

# **STS-41 SPACE SHUTTLE MISSION REPORT**

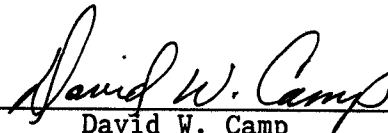
**November 1990**



National Aeronautics and  
Space Administration

Lyndon B. Johnson Space Center  
Houston, Texas

STS-41  
SPACE SHUTTLE  
MISSION REPORT

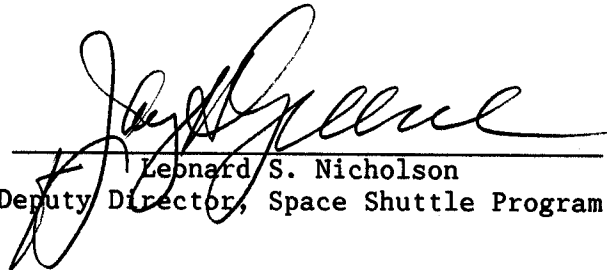


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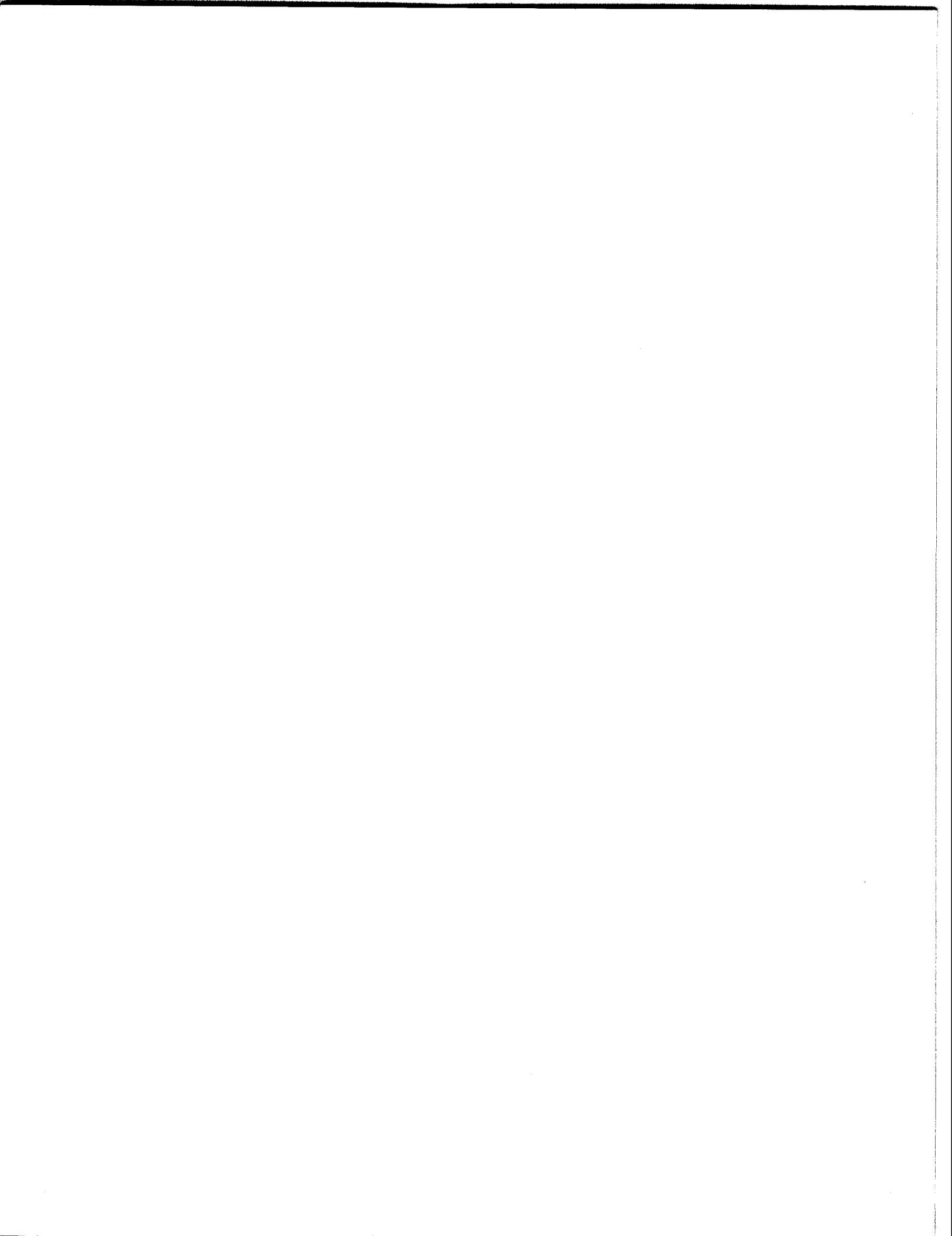
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## INTRODUCTION

The STS-41 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem activities on this thirty-sixth flight of the Space Shuttle and the eleventh 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-39/LWT-32), three Space Shuttle main engines (SSME's) (serial numbers 2011, 2031, and 2107), and two Solid Rocket Boosters (SRB's), designated as BI-040.

The primary objective of the STS-41 mission was to successfully deploy the Ulysses/inertial upper stage (IUS)/payload assist module (PAM-S) spacecraft. The secondary objectives were to perform all operations necessary to support the requirements of the Shuttle Backscatter Ultraviolet (SSBUV) Spectrometer, Solid Surface Combustion Experiment (SSCE), Space Life Sciences Training Program Chromosome and Plant Cell Division in Space (CHROMEX), Voice Command System (VCS), Physiological Systems Experiment (PSE), Radiation Monitoring Experiment - III (RME-III), Investigations into Polymer Membrane Processing (IPMP), Air Force Maui Optical Calibration Test (AMOS), and Intelsat Solar Array Coupon (ISAC) payloads.

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

The crew for this thirty-sixth flight of the Space Shuttle was Richard N. Richards, Capt., USN, Commander; Robert D. Cabana, Lt. Col., USMC, Pilot; Bruce E. Melnick, Cmdr, USCG, Mission Specialist 1; William M. Shepard, Capt., USN, Mission Specialist 2; and Thomas D. Akers, Major, USAF, Mission Specialist 3. This was the second flight for the Commander and Mission Specialist 2, and the first flight for the remaining three crew members.

## MISSION SUMMARY

The 4-day STS-41 mission was successfully launched from launch pad 39B at 279:11:47:14.983 G.m.t. (8:47:14.983 a.m. e.d.t.), and all subsystems operated satisfactorily. Three unscheduled holds occurred during the final countdown. The first was a 10-minute 43-second hold at T-9 minutes because of a rain shower north of the Shuttle landing facility. The second was at T-5 minutes when the countdown was held for 10 seconds to add a mask to the ground launch sequencer (GLS) because of the loss of hydraulic system 2 water spray boiler "OK" indications. Previous analysis has shown that loss of the "OK" indication is acceptable for flight. The third was a 1-minute 22-second hold at T-31 seconds because of payload interface purge pressure oscillations outside the GLS limit. Purge control was transferred from automatic control to manual control and the

countdown was resumed. All SSME and redesigned solid rocket motor start sequences occurred as expected and the launch phase performance was satisfactory in all respects. First stage ascent performance was normal with SRB separation, entry, deceleration and water impact occurring as planned. Performance of the SSME's, ET, and main propulsion system (MPS) was also normal, with main engine cutoff (MECO) occurring approximately 510.1 seconds after lift-off. A dual-engine OMS-2 maneuver was performed as planned at 279:12:27:08 G.m.t. The maneuver was 145.3 seconds in duration with a differential velocity of 223.3 ft/sec being imparted to the vehicle. Some small discrepancies in fuel quantities were noted following the maneuver, but these were expected based on previous flight data. The vehicle was placed in a 160-nmi. orbit by the OMS-2 maneuver.

