NSTS-08254

STS-48 SPACE SHUTTLE MISSION REPORT

NASA-CR-193060
19930016801

(NASA-CR-193060) STS-48 SPACE SHUTTLE MISSION REPORT (Lockheed Engineering and Sciences Co.) 30 p

N93-25990

Unclas

G3/16 0163572

October 1991

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

NSTS-08254

STS-48

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke
LESC/Flight Data Section

Approved by

David W. Camp
Manager, Flight Data and
Evaluation Office

D. M. Germany
Manager, Orbiter and GFE Projects

Leonard S. Nicholson
Deputy Director, Space Shuttle Program

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 1991

N93-25990#

Table of Contents

Table of Contents (Concluded)

List of Tables

INTRODUCTION

The STS-48 Space Shuttle Program Mission Report is a summary of the vehicle subsystem operations during the forty-third flight of the Space Shuttle Program and the thirteenth flight of the Orbiter vehicle Discovery (OV-103). In addition to the Discovery vehicle, the flight vehicle consisted of an External Tank (ET) designated as ET-42 (LWT-35); three Space Shuttle main engines (SSME's) (serial numbers 2019, 2031, and 2107 in positions 1, 2, and 3, respectively); and two Solid Rocket Boosters (SRB's) designated as BI-046. The lightweight redesigned Solid Rocket Motors (RSRM's) installed in each one of the SRB's were designated as 360L018A for the left SRB and 360L018B for the right SRB.

This report satisfies the Level II Space Shuttle Program requirement, as documented in NSTS 07700, Volume VIII, Appendix E, which requires each major organization supporting the Space Shuttle Program to report the results of its evaluation of the mission and identify all related in-flight anomalies.

The primary objective of the flight was to successfully deploy the Upper Atmospheric Research Satellite (UARS) payload.

The sequence of events for the STS-48 mission is shown in Table I, and the official Orbiter Problem Tracking List is presented in Table II. In addition, each Orbiter subsystem anomaly is discussed in the applicable subsystem section of the report, and a reference to the assigned tracking number is provided. Official ET, SRB, and SSME anomalies are also discussed in their respective sections of the report and the assigned tracking number is also shown.

The crew for this forty-third Space Shuttle flight was John O. Creighton, Capt., USN, Commander; Kenneth S. Reightler, Cdr., USN, Pilot; James F. Buchli, Col., USMC, Mission Specialist 1; Mark N. Brown, Col., USAF, Mission Specialist 2; and Charles D. (Sam) Gemar, Lt. Col., U. S. Army, Mission Specialist 3. STS-48 was the fourth Space Shuttle flight for Mission Specialist 1, the third Space Shuttle flight for the Commander, the second Space Shuttle flight for Mission Specialists 2 and 3, and the first Space Shuttle flight for the Pilot.

MISSION SUMMARY

The launch of the STS-48 vehicle occurred at 255:23:11:04.005 G.m.t. (7:11:04 p.m. e.d.t. on September 12, 1991) from launch pad A at KSC. Orbiter performance was satisfactory during ascent; however, the flash evaporator system (FES) primary A controller experienced an automatic shutdown. The FES was restarted with primary B controller and operated normally. After orbit was reached, the FES A controller was reactivated and operated nominally.

At 255:12:54:40 G.m.t. (approximately 11 hours prior to launch), smoke detector B in avionics bay 1 annunciated a master caution and warning (C&W) alarm and fire siren. Approximately 50 seconds later, the same event indicator came on again for 2 seconds. During the alarm periods, no increases in smoke concentration were noted and all alarms were determined to be false. To preclude any erroneous nuisance smoke detector alarms during flight, a decision was made to open the circuit breaker before lift-off, then reset it again during on-orbit operations, and open it again for each sleep period. During on-orbit activities, at 257:20:26:24 G.m.t., a false fire siren occurred on the same smoke detector. The circuit breaker was pulled for the remainder of the mission.

The launch countdown was held at T-5 minutes for 14 minutes 4 seconds because of an air-to-ground (A/G) 1 and A/G 2 noise problem that occurred just prior to the count being resumed at T-9 minutes. Discussions during the period from T-9 minutes to T-5 minutes led to the decision to hold the countdown at T-5 minutes to determine the cause of the noise. The source of the noise could not be isolated, but since it appeared to be a ground problem and the S-Band A/G 1 and A/G 2 systems have a backup in the UHF system, a determination was made to resume the countdown at T-5 minutes. The noise did disappear prior to launch. Further analysis after lift-off confirmed that the problem originated in the ground equipment.

An examination of the data shows that all SSME and RSRM start sequences occurred as expected and the launch phase performance was satisfactory in all respects. First stage ascent performance was nominal with SRB separation, entry, deceleration, and water impact occurring as predicted. Both SRB's were successfully recovered. Performance of the SSME's, ET, and main propulsion system (MPS) was also nominal with main engine cutoff (MECO) occurring at approximately 8 minutes 36.1 seconds after lift-off. No orbital maneuvering system (OMS)-1 maneuver was required. The OMS-2 maneuver was performed at 255:23:54:44 G.m.t. Duration of the maneuver was 4 minutes 37 seconds, resulting in a velocity change of approximately 450.0 ft/sec, and the Orbiter was inserted into a 307 nmi. circular orbit with an inclination of 57 degrees.

The remote manipulator system (RMS) was powered up and communications were established with the general purpose computer (GPC) about 2 1/2 hours into the mission. The shoulder brace was released satisfactorily and the RMS on-orbit checkout was completed with no anomalies. The payload bay scan of the UARS was completed, the arm was cradled and latched properly, and power was deselected nominally.

An anomaly occurred at 257:00:14:21.6 G.m.t. when the fuel cell 1 oxygen reactant valve indicated closed. Because of the valve indication, the main A and B busses were tied together in case a hard failure of the valve occurred. Data showed normal oxygen flow and that the fuel cell was healthy except for the valve indicator. While the manifold valves were being reconfigured for the flight day 3 sleep period, the indicator on fuel cell 1 oxygen reactant valve began indicating properly. Prior to entry, the main A and B busses were untied as planned.

Cabin pressure was lowered to 10.2 psia in preparation for a possible EVA should a problem develop with the payload deployment. The FES was shut down prior to the payload deployment to minimize any possible contamination of the payload.

The cabin temperature was maintained within satisfactory limits with a partial cabin power down during the UARS deployment activities. As a result, the FES was not reactivated during that period.

The UARS was unberthed successfully with the RMS. The UARS solar array and high gain antenna were deployed satisfactorily, and no EVA was required. All mechanical systems related to the payload deployment operations performed nominally. After releasing the satellite at 258:04:23:08 G.m.t., the RMS was restowed satisfactorily.

A 7-second reaction control subsystem (RCS) retrograde maneuver with a velocity change of 2 ft/sec was performed at 259:01:31:04 G.m.t. as an evasive maneuver from a Soviet Cosmos 955 upper stage spent rocket body (launched in 1977). This was the first evasive-type maneuver performed during the Space Shuttle Program.

The flight control system (FCS) checkout was performed at 260:00:37:41.81 G.m.t. and all data were nominal. Auxiliary power unit (APU) 2 was used for the FCS checkout instead of APU 3 as planned because of an accumulator pressure decay in hydraulic system 2. APU 3, however, remained the first APU to be started for entry. APU 2 was operated for 6 minutes 10 seconds and consumed 14 lb of fuel during the FCS checkout.

The RCS hot fire was performed satisfactorily at 260:01:51:04 G.m.t. To conserve propellant, only one pulse of each thruster was fired rather than the planned two pulses.

