NASA-TM-108735

NASA-TM-108,735

NSTS-08273

NASA-TM-108735 19930016799

STS-44 SPACE SHUTTLE MISSION REPORT

(NASA-TM-108735) STS-44 SPACE SHUTTLE MISSION REPORT (Lockheed Engineering and Sciences Co.) 32 p

N93-25988

Unclas

G3/16 0163539

January 1992

NASA
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Solid Rocket Motors (RSRM's) installed in each one of the SRB's were designated as 360L019A for the left SRB and 360W019B for the right SRB. The primary objective of the STS-44 mission was to successfully deploy the Department of Defense (DOD) Defense Support Program (DSP) satellite/inertial upper stage (IUS) into a 195 nmi. earth orbit at an inclination of 28.45 deg. Secondary objectives of this flight were to perform all operations necessary to support the requirements of the following: Terra Scout, Military Man in Space (M88-1), Air Force Maui Optical System Calibration Test (AMOS), Cosmic Radiation Effects and Activation Monitor (CREAM), Shuttle Activation Monitor (SAM), Radiation Monitoring Equipment-3 (RME-3), Visual Function Tester-1 (VFT-1), and the Interim Operational Contamination Monitor (IOCM) secondary payloads/experiments.

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93N25988*#   ISSUE 9   PAGE 2612   CATEGORY 16

RPT#: NASA-TM-108735 NAS 1.15:108735 NSTS-08273   92/01/00   32 PAGES

UNCLASSIFIED DOCUMENT

UTTL: STS-44 Space Shuttle mission report

AUTH: A/FRICKE, ROBERT W.

CORP: Lockheed Engineering and Sciences Co., Houston, TX.   CSS: (Flight Evaluation Section.)

SAP: Avail: CASI HC A03/MF A01

CIO: UNITED STATES Sponsored by NASA. Lyndon B. Johnson Space Center

MAJS: /*ATLANTIS (ORBITER)/*SPACE MISSIONS/*SPACE SHUTTLES/*SPACE TRANSPORTATION SYSTEM FLIGHTS

MINS: / CALIBRATING/ DEFENSE PROGRAM/ EARTH ORBITS/ EXTERNAL TANKS/ INERTIAL UPPER STAGE/ RADIATION EFFECTS/ SPACE SHUTTLE BOOSTERS

ABA: Author (revised)

ABS: The STS-44 Space Shuttle Program Mission Report is a summary of the vehicle subsystem operations during the forty-fourth flight of the Space Shuttle Program and the tenth flight of the Orbiter vehicle Atlantis (OV-104). In addition to the Atlantis vehicle, the flight vehicle consisted of the following: an External Tank (ET) designated as ET-53 (LWT-46); three Space Shuttle main engines (SSME's) (serial numbers 2015, 2030, and 2029 in positions 1, 2, and 3, respectively); and two Solid Rocket Boosters (SRB's) designated as BI-047. The lightweight redesigned

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STS-44

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke
LESC/Flight Evaluation Section

Approved by

David W. Camp
Manager, Flight Data and
Evaluation Office

D. M. Germany
Manager, Orbiter and GFE Projects

Leonard S. Nicholson
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

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INTRODUCTION

The STS-44 Space Shuttle Program Mission Report is a summary of the vehicle subsystem operations during the forty-fourth flight of the Space Shuttle Program and the tenth flight of the Orbiter vehicle Atlantis (OV-104). In addition to the Atlantis vehicle, the flight vehicle consisted of an External Tank (ET) designated as ET-53 (LWT-46); three Space Shuttle main engines (SSME's) (serial numbers 2015, 2030, and 2029 in positions 1, 2, and 3, respectively); and two Solid Rocket Boosters (SRB's) designated as BI-047. The lightweight redesigned Solid Rocket Motors (RSRM's) installed in each one of the SRB's were designated as 360L019A for the left SRB and 360W019B 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 STS-44 mission was to successfully deploy the Department of Defense (DOD) Defense Support Program (DSP) satellite/inertial upper stage (IUS) into a 195 nmi. earth orbit at an inclination of 28.45 degrees. Secondary objectives of this flight were to perform all operations necessary to support the requirements of the Terra Scout, Military Man in Space (M88-1), Air Force Maui Optical System Calibration Test (AMOS), Cosmic Radiation Effects and Activation Monitor (CREAM), Shuttle Activation Monitor (SAM), Radiation Monitoring Equipment-III (RME-III), Visual Function Tester-1 (VFT-1), and the Interim Operational Contamination Monitor (IOCM) secondary payloads/experiments.

The sequence of events for the STS-44 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 MSFC-assigned tracking number is also shown.

The crew for this forty-fourth Space Shuttle flight was Frederick D. Gregory, Col., USAF, Commander; Terence T. Henricks, Col., USAF, Pilot; James S. Voss, Lt. Col., USA, Mission Specialist 1; F. Story Musgrave, Ph.D., Mission Specialist 2; Mario Runco, Jr., Lt. Cmdr., USN, Mission Specialist 3; and Thomas J. Hennen, CWO, USA, Payload Specialist. STS-44 was the third flight for the Commander, the fourth flight for Mission Specialist 2, and the first flight for the remaining four crew members.

MISSION SUMMARY

The first launch attempt occurred on November 19, 1991, but the attempt was scrubbed because of erratic operation of the inertial upper stage (IUS) redundant inertial measurement unit (RIMU). The RIMU was removed, replaced, and the launch of the STS-44 vehicle occurred at 328:23:44:00.006 G.m.t. (6:44:00 p.m. e.s.t.) from launch pad A at KSC on November 24, 1991, with a total vehicle weight of 4,522,272 lb. Lift-off occurred 13 minutes later than planned because of a liquid oxygen stop-flow condition that was required to correct a ground facility liquid oxygen replenish valve leak.

Main engine cutoff (MECO) occurred at 328:23:52:29.72 G.m.t. The ET was separated satisfactorily at the planned time. The first orbital maneuvering subsystem (OMS-1) maneuver was not planned nor conducted because of the direct insertion trajectory that was flown. Ignition for the OMS-2 maneuver occurred at 329:00:24:48.23 G.m.t., and cutoff occurred at 329:00:27:52.02 G.m.t. The 183.79-second maneuver imparted a differential velocity of 286.1 ft/sec.

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. Performance of the SSME's, ET, and main propulsion system (MPS) was also normal.

An examination of prelaunch and flight data shows that all Orbiter, SRB, ET, and SSME subsystems performed properly during ascent, and all launch objectives were accomplished. A determination of the vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) determined for the time period between SRB separation and the start of 3-g throttling was 451.4 seconds.

The DSP/IUS satellite deployment occurred successfully at 329:06:03 G.m.t. Following the successful deployment, the OMS-3 maneuver was performed at 329:06:17:46.5 G.m.t. This maneuver was 16.4 seconds in duration and imparted a differential velocity of 30.2 ft/sec.

The two DSP/IUS burns were successfully completed with nominal results, and the DSP was inserted into a geosynchronous orbit.

For the first time on a Shuttle flight, the water cooling loop bypass valve temperature controller was placed in the automatic position. The performance of the valve in the automatic mode was satisfactory. With the water bypass valve in the automatic position, the crew was able to maintain more acceptable cabin temperatures than on previous missions.

After supply water dumps 2 and 4, data indicated internal leakage through the supply water dump valve. An IFM procedure was successfully performed after supply water dump 4 to isolate and purge the supply water dump line with cabin air. The remaining supply water dumps were made through the FES.

A 7-second retrograde reaction control subsystem (RCS) firing was performed at 332:22:10 G.m.t. to avoid space debris (Cosmos 851) that would be near the Orbiter during the following sleep period.

At 334:15:14 G.m.t., the inertial measurement unit (IMU) 2 registered redundant-rate and velocity-fail BITE indications. Subsequently, IMU 2 was "voted" failed by redundancy management software. The IMU was taken to standby, then operate, and the power was cycled, all in an unsuccessful attempt to recover the IMU. This failure invoked the flight rule requiring a minimum duration flight for loss of one IMU.

As a result of the IMU 2 failure and the decision to perform a minimum duration mission, the RCS hot-fire was performed, beginning at 334:20:55 G.m.t. All thrusters were fired twice and exhibited nominal performance.

Following the RCS hot-fire test, the flight control system (FCS) checkout was satisfactorily performed at 334:21:19:05.76 G.m.t. APU 2 ran for 8 minutes 43.15 seconds during the checkout, and approximately 20 lb of fuel was consumed.

