed and has been in work since August 14. A chit was not required. No audible leaks were detected on the runway. CV20 failed its leak test and has been removed for failure analysis.
STS-46-V-06	Fan Separator 1 Stalled	216:05:23 G.m.t. IM46RF04	Stall currents were observed on fan separator 1. Fan separator 1 was restarted and the flooding was cleared at 216:06:49 G.m.t. At 216:07:45 G.m.t., stall currents were again observed. IFM was run and fan separator 1 cleared, but stalled again after some usage. The second attempt to run IFM was unsuccessful in regaining normal operations. No definitive data to show flooding or mechanical failure. KSC: WCS has been removed and will be sent to JSC for troubleshooting.

TABLE II.- STS-46 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-46-V-07	a) Audio Interface Unit C Channel 1 Failure	216:13:20 G.m.t. FIAR BFCE 029-F062	a) Crew reported that they could receive transmissions from the C1 portion of the audio interface unit (AIU) over their CRU, but were unable to transmit on channel 1 of the AIU. Several CRU's would not transmit to channel 1 of the AIU.
	b) AIU-D Performance was Intermittent	DR BH230301	b) The crew reported during the crew debriefing that performance of the D AIU was intermittent.
STS-46-V-08	WCCS CRU Low Battery Beep Tone	215:15:19 G.m.t. DR BH230291	The crew was able to operate the CRU's for up to 30 hours after receiving the initial "low battery" beep tone. The units have been removed and will be sent to JSC for troubleshooting.
STS-46-V-09	Right OMS GN_2 Pressure Valve Indicates Open	217:03:52 G.m.t. IM 46RF05 IPR TBD-0007	The right OMS pressure valve indicator suddenly showed open at 217:03:52:09 G.m.t. Crew verified switch in closed position. The valve was cycled and the correct position indication returned. A troubleshooting plan has been developed. A chit was not required. The valve has been cycled 10 times with nominal results. KSC: The valve will be removed and replaced for failure analysis.
STS-46-V-10	Over-modulation of Ku-Band Channel 3	217:03:00 G.m.t. IPR TBDV-0005	All payload cameras can cause the over-modulation condition which results in loss of channel 2 (OPS recorder dumps) and channel 1 (real-time data). A test matrix was developed to gather on-orbit data for troubleshooting. A troubleshooting plan has been developed and work began on August 19. A chit was not required.
STS-46-V-11	Manifold 5 Left RCS Valves Failed to Cycle	221:13:35 G.m.t. IPR TBDV-0013	During the nominal postlanding redundant circuit verifications, the left RCS manifold 5 valves failed to close when the crew cycled the switch. The RPC power indication was received. The valves operated nominally when cycled by the ground crew during the OMS/RCS safing. The valves will be cycled for additional troubleshooting.
STS-46-V-12	ADTA 1 and 3 Temperature Differential during FCS Checkout	220:10:24 G.m.t. IPR TBDV-0018	While in OPS 8 for FCS checkout, a 4.5° C temperature difference was indicated between the ADTA 1 and 3 temperature measurements. These temperatures normally track much closer and a difference of greater than 5° C would violate LCC GNC-75. This LCC utilizes these measurements as an indication of the health of the analog to digital converter, which also processes pressure measurements.

NASA Headquarters
QP/B. Greenly
QP/R. Perry
QT/M. Greenfield
MCF/D. Hedin
MOJ/C. Perry

Goddard Space Flt Ctr
300/R. C. Bauman
700/T. E. Huber
710//W. Meyer
730/E. I. Powers
730.1/J. P. Young
400/V. Weyers
100/P. T. Burr
302/W. F. Bangs
313/R. Marriott
130/J. Katz

KSC
Library-D (20 copies)
MK/B. H. Shaw
LSO-420/W. K. Hollis

MSFC
CN22D/Respository (30)
EP51/J. Redus (5)
EE31/P. Hoag (5)
FA51/S. P. Sauchier
JA01/J. A. Downey
SA12/O. E. Henson