The data taken during the dump nozzle bakeout period following the fifth supply water dump showed indications of a small periodic water leak through the supply water dump valve. A subsequent detailed review of the dump 4 and 5 data showed several occurrences of dump valve leakage. A purge of the supply water dump line/valve was successfully performed, using the free fluid disposal in-flight maintenance (IFM) procedure. The crew was instructed to leave the isolation valve and dump valve closed for the remainder of the mission. The last supply water dump was performed through the FES.

The crew reported that the third (last) Linhoff film magazine was not transporting film properly. The crew performed an IFM procedure, but without success. The camera and magazine were stowed for the rest of the flight and postflight troubleshooting will be performed.

At 260:03:59 G.m.t., the crew reported a cable problem with the electronic still camera (ESC). An IFM procedure was uplinked to the crew, and the crew performed the procedure which recovered use of the camera. At 260:05:20 G.m.t., the crew began again transmitting data from the ESC.

The payload bay doors were satisfactorily closed at 261:02:22:52 G.m.t. The crew completed all planned experiment operations, as well as entry preparations and stowage. An evaluation of weather conditions at the Shuttle Landing Facility area resulted in a decision to delay the landing one revolution. However, the weather continued to be unfavorable at the primary landing site (KSC), and a decision was made to land at Edwards Air Force Base, CA. APU 3 was started at 261:06:23:13.63 G.m.t. The deorbit maneuver was performed at 261:06:28:13.9 G.m.t. The maneuver was approximately 266 seconds in duration and the differential velocity was 516.5 ft/sec. Entry interface occurred at 261:07:07:43 G.m.t.

Main landing gear touchdown occurred on Edwards Air Force Base runway 22 at 261:07:38:42.34 G.m.t. Nose landing gear touchdown occurred 11 seconds later with wheels stop at 261:07:39:31.62 G.m.t. (2:39:31 a.m. c.d.t. on September 18, 1991). The rollout was normal in all respects. The flight duration was 5 days 8 hours 28 minutes 27 seconds. The results of the hydraulic load test performed prior to APU shutdown were very satisfactory. The APU's were shut down by 261:07:57:07.52 G.m.t., and the crew completed the required postflight reconfigurations and departed the Orbiter landing area at 261:08:25:00 G.m.t.

VEHICLE PERFORMANCE

The vehicle performance section of this report contains a discussion of the various subsystems of the SRB and RSRM, ET, SSME, and the Orbiter vehicle (Discovery).

SOLID ROCKET BOOSTER/REDESIGNED SOLID ROCKET MOTOR

All SRB subsystems performed as expected throughout ascent. The SRB prelaunch countdown was normal. RSRM propulsion performance was well within the required specification limits, and the propellant burn rate for each RSRM was nominal. 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 were performed properly. No RSRM in-flight anomalies were identified during the postflight analysis; however, two SRB anomalies were identified. No SRB or RSRM Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specification Document (OMRSD) violations were noted.

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

SRB structural temperature response was as expected during the flight. Postflight inspection of the recovered hardware indicated that the SRB thermal protection system performed properly during ascent with very little acreage ablation. However, one divot, measuring 3.0 inches long (forward to aft) and 2.75 inches wide was discovered on the left SRB frustum. A review team is investigating this occurrence.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 78 °F		Right motor, 78 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	66.55	65.76	66.31	66.07
I-60, 10^6 lbf-sec	176.99	175.63	176.46	176.05
I-AT, 10^6 lbf-sec	296.94	296.82	296.86	296.78
Vacuum Isp, lbf-sec/lbm	268.6	268.5	268.6	268.6
Burn rate, in/sec	0.3750	0.3722	0.3740	0.3730
Event times, seconds				
Ignition interval	0.232	N/A	0.232	N/A
Web time	108.3	109.1	108.6	109.0
Action time	120.0	121.9	120.4	120.9
Separation cue, 50 psia	117.9	120.0	118.3	118.6
PMBT, °F	83.0	83.0	83.0	83.0
Maximum ignition rise rate, psi/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	2.8	2.8	3.1
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 636.3	

Separation subsystem performance was normal with all booster separation motors (BSM's) expended and all separation bolts severed. Nose cap jettison, frustum separation, and nozzle jettison occurred normally on each SRB. The entry and deceleration sequence was properly performed on both SRB's. RSRM nozzle jettison occurred at frustum separation, and the subsequent parachute deployments were performed nominally.

The two SRB in-flight anomalies that were baselined as a result of discrepancies that were observed after the SRB's were recovered and returned to KSC are as follows:

a. The BSM aeroheat shield/hinge assembly and cover (located on the upper right position of the BSM cluster) was missing from the left SRB (Flight Anomaly STS-48-B-01);

b. A black mark with flow lines was observed at the ET/SRB strut segment interface on the right SRB (Flight Anomaly STS-48-B-02).

EXTERNAL TANK

All objectives and requirements associated with ET propellant loading and flight operations were met. During liquid hydrogen replenish, liquid hydrogen ullage transducer 1 dropped off-scale low several times. Transducer dropouts of this type have been observed and are considered a normal characteristic of this type of transducer. The transducer operated satisfactorily throughout ascent.

Propellant loading was completed as scheduled, and all prelaunch thermal requirements were met. Thermal protection system performance was as expected for the existing ambient conditions. There were no LCC or OMRSD violations during the launch countdown.

Only the normal ice/frost formations for the September 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 liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. A small amount of frost was also present along the liquid hydrogen protuberance air load (PAL) ramps. All of these observations were acceptable per Space Shuttle documentation. The Ice/Frost Red Team reported that there were no anomalous thermal protection subsystem (TPS) conditions and that the ET had less ice/frost and condensate than previously observed during normal propellant loadings.

The ET pressurization subsystem functioned properly throughout the engine-start and flight periods. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 14.5 psid.

ET flight performance was excellent. All ET electrical equipment and instrumentation performed satisfactorily. The operation of the ET heaters and purges was monitored and all performed properly. The ET tumble system was deactivated for this flight. The predicted postflight ET intact impact point was approximately 65 nmi. up-range from the preflight predicted impact point and was within the predicted footprint.

SHUTTLE RANGE SAFETY SYSTEM

Shuttle range safety system (SRSS) closed-loop testing was completed as scheduled during the launch countdown. All SRSS safe and arm (S&A) devices were armed and system inhibits were turned off at the appropriate times. All SRSS measurements indicated that the system performance was as expected throughout the launch phase. Prior to SRB separation, the SRB S&A devices were safed and SRB system power was turned off, as planned. The ET system remained active until ET separation from the Orbiter. The system signal strength remained above the specified minimum (-97 dBM) for the duration of the powered flight.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters were normal throughout the prelaunch countdown and compared well with prelaunch parameters observed on previous flights.

The engine-ready indication was achieved at the proper time, all LCC were met, and engine start and thrust buildup were normal.

Preliminary flight data indicate that SSME performance at engine start, and during thrust buildup, mainstage, throttling, shutdown, and propellant dumping operations were within specifications. All three engines started and operated normally. High pressure oxidizer turbopump and high pressure fuel turbopump temperatures appeared to be well within specifications throughout engine operation. The SSME controllers provided the proper control of the engines throughout powered flight and no failures or significant in-flight anomalies were identified during ascent. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

ORBITER VEHICLE SUBSYSTEMS

Main Propulsion System

The overall performance of the MPS was excellent. All pretanking purges were properly performed, and liquid oxygen and liquid hydrogen loading was performed as planned with no stop-flows or reverts. There were no OMRSD or LCC violations.