The payload bay doors were closed at 335:18:46:55.49 G.m.t. The crew completed experiment operations, as well as entry preparations and stowage. Ignition for the deorbit maneuver occurred at 335:21:28:16.22 G.m.t. The maneuver was 183.01 seconds in duration and the differential velocity was 355.6 ft/sec. Entry interface occurred at 335:22:03:23 G.m.t.

Main landing gear touchdown occurred at Edwards Air Force Base lakebed runway 5 at 335:22:34:42.77 G.m.t. Nose landing gear touchdown occurred 8 seconds later with wheels stop at 335:22:36:28.7 G.m.t. Preliminary indications are that the rollout was normal in all respects with the crew not applying brakes until the Orbiter speed reached 15 knots. The flight duration was 6 days 22 hours 52 minutes 28 seconds. The APU's were shut down by 335:22:52:15.39 G.m.t., and the crew completed the required postflight reconfigurations and departed the Orbiter landing area at 335:23:27 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 (Atlantis).

SOLID ROCKET BOOSTER/REDESIGNED SOLID ROCKET MOTOR

All SRB systems 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 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 were performed properly. Five SRB/RSRM anomalies were identified during the data review and postflight visual inspection of the hardware. No SRB or RSRM launch commit criteria (LCC) or Operations and Maintenance Requirements and Specification Document (OMRSD) violations occurred.

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 in the SRB aft skirt was powered up and maintained the case/nozzle joint temperature within the required LCC ranges. On November 19, 1991, the aft skirt gaseous nitrogen purge heater failed during the first power-up at L-12 hours and 24 minutes. The heater was repaired and functioned normally following activation on November 24 at L-10 hours and 51 minutes.

The flight performance of both RSRM's was well within the allowable performance envelopes and was typical of the performance observed on previous flights. The following table provides data for the primary propulsion parameters.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 73 °F		Right motor, 73 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.39	64.53	65.53	64.33
I-60, 10^6 lbf-sec	174.42	173.02	174.75	172.65
I-AT, 10^6 lbf-sec	296.83	296.45	297.07	297.24
Vacuum Isp, lbf-sec/lbm	268.5	268.2	268.5	268.7
Burn rate, in/sec	0.3671	0.3650	0.3673	0.3642
Event times, seconds				
Ignition interval	0.232	N/A	0.232	N/A
Web time	110.1	110.8	110.0	111.5
Action time	122.5	123.4	121.8	123.5
Separation cue, 50 psia	119.9	121.4	119.7	120.9
PMBT, °F	73.0	73.0	73.0	73.0
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	2.7	2.8	3.4
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 634.7	

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

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

Both SRB's were successfully separated from the ET at 126.6 seconds after lift-off. The entry and deceleration sequence was properly performed on both SRB's. RSRM nozzle jettison occurred after frustum separation, and subsequent parachute deployments were successfully performed.

During the SRB recovery operations, the retrieval team reported structural damage to the left SRB forward skirt, systems tunnel, and External Tank Attach (ETA) ring (Flight Problem STS-44-B-1). Varying degrees of structural damage were also observed on the left RSRM forward and forward center motor segments, as well as the aft and forward ET flanges. The postflight inspection revealed major structural damage to the following areas:

a. The forward skirt was buckled over a 150-degree circumferential distance, from the +Z axis through the systems tunnel (-Y axis) on toward the -Z axis. Cracks were observed around the buckled areas ranging from 8 inches to 19 inches across.

b. The Shuttle Range Safety System (SRSS) antenna was missing from the +Z axis side. The antenna found later floating nearby in the ocean and it was retrieved.

c. The left SRB systems tunnel forward feed-through cover closeout was cracked on the -Z side. The first cover was severely damaged in the area of the forward skirt buckle. The K5NA closeout was missing from between covers 4 and 5. Cover 6 had a 4 in^2 area divot with a clean substrate, and the aft end of cover 12 was buckled and fasteners on the -Z side were broken.

d. The left SRB ETA ring was buckled along all segments of the forward and aft webs with ring caps cracked and numerous fasteners either broken or missing. The failed fasteners are located on either side of the +Z and -Z axes. The ring was also separated from the web at several locations circumferentially.

All of the left SRB damage was mapped and the data were supplied to the anomaly investigation team. Postflight investigations assured that there were no ascent or separation conditions that might have contributed to these observations, and thus there are no flight safety issues or constraints for subsequent flights. All observed damage is attributed to loads imposed on the SRB at water impact/slapdown as a result of high winds and sea conditions in the recovery area.

Only two descent phase loads exist that could cause SRB structural damage; drogue parachute deployment and water impact/slapdown. It is improbable that the drogue parachute deployment loads caused the damage as the STS-44 ninety ninth percentile load case could not generate the loads required to cause this failure; therefore, the most probable cause of the failure was conditions that occurred at water impact/slapdown.

In addition to the left SRB damage, the left RSRM exhibited varying degrees of structural damage on the forward and forward center segments, as well as the aft and forward ET flanges (Flight Problem STS-44-M-1). The left RSRM forward segment had visible case deformation on the aft cylinders at two locations, and the center forward segment had visible damage at five locations. Outer ligament cracks existed on the forward ET flange at 211 degrees and on the aft flange at 212 degrees. The holes were elongated on the outboard side. Visual deformation existed on both ET flanges at approximately 330 degrees. The forward flange is bent approximately 0.20-inch aft over a span of 5 degrees. The aft flange is bent approximately 0.12-inch forward over a span of 4 degrees.

The major buckling damage at approximately station 980 was caused by a bending load on the motor. A bending moment of over 500,000,000 in-lb is required to buckle the case. The parachute loads can generate a maximum load of less that 200,000,000 in-lb, assuming the worst case loading condition. No identified preflight or flight load can cause a significant bending moment at this location. No damage occurred on the aft end of the motor (stiffener segments, aft dome, nozzle, and aft skirt), suggesting that the aft end of the motor did not hit the water in a normal vertical attitude. As a result of the analysis, previous experience, and the physical evidence, it was concluded that the damage occurred after motor operation and the most likely scenario is that the damage was the result of water impact.

The postflight inspection of the left SRB also revealed that the aft booster separation motor (BSM) system A firing-line cable connector had two recessed socket contacts (Flight Problem STS-44-B-3). The functional integrity of the cable was verified through the launch countdown. The anomalous connector was found in line with the ETA ring damage, and the cable was pushed inward and the tie wrap was broken. The cable had functioned properly during STS-44 as well as four previous missions. A postflight continuity test was performed with normal readings, confirming that continuity had been maintained. A teardown analysis, including a Scanning Electron Microscope analysis, determined that the retainer clips were damaged during cable manufacture. The analysis also showed that the damage was due to a ductile overload. In addition, the analysis shows that the cable design precludes loss of continuity due to recessed contacts.

Postflight analysis revealed that during the lift-off sequence, tensile strains were recorded from the right SRB aft-skirt post-4 critical welds which measured outside the maximum tensile strain data base (Flight Problem STS-44-B-2). The maximum post-4 tensile strain was measured to be 5,552 micro strain compared with a maximum of 5,072 micro-strain measured during STS-34. The mobile launch platform measured loads revealed that the flight loads were within expected values. No visual damage was detected during the postflight inspection of the hardware.

During the postflight inspection of the right RSRM nozzle cowl and outer boot ring (OBR), abnormal erosion patterns/wash areas were noted (Flight Problem STS-44-M-2). The right RSRM nozzle had material missing on the aft end of the cowl ring insulation and the forward end of the OBR. The abnormal operational/erosion wash areas at the aft end of the nozzle cowl were more extensive than previously observed. The greatest concern for this condition is its effect on the cowl/OBR bondline integrity and the subsequent reduced flex bearing protection. The maximum radial depth on the nozzle cowl was 10 percent deeper than that experienced on STS-39 where this anomaly occurred previously. Also, the cowl wedgeouts from STS-44 were incurred for approximately 360 degrees in comparison to 130 degrees on STS-39. The depth of the eroded/rounded surfaces on STS-44 also indicated that the wedgeouts occurred during motor operation. An assessment of the deepest postburn wedgeout area (at approximately 36 degrees) of the cowl established a positive margin of safety.