An examination of prelaunch and flight data for the SSME's ET, and SRB's indicate that all systems performed properly, and all launch objectives were accomplished. A quick-look determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) determined from the time period between SRB separation and start of 3-g throttling was 452.1 seconds as compared to a fleet average tag value of 452.66 seconds. The relative velocity of the vehicle reached the adaptive guidance/throttling reference value at 17.604 seconds, resulting in a calculated time difference of -0.2377 second that was used to adjust the pitch and throttle profiles.

Analysis of ascent data from the main propulsion system gaseous oxygen and hydrogen flow control valves showed nominal performance throughout the main propulsion system period of operation. This was the first flight of the step-1 gaseous oxygen fixed-orifice flow control valve.

Following ascent, at 279:11:56:09 G.m.t. (8 minutes 54 seconds elapsed time), a fault message from the backup flight system (BFS) backup dP/dT calculation indicated a momentary cabin leak rate of -0.14 psi/min (-0.12 psi/min limit). This indication had no effect on the mission.

The auxiliary power units (APU's) operated for 21 minutes 9 seconds during ascent and a total of 180 lb of fuel was consumed by the three APU's.

Prior to OPS-2 transition following ascent, the crew reported that the nominal bus assignment table showed general purpose computer (GPC) 2 assigned to string 3 when the GPC should have been unassigned. Analysis of the T-20 minute GPC dumps indicated the condition existed during prelaunch operations. This anomaly did not impact the mission.

The payload bay doors were opened as planned. The Ulysses spacecraft rotation, umbilical separation, and deployment were executed on time. All Ulysses solid rocket motor burns were completed on time and the Ulysses spacecraft was placed on the planned trajectory.

The right OMS engine was used to perform a circularization maneuver at 280:10:43:53 G.m.t. The engine was fired for approximately 44 seconds with a differential velocity of 41 ft/sec. All OMS parameters remained within expected ranges during the maneuver. The resulting orbit was 178 by 160 nmi.

The remote manipulator system (RMS) was successfully activated at 280:14:07:22 G.m.t., and the RMS checkout was completed with no discrepancies identified. The RMS was parked in the Intelsat Solar Array Coupon position with the brakes on at approximately 280:15:22:14 G.m.t.

The APU 2 was operated for 9 minutes 15 seconds during the flight control system checkout. Data indicate no anomalies occurred. The RCS hot-fire test was delayed about 8 hours. All thrusters operated nominally during the hot-fire test.

At 282:12:10 G.m.t., the crew switched the gas generator/fuel pump (GG/FP) heater system from A to B on APU 1 as planned. Within 4 minutes after the reconfiguration, the fuel pump bypass line temperature (V46T0128A) increased above the fault detection annunciator (FDA) upper limit of 180 °F. The crew switched back to the A heaters, and the temperature then decreased to the normal limits.

Inertial measurement unit (IMU) 1 began experiencing transient Z-axis accelerometer shifts of up to 10,000 micro g's, and the IMU was failed by the redundancy management (RM) at 282:20:36:57 G.m.t. This anomaly did not impact the mission.

After completion of all entry preparations including stowage and payload bay door closure, the OMS deorbit maneuver was performed at 283:13:00:05 G.m.t., with a firing duration of 158 seconds and a differential velocity of 296.6 ft/sec. Entry interface occurred at 283:13:26:14 G.m.t., and because of the presence of Tracking and Data Relay Satellites (TDRS), communications were maintained throughout entry.

Main landing gear touchdown occurred at 283:13:57:19 G.m.t., on concrete runway 22 at Edwards AFB, CA. Nose landing gear touchdown occurred 12 seconds later with wheels stop at 283:13:58:08 G.m.t. The rollout was normal in all respects. The APU's were shutdown at 283:14:13:26 G.m.t., and the crew completed the required postflight reconfigurations and exited the vehicle at 283:14:53:55 G.m.t. During the postlanding walkaround video inspection of the Orbiter, part of a 2.5-inch frangible nut detonation booster was found on the runway underneath the umbilical disconnect area.

All scheduled development test objectives (DTO's) and detailed supplementary objectives (DSO's) were completed. DTO 797 (Star Line Maneuver Validation) was performed during the Ulysses/IUS deployment operations. All five scheduled data takes for DTO 785 (HUD Backup to COAS) were performed, and three data takes for DTO 1206 (Space Station Cursor Control Device Evaluation) were completed. DTO 827 (Tracking Using High Pitch Rates) was stopped after 40 seconds of the planned 30-minute test with propellant usage 191 lb greater than predicted for

the 30-minute test (112 lb). DTO 519/Test Condition 2 (Carbon Brake System Test, Concrete Runway) was completed successfully since the landing was made on concrete runway 22.

### VEHICLE PERFORMANCE

#### SOLID ROCKET BOOSTERS/REDESIGNED SOLID ROCKET MOTORS

All SRB systems performed as expected throughout ascent. The SRB prelaunch countdown was normal, redesigned solid rocket motor (rsrm) propulsion performance was well within the required specification limits, and the propellant burn rate for each RSRM was normal. RSRM thrust differentials during 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 SRB or RSRM launch commit criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred during the countdown.

Power up of all igniter joint and case heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. The nozzle bearing and flexible boot temperatures were maintained within the required LCC ranges. Ground purge operation was not necessary for thermal conditioning, but the purge was activated at T-15 minutes to inert the aft skirt atmosphere.

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 (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 after frustum separation and the subsequent parachute deployments were successfully completed. Both SRB's were successfully separated from the External Tank (ET) near the proper time, and the deceleration subsystems performed as designed. Both SRB's were observed during descent and were retrieved and returned to KSC for disassembly.

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

1. A blowhole was discovered in the vacuum putty in both the left and right RSRM igniters' outer joint along with cadmium plating damage and sooting. This condition is similar to a previous occurrence found after SRB recovery on the STS-36 mission. The left RSRM igniter joint damage consisted of a blowhole through the vacuum

putty at 165 degrees, and the hole was 0.20 inch at the gasket interface. The hole widened to 0.50 inch and then narrowed to 0.25 inch at the aft putty edge. A small area of pitting (0.003-inch maximum depth) was also found on the inside diameter of the forward dome boss at 165 degrees. At the location of the blowhole, cadmium plating was missing and corrosion was evident on the inside diameter of the outer gasket retainer between 160 and 185 degrees. Black combustion products were present on the gasket faces up to the primary seal cushion at three locations - the forward gasket face between 162 and 171 degrees, at 144 degrees, and on the aft face between 95 and 108 degrees. Combustion products were also observed on the outside diameter edge and aft face of the inner gasket around the entire circumference.