Throughout the preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration in the Orbiter aft compartment was 181 ppm, which compares very well with previous data from this vehicle. The aft Helium concentration peaked at 10,800 ppm early in the countdown and stabilized at a satisfactory level of 6000 ppm for launch. These values are within the historical boundaries observed on this vehicle.

At approximately T-3 hours, ET liquid hydrogen ullage pressure transducer 1 began showing erratic behavior. The transducer displayed readings between 12 (off-scale low) and 14.7 psia in a cyclic manner. When prepressurization activities began about 2 minutes prior to launch, the transducer began reading nominally and followed the other two transducers to 44 psia. This condition has been observed on previous flights and is attributed to contamination on the transducer windings.

A comparison of the calculated propellant loads at the end of replenish versus the inventory load results in a loading accuracy of +0.002 percent for the liquid hydrogen and +0.06 percent for liquid oxygen.

Ascent MPS performance appeared to be completely normal. Data indicate that the liquid oxygen and liquid hydrogen pressurization systems performed as planned and that all net positive suction pressure (NPSP) requirements were met throughout the flight. SSME cutoff (MECO) occurred at T + 515 seconds.

STS-48 was the first flight of the gaseous oxygen fixed-orifice configuration flow control valves on OV-103 and the third flight for the fixed-orifice flow control valves during the Space Shuttle Program. The valves are shimmed to 78-percent flow. Review of the data revealed satisfactory operation of these valves, and ullage pressures were maintained within satisfactory limits.

The required aft purge was completed nominally during the entry/landing phase of the flight. Approximately 58 lb of Helium were expended during entry, and this usage is considered nominal for OV-103.

Reaction Control Subsystem

The performance of the RCS was satisfactory with five maneuvering-type burns performed in addition to the normal attitude-control activities. However, development test objective (DTO) 249 [Forward RCS Flight Test (12-Second Pulse)] was canceled during entry because of insufficient propellant remaining (<29 percent) to meet placard requirements. Also, only one pulse firing of each thruster was performed during the RCS hot fire test to conserve propellant. A total of 4899 lb of propellant was consumed during the mission inclusive of the forward RCS propellant dump during entry.

The RCS was used to perform an Orbiter evasive maneuver from a Soviet Cosmos 955 upper stage spent rocket body (launched in 1977). The 7-second, 2 ft/sec retrograde maneuver assured that no contact would occur with the spent rocket.

When the forward RCS manifold 2 isolation valves (LV127 and LV128) were closed after the forward RCS dump following entry, phase C of the ac power showed no current (Flight Problem STS-48-V-06). The same signature was observed in the data when the manifold was opened during postlanding operations. The valves operated in both situations because the normally operated 3-phase valves will also operate on two phases.

Orbital Maneuvering Subsystem

The OMS operated properly throughout the mission with two maneuvers being performed. The total firing time for the maneuvers was 543 seconds and 78.9 percent (20,382 lb) of the propellant was used. No OMS/RCS interconnect operations were performed during the mission.

Four minor OMS problems occurred during the mission, none of which impacted the mission in any manner.

a. The backup flight system (BFS) set a warning flag on the right orbital maneuvering engine (OME) gaseous nitrogen tank pressure. Analysis showed that the warning occurred because the OME gaseous nitrogen regulator outlet pressure dropped below 299 psi during an engine purge. Some of the gaseous nitrogen regulators have a low set-point, and this condition has been known.

b. Both OMS fuel quantity gauges indicated high throughout the flight. This condition occurred on STS-41 and again on STS-39, and the gauges exhibited biases on STS-31. Corrective action for this condition has not yet been scheduled.

c. The OMS fuel crossfeed pressure drifted downward after an initial relief through the crossfeed valves. The condition was expected; however, there were several periods during which the crossfeed pressure transducer indicated a constant pressure when the pressure would be expected to be increasing or decreasing because of heater cycles. These periods of constant pressure lasted as long as 45 minutes.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem operated satisfactorily in the four-tank-set configuration throughout the mission. A total of 163.2 lb of hydrogen and 1309.0 lb of oxygen was consumed during the mission. Thirteen pounds of oxygen were provided to the crew cabin. Reactants remaining provided a mission extension capability of 74 hours at 14.7 kW.

At 257:00:14 G.m.t. while the PRSD subsystem was being configured for the flight day 3 sleep period, the fuel cell 1 oxygen reactant valve position indicator went to the closed position while the valve remained open (Flight Problem STS-48-V-03). The crew was instructed to tie the main A and main B busses together in case the indication was correct. At 258:09:16 G.m.t., approximately 33 hours later, the open indication returned and this change-of-state occurred simultaneously with oxygen manifold 1 isolation valve closure. These two valves share the same mounting base on the panel. Data showed that the fuel cell continued to operate nominally but because of the erratic operation of the indicator, the decision was made to leave the bus tie in place until the deorbit preparations were begun. Prior to the deorbit maneuver, the busses were untied.

Fuel Cell Powerplant Subsystem

The fuel cells operated nominally throughout the mission and provided 1891 kWh of electrical energy at an average power level of 14.7 kW. The total Orbiter electrical load averaged 479 amperes during the mission. A total of 163.2 lb of hydrogen and 1296 lb of oxygen was consumed and the fuel cells produced 1459 lb of water.

Auxiliary Power Unit Subsystem

The APU subsystem performed satisfactorily throughout the mission. The FCS checkout was performed using APU 2 instead of APU 3 as planned because of a hydraulic system 2 accumulator pressure decay (Flight Problem STS-48-V-05). APU 3 was still the first APU started for entry. Following landing, a hydraulic load test was performed with satisfactory results.

After ascent, the APU 1 seal cavity drain pressure began decaying at a slow, steady rate. The decay continued throughout the mission. The decay was most likely due to leakage of trapped atmospheric gases through the overboard relief valve which was not properly seated. This problem did not have any impact on the conduct of the mission.

The following table presents the operating time and fuel usage by the APU's during the mission.

Flight Phase	APU 1 (S/N 203)		APU 2 (S/N 301)		APU 3 (S/N 312)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	00:18:30	51	00:18:30	53	00:18:30	48
FCS checkout			00:06:10	14		
Entry	01:02:19	137	01:02:20	144	01:33:54	194
Total[a]	01:20:49	188	01:27:00	211	01:52:24	242

[a] The total includes 18 minutes 26 seconds of APU operation after landing.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem performed satisfactorily during the mission. One anomaly was identified, but it did not affect the successful completion of the mission in any manner.

The hydraulics circulation pumps were operated three times for thermal conditioning. During the same circulation pump runs, the hydraulic system 2 bootstrap accumulator was also recharged three times because of excessive pressure decay rates (Flight Problem STS-48-V-05). Decay rates should have been no greater than 48 psi/hr; however, rates as high as 369 psi/hr were observed. A minor problem was noted during entry when an overcooling condition was observed on APU lubrication oil system 2. This condition invalidated the in-flight checkout results, but it did not affect the mission in any manner.

Pyrotechnics Subsystem

The pyrotechnics subsystem performed all assigned functions satisfactorily.

Environmental Control and Life Support Subsystem

The environmental control and life support subsystem (ECLSS) performed very satisfactorily throughout the mission with only one anomaly identified in the supply water dump system.

Atmospheric Revitalization System: The performance of the atmospheric revitalization subsystem coolant loops was satisfactory. The carbon dioxide partial pressure was maintained below 7.6 mm Hg. The cabin air temperature and relative humidity peaked at 84 °F and 49 percent, respectively. Avionics bays 1, 2, and 3 air outlet temperatures peaked at 107 °F, 107 °F, and 89 °F, respectively. The avionics bays 1, 2, and 3 water coldplate temperatures peaked at 91 °F, 95 °F, and 82 °F, respectively. During 10.2 psia operations, a partial group B powerdown was performed to prevent exceeding cabin avionics cooling limits with the FES deactivated, which was done at the request of the UARS payload representatives. Cabin avionics cooling during this period was marginal, but acceptable.

