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STS-43 SPACE SHUTTLE MISSION REPORT

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STS-43

SPACE SHUTTLE

MISSION REPORT

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INTRODUCTION

The STS-43 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem operations during the forty-second flight of the Space Shuttle Program and the ninth 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-47 (LWT-40), three Space Shuttle main engines (SSME's) (serial numbers 2024, 2012, and 2028 in positions 1, 2, and 3, respectively), and two Solid Rocket Boosters (SRB's) designated as BI-045.

The primary objective of the STS-43 mission was to successfully deploy the Tracking and Data Relay Satellite-E/Inertial Upper Stage (TDRS-E/IUS) satellite and to perform all operations necessary to support the requirements of the Shuttle Solar Backscatter Ultraviolet (SSBUV) payload and the Space Station Heat Pipe Advanced Radiator Element (SHARE-II).

The sequence of events for the STS-43 mission is shown in Table I, and the official Orbiter Problem Tracking List is presented in Table II. In addition, each Orbiter subsystem anomaly is discussed in the applicable subsystem section of the report and a reference to the assigned tracking number is provided. Official ET, SRB, and SSME anomalies are also discussed in their respective sections of the report and the assigned tracking number is also shown.

The crew for this forty-second flight of the Space Shuttle vehicle was John E. Blaha, Col., USAF, Commander; Michael A. Baker, Lt. Cdr., USN, Pilot; Shannon W. Lucid, Ph.D, Mission Specialist 1; G. David Low, Mission Specialist 2; and James C. Adamson, Lt. Col., USA, Mission Specialist 3. STS-43 was the third Space Shuttle flight for the Commander and Mission Specialist 1, the second Space Shuttle flight for Mission Specialist 2 and 3, and the first Space Shuttle flight for the Pilot.

SUMMARY

The launch of the STS-43 vehicle occurred at 214:15:01:59.986 G.m.t. (11:01:59.986 a.m. e.d.t. on August 2, 1991) from launch pad A at Kennedy Space Center (KSC), and all subsystems performed satisfactorily during the ascent phase. All SSME and redesigned Solid Rocket Motor (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, with main engine cutoff (MECO) occurring approximately 505.9 seconds after lift-off. No orbital maneuvering subsystem (OMS) 1 maneuver was required as a direct insertion trajectory was flown. The OMS 2 maneuver was performed at 214:15:41:50.9 G.m.t. The 142.7-second maneuver imparted a differential velocity (ΔV) of 222.2 ft/sec and placed the Orbiter in the planned circular orbit. Both SRB's were successfully recovered and returned to KSC for inspection and disassembly. No significant discrepancies were noted in the subsystem performance data. The successful launch of STS-43 followed two launch countdown scrubs which are discussed in the following paragraphs.

The SSME 3 controller went to halt when an unrecoverable channel A parity error was detected during the countdown for the anticipated launch on July 24, 1991. Data indicated that a hardware failure of the main engine controller had occurred. As a result, the launch was scrubbed to allow replacement of the controller, and the launch was rescheduled for August 1, 1991.

During the countdown for the anticipated launch on August 1, 1991, the T-9 minute hold in the countdown was extended. The initial reason for the extended hold was the lack of a closed indication from the cabin vent valve when the cabin pressure check was completed. The vent valve was cycled several additional times, but the closed indication was never received. A retest of the cabin pressure integrity verified that the cabin-pressure vent-valve was closed, and the vehicle was declared ready for launch.

Following the cabin pressure integrity retest, crosswinds at the return to launch site (RTLS) Shuttle Landing Facility were exceeding the limits and the T-9 minute hold was further extended. During this hold extension, the weather conditions deteriorated at the launch site and the launch scheduled for August 1 was scrubbed. A recycle of 24 hours was executed.

The countdown for the August 2, 1991, launch proceeded smoothly. One problem surfaced early in the countdown when the payload 2 multiplexer/demultiplexer (MDM) bite status register bit 4 (unable to transfer data to/from the input/output module) was set on both ports. Special KSC tests determined that the serial digital input/output card 15 was not properly communicating with the MDM's sequence control units. Since card 15 was not to be used on this MDM for this mission, the decision was made to fly in the present configuration.

After auxiliary power unit (APU) 1 shutdown following ascent, the fuel pump/gas generator valve module (GGVM) cooling system A indicated erratic water spraying and also a slight overcooling of the APU fuel pump. This phenomenon was observed on STS-37 and STS-38. This problem did not impact the mission.