The right RSRM igniter joint damage consisted of a blowhole through the outer-joint putty at the 268-degree location. The hole measured 1.3 inches wide at the starting point and 0.25 inch at the through point. The inner joint putty/insulation and chamber insulation was in normal condition. The forward face had soot to the primary cushion between 262 and 270 degrees, and soot was found on the gasket inside diameter for the full 360 degrees. A light heat effect was noted to the cadmium from 262 to 270 degrees. Soot was also found on the aft face of the metal retainer through 171-0-45 degrees. Light corrosion was also present on the aft face and the inside diameter at 270 degrees, with no evidence of soot past the primary seal. The damage to the right RSRM was much less extensive when compared with the left RSRM damage, and well within the experience data base for this type of condition. No damage was noted to the elastomeric seal, the seal retainer, or the case igniter steel parts. Also, the overall joint capability was not affected.

2. Evidence of abnormal erosion to internal insulation (forward edge) was found on the left and right RSRM aft dome-to-stiffener and stiffener-to-stiffener factory joints. The erosion pattern is most evident at the areas of ply overlaps. The condition is random over the full circumference of the aft dome-to-stiffener factory joint, and at only four to six locations on the stiffener-to-stiffener factory joint. This type of erosion has been observed on three previous ground-test RSRM's; however, this is the first instance of erosion being found during postflight inspections. The remainder of the internal case insulation was in very good condition. Also, there were no indications of unusual erosion or of hot gas passing through the insulation.

#### EXTERNAL TANK

All objectives and requirements associated with the External Tank (ET) support of the launch countdown and flight were successfully accomplished. Propellant loading was completed as scheduled, and all prelaunch thermal requirements were



met. The ice/frost team reported that there was a 2-inch ice/frost ball on the liquid hydrogen umbilical located near a closeout area. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feed lines and on the pressurization line brackets. Frost was also present along the liquid hydrogen protuberance air load (PAL) ramps. All of these observations were acceptable. Overall thermal protection system performance was as expected for the existing ambient conditions. No LCC or OMRSD violations were identified during the countdown and no acreage ice was found on the ET.

Readings from liquid hydrogen ullage transducer 2 indicated a dropout for approximately 15 minutes. Readings went from 14.8 psi to 11.2 psi and back to 14.8 psi. This condition has been observed during other liquid hydrogen loadings with prepressurization and flight activities supported successfully.

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 15.4 psid. ET flight performance was excellent. All electrical and instrumentation equipment on the ET performed properly throughout the countdown and flight. The ET tumble system was deactivated for this flight. ET separation was confirmed, and radar data confirmed that the ET did not tumble. Preliminary data indicate that the ET impact was within the planned footprint and about 52 nmi. uprange from the preflight predicted impact point. No significant ET problems have been identified.

#### SPACE SHUTTLE MAIN ENGINE

All prelaunch operations associated with the SSME's were executed successfully. All SSME parameters were normal throughout the prelaunch countdown and compared well with expected values for this hardware. All engine-related conditions for engine start were achieved at the proper time. All LCC were met. All three engines started and operated normally, with engine start, thrust build-up, mainstage, shutdown, and propellant dump conditions well within specification. The 82-second hold at T-31 seconds did not significantly reduce the margin in the liquid oxygen inlet temperature LCC.

High pressure oxidizer turbopump and high pressure fuel turbopump temperatures were well within specification throughout engine operation. The SSME controllers provided the proper control of the engines throughout powered flight and no failures have been identified. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

#### SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown. The SRSS safe and arm (S&A) devices were armed and all system inhibits were turned off at the appropriate times. All SRSS measurements indicated that the system performed as expected throughout the flight. The system signal strength remained above the specified minimum (-97 dBm) throughout 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 SUBSYSTEM PERFORMANCE

### Main Propulsion System

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

A comparison of the calculated propellant loads at the end of replenish versus the inventory loads shows a loading accuracy of +0.01 percent for liquid hydrogen and -0.035 percent for liquid oxygen.

The gaseous hydrogen flow control valve "close command" verification during reduced fast fill failed for flow control valve 3 because of an inhibit which was caused by sequencing of other traffic on the command stream. A waiver was approved to move this verification forward to the LCC flow control valve "close check" after liquid hydrogen prepressurization. This verification was completed successfully.

The MPS helium system performed satisfactorily. During preflight operations, no hazardous gas concentrations of any significance were detected, and the maximum hydrogen level in the Orbiter aft compartment was 125 ppm, which is well within the historical limits for this vehicle. There was some evidence from the Orbiter grab bottle data that elevated hydrogen concentration levels occurred in the aft compartment during ascent. Although the concentration levels observed are well within specification and did not present a flight hazard, an investigation is in progress.

The gaseous oxygen flow control valves (FCV's) remained open during the engine start sequence and the early part of ascent and performed normally throughout the remainder of the flight. The minimum liquid oxygen ullage pressure experienced during the period of the ullage pressure slump was 15.4 psid, which is well within the expected band.

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

The STS-41 mission was the first flight of the step-1 gaseous oxygen fixed orifice/flow control valve. The initial postflight analysis of the step-1 performance versus the predicted performance initially revealed some discrepancies. However, the discrepancies were primarily caused by the

difference in the predicted and actual SSME performance concerning the Orbiter/engine gaseous oxygen interface pressure. The actual gaseous oxygen supply pressure, which was 107 to 144 psi higher than predicted, was based on one SSME operating at +3 sigma with the other two operating nominally. Actual engine performance showed one engine +3 sigma higher than predicted and the other two +2 sigma higher than predicted. The reconstructed analysis based on actual SSME performance and the throttling profile plus the 82-second hold showed excellent agreement with the actual liquid oxygen ullage pressure. The analytical model does not require updating, but a bias of SSME predicted (TAG) values based on the SSME flight history will be incorporated.

Out-of-specification valve response times were noted for the liquid oxygen and hydrogen outboard fill and drain valves (PV9 and PV11) at vacuum inert initiation. The OMRSD identifies the minimum response time as 2.9 seconds. The quick valve response times for PV9 and PV11 (2.851 and 2.710 seconds, respectively) are the result of the deletion of the manual anti-slam procedure. The valves are certified for this condition which is encountered frequently at vacuum inert conditions. These short response times are not considered anomalous.

STS-41 was also the first flight in which the direct insertion +X RCS settling maneuver at MPS dump start was deleted. Analysis had shown that the maneuver was not required and this was verified by the STS-41 data. The post-dump manifold pressures were not abnormal and a second vacuum inert was not needed.

#### Reaction Control Subsystem

The performance of the reaction control subsystem (RCS) was excellent with no anomalies noted. A total of 4238 lb of propellant was consumed with no forward RCS dump firing performed. The RCS was used for the performance of two development test objectives (DTO's). DTO 0827 - Tracking Using High Pitch Rates - was terminated by the crew after 40 seconds of the planned 30-minute duration by the crew, and a total of 191 lb of propellant in excess of the amount predicted for the entire 30-minute test (112 lb) was used. Additionally, DTO 0247 - Forward RCS Flight Test - was performed at three altitudes during entry.

During RCS configuration switching from regulator A to regulator B at 281:08:22 G.m.t., the crew reported that with the right RCS helium regulator A valve and switch in the open position, helium regulator B was switched by the GPC from closed to open. When this switching was done, the helium A talkback went from open to barberpole to open without the crew touching the helium regulator A switch. This was a known condition that happened previously on STS-28 and during testing at White Sands, and that the condition is caused by a water-hammer effect. This condition did not impact the mission.