EXTERNAL TANK

All objectives and requirements associated with the ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation performed satisfactorily. 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 November atmospheric environment were observed during the countdown. No frost or ice was present 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 rackets. A small amount of frost was also present along the liquid hydrogen protruding air load (PAL) ramps. All of these observations were acceptable based on NSTS 08303. The Ice/Frost Red Team reported that no anomalous TPS conditions existed.

The ET pressurization system functioned properly throughout engine start and flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 14.1 psid.

The ET tumble system was deactivated for this flight. ET separation was completed on time, main engine cutoff (MECO) occurred within the expected tolerances, and ET entry and breakup occurred within the predicted footprint.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters were 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.

Flight data indicate that SSME performance during engine start, and during thrust buildup, mainstage, throttling, shutdown, and propellant dumping operations was well within specification. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within specification throughout engine operation.

The SSME controllers provided the proper control of the engines throughout powered flight and no failures were indicated. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

There were no significant SSME problems identified; however, a main combustion chamber (MCC) pressure measurement bias of 35 psi existed on main engine 2 for the first 270 seconds following engine start with a consequence that thrust and mixture ratio on that engine was approximately -0.6-percent low during that interval (Flight Problem STS-44-E-1). This condition resulted in SSME 2 operating at 103.4-percent power level until the bias disappeared at approximately 270 seconds. The postflight analysis suggested that the most likely cause was a partial blockage of the channel B transducer sense passage by contaminant. The anomaly cleared when the contaminant cleared from the sense tube. The postflight hardware inspection revealed a gel-like contamination in the channel B transducer seal at joint G8.8. Analysis of the contaminant most closely resembled a mercaptan epoxy, which is used for several applications on the SSME but not at this joint. A special inspection revealed that all other flight-engine transducer installations were free of contaminants.

Also during the postflight film review, a small fire was observed in the area of the aft manifold of SSME 2 (ser. no. 2030) just prior to lift-off. A small cold wall nozzle leak is suspected. A large experience base exists with nozzle cold wall leaks which occur during ground testing. A postflight leak check of the aft manifold will be performed to repair any existing leaks.

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 turned off at the appropriate times. All SRSS measurements indicated that the system performance was satisfactory throughout the flight with the system signal strength remaining above the specified minimum of -97 dBM for the duration of the flight.

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

ORBITER VEHICLE SUBSYSTEMS

Main Propulsion System

The overall performance of the MPS was excellent. Liquid hydrogen loading was performed as planned with no stop flows or reverts. A liquid oxygen revert and stop flow condition occurred during the replenish cycle to allow time for the Red Team to retorque a leaking facility replenish valve. Liquid oxygen replenish was resumed about 2 hours 25 minutes after initiation of the revert. The leak did not recur. This condition was the cause of the 13-minute delay in the launch.

An OMRSD violation occurred when the liquid oxygen T-0 umbilical cavity purge circuit A pressure measured 690 psia. The requirement is 750 $\pm$ 50 psia. A waiver was written with the rationale being that the circuit A pressure was sufficient and circuit B was operating normally and in parallel with circuit A. Loading of liquid hydrogen was completed during the launch countdown and no problems were noted.

At 328:15:43:45 G.m.t., about 20 minutes into the liquid oxygen fast fill of the ET and approximately 8 hours prior to launch, liquid oxygen temperature sensor A on the 17-inch disconnect/manifold began operating erratically (off-scale low readings) (Flight Problem STS-44-V-01). About 10 minutes later, the sensor began displaying a steady off-scale low condition. The sensor then began operating nominally about 2 hours later; however, one 40-second period of erratic behavior was again noted, beginning at 328:18:02:20 G.m.t. Following this condition, the sensor operated satisfactorily for the remainder of the countdown and through the MPS dump sequence following ascent.

Throughout the preflight operations, no significant hazardous gas concentrations were detected in the aft compartment. The maximum hydrogen concentration in the

Orbiter aft compartment was 190 ppm (corrected), which compares well with previous data for this vehicle. Early in the liquid hydrogen topping process, two indications of high hydrogen concentrations existed in the ground umbilical carrier plate (GUCP) area. These concentrations remained high for approximately 45 minutes, reaching a maximum value of about 31,000 ppm. This was not an LCC violation since the maximum limit is 44,000 ppm. The hydrogen concentration level was within nominal limits at lift-off.

A comparison of the calculated propellant loads at the end of replenish cycle versus the inventory loads resulted in a loading accuracy of -0.0561 percent for liquid hydrogen and -0.11 percent for liquid oxygen. The liquid oxygen load was low because only 45 minutes of stable replenish was performed after coming out of liquid oxygen revert period.

Ascent MPS performance was normal. Data indicate that the liquid hydrogen and oxygen pressurization systems performed as planned and that all net positive suction pressure (NPSP) requirements were met throughout the flight. MECO occurred 509.714 seconds after SRB ignition.

STS-44 was the second flight of the gaseous oxygen fixed orifice flow control valve on OV-104 and the fourth flight for the Shuttle Program. The minimum liquid oxygen ullage pressure experienced during the countdown ullage pressure slump was 14.1 psid. The postflight analysis of performance showed that the valves operated properly. The gaseous hydrogen pressurization system also performed nominally.

During on-orbit operations, the SSME 1 helium decay rate was 0.274 lb/day, which was above the specification limit of 0.26 lb/day. As a result of the normal turnaround testing, SSME 1 midbody Helium tank 7 was found to be leaking above allowable limits. The tank was replaced and as a result, the on-orbit decay rate is expected to be within specification during future flights.

Reaction Control Subsystem

The RCS performed nominally throughout the mission. The RCS was used to support Development Test Objective (DTO) 242 - Entry Aerodynamic Control Surfaces Test, although the automatic portion of the second and third programmed test input (PTI) as well as the entire fourth PTI were not performed. The RCS was also used to participate in the Air Force Maui Optical Site (AMOS) Calibration Test. Propellant consumption for the mission was 5048 lb, which includes the propellant dumped from the forward RCS module during entry operations.

The three planned RCS maneuvers and one unplanned RCS maneuver were performed with nominal subsystem operation. The first maneuver, FRCS-1, was a 7-second -X axis firing using primary thrusters F1F and F2F. The second maneuver, ARCS-1, was a 75-second +X axis firing using primary thrusters L3A and R3A. The third maneuver, FRCS-2, consisted of a series of 12 pulses with primary thrusters F3D and F4D along with a 30-second firing of thrusters F1F and F2F. The unplanned debris-avoidance maneuver was a 7-second +X axis firing using thrusters L3A and R3A.

Orbital Maneuvering Subsystem

The OMS performed nominally throughout the STS-44 mission, during which three two-engine maneuvers were performed. The total firing time of the engines for the three maneuvers was 383.20 seconds with 14,743 lb of propellant consumed. No OMS-RCS interconnect operations were performed during this mission.

OMS operations	Configuration	Burn length, sec	Differential velocity, ft/sec
OMS-2	Dual engine	183.79	286.1
OMS-3	Dual engine	16.4	30.2
Deorbit	Dual engine	183.01	355.6

Three minor OMS problems were noted during the mission, none of which had an impact on the mission. The OMS aft fuel high-point bleed temperature (V43T6238A) increased to 95 °F (expected temperature of 87 °F) during prelaunch operations. Data indicate that both the A and B system heaters were on simultaneously. This condition has been noted during previous missions and is not considered an anomaly.

The right OMS engine bi-propellant valve transducer indication remained at a constant value of 94.6 percent (specification = 100 $\pm$5 percent) during the OMS-2 engine firing. This condition has been noted on two previous missions and is normal performance for this transducer. This transducer was replaced prior to the STS-27 mission, but the transducer was not calibrated after the installation.

The crew noted a left OMS low quantity indication at the end of the deorbit maneuver. The aft quantity decreased to less than 5 percent for a brief period during the firing, and a low quantity indication under this condition is normal subsystem operation.

Power Reactant Storage and Distribution Subsystem

The performance of the power reactant storage and distribution (PRSD) subsystem was nominal throughout the mission. The vehicle was flown in the four-tank-set configuration, and a total of 183 lb of hydrogen and 1,525.3 lb of oxygen was consumed during the mission, including 72.3 lb oxygen consumed by the crew. A mission extension capability of 154 hours at an average power level of 12.8 kilowatts remained at landing.