Water spray boiler (WSB) 2 did not cool lubrication oil following ascent. The crew was requested to switch to the WSB B controller when APU 2 lubrication-oil-return temperature reached approximately 297 °F. Lubrication-oil-return temperature should be controlled to approximately 250 °F by the WSB's. An extended flight control system (FCS) checkout using APU 2 was performed on flight day 8 and WSB 2 did not cool on either controller A or B. As a result, APU 2 was not activated until terminal area energy management (TAEM) was reached about 7 minutes before landing.

A detailed review of film and video taken during ascent revealed that a section of an engine dome blanket became detached from the area of SSME 1 and 2 approximately 43 seconds into the flight. Postflight inspection showed that the blanket came from SSME 1. Thermal analysis indicated that no structural degradation from the detachment of the blanket occurred during ascent. Thermal assessments indicated no concern with structural temperature conditions that exist during entry, since entry heating is benign in the base-heat-shield area.

The TDRS-E payload was deployed at 214:19:16 G.m.t. A subsequent dual-engine, payload-separation orbital maneuvering subsystem (OMS) maneuver was performed at 214:21:29:37 G.m.t. Performance was nominal during the 16.8-second maneuver, which imparted a ΔV of 31 ft/sec to the Orbiter.

Payload data interleaver (PDI) decommutator 2 ceased operating on format 7 and decommutator 1 experienced intermittent data dropouts, resulting in data processing problems for the SHARE-II payload. Processing of SHARE-II data was switched to decommutator 3, and no further problem occurred with the SHARE-II data processing for the remainder of the mission.

At the end of the first sleep period, the power reactant storage and distribution (PRSD) hydrogen tank 1 heater B failed off. Pressure data verified that only one heater was operational, and onboard troubleshooting showed that heater B would not operate in either the automatic or manual mode. This anomaly did not impact the mission.

Closed circuit television (CCTV) camera D was powered up, but no video output was noted. Each time the camera was powered on, a camera over-temperature message was received. The crew performed a camera recovery procedure with no success, and the camera was declared inoperative for the remainder of the mission. This anomaly did not impact the mission.

Subsequent to the deployment of the TDRS-E, video showed an object moving away from the aft end of the Orbiter. A similar object was also noted during STS-41 and STS-35. The video of the object observed at TDRS-E/IUS deployment was reviewed. The analysis indicated that the object was solid oxygen that was dislodged from one of the main engine nozzles. This phenomenon has been seen on previous flights. A postflight inspection showed that the object was not Orbiter hardware or blankets.

Power amplifier 2 (PA2) exhibited decreasing output power in the low-frequency mode until switchover to PA1 prior to entry. At 221:19:00 G.m.t., S-Band PA2 began exhibiting erratic behavior. The power output increased from about 99 watts to 108 watts, then decreased again to about 99 watts. A few minutes later, the output power again increased to 117 watts. PA2 continued to oscillate between 99 watts and 117 watts. A switch from PA2 to PA1 was made at 223:10:22:05 G.m.t., approximately 2 hours prior to landing, to ensure good communications during entry. This anomaly did not impact the mission.

At 216:13:07:29 G.m.t., the Ku-Band power output indication dropped from the nominal 31 watts to 7 watts, then 1 second later dropped to -22 watts. The actual power output appeared to be satisfactory as the video being transmitted at that time showed no degradation. The erratic behavior recurred three times during the mission. This anomaly is believed to be the result of a failing transducer.

An abnormal current reading was detected on the mid-power control assembly (MPCA) 3 bus during power-up of the payload bay floodlights. The current readings indicated a possible problem with either the mid-starboard or the aft port floodlight. As a result, a special payload-bay floodlight test was performed at 222:06:45 G.m.t. The forward port and mid port floodlights flickered and never fully illuminated. The aft port floodlight came up to full illumination. The starboard floodlights were also turned on, with the forward and aft starboard floodlights fully illuminating. The mid-starboard light never came on and the remote power controller (RPC) tripped at floodlight activation. All lights were turned off at 222:06:56 G.m.t. At payload-bay door closure, the mid-port floodlight did illuminate fully.

At 222:12:27 G.m.t., the star tracker exhibited intermittent star presence while pointed at the Sun with the shutter closed. This intermittent problem did not affect the mission in any manner.