The vernier RCS thrust chamber pressure values were observed to be occasionally low. This condition has been observed previously and is most likely caused by a residue build-up as a result of repeated short firing pulses. The condition was cleared by subsequent longer-duration firings of the affected thrusters. The

RCS hot-fire test was extended in length to obtain these longer duration firings on each thruster plus perform three pulses on each thruster. The burn times were 800 msec for the X and Y translations and 480 msec for the Z translations. This procedure was implemented in an attempt to clear any nitrate residue from the thruster valves. The extended pulse duration served to flush the valve main stage while the multiple pulses flushed the valve pilot stage.

#### Orbital Maneuvering Subsystem

The OMS operated very satisfactorily throughout the mission. No anomalies were recorded; however, both fuel quantity gaging systems (left and right) provided discrepant readings. These discrepancies had been predicted and were waived prior to the flight based on gaging system operation on the previous flight of these OMS pods.

Four OMS maneuvers were performed during the mission with two maneuvers being two-engine firings, one being a left-engine firing and the other being a right-engine firing. The total burn time of the engines was 369.5 seconds with a total differential velocity of 581.4 ft/sec. A total of 7983 lb of oxidizer and 4824 lb of fuel were used during the four maneuvers. Total firing time for the left engine was 325.4 seconds and for the right engine was 336.2 seconds.

#### Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem met all oxygen and hydrogen demands placed on the subsystem and operated nominally during the 98.2-hour mission. No subsystem anomalies were noted. The mission was flown with the three-tank configuration and a total of 1033 lb of oxygen and 128 lb of hydrogen were consumed during the mission (17 lb of oxygen used by crew). A 4-day (100-hour) mission extension at the average power level was possible with the available 1172.4 lb of oxygen and 133 lb of hydrogen reactants remaining at landing.

#### Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem satisfactorily supported the 98.2-hour mission and no anomalies were noted during the flight. However, one anomaly was noted during the prelaunch operations (at fuel cell startup) when the hydrogen flow meter for fuel cell 1 did not change from the 0.17 lb/hr initial reading. The flow meter showed no response to a change in current during the fuel cell load adjustment test. This condition did not impact mission operations.

The fuel cells produced 1495 kWh of electrical energy and 1144 lb of potable water from the 1016 lb of oxygen and 128 lb of hydrogen consumed during the mission. The average power level during the mission was 15.3 kW and 493 A. The fuel cells remained powered up for approximately 34 hours after landing.

### Auxiliary Power Unit Subsystem

The APU subsystem performance was very satisfactory during all phases of the mission. One heater anomaly was noted late in the mission and it did not impact the mission. The following table shows the run time and fuel consumption of each APU during the flight.

Flight phase	APU 1		APU 2		APU 3	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	21:08	58	21:09	62	21:08	58
FCS checkout			9:15	19		
Entry	01:18:09	188	59:33	138	59:33	145
Total <sup>a</sup>	01:39:17	246	01:29:57	219	01:20:41	203

Note:

<sup>a</sup> A total of 16 minutes 8 seconds of APU operation occurred after landing.

Upon selection of APU 1 fuel pump/gas generator valve module (FP/GGVM) heater system B, following flight control system (FCS) checkout, the fuel bypass line temperature rose from 110 °F to 258 °F in about 4 minutes. This abnormally high temperature rise rate (should have been approximately 6 °F/min) caused the A system heaters to be reselected after which heater operation was nominal for the remainder of the mission (STS-41-03).

During the APU 2 and 3 FP/GGVM heater A operation throughout the mission, the fuel bypass line temperatures indicated a 10 °F and 6 °F controlling band, respectively (STS-41-11). When the heater systems were reconfigured to the B system heaters, both thermostats functioned nominally with approximately 30 °F controlling bands.

### Hydraulics/Water Spray Boiler Subsystem

The performance of the hydraulics/water spray boiler subsystem was satisfactory throughout the mission. During the final countdown, the normal temperature decrease in the aft compartment resulted in a lower temperature in the water spray boiler (WSB) 2 steam vent duct which led to the loss of the WSB "okay" indication. The countdown was held at T-5 minutes for a 10-second period to mask the measurement in the GLS. This condition has been observed on previous missions and does not constitute a LCC violation, if trend data indicates the lower temperature is the result of a heater failure. This heater operated properly later in the flight. The LCC has been deleted for subsequent flights in favor of a heater confidence check earlier in the count.

Water spray boiler regulator 3 outlet pressure showed some decay during the mission. However, the decay rate was within specification and continued to decrease as the mission progressed, although it did not reach zero before the end of mission. This condition was observed on previous missions and is caused by the relief valve in the regulator not seating fully after ascent. Experience has shown that this valve will tend to reseat with time.

During FCS checkout, the operational time for APU 2 was longer than previously experienced (9 minutes 15 seconds) and, as a result, water spray boiler spraying for APU lubrication oil cooling was initiated about 7 minutes after APU start. About 1 lb of water was used during the period of the spraying.

Hydraulic performance was nominal during the mission, although some toggling of the thrust vector control actuator switching valves was noted prior to and during entry. The toggling activity did not occur during ascent, FCS checkout, or postlanding operations when the engines were moved to the "rain-drain" position. This condition did not impact the mission in any manner, but an analysis of the data during the period of toggling is underway.

During the APU 2 start sequence for entry, the hydraulic system 2 priority valve exhibited a sluggish response, requiring 5.8 seconds to open and at an elevated differential pressure of 400 - 500 psi (STS-41-10). The valve normally opens instantaneously and at a differential pressure of 25 psid. However, the sluggish operation did not affect the mission in any manner.

During entry, an overcooling of the APU 3 lubrication oil occurred for a 6-minute period after spraying began for lubrication oil cooling. The temperature drop indicating overcooling lasted for approximately 1 minute before recovering. This condition has been observed on three of the last four flights of this vehicle with no impact to the flight.

#### Pyrotechnics Subsystem

The pyrotechnics subsystem operated properly during the mission. However, when the ET umbilical door was opened postlanding, a 2 1/2-inch piece of a pyrotechnic device dropped to the runway (STS-41-07). This anomaly is discussed in the Mechanical section of this report.

#### Environmental Control and Life Support System

Performance of the environmental control and life support system (ECLSS) was satisfactory throughout the mission with two anomalies identified.

Performance of the atmospheric revitalization system was normal. However, the cabin temperatures were cooler than desired by the crew. The cabin temperature controller upper control limit of 80 °F was too cool for crew comfort. The crew pinned the controller to 2/3 cool and the indicated cabin upper temperature peaked at 85 to 87 °F. A cabin temperature survey was performed using the temperature probe in the in-flight maintenance (IFM) tool kit. Preliminary results showed the temperature of the air, prior to entering the cabin temperature sensors, was 3 to 10 °F less than indicated. Analysis of this condition is continuing.

The pressure control system performed normally. At 8 minutes 54 seconds after lift-off, a systems management (SM) alert message was generated, indicating an out-of-specification (>0.12 psi/min) momentary cabin leak rate on the backup dP/dT calculation (STS-41-05). Subsequent evaluation of the data indicates that the calculation algorithm exaggerated the actual pressure change, and that all hardware had operated properly. Evaluation of this condition continues.