Performance of pressure control system 1 and 2 was normal. Automatic pressure control was used and performed satisfactorily while operating at 14.7 psia. At 256:22:21:00 G.m.t., the cabin was depressurized to 10.2 psia for prebreathing in preparation for a possible EVA in support of the UARS payload. The cabin remained at this pressure level for 31 1/2 hours.

A high nitrogen flow alarm occurred at 260:14:45:14 G.m.t. The high flow was the result of the regulator flowing near its high flow trigger point during a switchover from 100 psig oxygen to 200 psig nitrogen. When these operating situations happen at the same time, a high flow activation will occur as has been experienced on several previous missions. This alarm was not the result of anomalous equipment operation.

Active Thermal Control System: The active thermal control subsystem operation was satisfactory throughout the mission. FES primary controller A shut down during ascent about 3 minutes after lift-off. The shutdown was caused by the OV-103 unique midpoint manifold and is a known condition. Primary controller B was started successfully and was used until 52 minutes into the flight. Primary controller A was used after that period for normal on-orbit operations and the performance was nominal. The FES was also deactivated during deployment of the UARS as desired by the UARS payload representatives.

Supply and Waste Water Systems: The supply and waste water systems performed adequately throughout the mission. Supply water was managed through the use of the overboard dump system and the FES. Five supply water dumps were performed at an average dump rate of 1.53 percent/minute (2.52 lb/min). The supply water dump line temperature was satisfactorily maintained between 63 °F and 95 °F using the line heaters. Data from the second supply water dump showed momentary supply water dump nozzle temperature drops. The cause of this condition is being evaluated and appears to be the same as on a previous flight of OV-103. One waste water dump was performed with satisfactory results.

Data taken after the bakeout period following the fifth supply water dump showed brief periods of rapid water line and nozzle temperature drops during the nozzle cooldown (Flight Problem STS-48-V-04). Data evaluation indicated water leakage past the supply water dump valve following dump five. An IFM procedure was successfully performed on the third attempt after dump five to isolate and purge the supply water dump line with cabin air. (The first two attempts were unsuccessful because the purge was terminated too early.) The crew was instructed to leave the isolation valve and dump valve closed for the remainder of the mission. The remaining supply water dump requirements were met through the use of the FES. A subsequent detailed review of the data showed several occurrences of water leakage in the water dump 4 and 5 data.

Waste Collection System: The waste collection system performed normally throughout the mission.

Smoke Detection and Fire Suppression Subsystems: The smoke detection and fire suppression subsystems operated normally except for the avionics bay 1 smoke detector B. Two erroneous alarms were generated by this smoke detector (Flight Problem STS-48-V-01). Prior to launch at 255:12:54:40 G.m.t., the astronaut support person reported the annunciation of the onboard fire siren. Further investigation revealed the cause to be avionics bay 1 smoke detector B. However, no off-nominal smoke concentrations were observed on the avionics bay 1 smoke detector B during the time of the alarm. The checkout personnel at KSC reported as many as four other event indications from the avionics bay 1 smoke detector B had occurred over the previous 13 hours (none of which lasted long enough to trip the alarm), and no high smoke concentrations were associated with the events. Prior to lift-off, the avionics bays 1B/3A smoke detector circuit breaker was opened to prevent alarms during ascent. About 1 hour into the mission, the circuit breaker was closed and no alarms were noted. As a precautionary measure, the circuit breaker was opened during sleep periods and closed for crew-awake periods. About 2 days into the flight, the only in-flight alarm of avionics bay 1 smoke detector B caused an intermittent alarm and siren, and the decision was made to open the circuit breaker for the remainder of the mission since redundant detectors were available in avionics bays 1 and 3.

Airlock Support Subsystem: The airlock support system was not exercised this mission as no EVA was required.

Avionics and Software Subsystems

The integrated guidance, navigation, and control subsystem, the flight control system, the inertial measurement units, displays and controls, and the star trackers all performed satisfactorily during the mission. The electrical power distribution and control subsystem performance was adequate, but two electrical motor anomalies were noted. During the ET umbilical door closure activities following ET separation, the centerline latch 1 motor 2 indicated no ac phase B operation (Flight Problem STS-48-V-02). This loss of phase B had no effect on the mission as the motor will operate acceptably on two phases, and this motor was not to be used again during the remainder of the mission.

When the forward RCS manifold 2 isolation valves (LV127 and LV128) were closed after the forward RCS dump following entry, phase C of the ac power showed no current (Flight Problem STS-48-V-06). The same signature was observed in the data when the manifold was opened during postlanding operations. The valves operated in both situations because the normally operated 3-phase valves will also operate on two phases.

During entry at Mach 23, an oscillation was observed in the body flap that lasted 1 minute (Flight Problem STS-48-V-09). The oscillation consisted of three distinct regions of square-wave type motion with a peak-to-peak amplitude of 1.7 degrees and a period of 4 seconds. Due to the longitudinal trim change caused by the body flap motion, the elevons responded with a corresponding oscillation to keep the vehicle properly trimmed. The elevon oscillation had an average peak-to-peak amplitude of 1 degree. Evaluation has shown that the body flap motion was the result of the OI-20 software because the I-load is designed to protect the SSME bells from heating at a midrange center of gravity. The motion was normal for the conditions and had no impact on entry flight operations, although more cycles were observed than predicted.

Communications and Tracking Subsystem

The communications and tracking subsystem performed satisfactorily throughout the mission with only one television camera anomaly identified. A UHF-only communications test was performed at 1 minute 40 seconds after launch to help determine the severity of the SRB plume attenuation at UHF frequencies. Analysis of the onboard and downlink audio tapes indicates that the crew did not hear or respond to the call because of plume attenuation.

Beginning at approximately T-10 minutes in the countdown, a "motorboating" sound effect was present on the A/G 1 and 2 audio links at JSC. The cause was not isolated before it stopped. Subsequent investigation revealed that the delta modulation system (DMS) at the Mission Control Center (MCC) had falsely locked to the downlink signal. The false-lock condition caused a skewing of the voice bit pickup locations in the downlink and was manifested as noise on the A/G loops. The condition was cleared when the Commander keyed his microphone to talk to ground personnel and this caused the DMS to lock-up to the correct synchronization pattern. This same noise was noted during the STS-29 flight and was documented at that time as an explained MCC anomaly.

The Ku-band radar dropped lock several times while being used to support UARS deployment operations, exhibiting the same signature as observed during the STS-39 mission. The radar was turned on for a period of 27 minutes after separation from the satellite. During that period, radar lock was steady with no losses of lock. This condition did not impact this mission.

At 257:23:16 G.m.t., closed circuit television (CCTV) camera D was noted to have full-frame horizontal multicolored lines across the center of the picture (Flight Problem STS-48-V-07). The lines appeared to jitter rapidly up and down over a range of five to six TV lines and caused some degradation in the picture quality. The camera was used when required for the remainder of the mission.

Operational Instrumentation Subsystem

The operational instrumentation performed nominally throughout the mission with no identified anomalies.

Structures and Mechanical Subsystems

All structures and mechanical subsystems performed nominally except ET door centerline latch actuator 1, which operated on only two of three ac bus phases (phases A and C) during ET door closure (Flight Problem STS-48-V-02). This anomaly did not affect door closing and latching operations, nor did it affect the flight in any manner, as this motor was not required to operate during the remainder of the mission.