Fuel Cell Powerplant Subsystem

The fuel cell performance was nominal throughout the mission. The total electrical energy produced was 2,138 kWh at an average power level of 12.8 kW and 413 amperes. The fuel cells consumed 183 lb of hydrogen and 1,453 lb of oxygen and produced 1,636 lb of water. Fuel cell 1 is the fleet leader in operational time and will approach the certified life of 2,000 hours during the next mission of OV-104, which is STS-45.

The fuel cell 1 hydrogen and fuel cell 3 oxygen flowmeters were biased low on-orbit (approximately 70 percent of normal reading), but returned to normal readings after landing. Fuel cell flowmeters have a history of erratic behavior; therefore, this off-nominal performance poses no concern for future operation of these fuel cells.

Auxiliary Power Unit Subsystem

The APU subsystem performed satisfactorily throughout the mission, although two anomalies were noted. 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 208)		APU 3 (S/N 307)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	18:31	41	18:32	49	18:31	47
FCS checkout			08:43	20		
Entry	89:06	147	62:02	157	62:00	129
Total[a]	107:37	188	89:17	226	80:31	176

[a] The total includes 17 minutes 39 seconds of APU operation after landing.

At 333:04:38 G.m.t., the APU 2 fuel pump drain line pressure decreased to 3.5 psia from 15 psia over a 75-minute period (Flight Problem STS-44-V-10). During preflight operations, the drain line had been vented twice because of static leakage from the fuel pump manifold into the seal cavity, and a waiver was processed for this condition. This APU was used for the flight control system checkout, and no anomalous conditions were noted nor was any further leakage noted from the drain line system. This condition is indicative of a leaky seal cavity drain system relief valve and has been observed on other APU's on previous flights. A postflight leak check revealed no external hydrazine leakage. The relief valve will be replaced with a redesigned valve. This anomaly did not impact the mission.

About 20 minutes after APU 2 start during entry, the APU 2 seal cavity drain line temperature 2 measurement (V46T0270A) increased from 111 °F to 170 °F in 8 seconds, then dropped to 155 °F. Two minutes later, the temperature increased from 156 °F to 196 °F in 11 seconds, tripping the 195 °F fault detection annunciator (FDA) set-point (Flight Problem STS-44-V-11). The temperature then immediately began a slow decrease to an acceptable level of 100 °F. As a result, no action was taken to turn the heaters off because of the dropping temperature. A warm slug of fuel is suspected to have migrated near the temperature sensor and this was coupled with a heater-on cycle, causing the FDA message. The anomaly did not impact the mission.

Also shortly before landing, the APU 1 gas generator valve module (GGVM) temperature 1 measurement increased to about 155 °F (about 20 °F above the expected temperature), which was not outside the established limits. This temperature signature has been observed on previous flights of the OV-104 vehicle (STS-37, STS-38, and STS-36) with APU's in position 1.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem performed satisfactorily throughout the mission with one anomaly and a number of minor irregularities identified.

The water spray boiler (WSB) 2 ready indication was lost 16 minutes prior to APU start for ascent because the steam vent temperature dropped below 130 °F. The condition has been noted on many previous missions and is an understood and acceptable response. This condition occurred on the previous flight of this vehicle.

During ascent, WSB 2 gaseous nitrogen regulator relief valve cracking pressure was 35.08 psig and should have been no greater than 33.5 psig. As a result, the relief valve crack in-flight checkout requirement was not met. Data analysis indicates that the WSB system operated nominally, and the transducer momentarily delayed its response. This same type of response was seen with this sensor on STS-37 and was attributed to contamination of the transducer resistive element that inhibited brush arm movement.

Hydraulic system 3 main pump pressure momentarily decreased approximately 140 psi in approximately 1.2 seconds during APU 3 shutdown following ascent. The decrease occurred at approximately 55 percent APU speed and then recovered completely before following a normal decay rate. This same condition was noted twice during APU 3 shutdown following landing. The initial data review from this and a previous OV-104 flight indicates that this may be a peculiarity of this system; however, data review and evaluation continues.

WSB vent heater system 2 required 1 hour 9 minutes to raise the vent temperature above 123 °F (off-scale low), whereas system 1 and 3 required 25 minutes to achieve 123 °F during the post-ascent ice removal process. Numerous incidents of similar heater operation have been noted during the last five flights of this vehicle. This problem did not affect subsystem operation during the mission.

When APU 1 was switched from low to normal at approximately entry interface minus 13 minutes, an out-of-specification delay in priority valve 1 cracking was observed (Flight Problem STS-44-V-13). Cracking required 1.039 seconds, and the specification requires almost instantaneous but no more than 1.0 second of time for cracking. Previous occurrences of this condition have been attributed to accumulator-generated contamination in the bootstrap system. The valve was replaced with a newly redesigned valve during turnaround activities at KSC.

Pyrotechnics Subsystem

The pyrotechnics subsystem performed nominally. All ET/Orbiter separation ordnance device plungers functioned properly. The stop-bolts on the EO-1 separation assembly did not sustain any damage or bending.

An assembly consisting of an ordnance connector, NASA standard initiator, and lockwire fell from the ET/Orbiter liquid hydrogen umbilical cavity upon door opening (Flight Problem STS-44-V-14). Part numbers on the assembly identify it as having come from one of the three umbilical separation devices.

Environmental Control and Life Support Subsystem

Atmospheric Revitalization System: The atmospheric revitalization system (ARS) performed satisfactorily with the exception of water found in the area of humidity separator B. At approximately 332:18:35 G.m.t., the crew reported observing water around the humidity separator B outlet which appeared to be emitting water (Flight Problem STS-44-V-05). The crew used towels to absorb the accumulated water (approximately 1 to 2 cups). Humidity separator A was selected and functioned nominally. No water was observed near humidity separator A during a subsequent check.

The water around humidity separator B occurred when the environmental control life support system (ECLSS) redundant component check was performed. The switchover of the cabin temperature controller caused the bypass valve to move from the cooling position to the full heat position, forcing a slug of water to the separator at a rate that exceeded the pump capacity. As a precautionary measure, the crew performed an in-flight maintenance procedure on humidity separator B, installing a water collection bag around the humidity separator B outlet.

The water coolant loop bypass valve was operated in the automatic position for the first time on a Space Shuttle flight. This valve controls the water loop avionics bay inlet temperature to 63 °F. The performance of this valve was normal with the valve reacting the most to coolant temperature changes instead of the cabin temperature controller air bypass valve. The crew reported comfortable cabin temperatures.

The ARS maintained the carbon dioxide partial pressure below 6.8 mm Hg. The cabin air temperature peaked at 79 °F, and the relative humidity reached 62.5 percent. The avionics bays 1, 2, and 3 air outlet temperatures peaked at 106.5 °F, 107.5 °F, and 90 °F, respectively. The avionics bays 1, 2, and 3 water coldplate temperatures peaked at 90 °F, 93 °F, and 82.5 °F, respectively.

Pressure Control System: The pressure control systems (PCS) 1 and 2 were used to maintain cabin pressure during the flight. All operating parameters remained within normal operational ranges throughout the flight.

Active Thermal Control System: The active thermal control system (ATCS) performed nominally throughout the flight. The FES was used to perform two successful water dumps after a problem was noted with the supply water dump system. The ammonia boiler system was used after landing and operation was nominal for the short duration of System B operation while awaiting ground cooling to be connected.

Supply Water, Waste Management, and Waste Collection Systems: The supply water, waste management, and waste collection subsystems performed normally throughout the mission. By the completion of the shortened mission, all of the associated supply water in-flight checkout requirements were satisfied.

Supply water was managed through the use of the overboard dump system and the FES. Four supply water dumps were performed at an average dump rate of 1.7 percent per minute (2.8 lb/min). The supply water dump line temperature was maintained between 63 °F and 95 °F throughout the mission with the operation of the line heater. The system A heaters experienced a dithering thermostat.

Shortly after completion of the second supply water dump, the supply water dump line and nozzle temperatures indicated a momentary release of water through the dump valve. This behavior is similar to that observed on OV-103 during the STS-48 mission. The supply water dump valve momentary leakage occurred several additional times following the fourth dump (Flight Problem STS-44-V-06). The crew successfully performed an IFM procedure on the supply water dump line, purging it with cabin air. The dump valve remained closed for the remainder of the mission and supply water was dumped through the flash evaporator system (FES).

Waste water was gathered at about the predicted rate. Two waste water dumps were performed at an average rate of 1.93 percent/minute (3.19 lb/min). The waste water dump line temperature was maintained between 57 °F and 76 °F throughout the mission, while the vacuum vent line temperature was maintained between 58 °F and 76 °F.