Performance of the active thermal control system was satisfactory. During ascent, a flash evaporator over-temperature shutdown occurred because of the effect of the midpoint sensor block unit which is unique to OV-103 and the thermal effects of the radioactive thermoelectric generator (RTG) cooling loop. This condition was expected. After landing, the ammonia boiler primary A controller controlled the evaporator outlet temperature to 31.6 °F. This temperature was outside of the  $35 \pm 3$  °F control band specification (STS-41-09).

The supply and waste water were managed successfully throughout the mission with one supply and one waste water dump performed.

The waste collection system (WCS) performance was normal and met all crew requirements. During day 3 of the mission, the A circuit breaker for the WCS was inadvertently pulled and this caused the WCS to operate on two-phase current only. The WCS operated properly during the period that the circuit breaker was open, and normal three-phase operation resumed after the circuit breaker was closed. Also, the WCS door/curtain attachment bracket on the galley became unbonded. This occurred on previous flights and is not considered to be a problem.

#### Smoke Detection and Fire Suppression Subsystem

The smoke detection and fire suppression subsystem operated satisfactorily.

#### Airlock Support System

The airlock support system was not exercised this mission except the airlock was used for stowage.

#### Avionics and Software Subsystems

The avionics and software subsystems performed nominally; however, several anomalous conditions were noted during the mission.

The integrated guidance, navigation, and control subsystem performance was nominal for all phases of the mission. The flight control system (FCS) was operated during the checkout on the day before entry, and also it was used to perform three maneuvers with the forward RCS thrusters during entry in support of DTO 0247.

At 282:20:35:00 G.m.t., the IMU in slot 1 exhibited a Z-accelerometer channel failure (STS-41-04). The IMU redundancy management (RM) isolated the failure and deselected the IMU at 282:20:36:57 G.m.t. The transient problem occurred several times with the transients lasting from 5 to 15 minutes. After data analysis and monitoring of the IMU parameters for several hours, the decision was made to keep IMU 1 deselected for the remainder of the mission, but left in the operate mode. Performance remained anomalous for the remainder of the on-orbit phase. However, during entry, the performance appeared to improve as acceleration was sensed.

Prior to transition to OPS-2 following main engine cutoff, the crew reported that the system management bus assignment table in the software was incorrect (STS-41-01). Review of the T-20 minute dump data revealed that this condition

was caused by activities that occurred during the countdown. Launch data bus commands had been transmitted to an incorrect cathode ray tube, causing string 3 to be assigned to general purpose computer 2.

The electrical power and distribution control subsystem performance was nominal throughout the flight and all in-flight checkout requirements were satisfied. During the postflight inspection, a loose electrical connector backshell was found on the bulkhead (starboard side) on one of the forward attachment pyrotechnic lines. Further inspections showed that the connector backshell on the port side was also loose. Analysis of the cause of loose backshells is in progress.

The left-hand rotational hand controller trim enable/inhibit switch data indicated that one of the two contacts opened momentarily at 283:11:44 G.m.t. (STS-41-08). The switch was cycled and operated properly thereafter.

The left-hand attitude direction indicator rate/scale switch telemetry showed high and medium at the same time for a 26-second period (STS-41-06). A review of the data indicates that both signals were active for this period of time.

The communications and tracking systems operated satisfactorily. During the early orbits (1-3) of the mission, a number of unexplained communications dropouts occurred when transmitting on the lower left antenna. The dropouts did not impact the mission.

Also, early in the mission, downlink of a signal from closed circuit television (CCTV) camera C showed an image burn (STS-41-02a). The image of the Orbiter structure was present on all video from that camera, indicating an extended overexposure to intense light. The image from CCTV camera D showed blinking and flashing colors (STS-41-02b). This condition is indicative of incorrect color phasing. Neither of these anomalies had any impact on the mission.

#### Mechanical Subsystems

The mechanical subsystems operated satisfactorily. During the postlanding inspection, pyrotechnic debris was found on the runway below the opened Orbiter/ET door (STS-41-07). The inspection revealed that the debris plunger in the liquid hydrogen separation fitting debris container was caught by the frangible nut halves and the plunger failed to seat properly. Three pieces of a spent ordnance assembly fell to the runway when the door was opened. Four pieces of hardware are missing and apparently exited the debris container prior to ET door closure.

#### Aerodynamics

The ascent and entry aerodynamics were nominal and the vehicle responded as expected. Three programmed test inputs (PTI's) were inputted during entry for DTO 247, and the results from these inputs are being evaluated.



### Thermal Control Subsystem

The thermal control subsystem (TCS) performed satisfactorily, maintaining temperatures within the desired ranges. The APU FP/GGVM system B heater failed in the on condition during the third day of the mission, immediately after reconfiguring that heater from system A to system B (STS-41-03). This anomaly is discussed in the Auxiliary Power Unit section section of this report.

The water spray boiler vent system A heater, which has performed anomalously on the last three flights of this vehicle, again showed sluggish performance during the post-insertion bakeout period and one anomalous cycle during the pre-entry conditioning period. However, the heater did maintain the required vent temperatures during the mission.

One thermal blanket on the upper X<sub>0</sub> 1307 bulkhead became partially unfastened during ascent. Video of the payload bay revealed this condition which did not impact the mission. During postflight inspection, a 6-inch piece of the aft payload bay door environmental seal (on the X<sub>0</sub> 1307 bulkhead) was found behind the damaged blanket (STS-41-12). Loss of this piece of seal did not result in any damage to the payload bay.

### Thermal Protection Subsystem and Aerothermodynamics

The thermal protection subsystem (TPS) performance was nominal based on structural temperature responses and some tile surface temperature measurements. The overall boundary layer transition from laminar flow to turbulent flow was nominal, occurring at 1235 seconds after entry interface. Transition was symmetrical.

All vehicle temperatures were maintained within acceptable limits during the mission. Acreage heating was nominal, although some evidence of localized heating was noted on the body flap where a 2-inch gouge with melting (glazing) indicated was noted during the postflight inspection. The body flap had a 12-degree down deflection during entry and this condition increases heating.

Postflight inspection of the TPS revealed a total of 76 hits of which 16 had a major dimension of one inch or greater. The majority of the hits (64) were on the lower surface of which 13 had a dimension greater than one inch. The hits were evenly distributed about the vehicle centerline with the total number of hits considered to be better than average and the severity of damage also being better than average.

Overall, the reinforced carbon carbon (RCC) parts looked good. The port leading edge structure subsystem (LESS) T-seal 7 had damage to a previously repaired edge. The seal will be removed and replaced. The nose landing gear door thermal barrier was in good condition with a small detached section of forward Nicalon sacrificial patch. The chin area tiles looked in good condition, with one small chip on the forward edge of one tile. The forward RCS thermal barrier was in excellent condition. The right main landing gear door thermal barrier had a small fray in the aft outboard section. The left main landing gear door thermal barrier had a frayed section on each corner. The ET door thermal barriers were in good

condition with evidence of minor flow paths. The elevon-elevon gap tiles were in good condition. Three right-hand rudder speed brake (trailing edge) tile had broken coating. The engine-mounted heat shield thermal curtains (new design) were in excellent condition. Orbiter windows 2, 3, and 4 were heavily hazed with some minor streaking. The remaining windows had a cover of light haze. Overall, the upper surface and OMS pods TPS was in good condition with minor blanket damage and protruding pillow gap fillers.