Main landing gear touchdown occurred on the Edwards Air Force Base concrete runway 22 at a ground speed of 215.7 knots and 1829 feet from the runway threshold. Nose landing gear touchdown occurred 11 seconds later at a ground speed of 172.0 knots approximately 4882 feet from the runway threshold. Braking was initiated at a ground speed of 145.4 knots with wheels stop at 10,702 feet from the runway threshold. The sink rate at main gear touchdown was less than 1 ft/sec and the pitch rate at nose gear touchdown was 2.52 deg/sec. Winds at landing were 6 knots steady from 190 degrees. The rollout was 9513 ft based on Orbiter data and lasted 49 seconds. The Orbiter weight at landing was 192,790 lb.

The brake system operation was satisfactory during the rollout. The maximum brake pressures during the rollout phase ranged from 1110 to 1190 psi on the left main landing gear and 1150 to 1361 psi on the right main landing gear. Brake energies were 26.03 million ft-lb for the left-hand outboard brake, 26.62 million ft-lb for the left-hand inboard brake, 30.45 million ft-lb for the right-hand outboard brake, and 31.64 million ft-lb for the right-hand inboard brake.

After the landing gear hydraulic isolation valve 2 was opened during entry, the hydraulic system 2/3 right outboard main gear brake pressure transducer indicated slightly higher than expected pressure measurements. These measurements reached as high as 172 psi prior to main gear touchdown and that was 30 to 40 psi greater than the other brake pressure transducer readings (prior to main gear touchdown). This problem did not affect the operation of the brakes during rollout.

Remote Manipulator System

The performance of the RMS was excellent throughout the mission. No anomalies were noted and all mission objectives were accomplished. The primary mission objective for the RMS was the deployment of the 14,264 lb UARS.

About 2 1/2 hours into the flight, the RMS was powered up and communications were established with the GPC. The shoulder brace was released satisfactorily and the RMS on-orbit checkout was completed. The payload bay scan of the satellite was completed, the arm was cradled and latched properly, and power was deselected nominally.

At approximately 257:21:41:04 G.m.t., the arm was uncradled to deploy the UARS. By 257:23:26:04 G.m.t., the UARS was in the release position on the end of the RMS. Solar arrays and antenna were deployed and satellite systems were verified. At 258:04:23:08 G.m.t., the UARS was released by the RMS end effector. The UARS release occurred one orbit later than planned to provide additional time to resolve a UARS communications concern.

This mission was the first flight of a redesigned manipulator controller interface unit (MCIU), as well as the first flight of the RMS with the OI-20 software. All RMS payload deployment operations were completed nominally. After releasing the satellite, the RMS was restowed satisfactorily.

Aerodynamics and Heating

The ascent aerodynamics were satisfactory in all aspects. The entry aerodynamics were as expected; however, the elevon schedule varied slightly from the predicted. DTO 249 - Forward RCS Flight Test - was not performed as adequate propellants for the 12-second pulse were not available. Entry heating was nominal in all respects. No heating damage was noted in the postlanding inspection of the vehicle.

Thermal Control Subsystem

The performance of the thermal control subsystem was nominal during all phases of the mission. All temperatures were maintained within acceptable limits, and no anomalies were identified. The starboard OMS pod oxidizer tank temperature measurement was inoperable again during this mission. This measurement failed during prelaunch activities for the STS-39 mission, the previous flight of this vehicle.

Aerothermodynamics

The acreage heating was nominal in all areas with all structural temperatures within limits. The only slumped tiles were found at one wing tip and the nose landing gear door, both of which were expected because of local protuberances. Analysis of the modular auxiliary data system output data is still being performed.

Thermal Protection Subsystem

The thermal protection subsystem (TPS) performance was nominal, based on structural temperature response data and some tile surface measurements. The overall boundary layer transition from laminar to turbulent flow was the earliest transition ever recorded for this vehicle. Transition was asymmetric, occurring 1005 seconds after entry interface on the aft and left side of the vehicle and between 1055 and 1060 seconds after entry interface on the forward and right side of the vehicle. These times are the second earliest boundary-layer-transition times ever recorded on any flight with instrumentation (23 of 43 flights). The earliest transition ever recorded occurred on the STS-28 flight with the OV-102 vehicle, and on that flight, transition occurred 900 seconds after entry interface in the aft section of the vehicle. The early transition on STS-28 was attributed to a protruding gap filler. No evidence has been found on the OV-103 vehicle that would explain the earlier transition times.

A postlanding debris inspection of OV-103 was conducted on September 18 and 19, 1991 in the mate/demate device. The inspection revealed at total of 182 hits had been sustained by the Orbiter. A total of 25 of these hits had a major dimension of 1 inch or greater. The total number of hits does not include the numerous hits on the base heat shield that are attributed to engine vibroacoustics and exhaust plume recirculation.

The inspection showed that the Orbiter lower surface had a total of 100 hits, of which 14 had a major dimension 1 inch or greater. A comparison of these numbers with the statistics from 30 previous missions of similar configuration indicates that the total number of hits on STS-48 was slightly greater than average, and the number of hits 1 inch or greater was slightly less than average.

Twelve of the 14 hits on the lower surface that were 1 inch or greater in dimension were to the right of the Orbiter centerline. This pattern is consistent with ice originating from the ET liquid oxygen feedline bellows and support brackets. No TPS damage was attributed to material from the wheels, tires, or brakes. Although the inboard main landing gear tires exhibited some minor material loss, the main landing gear tires were considered to be in good condition for a concrete runway landing.

Overall, the external inspection of all reusable carbon carbon (RCC) parts revealed nominal flight performance. However, inspections performed in support of the normal turnaround operations for the OV-104 vehicle revealed internal tee-seal cracks. As a result, inspections were also performed on the OV-103 vehicle, and these revealed internal tee-seal cracks. An investigation is being performed of these expansion-seal-material crack issue.

Minor slumping was also observed between the right-hand leading edge structural system (LESS) lower carrier panels 21 and 22. The nose landing gear door TPS was in good condition with the exception of minor slumping of two door tiles and a section of inner moldline barrier that was debonded. The most probable cause for the slumping condition that was observed on the door tiles is the increased heating rates that are a result of the high- inclination, high-altitude orbital trajectory flown coupled with the earlier than normal boundary layer transition.

The forward RCS plume shield barriers showed no evidence of damage. The right-hand main landing gear door aft thermal barrier was split with internal material protruding through the outer cover. Approximately 9 inches of forward thermal barrier also showed evidence of the same damage. The left-hand forward outboard corner tile was broken. Fraying was noted on the outboard forward corner of the thermal barrier, directly opposite the broken corner tile. This condition is typical and occurs on almost every flight, and the cause is not known.

The engine-mounted heat shield thermal curtain was damaged on SSME 1 at the 6 o'clock position. All other engine blankets were in excellent condition. Slight haze was identified on windows 1, 2, 5, and 6. Heavy hazing was observed on windows 3 and 4. A larger than previously observed number of damage sites was noted on the perimeter tiles of Orbiter windows 1 through 6. Most of the impact sites were only coating losses or were no more than 1/16 inch deep. The source of this damage is still being evaluated. The ET door thermal barrier performed nominally. The upper fuselage, payload bay doors, upper wings, and OMS pods TPS performance was nominal. Damage to the base heat shield tiles was less than average.

A cluster of seven hits with one larger than 1 inch was present on the leading edge of the vertical stabilizer near the root. Damage in this area is uncommon, and the source of the damage is still being evaluated.