Langley Research Center
Technical Library/
Mail Stop 185

Rockwell-Downey
AD75/Data Management (50)

Rockwell-Houston
R12A-130/J. C. Snowden
R12A-130/J. P. Shea
ZC01/C. Ritrivi
R20A/J. Woodard
R20B/R. Pechacek
R16H/K. M. Rahman
ZC01/J. Woodall
ZC01/W. Scott

JSC
AA/A. Cohen
AC/D. A. Nebrig
AC5/J. W. Young
AP3/J. E. Riley (4)
AP4/B. L. Dean (3)
LA/W. L. Draper
BY4/History Office (2)
CA/S. A. Hawley
CA4/R. Filler
CA4/J. Williams
CB/Astronaut Office (10)
CB/K. Colgan
CB/T. Henricks
DA/Library
DA15/D. Nelson
DA3/S. G. Bales
DA3/R. K. Holkan
DA8/R. Legler
DA8/Library
DF/J. Knight
DF7/P. Cerna
DF72/Q. Carelock
DG/J. A. Wegener
DH4/D. Rickerl
DH4/Lead FAO
DH411/E. B. Pippert
DH/J. F. Whitely
DH45/M. LeBlanc
DH6/J. L. Clement
DG47/Sim Sup's
DG66/H. Lampazzi
DG67/C. Moede
DM/J. C. Harpold
DM22/J. R. Montalbano
DM22/W. Hollister
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
EC3/H. Rotter (2)
EC3/N. Faget
EC6/J. W. McBarron
EE/J. Griffin
EE2/H. A. Vang
EE3/P. Shack
EE6/L. Leonard
EE6/R. Nuss
EE7/M. D. Schmalz
EE7/J. C. Dallas
EK/I. Burtzlaff
ET5/J. A. Lawrence
EG/J. Thibodeau
EG2/K. D. Frank
EG3/R. Barton
EG3/P. Romere
EG3/S. Derry
EK5/W. N. Trahan
EP2/H. J. Brasseaux
EP2/L. Jenkins
EP5/T. L. Davies
ER/W. W. Guy
ES/D. C. Wade
ES/W. G. McMullen (2)
ES/J. A. Smith
ES3/Y. C. Chang
ES3/P. Serna
ES6/C. W. Norris (2)
ET/C. A. Graves, Jr. (8)
ET3/T. Farrell
EK/FDSD Library
DJ/J. W. Seyl (2)
GA/T. W. Holloway
GM/D. C. Schultz
JL4/R. L. Squires
JM2/Library (3)
MJ/T. R. Loe (2)
NA/C. S. Harlan
ND/M. C. Perry
ND3/L. Lewallen
NS/D. W. Whittle
PA/R. L. Berry
PA/J. R. Garman
PT3/S. Morris
SA/C. L. Huntoon
SA/W. D. Womack
SD/S. L. Pool
SD2/R. D. Billica
SD24/D. A. Rushing
SD4/N. Cintron
SD5/J. Charles
SE/J. H. Langford
SN15/D. Pitts
SP/C. D. Perner (5)
TA/C. H. Lambert
TC3/J. Lowe
TC3/T. Bruce
TJ/L. E. Bell
TJ2/G. W. Sandars
TM2/G. Nield (2)
VA/D. M. Germany
VA/P. C. Glynn
VE/W. H. Taylor
VF/D. W. Camp
VF/E. R. Hischke
VF2/W. J. Gaylor
VF2/J. W. Mistrot
VF2/R. Brasher
VF3/M. T. Suffredini (13)
VF5/H. Kolkhorst
VG/F. Littleton
VK/C. G. Jenkins
VM/C. Critzos
VM2/K. E. Kaminski (25)
VP/C. McCullough (3)
VP12/D. Fitts
VP5/J. Goodman
VR/D. D. Ewart
WA/L. G. Williams
WC/L. D. Austin
WE/R. D. White
WG/W. J. Moon
ZR/Lt. Col. J. McLeroy
ZR12/J. A. Yannie
BARR/J. White
BARR/H. Jones
BARR/R. Hennan
ECHS/Hamilton Standard
KN/NASDA (3)