Smoke Detection and Fire Suppression: The smoke detection system performed normally throughout the flight, showing no indications of smoke being generated. The fire suppression system was not required.

Airlock Support System: The airlock support system was not exercised this mission as no extravehicular activity was required. The active system monitor parameters indicated normal outputs throughout the flight.

Avionics and Software Subsystems

Integrated Guidance, Navigation and Control: The integrated guidance, navigation and control subsystem performed nominally throughout the mission.

Flight Control: The flight control system performed satisfactorily throughout the mission and was used in performing DTO 242. Results of this DTO are presented in the Development Test Objective section of this report.

The STS-44 elevon/body flap activity in the Mach 23 region was similar to the activity observed on STS-48. This behavior was expected because of the position of the center-of-gravity along the vehicle X axis.

Inertial Measurement Unit: At 334:15:14 G.m.t., the IMU 2 registered redundant-rate and velocity-fail BITE indications. Subsequently, IMU 2 failed redundancy management (Flight Problem STS-44-V-07). The IMU was taken to standby, then operate, and the power was cycled, all in an unsuccessful attempt to recover the IMU. This failure invoked the flight rule requiring a minimum duration flight for loss of one IMU. Data analysis indicate that the failure in IMU 2 is in the Z-axis accelerometer output which was saturated at 15.22 g's. The indicated 5.77 deg/hr rate on the redundant gyro monitor reflects the product of the saturated Z-axis accelerometer output and the redundant gyro monitor g-sensitivity term. The IMU remained powered up to allow the ground controllers to monitor IMU 2 attitude information for the remainder of the mission, but was not used for onboard navigation.

The IMU 1 performance was nominal. The high accuracy inertial navigation system (HAINS) improved IMU was installed in position 3 and its performance was exceptional with drift far below that of IMU 1.

Star Tracker: The performance of both star trackers was nominal.

Data Processing System/Flight Software: The performance of the data processing system/flight software was nominal. Because of the IMU 2 failure, a total of 4,094 general purpose computer (GPC) errors were logged in major mode 304/305. Errors ceased at the Operations 901 transition after landing.

Electrical Power Distribution and Control: The electrical power distribution and control (EPDC) subsystem performance was nominal except for one instance late in the mission. At approximately 335:22:26:30 G.m.t. (about 8 minutes before landing), the left air data probe deployment occurred using only a single ac motor (Flight Problem STS-44-V-09). The air data probe still operated in less than the required time. Motor 2 did not operate. The relay controlling motor 2 operation went to the deploy position for 1 second, and then reverted to the wrong (stow) position for the remainder of the probe travel. This anomaly has occurred on OV-104 several times during previous turnaround flows and was attributed to "toggle switch teasing" as no hardware problems have ever been found.

Displays and Controls: The displays and controls operated nominally throughout the STS-44 mission except for one anomaly that occurred late in the mission. A test of the payload bay floodlights was conducted about midway through the mission and all floodlights were reported to be functioning nominally. The test was performed as a troubleshooting measure to isolate an intermittent midport floodlight anomaly that was reported on a previous flight of this vehicle and was not reproduced in ground tests; however, the problem did not reappear during this test. Later use of the payload bay floodlights for payload bay door closure revealed that neither the midport or midstarboard lights were working properly (Flight Problem STS-44-V-16).

Communications and Tracking

The performance of the communications and tracking subsystem was satisfactory with two minor anomalies that did not significantly impact the mission.

The crew reported that VIU serial number 1009 failed, and the camcorder would operate only on battery power (Flight Problem STS-44-V-02). Subsequent troubleshooting indicated that only the power output from the VIU was malfunctioning, and that the video signal input was functioning normally. The normal VIU output voltage level to the camcorder is 7.4 volts, but a multimeter reading indicated an output of 7.2 volts. An IFM procedure to adjust the output voltage was available, but was not implemented since a spare VIU was available. The spare VIU was used with the camcorder and the malfunctioning VIU was used with an Air Force payload (SPADVOS) which only required the video connection to the VIU.

Closed-circuit television (CCTV) camera B contained horizontal white lines which appeared in low-light situations (Flight Problem STS-44-V-08). This condition is indicative of a degrading high-voltage power supply circuit in the camera. This condition was transient and only affected low-light video.

During a pass over the continental United States with operations on both Tracking and Data Relay Satellites (TDRS), the Orbiter experienced a significant number of signal dropouts on the forward and return links. Analysis of these dropouts indicated that RFI, not hardware, was the cause of the problem.

The crew reported at 329:01:22 G.m.t., that color television (TV) monitor 2, flown for the first time on a Shuttle flight, did not power up on the first attempt. On the third attempt to power up the TV, the crew reported that the monitor was operating properly. This problem did not subsequently repeat or affect operations being performed at that time.

Operational Instrumentation Subsystem

The operational instrumentation subsystem (OIS) performance was satisfactory with two anomalies.

While dumping track 1 of OPS recorder 2, the data quality was very poor (Flight Problem STS-44-V-04). The same data were dumped three times, and all data were of poor quality when dumped in the reverse direction, and better but not good in the forward direction. A fourth dump of track 1 on orbit 17 showed poor quality data when dumping in the reverse direction, but good quality data in the forward direction. Since track 1 could not be relied upon to provide usable data, track 1 on OPS recorder 2 was no longer used to record data.

An Orbiter problem was noted at 328:15:43:45 G.m.t., approximately 8 hours prior to launch, when liquid oxygen temperature sensor A on the 17-inch disconnect/manifold began operating erratically (Flight Problem STS-44-V-01). A more detailed discussion of the sensor operation is presented in the Main Propulsion System section of this report.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily. DTO 520 - Edwards Lakebed Runway Bearing Strength and Rolling Friction Assessment for Orbiter Landing - was performed with no braking taking place until the Orbiter decelerated to 15 knots ground speed.

The main gear touchdown occurred at 192.6 knots and nose gear touchdown occurred at 151.4 knots. The sink rate at main gear touchdown was approximately 1 ft/sec and the pitch rate at nose gear touchdown was 4.48 deg/sec. Braking was not initiated until 15 knots ground speed because DTO 520 was performed. Consequently, maximum brake pressures during the 12 seconds of brake-on time on the left main gear was 396 psi and on the right main gear was 624 psi. Brake energies also were very low as a result of the DTO being performed. Rollout distance was 11,190 feet. The main landing gear tires were in excellent condition.

Postflight disassembly of the brakes revealed two hairline cracks (1/2 to 3/4 inches in length) in the right inboard brake rotor (Flight Problem STS-44-V-18). The brake assemblies from all four wheels were removed at KSC and sent to the vendor for inspection and analysis. Preliminary analysis indicates that the cracking was caused by over-tightening of the rivets on the rotor. The manufacturer has stated that this condition was caused by an improper production line procedure. The procedure has been revised to correct this condition.

Aerodynamics, Heating and Thermal Interfaces

The ascent aerodynamics of the Orbiter vehicle were satisfactory with no reportable observations.

The entry aerodynamics of the Orbiter were nominal with control surface responses and angle-of-attack as expected. The elevon schedule was slightly off the predicted values and postflight analysis continues.

DTO 242 was performed and a discussion is contained in the DTO section of this report.

The integrated heating of the Orbiter was nominal during all phases of the mission.

All thermal interface temperatures were maintained within established limits. One area of concern arose during the scrub after the first planned launch time. During the reset-of-purge-pressure operations following the scrub, source pressures spiked at approximately twice the normal setting. This spike could have resulted in the loss of seal integrity to the aft compartment. However, the aft Helium concentration indicated the seals were normal.

Thermal Control Subsystem

The performance of the thermal control subsystem (TCS) was nominal during all phases of the mission with no thermostat or instrumentation problems identified. A portable infrared thermometer was used to measure the surface temperatures of three areas on the Orbiter TPS after landing. Seventeen minutes after wheel stop, the Orbiter nose cap reusable carbon carbon (RCC) temperature was 183 °F, and 7 minutes later the right-hand wing leading edge RCC panel 9 was 87 °F, and the right-hand wing leading edge RCC panel 17 was 73 °F.

Aerothermodynamics

The acreage heating during entry was nominal with local heating normal based on the preliminary thermal protection subsystem inspection.

Thermal Protection Subsystem

The thermal protection subsystem (TPS) performance was nominal, based on structural temperature response data and some tile surface temperature measurements. The overall boundary layer transition from laminar to turbulent flow was symmetric, occurring at 1230 seconds after entry interface.