During presleep preparations at 220:18:20 G.m.t., the PRSD hydrogen manifold 1 isolation valve failed to close when commanded by the crew, and the valve failed to respond on two subsequent attempts at closure. The valve was successfully closed on five occasions earlier in the mission. The valve was left open for the remainder of the mission. This anomaly did not affect the mission.

The FCS checkout was performed at 222:07:13:56.79 G.m.t., using APU 2, and the checkout was extended to 11 minutes to verify WSB 2 operation. The FCS checkout was satisfactory except that WSB 2 did not cool on either the A or B controller. The lubrication-oil-return temperature had reached 307 °F and the forward bearing temperature had reached 340 °F when the APU was shut down. A total of 28 lb of APU fuel was consumed during the FCS checkout. All other APU and WSB parameters were nominal. Although the lubrication oil and bearing temperatures were higher than usual, no limits were exceeded.

A satisfactory reaction control subsystem (RCS) hot-fire test was performed after the FCS checkout. No thruster failures were noted. The RCS operated nominally while interconnected to the left OMS.

The partial pressure oxygen sensor C data began to degrade late in the mission. The C sensor is a backup to the A and B sensors and its data can only be observed on the ground. The loss of these data had no effect on the successful completion of the mission.

The payload bay doors were satisfactorily closed at 223:08:43:07.7 G.m.t. The crew completed all planned experiment operations, as well as entry preparations and stowage. The deorbit maneuver was performed at 223:11:21:14.97 G.m.t. The maneuver was approximately 158.6 seconds in duration and the ΔV was 307.0 ft/sec. Entry interface occurred at 223:11:51:51 G.m.t. Because of the WSB 2 anomaly during ascent and FCS checkout, APU 2 was not activated until 223:12:16:57.71 G.m.t. (approximately 7 minutes before landing). During entry for a 20- to 30-second period, the APU 1 chamber pressure did not return to a zero level after each pulse, indicating a possible leak in the pulse control valve. The anomalous operation did not affect entry operations.

Main landing gear touchdown occurred at the Shuttle Landing Facility runway 15 at 223:12:23:25 G.m.t. (August 11, 1991). Nose landing gear touchdown occurred 10 seconds later with wheels stop at 223:12:24:24.96 G.m.t. The rollout was normal in all respects. However, postflight data analysis showed that the right-hand outboard brake pressure 4 measurement was biased about 200 psi lower than the brake pressure 2 measurement. This anomaly did not affect the rollout braking activities in any manner. The flight duration was 8 days 21 hours 22 minutes 25 seconds. APU 2 was shut down 1 minute 32 seconds (223:12:24:57.22 G.m.t.) after touchdown, because of the WSB anomaly discussed earlier in the report. The remaining 2 APU's were shut down by 223:12:45:16.85 G.m.t., and the crew completed the required postflight reconfigurations and exited the Orbiter at 223:13:22:50 G.m.t.

A piece of metal, which was the ET umbilical stud yoke, was found on the runway below the liquid oxygen umbilical plate area. In addition, the left-hand inboard main landing gear tire was worn through two cords. This wear was on the inboard side of the tire and appeared to be evenly spread around the circumference of the tire. During postlanding leak checks, an audible leak was found in the main propulsion system at the liquid hydrogen 4-inch disconnect. A visual inspection of the disconnect showed that a piece of the valve flapper seal had come loose and was lodged in the flapper. The anomalous seal movement did not affect the mission in any manner.

VEHICLE PERFORMANCE

The vehicle performance section of this report contains a discussion of the operation and performance of the major subsystems of the flight vehicle.

A determination of vehicle propulsion 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 start of 3-g throttling was 453.1 seconds as compared to a fleet-average tag-value of 452.51 seconds. The relative velocity of the vehicle reached the Adaptive Guidance/Throttling (AGT) reference value at 20.564 seconds, resulting in a calculated time difference of +0.5623 seconds.

SOLID ROCKET BOOSTERS/REDESIGNED SOLID ROCKET MOTORS

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 build-up, steady-state, and tailoff phases were well within specifications. All SRB thrust vector control (TVC) 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 Operation and Maintenance Requirements and Specifications Document (OMRSD) violations occurred during the countdown. One SRB in-flight anomaly was identified during the postflight inspection.

Power up and operation of all case, igniter, and field joint heaters were accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the heated ground purge in the SRB aft skirt was not required to maintain the case/nozzle joint and flexible bearing temperatures within the required LCC ranges; however, the heated purge was operated until the count was resumed following the T-9 minute hold.