FLIGHT CREW EQUIPMENT

The performance of the flight crew equipment was satisfactory except for the Linhoff camera which the crew reported inoperative at 259:23:15 G.m.t. The third film magazine to be used was not transporting film, and all other camera indications were normal. The crew performed an IFM procedure, but without success. The camera and magazine were stowed for the remainder of the flight.

During the technical debriefing, the crew reported that a water leak existed around galley valve MV-2 (Flight Problem STS-48-V-08). The leak was found during the flight day 5 presleep activities and during postsleep activities on flight day 6. Approximately 4 ounces of water was wiped from the MV-2 temperature controller valve each day. This anomaly did not affect the mission in any manner.

EXTRAVEHICULAR ACTIVITY

On flight day 2, the crew performed extravehicular mobility unit (EMU) checkout in preparation for a possible EVA in support of the UARS payload, should its deployment not progress satisfactorily. The oxygen bottles and batteries were charged to full capacity, and no anomalies were noted during the checkout. On flight day 3, the EMU's were again powered up for the potential EVA following UARS deployment. During this time, communications to and from both units and the Orbiter were verified. During these checks, real-time data were received from both units. Following the successful deployment of the UARS payload, the EMU's were restowed in the airlock.

PAYLOADS

The STS-48 mission payloads and experiments are discussed in the following paragraphs.

UPPER ATMOSPHERE RESEARCH SATELLITE

The UARS is the United States' first major flight element of NASA's Mission to Planet Earth, a multiyear global research program that will use ground-based, airborne, and space-based instruments to study the earth as a complete environmental system. UARS will help scientists learn more about the fragile mixture of gases that protects the earth from the harsh environment of space. Additionally, UARS will provide scientists with their first complete data set on the upper atmosphere chemistry, winds, and energy inputs.

The UARS was deployed in a 307 nmi. circular orbit at 258:04:23:08 G.m.t. No anomalies were noted during the deployment process. The satellite has been verified to be operating properly and will soon begin its data collection mission.

PROTEIN CRYSTAL GROWTH

The objective of the protein crystal growth (PCG) experiment was to demonstrate techniques for producing protein crystals for diffraction analysis. This payload was located in the middeck of the Orbiter. During flight day 1, the PCG experiment was activated. Photographs showed droplets on the syringe tip for some samples as planned, but other samples showed the plugs in contact with the protein droplets. The crew retracted the droplets in the syringes, retracted the plugs, and redeployed the droplets. Six samples were nominal with full droplets on the syringe tips. The deactivation procedures were modified to use camcorder video to downlink data which showed the protein solution on the plug surfaces. This provided positive information to the customer, and postflight analysis will determine the success of this experiment.

MIDDECK ZERO-GRAVITY DYNAMICS EXPERIMENT

The objective of the middeck zero-gravity dynamics experiment (MODE-1) was to study the mechanical and fluid behavior of components for Space Station Freedom and future spacecraft. The MODE-1 operations were very successful. All four fluid test articles (FTA) were tested, and all four structural test articles (STA) configurations were assembled and tested. Over a period of 2 1/2 days, the crew completed six planned FTA protocols, and eight planned and five unplanned STA protocols. Live video downlink of FTA and STA activities provided valuable and timely confirmation of predicted MODE-1 behavior.

PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT

The objective of the physiological and anatomical rodent experiment (PARE-1) was to study muscle atrophy in microgravity. The required observations were performed from flight day 1 to flight day 6 as planned per the nominal flight plan. Results of the PARE-1 experiment will be published by the experiment sponsor.

SHUTTLE ACTIVATION MONITOR

The objective of the Shuttle activation monitor (SAM-03) is to measure gamma ray data in the Orbiter as a function of time and location. The SAM-03 experiment operations were nominal throughout the flight with the exception of two problems. On flight day 2, the crew discovered that the signal cable was disconnected. The crew reconnected the cable. On flight day 3, a data tape failed to advance. Appropriate procedures were followed to correct the problem. The crew was able to perform an unscheduled tape turnover during the UARS activities and acquired six additional hours of data.

RADIATION MONITORING EQUIPMENT-III

The objective of the radiation monitoring equipment-III (RME-III) was to measure the ionizing radiation exposure to the crew within the Orbiter cabin. The RME-III was activated on flight day 1 and repositioned on flight day 2 and 4, RME-III was stowed on flight day 6 while still powered on for data collection through postlanding. All operations occurred according to the nominal plan.

COSMIC RADIATION EFFECTS AND ACTIVATION MONITOR

The objective of the cosmic radiation effects and activation monitor (CREAM) was to collect data at specific locations throughout the Orbiter cabin on cosmic ray energy loss spectra, neutron fluxes, and induced radioactivity. The CREAM was activated on flight day 1, repositioned on flight day 2 and 4, and stowed on flight day 5. All operations occurred according to the nominal flight plan.

AIR FORCE MAUI OPTICAL SYSTEM

The objective of the Air Force Maui optical system (AMOS) experiment was to use ground-based infrared and optical sensors to track the Orbiter to calibrate sensors at the facility. No AMOS sighting opportunities existed during the mission.

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

The objective of the investigations into polymer membrane processing (IPMP-04) experiment was to investigate the physical and chemical processes that occur during the formation of polymer membranes in microgravity. All IPMP-04 operations were successfully completed per the nominal flight plan on flight day 2.

ASCENT PARTICLE MONITOR

The objective of the ascent particle monitor (APM) experiment was to measure particle contamination in the payload bay during the prelaunch period and ascent. The APM is assumed to have functioned nominally on ascent. An on-orbit video survey of the payload bay verified that the APM door was in the closed position.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY EVALUATION

On launch day, 24 of the 25 expected videos of launch were screened and no anomalies were noted. On the day following launch, 63 of the expected 65 launch films were reviewed and again, no anomalies were noted. Significant items noted in the launch data were:

a. A large amount of possible free burning hydrogen that originated from under the Orbiter and went between the body flap and the SRB's.

b. Two large flares in the SSME plume at 28.878 seconds and 31.347 seconds after lift-off.

c. Five pieces of dark debris falling from the left SRB stud hole of holddown plate M-5 (none of the debris appeared to strike the vehicle).

d. Three pieces of white debris falling along the right SRB plume at 6.14 seconds after lift-off. At 20.45 seconds after lift-off, a large piece of white debris of undetermined origin was first seen between the upper third of the right SRB and the ET, and then the debris fell aft along the vehicle.

LANDING PHOTOGRAPHY EVALUATION

Four landing videos and NASA Select were reviewed and analyzed. No significant events were noted during the screening.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

Eight DTO's were scheduled for the STS-48 mission. Six of these DTO's were accomplished. DTO 0249 and 0312 were not accomplished.

Ascent Development Test Objectives

DTO 0301D - Ascent Wing Structural Capability Evaluation - Data were collected for this DTO. The analysis and results of this DTO will be published by the sponsor.

DTO 0305D - Ascent Compartment Venting Evaluation - Data were collected for this DTO. The analysis and results of this DTO will be published by the sponsor.

DTO 0308D - Vibration and Acoustic Evaluation - Data were collected for this DTO. The analysis and results of this DTO will be published by the sponsor.

DTO 0312 - ET TPS Performance (Method 2) - This DTO was not accomplished because it was too dark to produce usable photographic data.

On-Orbit Development Test Objectives

DTO 0648 - Electronic Still Photography Test - The ESC performed very well. The camera downlink cable became disconnected. An IFM was performed and the camera continued to downlink satisfactory photography.