The postlanding debris inspection of the TPS was conducted on December 4 and 5, 1991, in the mate/demate device at Edwards Air Force Base, CA. The inspection revealed that the Orbiter had sustained at total of 109 hits, of which nine had a major dimension of 1 inch or greater. This total does not include the base heat shield peppering that was attributed to main engine vibro-acoustics and exhaust plume recirculation. A comparison of these numbers with statistics from 30 previous missions of similar configuration indicates that both the total number of hits as well as the number of hits with a major dimension of 1 inch or greater were less that average. From a debris damage standpoint, the STS-44 flight is considered one of the best of the Space Shuttle Program. The distribution of hits on the Orbiter does not point to a single source for ascent debris, but does indicate a shedding of ice and TPS debris from random sources.

The inspection showed that the Orbiter lower surface had a total of 74 hits of which six had a major dimension of 1 inch or greater. No lower surface TPS damage was attributed to material from the wheels, tires, or brakes.

Overall, the external inspections of the reusable carbon carbon (RCC) parts revealed nominal flight performance. The nose landing gear door TPS was in good condition with the exception of the forward right-hand corner tile which exhibited damage. Removal and replacement of the nose landing gear door tile is required. The main landing gear door thermal barriers were in good condition. The elevon-elevon gap tiles were in good condition, with minor gap filler degradation.

Damage to the base heat shield tiles was less than average. The main engine closeout blankets were in good condition with the only observed damage being minor fraying from the 5 to 6 o'clock position on SSME 1 and a 6-inch long detached outboard blanket edge on SSME 2 at the 5 o'clock position.

The ET door thermal barrier's performance was nominal. The condition of the barrier was excellent. The TPS performance on the upper fuselage, payload bay doors, upper wings, and OMS pods was nominal.

The forward edge of the side seal between flipper doors 1 and 2 on the right-hand inboard elevon was peeled backward approximately 3 inches. Similar observations have been made on previous missions, and this condition is not considered a problem.

Orbiter windows 1, 2, 5, and 6 were lightly hazed. Windows 3 and 4 exhibited moderate to heavy hazing. Laboratory analysis will be performed on samples taken from all windows.

GOVERNMENT FURNISHED EQUIPMENT AND FLIGHT CREW EQUIPMENT

The overall performance of the flight crew equipment was satisfactory, although two anomalies and one irregularity were noted with the equipment during the mission.

The second of three crew members that consecutively used the treadmill on flight day 2 reported a grinding noise from the treadmill. The noise disappeared and the treadmill run was completed. While the third crew member was using the treadmill, the noise returned and the treadmill belt exhibited excessive resistance with the belt becoming jammed shortly afterward (Flight Problem

STS-44-V-03). The treadmill was unusable for the remainder of the flight. Alternate exercise methods were developed that used the treadmill hardware, but these procedures resulted in breaking the treadmill handle.

The newly developed display driver unit filter (DDU) cleaning tool that was being flown for the first time failed (Flight Problem STS-44-V-12). The crew was able to make a temporary repair with gray tape and use the tool for the remainder of the mission.

At 331:18:14 G.m.t., the crew reported that the Arriflex 16mm motion picture camera film movement was very slow and that the shutter switch would not operate. Changing the magazine did not fix the problem. A malfunction procedure was performed and the crew reported that the camera began operating properly; however, the shutter switch continued to cause operational problems throughout the mission.

The crew reported that the video tape recorder (VTR) lid would not fully close, leaving the lid approximately 1/8-inch higher than the case (Flight Problem STS-44-V-15). The recorder worked well initially; however, a tape jammed on flight day 2 and the lid had to be pried open to remove the tape. Following this occurrence, the crew reported that they had to force the tape door down to allow the recorder to operate properly. This condition did not affect VTR operations.

During the postflight crew debriefings, Mission Specialist 2 reported that the pin in his shoulder belt tightening mechanism came out, and tension could not be maintained (Flight Problem STS-44-V-17). As a result, he reported that a knot was tied in the strap and this tightened the strap adequately for launch and landing operations.

PAYLOADS/EXPERIMENTS

The primary objective of this mission was to deploy the Defense Support Program/Inertial Upper Stage, and this objective was accomplished successfully as planned. The secondary objectives were to operate several small payloads, and to perform medical evaluations for the extended-duration Orbiter capability.

DEFENSE SUPPORT PROGRAM

The DSP/IUS satellite detects missile launches and nuclear detonations using infrared detectors. The DSP was deployed at 329:06:03 G.m.t. The IUS transported the DSP to a geosynchronous orbit where functional checkout was initiated in preparation of full system operation.

TERRA SCOUT

The objective of the Terra Scout secondary experiment was to evaluate the ability of a specially trained payload specialist to detect specific ground targets using a variety of visual aids, such as the Spaceborne Direct View Optical System (SPADVOS). The Terra Scout payload specialist performed numerous observations that were planned as well as sights of opportunity. The primary objectives of the experiment were accomplished. During the flight, 29 site observations were attempted with 27 sites acquired. Specific target definition was accomplished over 22 sites, five sites were obscured by weather, and two sites were missed because of hardware and timing input errors.

ULTRAVIOLET PLUME INSTRUMENT

The ultraviolet plume instrument (UVPI) experiment uses a low-power atmospheric compensation experiment (LACE) satellite to observe Orbiter thruster firings. No UVPI opportunities/intersections occurred during the flight.

MILITARY MAN IN SPACE (M88-1)

The military man in space regimen consists of a series of experiments that were designed to assess the crewmembers' ability to visually observe air, naval, and ground force operations, and then communicate these observations to the ground. Three experiments comprised the M88-1:

a. Maritime Observations Experiments in Space (MOSES);

b. Battlefield Surveillance from Space (BATTLEVIEW); and

c. Night Mist.

Numerous target observations were performed, both planned and sites of opportunity. The primary objectives to acquire and identify targets and relay this information to ground controllers were accomplished. A payload radio failure precluded direct Orbiter-to-ground-controller personnel communications. During the flight, 16 site observations were planned and 16 sites were acquired. Specific target definition was accomplished over 10 sites, and 6 sites were obscured by weather.

SHUTTLE ACTIVATION MONITOR

The SAM experiment was used to measure specific types of radioactivity produced in spacecraft and sensor materials when the materials are exposed to the space environment. The SAM objectives to gather radiation measurements in various Orbiter crew compartment locations with different sensing elements were accomplished. The hardware functioned nominally throughout the mission; however, minor software anomalies resulted in recording data tape stoppage. Prompt crew troubleshooting resulted in minimal loss of data and return to normal operations.

COSMIC RADIATION EFFECTS AND ACTIVATION MONITOR

The CREAM experiment collected data on cosmic ray spectra and intensity within the Orbiter crew compartment. The CREAM objectives to gather radiation measurements coincident with the SAM experiment were accomplished. The hardware functioned nominally throughout the mission.

RADIATION MONITORING EQUIPMENT III

The RME-III measured and recorded the rate and total dosage of ionizing radiation inside the Orbiter crew compartment. The RME-III objectives to gather radiation measurements coincident with the SAM and CREAM experiments were accomplished. After the initial memory module failed, the flight crew replaced the memory module and subsequent operations were nominal.

AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST

The AMOS uses the Orbiter as a calibration target for ground-based electro-optical sensors. Three of the four planned observations of the Orbiter by the Maui ground site were accomplished. The two night RCS tests were successfully observed; the night FES dump was not observed, but the Orbiter lights were visible; and the twilight nose track observation was canceled because of an AMOS hardware problem. An additional observation of an Orbiter night attitude maneuver was successfully recorded on orbit 21.

VISUAL FUNCTION TESTER-1

The VFT-1 experiment measured changes in the visual acuity of the STS-44 crewmembers during flight. The VFT-1 experiment hardware functioned nominally, and all objectives were accomplished.

INTERIM OPERATIONAL CONTAMINATION MONITOR

The IOCM experiment measured contamination in the Orbiter payload bay during all mission phases. The IOCM sensor modules are mounted on the payload bay sidewall and are totally automated. The IOCM operated nominally throughout the mission as evidenced by power usage.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

Eight DTO's were assigned to the STS-44 mission. DTO 242, Entry Aerodynamic Control Surfaces Test, was not completed in its entirety, and DTO 805, Crosswind Landing Performance, was not performed because insufficient crosswinds were present on the runway chosen for landing. Also, DTO 312, ET TPS Performance, was not performed as the ET could not be photographed because of the darkness.