This was the second flight of RSRM's that contain propellant with Ammonium Perchlorate that was procured from Western Electrochemical Corporation (WECCO). Preliminary key RSRM propulsion performance parameters are presented in the table on the following page.

The SRB flight structural temperature response was as expected. Postflight inspection of the recovered hardware indicated that the SRB thermal protection system (TPS) performed properly during ascent, with very little TPS acreage ablation. Separation subsystem performance was normal, and all booster separation motors (BSM's) were expended and all separation bolts were severed. Nose cap jettison, frustum separation, and nozzle jettison occurred normally on each SRB.

Both SRB's successfully separated from the ET near the proper time. The entry and deceleration sequences were properly performed on both SRB's. RSRM nozzle jettison occurred after frustum separation, and subsequent parachute deployments were successfully performed. One of the left-SRB-main-parachute (no. 1) floats became entangled in the aft skirt and had to be cut loose. As a result the parachute sank and could not be recovered. The SRB's were recovered and returned to KSC for disassembly and refurbishment.

During the postflight inspection, the left SRB holddown stud at post 7 hung up during lift-off, resulting in broaching along the aft edge of the aft skirt hole (on the inboard side) and thread impressions on the bore inside diameter (Flight Problem STS-43-B-1). This hang-up did not affect the flight performance of the vehicle. The broaching was very similar to that experienced on STS-51I. The thread impressions experienced on STS-43 (the most severe recorded) indicated severe lateral stud contact with the aft skirt holddown post, and this contact resulted in a loss of energy and velocity. The primary cause of the stud hang-up has been attributed to a skewed firing of the holddown post pyrotechnics, with frangible nut rebound into the holddown stud as a secondary contributor.

EXTERNAL TANK

All objectives and requirements associated with ET propellant loading and flight operations were met, and the ET flight performance was excellent. All ET electrical equipment and instrumentation performed satisfactorily. The operation of the ET heaters and purges was monitored and all performed properly. No LCC or OMRSD violations were identified.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 78 °F		Right motor, 78 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	66.18	64.56	65.96	65.03
I-60, 10^6 lbf-sec	176.22	174.02	175.73	174.18
I-AT, 10^6 lbf-sec	297.41	296.70	297.44	296.04
Vacuum Isp, lbf-sec/lbm	268.6	267.95	268.6	267.33
Burn rate, in/sec (625 psia)	0.3724	0.3705	0.3716	0.3716
Event times, seconds				
Ignition interval	0.232	N/A	0.232	N/A
Web time	109.0	110.0	109.4	109.1
Action time	120.8	122.3	121.2	121.6
Separation command, seconds	124.0	124.9	124.0	124.9
PMBT, °F	78.0	78.0	78.0	78.0
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	3.2	2.8	2.6
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 477.0	

Only normally expected ice/frost formations for the August atmospheric environment were observed during the countdown. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. No ice was observed on the acreage areas of the ET. A small amount of frost was also present along the liquid hydrogen protruding air load (PAL) ramps. All of these observations were acceptable under existing Space Shuttle documentation. The ice/frost Red Team reported that liquid air was observed for approximately 90 seconds coming from a crack or void in the thermal protection subsystem (TPS) (liquid hydrogen umbilical area). The observation was assessed and was determined to be a non-issue. There was no acreage ice found on the ET, and TPS performance was as expected for the existing ambient conditions.

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 14.2 psid.

The ET tumble system was inactive for this flight and radar reports from Antigua confirmed that the ET did not tumble. Main engine cutoff occurred within the expected tolerances and ET entry and breakup was within the predicted footprint.

SPACE SHUTTLE MAIN ENGINE

All prelaunch operations associated with the SSME's were executed successfully. Launch ground support equipment provided adequate control for the SSME's during the launch countdown. All SSME parameters were normal throughout the prelaunch countdown and compared very well with prelaunch parameters observed on previous flights. The engine-ready indication was achieved at the proper time, and all LCC were met.