DTO 0656 - PGSC Single Event Upset Monitoring - This DTO was apparently completed and the data are in the hands of the sponsor who will publish the results.

Entry/Landing Development Test Objectives

DTO 0249 - Forward RCS Flight Test (12-Second Pulse) - Inadequate fuel remained to meet minimum placard requirements. As a result, the DTO was not accomplished.

DTO 0306D - Descent Compartment Venting Evaluation - Data were collected for this experiment, and the data have been given to the sponsor. The sponsor will publish the results of the DTO.

DETAILED SUPPLEMENTARY OBJECTIVES

All 13 DSO/s were apparently accomplished.

DSO 0318 - Effects of Radiation on Photographic Film - This DSO was apparently performed and the data will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0469 - In-Flight Radiation Dose-Distribution, Configuration 2 - This DSO was apparently performed and the data will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0479 - Hyperosmotic Fluid Countermeasure - This DSO is related to the Extended Duration Orbiter (EDO). Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0602 - Blood Pressure Variability During Spaceflight - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0603 - Orthostatic Function During Entry, Landing and Egress - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0604 - Visual/Vestibular Integration as a Function of Adaptation - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0608 - Effects of Spaceflight on Metabolism at Rest and During Exercise - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0611 - Air Monitoring Instrument Evaluation and Atmosphere Characterization - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0613 - Changes in the Endocrine Regulation of Orthostatic Tolerance Following Spaceflight - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0614 - Effect of Spaceflight on Head and Gaze Stability During Locomotion - This DSO is related to the EDO. Data were apparently collected and will be evaluated by the sponsor. The sponsor will publish the results at a later date.

DSO 0901 - Documentary Television - This DSO was completed and data are being evaluated by the sponsor.

DSO 0902 - Documentary Motion Picture Photography - This DSO was completed and data are being evaluated by the sponsor.

TABLE I.- STS-48 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	255:23:06:19.11
	APU-2 GG chamber pressure	255:23:06:20.35
	APU-3 GG chamber pressure	255:23:06:21.50
SRB HPU activation	LH HPU system A start command	255:23:10:36.19
	LH HPU system B start command	255:23:10:36.35
	RH HPU system A start command	255:23:10:36.51
	RH HPU system B start command	255:23:10:36.63
Main propulsion System start	Engine 3 start command accepted	255:23:10:57.462
	Engine 2 start command accepted	255:23:10:57.585
	Engine 1 start command accepted	255:23:10:57.679
SRB ignition command (lift-off)	SRB ignition command to SRB	255:23:11:04.005
Throttle up to 100 percent thrust	Engine 3 command accepted	255:23:11:08.026
	Engine 2 command accepted	255:23:11:08.022
	Engine 1 command accepted	255:23:11:08.000
Throttle down to 89 percent thrust	Engine 3 command accepted	255:23:11:25.120
	Engine 2 command accepted	255:23:11:25.143
	Engine 1 command accepted	255:23:11:25.147
Throttle down to 67 percent thrust	Engine 3 command accepted	255:23:11:32.161
	Engine 2 command accepted	255:23:11:32.183
	Engine 1 command accepted	255:23:11:32.188
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	255:23:11:53
Throttle up to 104 percent thrust	Engine 3 command accepted	255:23:12:03.841
	Engine 2 command accepted	255:23:12:03.865
	Engine 1 command accepted	255:23:12:03.871
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	255:23:13:04.37
	RH SRM chamber pressure mid-range select	255:23:13:02.50
End SRM action	LH SRM chamber pressure mid-range select	255:23:13:06.32
	RH SRM chamber pressure mid-range select	255:23:13:05.16
SRB separation command	SRB separation command flag	255:23:13:09
SRB physical separation	SRB physical separation	255:23:13:09.49
Throttle down for 3g acceleration	Engine 3 command accepted	255:23:18:32:324
	Engine 1 command accepted	255:23:18:32.333
	Engine 2 command accepted	255:23:18:32.342
3g acceleration	Total load factor	255:23:18:33
MECO	MECO command flag	255:23:19:39
	MECO confirm flag	255:23:19:39
ET separation	ET separation command flag	255:23:19:57
OMS-1 ignition	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown

TABLE I.- STS-48 SEQUENCE OF EVENTS (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	255:23:24:49.14
	APU-2 GG chamber pressure	255:23:24:49.68
	APU-3 GG chamber pressure	255:23:24:51.49
OMS-2 ignition	Left engine bi-prop valve position	255:23:54:44
	Right engine bi-prop valve position	255:23:54:44
OMS-2 cutoff	Left engine bi-prop valve position	255:23:59:11
	Right engine bi-prop valve position	255:23:59:11
Payload bay door open	PLBD right open 1	256:00:44:45
	PLBD left open 1	256:00:46:04
TDRS/IUS Deployment	Voice call	258:04:23:08
Flight control system checkout		
APU start	APU-2 GG chamber pressure	260:00:37:41.81
APU stop	APU-2 GG chamber pressure	260:00:43:51.60
Payload bay door close	PLBD left close 1	261:02:21:68
	PLBD right close 1	261:02:22:52
APU activation for entry	APU-1 GG chamber pressure	261:06:54:45.69
	APU-2 GG chamber pressure	261:06:54:46.63
	APU-3 GG chamber pressure	261:06:23:13.63
Deorbit maneuver ignition	Left engine bi-prop valve position	261:06:28:14.2
	Right engine bi-prop valve position	261:06:28:13.9
Deorbit maneuver cutoff	Left engine bi-prop valve position	261:06:32:39.9
	Right engine bi-prop valve position	261:06:32:39.9
Entry interface (400k)	Current orbital altitude above reference ellipsoid	261:07:07:43
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	261:07:32.22
Main landing gear contact	LH MLG tire pressure	261:07:38:42.34
	RH MLG tire pressure	261:07:38:42.34
Main landing gear weight on wheels	LH MLG weight on wheels	261:07:38:43.35
	RH MLG weight on wheels	261:07:38:42.23
Nose landing gear contact	NLG tire pressure	261:07:38:53.20

TABLE I.- STS-48 SEQUENCE OF EVENTS (CONCLUDED)

Event	Description	Actual time, G.m.t.
Nose landing gear weight on wheels	NLG WT on Wheels -1	261:07:38:53.24
Wheels stop	Velocity with respect to runway	261:07:39:31.62
APU deactivation	APU-1 GG chamber pressure	261:07:57:04.91
	APU-2 GG chamber pressure	261:07:57:06.08
	APU-3 GG chamber pressure	261:07:57:07.52