Ascent Development Test Objectives

DTO 301D - Ascent Structural Capability Evaluation.- Data were collected for this data-only experiment, and these data will be evaluated by the sponsor. After completion of the evaluation, the results will be published by the sponsor.

DTO 312 - ET TPS Performance.- This DTO was not completed because the launch was made in darkness.

On-Orbit Development Test Objectives

DTO 645 - Combustion Products Analyzer.- Baseline data for this DTO were collected and are being analyzed by the sponsor.

DTO 649 - Shuttle Extended-Duration Orbiter Rehydratable Food Package Evaluation This DTO was accomplished successfully with good results.

Entry/Landing Development Test Objectives

DTO 242 - Entry Aerodynamic Control Surfaces Test.- This DTO was performed, but not in its entirety. Six of the seven planned programmed test inputs (PTI) were performed with the no. 4 PTI (Mach 9.5 to 8.5) not being performed. Also, the automatic portions of PTI's 2 and 3 were not completed. Two manual body flap maneuvers were also performed; however, these were apparently performed before the PTI's were complete and this may cause difficulty in reducing the data.

DTO 307D - Entry Structural Capability.- Data were collected for this DTO. The results of this DTO will be published by the sponsor.

DTO 520 - Edwards Lakebed Runway Bearing Strength and Rolling Friction Assessment for Orbiter Landing.- This DTO was accomplished by the crew not applying the brakes until the Orbiter had slowed to 15 knots. The results of this DTO will be published by the sponsor.

DTO 805 - Crosswind Landing Performance.- This DTO was not performed as the crosswind component that existed (low) on the runway used for landing did not fall within the criteria for this DTO.

DETAILED SUPPLEMENTARY OBJECTIVES

Fourteen detailed supplementary objectives (DSO's) were assigned to the STS-44 mission. Preliminary data indicate that all 14 were accomplished. A listing of all assigned DSO's follows:

a. DSO 316 - Bioreactor/Flow and Particle Trajectory in Microgravity - All planned activities were successfully completed plus one additional test.

b. DSO 463 - In-Flight Holter Monitoring - Data were collected during the preflight, on-orbit, entry, and postlanding phases of the mission.

c. DSO 472 - Intraocular Pressure - Early data for fluid shifts were recorded, however, late flight data were not recorded due to the shortened mission.

d. DSO 478 - In-Flight Lower Body Negative Pressure - No protocol combinations were completed because of the shortened mission.

e. DSO 603 - Orthostatic Function During Entry, Landing, and Egress - Preflight data were recorded. Data were also collected during entry, egress and postlanding.

f. DSO 604 - Visual Vestibular Integration as a Function of Adaptation - The on-orbit data collection was completed by moving the flight day 10 activities to flight day 7. Entry and postflight data were also collected.

g. DSO 605 - Postural Equilibrium Control During Landing/Egress - Data were collected during the preflight and postflight periods.

h. DSO 608 - Effects of Space Flight on Aerobic and Anaerobic Metabolism at Rest and During Exercise - Preflight and postflight data were collected; however, in-flight exercise was optional.

i. DSO 611 - Air Monitoring Instrument Evaluation and Atmosphere Characterization - Early and mid-flight data were collected; however, late flight data were lost due to the shortened mission.

j. DSO 613 - Changes in Endocrine Regulation of Orthostatic Tolerance Following Space Flight - Preflight and postflight data were collected.

k. DSO 614 - Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion - Preflight and postflight data were collected.

l. DSO 901 - Documentary Television - This DTO was accomplished successfully and the data are being evaluated by the sponsor.

m. DSO 902 - Documentary Motion Picture Photography - This DTO was accomplished very satisfactorily and the photography is being reviewed and evaluated by the sponsor.

n. DSO 903 - Documentary Still Photography - This DTO was accomplished with a large number of photographs being taken. The photography is being reviewed and evaluated by the experiment sponsor.

PHOTOGRAPHIC AND TELEVISION EVALUATION

LAUNCH PHOTOGRAPHY EVALUATION

On launch day, 24 videos (of 24 expected) were screened, and no potential in-flight anomalies were observed. Following launch day, 63 launch films were reviewed with no in-flight anomalies noted. However, a significant event was noted in the form of an orange vapor, possibly free burning hydrogen, above the rim of SSME 2 engine on the left side of the bell during the period from SSME ignition to lift-off. Postflight inspection of the SSME 2 showed no damage that would cause this type of event.

LANDING PHOTOGRAPHY EVALUATION

Five landing videos plus NASA Select and an after-landing helicopter view video were screened. One anomaly was noted; and two items of interest were observed:

a. From the helicopter view, a slight discoloration was seen on the -Z side of the leading edge of the body flap.

b. Postlanding video revealed a piece of hardware on the ground below the ET/Orbiter umbilical area (Flight Problem STS-44-V-14). The contingency debris team reported that the object fell from the liquid hydrogen umbilical cavity when the ET door was opened after wheels stop. The object was identified as a pyrotechnic igniter.

TABLE I.- STS-44 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	328:23:39:10.88
	APU-2 GG chamber pressure	328:23:39:11.76
	APU-3 GG chamber pressure	328:23:39:12.64
SRB HPU activation	LH HPU system A start command	328:23:43:32.15
	LH HPU system B start command	328:23:43:32.31
	RH HPU system A start command	328:23:43:32.43
	RH HPU system B start command	328:23:43:32.59
Main propulsion System start	Engine 3 start command accepted	328:23:43:53.455
	Engine 2 start command accepted	328:23:43 53.559
	Engine 1 start command accepted	328:23:43:53.694
SRB ignition command (lift-off)	SRB ignition command to SRB	328:23:44:00.006
Throttle up to 104 percent thrust	Engine 3 command accepted	328:23:44:04.136
	Engine 2 command accepted	328:23:44:04.119
	Engine 1 command accepted	328:23:44:04.134
Throttle down to 73 percent thrust	Engine 3 command accepted	328:23:44:27.017
	Engine 2 command accepted	328:23:44:27.000
	Engine 1 command accepted	328:23:44:27.015
Throttle up to 104 percent thrust	Engine 3 command accepted	328:23:44:56.458
	Engine 2 command accepted	328:23:44:56.441
	Engine 1 command accepted	328:23:44:56.456
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	328:23:45:06.62
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	328:23:46:00.606
	RH SRM chamber pressure mid-range select	328:23:46:01.526
End SRM action	LH SRM chamber pressure mid-range select	328:23:46:03.688
	RH SRM chamber pressure mid-range select	328:23:46:03.665
SRB separation command	SRB separation command flag	328:23:46:05.07
SRB physical separation	LH rate APU A turbine speed LOS	328:23:46:06.566
	RH rate APU A turbine speed LOS	328:23:46:06.566
Throttle down for 3g acceleration	Engine 3 command accepted	328:23:51:31.312
	Engine 2 command accepted	328:23:51:31.333
	Engine 1 command accepted	328:23:51:31.308
3g acceleration	Total load factor	328:23:51:32.21
MECO	MECO command flag	328:23:52:29.72
	MECO confirm flag	328:23:52:29.72
ET separation	ET separation command flag	328:23:52:47.67
OMS-1 ignition	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
OMS-1 cutoff	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown

TABLE I.- STS-44 SEQUENCE OF EVENTS (CONCLUDED)