RA/R. A. Colonna (2)
White Sands Test Facility
P. O. Drawer MM
Las Cruces, NM 88004

External Distribution
Mr. Willis M. Hawkins
Senior Advisor
Lockheed Corporation
P. O. Box 551
Burbank, CA 91520

NASA-Lewis Research Center
Cleveland, OH. 44135
Attn: 333-1/T. Fuller

Russell A. Larson
Mail Stop 4A
Charles Stark Draper Lab.
555 Technology Square
Cambridge, MA 02139

Mr. Ira Grant Hedrick
Presidential Assistant
for Corporate
Technology
Grumman Aerospace Corp
Bethpage, NY 11714

Dr. Seymour C. Himmel
12700 Lake Avenue, #1501
Lakewood, OH 44107

Mr. John F. McDonald
Vice President-Technical
Services
TigerAir, Inc.
3000 North Claybourn Ave
Burbank, CA 91505

Dr. John G. Stewart
Manager, Office of
Planning and Budget
TVA E6C9
400 Commerce Avenue
Knoxville, TN 37902

TRW
Houston, TX 77058
Attn: C. Peterson/H5

John Williams
1995 Ferndale Place
Thousands Oaks, CA 91360

Darryl Strickland
P. O. Box 1940
North Highlands, CA
95660-8940

Ames Research Center
Moffett Field, CA 94035
233-17/J. Hart

C. Woodland, Prog. Mgr.
SPAR Aerospace Limited
9445 Airport Road
Brampton, Ontario,
Canada, L6F4J3

A. S. Jones (2)
SPAR Aerospace Limited
9445 Airport Road
Brampton, Ontario
Canada L6F4J36

J. Middleton
SPAR Aerospace Limited
1700 Ormont Drive
Weston, Ontario,
Canada M9L 2W7

N. Parmet
5907 Sunrise Drive
Fairway, Kansas 66205

R. Peterson
3303 San Gabriel
Clearwater, FL 34619

Aerospace Corporation
P. O. Box 92957
Los Angeles, CA 90009
Attn: W. Smith, M5/619

McDonnell Douglas-Houston
T3A/A. D. Hockenbury

T. Myers, Sys Tech, Inc.
13766 So. Hawthorne Blvd.
Hawthorne, CA 90250

D. Molgaard
2525 Bay Area Blvd.
Suite 620
Houston, TX 77058

L. R. Adkins/IBM Bldg
Mail Code 6206
3700 Bay Area Boulevard
Houston, TX 77058

James R. Womack
JPL/233-307
4800 Oak Grove Dr
Pasadena, CA 91109

James V. Zimmerman
NASA European Rep
c/o American Embassy
APO New York, NY 09777

Capt. J. Behling
6555 ASTG/SMSP
Cape Canaveral AFS, FL.
32925

LESC-Houston
BO8/P. Davis
C07/LESC Library
C12/D. Harrison
C12/R. W. Fricke (10)
C87/D. Weissinger

GE Government Services
1050 Bay Area Blvd.
Houston, TX 77058
Attn: A. Verrengia

TRW
1 Space Park Drive
R11/1850 - L. Stytle
Redondo Beach, CA 90278

HQ AFSPACECOM/DOSL
Bldg 1 Stop 7
Peterson AFB
Colorado Springs, Co 80914
Attn: Capt. S. M. Young

Lockheed Advanced
Development Co.
P.O. Box 250
Sunland, CA. 91041
Attn: D. Urie D/7212,
B375, P/D6

R. Birman
General Electric Co.
Space Division
P. O. Box 8555
Philadelphia, PA 19101

Headquarters, SMC
Attn.: SMC/CULO
Major D. Joslyn
Los Angeles AF Base
P. O. Box 92960
Los Angeles, CA 90009-2960

Notify VF2/R. W. Fricke (713-483-3313) of any correction, additions, or deletions to this list.