TABLE II.- STS-48 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-48-V-01	Smoke Detector B Avionics Bay 1 False Alarms	Prelaunch PR ECL-3-A0039 IM 48RF01	Received several false smoke alarms. Circuit breaker out during ascent and crew sleep periods. On-orbit at 1 day 21 hours 16 minutes MET, another false smoke alarm occurred. The circuit breaker was pulled by the crew to avoid nuisance alarms. KSC: Remove and replace smoke detector and send to vendor for troubleshooting and repair. Activity has been completed.
STS-48-V-02	ET Door Centerline Latch 1 Motor 2 Phase B Failure	255:23:33 G.m.t. IPR 42V-0001 IM 48RF02	During ET umbilical door closing, centerline latch 1 motor 2 showed no phase B operation. No impact to unlatching. KSC: Standard troubleshooting. No chit required. Troubleshooting began October 1, 1991. Removal and replacement of aft MCA 2 was performed as a result of troubleshooting.
STS-48-V-03	Fuel Cell 1 Oxygen Reactant Valve Closed Indication	257:00:14 G.m.t. IPR 42V-0004 IM 48RF03	Valve status suddenly showed closed at the time listed. No corresponding decrease in oxygen flow or fuel cell coolant pressure verified that the valve was open. Main A and Main B busses were tied together in case of hard failure. At 258:09:16 G.m.t. G.m.t., the talkback indicated OPEN (at the same time oxygen manifold 1 valve was closed for presleep). Crew confirmed the onboard talkback was indicated OPEN. Main A and Main B remained tied together until the deorbit preparations. KSC: Troubleshooting beginning 10/17 to be performed prior to removal and replacement. Unable to repeat anomaly during troubleshooting. Community to propose to fly as is.
STS-48-V-04	Supply Water Dump Valve Leakage	259:11:10 G.m.t. IM 48RF04 UA-3-A0019	During the two post-bakeout periods following supply dump 5, the supply water line and nozzle temperatures indicated water leakage past the dump valve. Line purged downstream of isolation valve. Data evaluation also shows leakage following supply dump no. 4. KSC: Remove and replace dump valve, line, and nozzle and send to JSC. Walk-down inspection and leak check to be performed before removal and replacement of valve. Troubleshooting completed as well as removal and replacement.
STS-48-V-05	Hydraulic System 2 Unloader Valve Leakage	258:10:16 G.m.t. IPR 42V-0007 IM48RF05	Accumulator was recharged four times with circulation pumps and showed pressure decay as high as 369 psi/hr (specification = 48 psi/hr) Decay came back in specification after FCS checkout. KSC: Standard turnaround troubleshooting.
STS-48-V-06	Forward RCS Manifold Valve 2 Phase C Down	261:06:50 G.m.t. IPR 42V-0005	Forward manifold 2 isolation valves (LV127, LV128) cycled on two-phase power. No current was shown on C phase for both the open and close of valves. Troubleshooting began 10/1. Unable to repeat problem. Possibility that circuit breaker cycle cleared contamination.
STS-48-V-07	CCTV Camera D Line Across Screen (GFE)	258:01:00 G.m.t. BFCE-029-F039	Camera D showed a horizontal line across the image approximately one-third of the way from the top. LEVEL III CLOSURE ONLY. KSC: Remove camera, deliver to FEPC.
STS-48-V-08	Leak at Galley Valve MV-2 (GFE)	BFCE-023-F009 PR-FCS-3-14-0439	During the presleep period on flight day 5 and the postsleep period on flight day 6, approximately 4 oz of water (each day) was wiped from the MV2 temperature controller valve. KSC: No chit required. Troubleshooting plan has been completed.

TABLE II.- STS-48 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-48-V-09	Extraneous Body Flap	Mach 23	Body flap motion caused by the OI-20 I-load designed to protect the the engine bells from heating at a mid c.g. range. Expected motion.

NASA Headquarters
QP/B. Greenly
QP/R. Perry
QT/M. Greenfield
MA/R. L. Crippen
MCF/D. Hedin
MO/J. M. Boze
MO/J. E. Sidwell
MO/G. H. Ulbrich
MOJ/C. Perry
MP/H. T. Staples
ML/W. Hamby
MES/N. Frandsen
Q-1/G. L. Roth

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

KSC
NWSI-D/Respository (25)
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 (5)

Rockwell-Houston
R12A-130/J. C. Snowden
R12A-130/J. P. Shea
ZC01/C. Ritrivi
R16D/J. Woodard
R20B/R. Pechacek
R20B/K. M. Rahman

JSC
AA/A. Cohen
AC/D. A. Nebrig
AC5/J. W. Young
AP3/J. E. Riley (4)
AP4/B. L. Dean (3)
BL/W. L. Draper
BY4/History Office (2)
CA/D. R. Puddy
CA4/R. Filler
CA4/J. Williams
CB/D. Brandenstein (10)
CB/K. Colgan
CB/S. Nagel (5)
CB/T. Henricks
DA/Library
DA15/D. Nelson
DA2/T. W. Holloway
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/R. D. Snyder
DH411/E. B. Pippert
DH4/J. F. Whitely
DH45/M. LeBlanc
DG47/Sim Sup's
DG66/H. Lampazzi
DM/J. C. Harpold
DM/C. F. Deiterich
EA/H. O. Pohl
EC/W. E. Ellis
EC/F. H. Samonski
EC3/D. F. Hughes
EC2/M. Rodriguez
EC4/L. O. Casey
EC3/E. Winkler
EC3/H. Rotter (2)
EC6/J. W. McBarron (5)
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/K. J. Cox
EG2/L. B. McWhorter
EG2/K. D. Frank
EG3/R. Barton
EG3/P. Romere
EG3/S. Derry
EG4/J. E. Yeo
EK5/W. N. Trahan
EP/C. A. Vaughn
EP2/H. J. Brasseaux
EP2/L. Jenkins
EP5/T. L. Davies
EP5/N. Faget
ER/W. W. Guy
ES/D. C. Wade
ES/W. G. McMullen (2)
ES/J. A. Smith
ES3/C. R. Ortiz
ES3/Y. C. Chang
ES3/P. Serna
ES6/C. W. Norris (2)
ET/C. A. Graves, Jr. (8)
EK/SSD Library
DJ/J. W. Seyl (2)
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/J. Bates
VA/D. M. Germany
VA/J. C. Boykin
VE4/W. H. Taylor
VF/D. W. Camp
VF/E. R. Hischke
VF2/W. J. Gaylor
VF2/J. W. Mistrot
VF2/C. Critzos
VF2/R. Brasher
VF2/K. E. Kaminski (25)
VF3/M. T. Suffredini (10)
VF3/T. Welch
VF3/M. Engle
VF5/H. Kolkhorst
VG/F. Littleton
VK/C. G. Jenkins
VP/C. McCullough (3)
VP12/D. Fitts
VR/D. D. Ewart
WA/L. G. Williams
WC/L. D. Austin
WE/R. D. White
WG/W. J. Moon
C07/LESC Library
ZR/Lt. Col. J. McLeroy
ZR12/J. A. Yannie
BARR/J. White
BARR/H. Jones
BARR/R. Hennan
ECHS/Hamilton Standard

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

Russell A. Larson
Mail Stop 4A
Charles Stark Draper Lab. Inc.
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

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

R. Hoey
6510 Test Wing/TEG/236
Edwards AFB, CA 93523

Headquarters, Space Div
Attn.: SSD/CLP
Los Angeles AF Station
P. O. Box 92960
Worldway Postal Center
Los Angeles, CA 90009

John Williams
1995 Ferndale Place
Thousands Oaks, CA 91360

C. Woodland, Prog. Mgr.
SPAR Aerospace Limited
1235 Ormond Drive
Weston, Ontario
Canada, M9L 2W6

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

A. S. Jones (2)
SPAR Aerospace Limited
1235 Ormont Dr.
Weston, Ontario,
Canada M9L 2W6

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

N. Parmet
5907 Sunrise Drive
Fairway, Kansas 66205

R. Peterson
Mail Stop 351-4A
Honeywell Inc.
13350 Hwy 19
Clearwater, FL 34624

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

McDonnell Douglas-Houston
D2/M. D. Pipher
T3A/A. D. Hockenbury

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

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

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

Commanding General
U. S. Army Logistics Center
Attn: ATCL-PS/Col. Senegal
Ft. Lee, VA 238001-6000

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

R. A. Colonna (2)
U. S. Embassy
Box 14
APO AP 96549

LESC-Houston
C12/D. Harrison
C12/R. W. Fricke (5)

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

Notify VF4/R. W. Fricke (FTS-525-3313) of any correction, additions, or deletions to this list.