Event	Description	Actual time, G.m.t.
APU deactivation	APU-1 GG chamber pressure	328:23:57:42.24
	APU-2 GG chamber pressure	328:23:57:43.77
	APU-3 GG chamber pressure	328:23:57:44.34
OMS-2 ignition	Left engine bi-prop valve position	329:00:24:48.23
	Right engine bi-prop valve position	329:00:24:48.22
OMS-2 cutoff	Left engine bi-prop valve position	329:00:27:52.02
	Right engine bi-prop valve position	329:00:27:52.03
Payload bay door open	PLBD right open 1	329:01:18:12.57
	PLBD left open 1	329:01:19:32.34
DSP/IUS Deployment	Voice call	329:06:03
Flight control system checkout		
APU start	APU-2 GG chamber pressure	334:21:19:05.76
APU stop	APU-2 GG chamber pressure	334:21:27:48.91
Payload bay door close	PLBD right close 1	335:18:45:06.07
	PLBD left close 1	335:18:46:55.49
APU activation for entry	APU-1 GG chamber pressure	335:21:23:07.82
	APU-2 GG chamber pressure	335:21:50:11.63
	APU-3 GG chamber pressure	335:21:50:14.73
Deorbit maneuver ignition	Left engine bi-prop valve position	335:21:28:16.22
	Right engine bi-prop valve position	335:21:28:16.03
Deorbit maneuver cutoff	Left engine bi-prop valve position	335:21:31:19.23
	Right engine bi-prop valve position	335:21:31:19.03
Entry interface (400K)	Current orbital altitude above reference ellipsoid	335:22:03:23.35
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	335:22:27.51.67
Main landing gear contact	LH MLG tire pressure	335:22:34:42.77
	RH MLG tire pressure	335:22:34:42.77
Main landing gear weight on wheels	LH MLG weight on wheels	335:22:34:43.64
	RH MLG weight on wheels	335:22:34:43.65
Nose landing gear contact	NLG tire pressure	335:22:34:50.63
Nose landing gear weight on wheels	NLG WT on Wheels -1	335:22:34:50.77
Wheels stop	Velocity with respect to runway	335:22:36:28.7
APU deactivation	APU-1 GG chamber pressure	335:22:52:13.69
	APU-2 GG chamber pressure	335:22:52:14.05
	APU-3 GG chamber pressure	335:22:52:15.39

TABLE II.- STS-44 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-44-V-01	Liquid Oxygen 17-inch Manifold Temperature Probe A (V41T1528A)	328:15:43 G.m.t. IPR 45V-0001 IM 44RF04	The liquid oxygen 17-inch manifold temperature probe A measurement operated erratically for 10 minutes before failing off-scale low. At approximately 328:18:00 G.m.t., the readings returned to near normal values. At approximately 328:18:02:20 G.m.t., another 40-second period of erratic readings occurred, but then recovered with no subsequent anomalous readings. KSC: Troubleshooting required. Remove and inspect probe per existing chit. No ferry impact.
STS-44-V-02	Video Interface Unit Low Output Power	328:07:27 G.m.t.	Video Interface Unit (VIU) ser. no. 1009 supplied power to the camcorder at a lower level than that required by the camcorder (7.2 V should be 7.4 V). The VIU video output is good. KSC: Ship to JSC. Troubleshoot and adjust as required.
STS-44-V-03	Treadmill Failure (GFE)	331:06:54 G.m.t. FIAR BFCE-213F008	While using the treadmill, the crew reported hearing grinding sounds, followed by the treadmill belt locking up. Also, the handle broke off during subsequent usage for the alternate exercise program. KSC: Ship to JSC Flight Equipment Packing Center (FEPC)
STS-44-V-04	OPS Recorder 2 Track 1 Dump Problem	330:00:10 G.m.t. IPR 45V-0005 FIAR BFCE-029F042	Data dumps from track 1 were of poor quality in the reverse direction. Quality was better in the forward direction, but still below par. Dump problem verified at KSC. KSC: Dump, verify problem, remove and ship recorder to JSC.
STS-44-V-05	Humidity Separator Water Carryover	332:18:35 G.m.t.	The crew reported about 1 to 2 cups of water around the humidity separator screen, and the humidity separator appeared to be spitting water. KSC: Water test per existing OMRSD requirement.
STS-44-V-06	Supply Water Dump Valve Leak	331:19:30 G.m.t. IM-44RF02	Indications of a leaking dump valve were observed after the second and fourth water dumps. In-flight maintenance procedure was performed twice to purge the supply water dump line. First attempt indicated blockage, second attempt produced air flow. Normal configuration for ferry, dump valve closed and isolation valve open. KSC: Remove and replace pending results of OV-103 dump valve test at JSC.
STS-44-V-07	IMU 2 Failed Redundancy Management	334:15:30 G.m.t. IM 44RF01 IPR 45V-0006	The Z-axis accelerometer channel and redundant gyro showed excessive outputs (saturation). Taken to standby, then operate, then power cycled. Failure was still present. Unit will be replaced with a HAINS unit (ser. no. 203). KSC: Remove and replace IMU. Ship to JSC ISL.

TABLE II.- STS-44 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-44-V-08	Closed Circuit Television Camera B Degraded	330:00:10 G.m.t. FIAR BFCE-029F041	Video had multiple horizontal lines present on the screen. Crew indicated possible focus problem at end of mission. KSC: Troubleshoot at KSC. Remove and replace at KSC.
STS-44-V-09	Left Air Data Probe Single Motor Deployment	335:22:25 G.m.t.	Motor 2 (Main B AC 2) apparently did not run. Suspect FMCA2 relay, wiring, or switch tease. Previous occurrence during ground testing KSC: Standard troubleshooting required. Reference IPR's 36V-0251 and 27RV-0119. Single and dual motor drive tests scheduled 12/19. If okay, will attempt to duplicate switch tease.
STS-44-V-10	APU 2 Drain Line Pressure Drop	333:02:14 G.m.t. IPR 45V-0009 IM44RF03	Pressure decayed from 15.5 psia to 3.7 psia over a 45-minute period. KSC: Remove and replace relief valve. Replace with a new design of the relief valve.
STS-44-V-11	APU Drain Line Temperature Rose During Entry	335:22:10 G.m.t. IPR 45V-0010	APU 2 drain line temperature 2 increased to 196 °F, then fell to 100 °F. Fault detection limit is 195 °F. Suspect warm slug of fluid. Normal configuration for ferry, A and B heaters enabled. KSC: Test and standard troubleshooting.
STS-44-V-12	Data Display Unit (DDU) Filter Cleaning Tool Broke	FIAR JSC-SD-6053	The vacuum cleaner adapter used for cleaning the DDU filter broke at the joint between the base of the tool and the extension tube. Repaired in-flight with gray tape. Postflight analysis revealed the threads in the extension tube were cut too deep. The STS-42 tool will have the threads countersunk in the adapter to eliminate the bending stress from the threads.
STS-44-V-13	Hydraulic System 1 Priority Valve Sluggish	335:21:50 G.m.t. IM 44RF05 IPR 45V-0013	Priority valve hung up. Required 1.04 second to open and should have been instantaneous to a maximum of 1 second. KSC: Remove and replace valve.
STS-44-V-14	Loss of Hardware From ET Umbilical Attachment System	Postlanding IM 44RF06	An NASA standard initiator (NSI) with an intact electrical connector was found underneath the liquid hydrogen umbilical cavity after the vehicle was stopped on the runway. An accounting of debris in the containment system indicates that a similar piece of debris was lost on-orbit.
STS-44-V-15	Video Tape Recorder Door Jammed (GFE)	331:21:21 G.m.t. FIAR BFCE 029-F043	The video tape recorder (VTR) door jammed and had to be pried open by the crew. Subsequently, the door could not be fully closed unless the crew forced the door down into the closed position.

TABLE II.- STS-44 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-44-V-16	Payload Bay Floodlights Failed to Operate Properly	335:18:30 G.m.t. IM 44RF-08 (port) IM 44RF-07 (stbd) IPR 45V-0018	During payload bay door closure, the mid-port floodlight flickered and the mid-port starboard floodlight failed to illuminate. Occurred on STS-43 (Reference STS-43-V-10 - mid starboard lamp replaced prior to STS-44) Retested 12/16 and anomaly could not be reproduced.
STS-44-V-17	Mission Specialist 2 Shoulder Harness Would Not Tighten	Preflight PR MV-0610A-3-0019 IM 44RF-09	Mission Specialist 2 reported postflight that a pin in the shoulder harness tightening mechanism came out and tension could not be maintained. Shoulder belt was knotted to tighten it.
STS-44-V-18	Hairline cracks in right Inboard Brake Rotor	Postflight PR MEQ-4-11-0417 IM 44RF-10	Postflight inspection revealed two cracks (1/2 to 3/4 inch) on right inboard brake rotor. All four brakes were removed and shipped to vendor for inspection.

NASA Headquarters
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Mr. Willis M. Hawkins
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Lockheed Corporation
P. O. Box 551
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NASA-Lewis Research Center
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Attn: 302-1/T. Fuller

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Mail Stop 4A
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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. Hoey
6510 Test Wing/TEG/236
Edwards AFB, CA 93523

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
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Los Angeles, CA 90009
Attn: W. Smith, M5/619

McDonnell Douglas-Houston
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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

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

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

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