Inspections of the payload bay door environmental seal revealed a 6-inch section of the seal at the centerline of the X 1307 bulkhead missing (STS-41-12). Postflight inspections of the TCS blanket revealed that the missing seal wedge was behind the TCS blankets. Analysis of the seal will be performed to determine the cause of the seal movement. The loss of the seal did not impact the flight in any manner.

### Remote Manipulator System

The remote manipulator system (RMS) performance was nominal and the mission objective, which was to place the RMS witness plate assembly (WPA) outside the Shuttle payload bay in the atomic oxygen stream for a major portion of the flight, was accomplished. Attached to the WPA was the Intelsat Solar Array Coupon (ISAC) - a representative portion of the solar array material on the Intelsat satellite that failed to reach geosynchronous orbit on an earlier unmanned launch.

After performing a nominal RMS checkout, the arm was placed in the ISAC data-gathering position on flight day 2 at 280:14:07:00 G.m.t. The arm was deployed in this data-gathering position for approximately 48 hours. RMS operations were terminated and the arm was cradled and stowed on flight day 4 at 282:15:02:15 G.m.t.

The complete RMS checkout was performed including the end-effector procedures despite there being no end effector operations required by the mission objectives. STS-41 is the second flight of the redesigned end effector and a full checkout was performed to gather additional data. The end effector performed nominally.

Backup release of the snare wires required 13 seconds to complete. This was longer than the 11 seconds observed on the first flight (STS-31) of this end effector, but the end effector temperature on this flight was colder than on the previous flight. This extra time for backup release of the snare wires did not impact flight operations.

On flight day 3 a brief amount of RMS data were obtained during the performance of the DTO 0827, which included a primary RCS thruster firing. These data showed that the arm moved only 0.1° at the tip, and no brake slip alarms occurred.

### FLIGHT CREW EQUIPMENT

The flight crew equipment performed satisfactorily. A +X axis crew optical alignment sight (COAS) calibration was performed at 281:07:10 G.m.t., and the crew reported that the line-of-sight had shifted about 0.5° from the first calibration.

The operational requirement is for a line-of-sight shift no greater than 0.12°. All four subsequent +X COAS calibrations indicated no line-of-sight shift when compared to the first calibration. All head up display (HUD) data-takes also agreed with the first +X COAS calibration line of sight. This condition has occurred on three previous flights of OV-103. Extensive testing of the COAS and its mounting mechanism has shown no equipment problems, indicating that the problems may be due to on-orbit structural deformation of the Orbiter. DTO's are scheduled for STS-38 and STS-40 to determine if this condition also exists on OV-104 and OV-102.

During flight day 1, a large drop of water was observed in the area of the galley. The crew wrapped a towel around the valve and no further leakage was observed. The towel was checked postflight and found to be dry.

The crew reported that the combustion products analyzer daily readings showed an upward trend in the crew module carbon monoxide levels as follows:

- a. Flight day 1 - 5 ppm
- b. Flight day 2 - 16 ppm
- c. Flight day 3 - 28 ppm
- d. Flight day 4 - 48 ppm

The maximum permissible limit by Operational Safety and Health Administration (OSHA) standards is 50 ppm carbon monoxide and the spacecraft maximum allowable concentration (SMAC) is 25 ppm. Postflight analysis determined that the combustion products analyzer was misinterpreting normal hydrogen levels in the crew module as carbon monoxide.

#### PHOTOGRAPHIC AND VIDEO ANALYSIS

The video from 22 of 24 cameras used during launch was evaluated and no anomalies were noted. Also, 68 launch films were reviewed and no anomalies were noted; however, some debris and body flap vibration were noted.

A piece of debris was noted during the Ulysses deployment. The unusual arc-shaped piece of debris was documented by payload bay camera B at the aft end of the cargo bay. The length/width ratio of the debris was 8/1. The object was so thin in the other dimension as to almost disappear from view at times. The debris was also recorded for a short period of time with the hand-held camcorder, payload bay camera B, and a 16-mm film camera. Phototheodolite techniques were used for evaluation of the data that were obtained simultaneously from the two video cameras. The source of the debris has not as yet been determined. The position of the debris with respect to Orbiter coordinates and dimensions upon the initial viewing of the debris were as follows:

$X_o = 1244.72 \pm 0.05$  in.  
 $Y_o = 14.83 \pm 4.56$  in.  
 $Z_o = 529.82 \pm 4.86$  in.  
Chord length = 23.36 in.  
Width = 3.9 in.  
Radius = 27.1 in.  
Subtended angle = 51 degrees

Also, the crew obtained 27 70mm still photographs of the ET during and following the ET separation. In nineteen of the photographs, the ET could be distinguished from the background well enough for an analysis to be conducted.

Video of landing was obtained from six cameras, and an analysis of these data showed no anomalies. Also, 11 landing films were evaluated and no anomalies were noted in these data. The Point Mugu tracker cameras on one side of the runway did not operate; consequently, no phototheodolite solution of sink rates can be made.

#### DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

A total of 15 development test objectives (DTO's) and 10 detailed supplementary objectives (DSO's) were assigned to this mission. All but two of the scheduled DTO's were accomplished. Of these two, one is no longer active and the other, Crosswind Landing Performance, could not be performed because the landing crosswinds were too low to meet the requirements of the DTO. All of the scheduled DSO's were completed.

#### DEVELOPMENT TEST OBJECTIVES

DTO 247 - Forward RCS Flight Test - The objective of DTO 247 was to perform a series of forward RCS flight test maneuvers during entry to obtain flight data showing the aerodynamic effects created when the forward RCS side-firing thrusters are used as a means of eliminating RCS propellant. Three programmed test inputs (PTI's), consisting of 4-second pulse firings of the forward RCS yaw thrusters, were completed as planned during entry. The Orbiter performed well during the test maneuvers with the performance being as expected based on Shuttle mission simulator tests. The crew also reported that bright flames were visible during the forward RCS firings. Data have been given to the sponsor for evaluation.

DTO 301D - Ascent Structural Capability Evaluation - The objective of DTO 301D is to evaluate the Shuttle structural capability at (or near) design conditions during lift-off and ascent. Data were recorded for the periods of flight, and the data have been returned to the sponsor for evaluation.

DTO 305D - Ascent Compartment Venting Evaluation - The objective of DTO 305D is to collect data under operational conditions to evaluate and upgrade Orbiter ascent venting models, and to verify the capability of the vent system to maintain compartment pressure. Data were recorded for the period of interest, and the data have been returned to the sponsor for evaluation.

DTO 306D - Descent Compartment Venting Evaluation - The primary objectives of DTO 306D are to collect data under operational conditions to validate/upgrade the Orbiter descent venting math models and to verify the capability of the vent system to maintain compartment pressures within design limits. Data were collected during descent, and these data have been given to the sponsor for evaluation.

DTO 307D - Entry Structural Capability - The objectives of DTO 307D are to verify the adequacy of the structure at (or near) design conditions and to demonstrate structural system operational capability, to determine flight loads, and to verify the stress/temperature response of critical structural components. Data were collected during descent, and these data have been given to the sponsor for evaluation.

DTO 312D - ET Thermal Protection System Performance (Method 2) - The objective of DTO 312D is to obtain photographic documentation of the ET after separation to determine TPS charring patterns, identify any regions where the thermal protection system material spallation may be occurring, and evaluate overall ET thermal protection system performance. This DTO was successfully performed by the crew following Orbiter/ET separation. The crew took 27 photographs of the ET, including some rare views of the top of the ET. Nineteen of the photographs provided adequate definition of the ET from the background so that an analysis can be made.

DTO 319D - Shuttle/Payload Low Frequency Environment - The objective of DTO 319D is to obtain low frequency (0 to 50 Hz) payload/Orbiter interface data to enable development payload loads and responses. Data were collected both during ascent and during entry, and the data have been given to the sponsor for evaluation.

DTO 330 - Water Dump Cloud Formation - This DTO has been deleted from the list of active DTO's, and therefore was not planned, even though the DTO was manifested. The crew attempted to perform the DTO over Houston on the morning of flight day 3, but the dump was not visible to ground personnel because of decreasing nozzle temperatures.

DTO 519 - Carbon Brake System Test (Test Condition 2) - The objective of DTO 519 is to evaluate the Orbiter carbon brake system performance through a series of landing rollout brake tests on the lakebed and on concrete surfaces. Test condition 2 had a brake-on velocity of 140 knots ground speed and a deceleration rate of 8 to 10 ft/sec to 50 knots ground speed. This test was performed during the rollout at near the planned test conditions. The data have been given to the sponsor for evaluation.

DTO 785 - Head Up Display Backup to COAS - The objective of DTO 785 was to verify the suitability of the HUD as a sighting device for IMU alignments in all modes of COAS operation. The crew successfully completed this DTO, performing five +X calibrations with excellent results. Four of the tests were performed by the Commander and one was performed by the Pilot. The crew reported that the HUD is not only a valid backup to the COAS, but is much easier and more comfortable to use. The crew recommends that the HUD be used for this type of operation on all future flights. The crew also recommends the addition of a reticle to the HUD for ease of alignment.

DTO 795 - Payload and General Support Computer Electroluminescent Display Evaluation - The objective of DTO 795 is to evaluate the new payload and general support computer configuration which includes an electroluminescent display that is much brighter and has a wider viewing angle. The crew successfully completed the DTO and reported that the new electroluminescent display is much easier to read than the old liquid crystal display (LCD).

DTO 797 - Star Line Maneuver Evaluation - The purpose of DTO 797 is to align the inertial reference system of the payload directly using the Orbiter star trackers with Orbiter calibration maneuvers. This DTO was successfully performed; however, because of the downlist configuration, the data were not received successfully.

DTO 805 - Crosswind Landing Performance - DTO 805 was not performed because the crosswinds at landing were not sufficient to meet the planned test conditions.

DTO 827 - Tracking Using High Pitch Rates - The purpose of DTO 827 is to test the ability of the Orbiter to maneuver efficiently at high pitch rates with tight attitude and rate deadbands. DTO 827 was not completed as the performance of the DTO was terminated after 40 seconds because the Orbiter began to exhibit cross-coupling in both the roll and yaw axes and did not accelerate in the pitch axis as fast as desired. As a result, the digital autopilot (DAP) commanded additional thruster firings to null out the cross-coupling and compensate for the lack in acceleration. The additional thruster firings failed to stabilize the Orbiter; consequently the crew terminated the test. A total of 303 lb of RCS propellant was consumed during the 40 seconds compared with the planned 112 lb for the entire 30 minutes of planned DTO performance. The sponsor is currently evaluating the data and investigating possible causes for the cross-coupling and low acceleration, as well as evaluating the failure of the DAP to converge to a stable vehicle configuration.

DTO 1206 - Space Station Cursor Control Device Evaluation - The objective of DTO 1206 is to evaluate human performance under spaceflight conditions of cursor control devices which are similar to the devices under consideration for Space Station. DTO 1206 was successfully performed by the crew.

#### DETAILED SUPPLEMENTARY OBJECTIVES

DSO 472 - Intraocular Pressure - DSO 472 was performed as planned and data are being evaluated by the sponsor.

DSO 474 - Retinal Photography - DSO 474 was performed as planned and data are being evaluated by the sponsor.

DSO 601 - Changes in Baroreceptor Reflex Function - DSO 601 was performed as planned and the data are being evaluated by the sponsor.

DSO 602 - Blood Variability During Space Flight - DSO 602 was performed as planned and the data are being evaluated by the sponsor.

DSO 603 - Orthostatic Function During Entry, Landing and Egress - DSO 603 was performed as planned and the data are being evaluated by the sponsor.

DSO 604 - Visual/Vestibular Integration as a Function of Adaption - DSO 604 was performed as planned and the data are being evaluated by the sponsor.

DSO 605 - Postural Equilibrium Control During Landing/Egress - DSO 605 was performed as planned and the data are being evaluated by the sponsor.

DSO 901 - Documentary Television - DSO 901 was performed as planned and the video data are being evaluated by the sponsor.

DSO 902 - Documentary Motion Picture Photography - DSO 902 was performed as planned and the photographic data are being evaluated by the sponsor.

DSO 903 - Documentary Still Photography - DSO 903 was performed as planned and the photographic data are being evaluated by the sponsor.

TABLE I.- STS-41 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	279:11:41:05.76
	APU-2 GG chamber pressure	279:11:41:06.65
	APU-3 GG chamber pressure	279:11:41:07.63
SRB HPU activation	LH HPU system A start command	279:11:46:48.07
	LH HPU system B start command	279:11:46:48.07
	RH HPU system A start command	279:11:46:47.59
	RH HPU system B start command	279:11:46:48.59
Main propulsion System start	Engine 3 start command to EIU	279:11:47:08.413
	Engine 2 start command to EIU	279:11:47:08.556
	Engine 1 start command to EIU	279:11:47:08.669
SRB ignition command (lift-off)	SRB ignition command to SRB	279:11:47.14.983
Throttle up to 104 percent thrust	Engine 3 command accepted	279:11:47:19:053
	Engine 2 command accepted	279:11:47:19.076
	Engine 1 command accepted	279:11:47:19.069
Throttle down to 100 percent thrust	Engine 3 command accepted	279:11:47:32.814
	Engine 2 command accepted	279:11:47:32.836
	Engine 1 command accepted	279:11:47:32.830
Throttle down to 67 percent thrust	Engine 3 command accepted	279:11:47:42.735
	Engine 2 command accepted	279:11:47:42.757
	Engine 1 command accepted	279:11:47:42.750
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	279:11:48:06
Throttle up to 104 percent thrust	Engine 3 command accepted	279:11:48:13.616
	Engine 2 command accepted	279:11:48:13.638
	Engine 1 command accepted	279:11:48:13.631
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	279:11:49:13.74
	RH SRM chamber pressure mid-range select	279:11:49:13.86
End SRM action	LH SRM chamber pressure mid-range select	279:11:49:16.08
	RH SRM chamber pressure mid-range select	279:11:49:16.68
SRB separation command	SRB separation command flag	279:11:49:19
SRB physical separation	SRB physical separation	
	LH APU A turbine speed LOS*	279:11:49:19.10
	LH APU B turbine speed LOS*	279:11:49:19.06
	RH APU A turbine speed LOS*	279:11:49:19.14
	RH APU B turbine speed LOS*	279:11:49:19.10
Throttle down for 3g acceleration	Engine 3 command accepted	279:11:54:45.795
	Engine 2 command accepted	279:11:54:45.809
	Engine 1 command accepted	279:11:54:45.761
3g acceleration	Total load factor	279:11:54:45
MECO	MECO command flag	279:11:55:45
	MECO confirm flag	279:11:55:46
ET separation	ET separation command flag	279:11:56:03

\* = loss of signal



TABLE I.- CONTINUED

<u>Event</u>	<u>Description</u>	<u>Actual time, G.m.t.</u>
OMS-1 ignition	Left engine bi-prop valve position	None required/ Direct insertion
APU deactivation	APU-1 GG chamber pressure	279:12:02:14.18
	APU-2 GG chamber pressure	279:12:02:15.62
	APU-3 GG chamber pressure	279:12:02:15.91
OMS-2 ignition	Left engine bi-prop valve position	279:12:27:08.5
	Right engine bi-prop valve position	279:12:27:08.6
OMS-2 cutoff	Left engine bi-prop valve position	279:12:29:32.5
	Right engine bi-prop valve position	279:12:29:32.6
Ulysses deployment	Voice call	279:17:48:14
Ulysses first burn	Voice call	279:18:53:13
RCS separation 1 burn	Left engine 1 A jet driver	279:17:49:13
RCS separation 2 burn	Forward engine 2 F jet driver	Not performed
Flight control system checkout		
APU start	APU-2 GG chamber pressure	282:09:51:23.98
APU stop	APU-2 GG chamber pressure	282:10 00:39.16
APU activation for entry	APU-1 GG chamber pressure	283:12:55:09.37
	APU-2 GG chamber pressure	283:13:13:47.06
	APU-3 GG chamber pressure	283:13:13:48.81
Deorbit maneuver ignition	Left engine bi-prop valve position	283:13:00:05.3
	Right engine bi-prop valve position	283:13:00:05.1
Deorbit maneuver cutoff	Left engine bi-prop valve position	283:13:02:33.9
	Right engine bi-prop valve position	283:13:02:33.7
Entry interface (400k)	Current orbital altitude above reference ellipsoid	283:13:26:43
Blackout end	Data locked at high sample rate	No blackout because of TDRS
Terminal area energy management	Major mode change (305)	283:13:51:04
Main landing gear weight on wheels	LH MLG weight on wheels	283:13:57:18
	RH MLG weight on wheels	283:13:57:18
Nose landing gear weight on wheels	NLG WT on Wheels -1	283:13:57:31
Wheels stop	Velocity with respect to runway	283:13:58:08
APU deactivation	APU-1 GG chamber pressure	283:14:13:19.27
	APU-2 GG chamber pressure	283:14:13:20.62
	APU-3 GG chamber pressure	283:14:13:21.73

TABLE II.- STS-41 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-41-01	SM2 NEAT had GPC 2 assigned to String 3. (Should be unassigned)	279:12:50 G.m.t. IPR 39V-0001	Moved to integration as IFA STS41-1-01. CLOSED.
STS-41-02	CCTV (GFE) a) Camera C image burn	280:05:40 G.m.t. FIAR B-FCE-029-F018	a) Burned in image of the Orbiter structure seen in downlink. Indicative of extended overexposure to intense light. Remove and ship to FEPC. No ferry impact.
	b) Camera D incorrect color phasing	FIAR B-FCE-029-F019	b) Image showed blinking or flashing color. Remove and ship to FEPC for potentiometer adjustment. CLOSED
STS-41-03	APU GG/FP Heater System B failed on	282:12:10 G.m.t. IPR 39V-0003 IM 41RF01	When crew selected B heaters following FCS checkout, BYP LINE TEMP rose from 110 °F to 258 °F in approximately 3 minutes. Reselected A heaters and temperatures returned to normal. Short circuit verified - wire nicked at wire clamp. Removal and replacement completed.
STS-41-04	IMU-1 RM fail	282:20:36 G.m.t. PR-GNC-3-12-0105 IM 41RF02	IMU-1 experienced transient Z axis accelerometer shifts of up to 10,000 micro g's. The IMU was failed by RM. The problem occurred several times with the transient lasting from 5 to 15 minutes. Not considered to be generic problem. Testing complete and problem repeated. Remove and replace IMU.
STS-41-05	BFS Backup dp/dt calculation triggered FDA at MECO	279:11:56:09 G.m.t.	At 8 minutes 54 seconds after lift-off, a fault message by BFS backup dp/dt calculation indicated a cabin leak rate of 0.14 psi/min (FDA limit is 0.12 psi/min). Analysis shows that a two data bit step response (1 data bit normal) by the cabin pressure sensor caused the calculation to trigger FDA. Hardware dp/dt sensor showed no problem. No ferry impact. BFS change under consideration.
STS-41-06	Left ADI Rate/Scale Switch showed HI and MED Simultaneously	283:11:16 G.m.t. IPR 39V-0005 IM 41RF03	Data confirmed both signals active simultaneously for 26 seconds. Switch is single pole. Crew was not using switch during this occurrence (Crew debriefing information.) KSC unable to duplicate. Will verify wiring with breakout box and remove and replace switch
STS-41-07	Debris plunger (EO-2) fail to seat/Ordnance pieces found on runway	Orb/ET separation Found Postlanding PR-PTR-3-12-0153 CAR 41RF04	The debris plunger in the EO-2 (LH2) separation fitting debris container was caught by the frangible nut halves and failed to seat properly. Three pieces of spent ordnance assembly were found on the runway beneath the LH2 Orbiter/ET umbilical opening and may be attributed to this failure. In addition, a 2-inch long piece of what appears to be lockwire was found on the runway beneath the LO2 Orbiter/ET umbilical opening. The origin of this wire is unknown. Four pieces of hardware are missing and apparently exited the debris container prior to ET door closure. The EO-1 and EO-3 separation ordnance device plungers appeared to have functioned properly. Debris to be shipped to JSC. Redesign is in work.

TABLE II.- STS-41 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-41-08	Left RHC Trim Inhibit Switch Contact Mismatch	283:11:44 G.m.t. IPR 39V-0009 IM 41RF05	The A contact discrete failed low for 16 seconds. KSC troubleshooting could not reproduce the failure. Crew does not recall moving the switch in this time frame. Possible unexplained anomaly - fly as is.
STS-41-09	Ammonia Boiler Primary A Controller to 31.6 °F, Evaporator Outlet Temperature should be 35 + 3 °F.	Postlanding IM41RF06 IPR 39V-0018	Controller stabilized at 31.6 °F, KSC to check evaporator outlet temperature sensor accuracy. Testing scheduled for November 1.
STS-41-10	Hydraulic System 2 Priority Valve Sluggish Response	283:13:14:09 G.m.t. PR HYD-3-12-0426 IM 41RF07	During APU 2 start for entry, the priority valve took 5.8 seconds to open and opened at a differential pressure of 400 - 500 psi. Normally, valve opens instantaneously at differential pressures of 25 psi. Remove and replace valve and analyze for failure.
STS-41-11	a) APU 2 Heater 2A Set Point Dithering b) APU 3 Heater 3A Set Point Dithering	Flight Duration	Deleted by PRCBD S488406
STS-41-12	Lost 6 inch Section of Aft Payload Bay Door Environmental Seal	Ascent	Postflight inspections revealed a 6-inch section of aft payload bay environmental seal (X <sub>0</sub> 1307 bulkhead) missing. Thermal control blanket (TCS) unfastening was also recorded. Postflight analysis of on-orbit X <sub>0</sub> bulkhead photographs of TCS blankets revealed that seal was missing. Seal found behind unfastened blanket.