Flight data indicate that SSME performance during engine start, thrust buildup mainstage, throttling, shutdown, and propellant dump operations was within specifications. All three engines started and operated normally. High pressure oxidizer turbopump and high pressure fuel turbopump temperatures were normal throughout engine operation. The SSME controllers provided proper control of the engines throughout powered flight. Engine data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

During the countdown for the anticipated launch on July 24, 1991, the SSME 3 controller went to halt when an unrecoverable channel A parity error was detected (Flight Problem STS-43-E-1) prior to the start of liquid oxygen replenish. Data indicated that a hardware failure of the main engine controller had occurred. As a result, the launch was scrubbed to allow replacement of the controller, and the launch was rescheduled for August 1, 1991. The failure analysis of the controller revealed a broken blind lap solder joint connection of the bit jumper to the half stack, which is not a generic design problem.

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 with the SRSS signal strength remaining above the specified minimum of -97 dBm for the flight duration.

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 main propulsion system (MPS) was excellent. All pretanking purges were properly performed, and liquid oxygen and liquid hydrogen loading was performed as planned with no stop-flows or reverts. No OMRSD violations occurred.

Throughout the preflight operations, no significant hazardous gas concentrations were detected, and the maximum hydrogen level in the Orbiter aft compartment was 130 ppm, which is well within the historical boundaries for this vehicle. A hydrogen leak was detected in the ground carrier umbilical plate assembly. The leak was within limits and did not pose a constraint to launch. A comparison of the calculated propellant loads at the end of replenish versus the inventory loads resulted in a loading accuracy of +0.04 percent for liquid hydrogen and -0.012 for liquid oxygen.

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

STS-43 was the second flight of the Shuttle Program and the first flight of the OV-104 vehicle to use the gaseous oxygen fixed-orifice flow control valve which was shimmed to a target position corresponding to a 78 percent flow area. The gaseous oxygen pressurization system performed normally throughout the entire flight. All ullage pressures corresponded well with preflight predictions.

Feed system performance was normal, and liquid oxygen and liquid hydrogen propellant conditions were within specified limits during all phases of operation. Propellant dump and vacuum inerting were accomplished satisfactorily.

A detailed review of film and video taken during ascent revealed that a section of an engine dome blanket became detached from the area near SSME 1 and SSME 2 approximately 43 seconds into the flight. The postflight inspection showed that the material had come from around SSME 1. The OV-104 vehicle has the original S-glass-type blanket design, which has shown degradation on almost every flight. Thermal analysis indicated that no structural degradation from the detachment of the blanket occurred during ascent. Thermal assessments also indicated no concern with structural over-temperature conditions that exist during entry, since entry heating is benign in the base heat shield area.

Subsequent to the deployment of the TDRS-E, video showed an object moving away from the aft end of the Orbiter. A similar object was also reported during STS-41 and STS-35. The video of the object observed at TDRS-E/IUS deployment was reviewed. Data showed that the main propulsion system contained 3869 lb of liquid oxygen at ET separation. Of this amount, 3400 lb was vented through the engine nozzles. Below -360 °F, oxygen solidifies and accumulates on the nozzles. The analysis indicated that the object was solid oxygen that was dislodged from one of the main engine nozzles. This phenomenon has been seen on previous flights. A postflight inspection did not reveal any missing Orbiter hardware or blankets.

The helium system performed nominally during ascent and entry; however, after manifold repressurization during entry, a helium leak was detected around the 4-inch disconnect. The postlanding inspection revealed an audible leak that was caused by a piece of the seal (1.2 inch by 0.13 inch) being lodged in the flapper of the 4-inch disconnect valve (Flight Problem STS-43-V-13). A similar problem was encountered on a STS-26 mission. A piece of the material was sent to a laboratory at KSC for analysis. The anomalous seal movement did not affect the successful completion of the mission.

During the postflight inspection, an Orbiter lightning strip epoxy bead was found loose on the 17-inch umbilical. This condition has occurred on a number of past Shuttle missions.

The postflight data review confirmed that the right SSME (3) liquid oxygen inlet pressure increased to 33 psia after repressurization and tracked the manifold pressure instead of following the ambient pressure during entry (Flight Problem STS-43-V-16). The analysis is continuing in an effort to explain the cause of this anomaly.

Reaction Control Subsystem

The RCS performance was nominal throughout the mission with 4749 lb of propellant consumed plus 1.95 percent of OMS propellant used by the RCS when interconnected to the OMS. The RCS was used during entry to support development test objective (DTO) 248 [Forward RCS Flight Test (8-Second Pulse)] which required two 8-second pulses.

The update configuration of onboard software incorporated the primary thruster alternate digital autopilot (DAP) mode. Because of the need to conserve forward RCS propellant, the alternate DAP mode was used as an operational program in addition to the DTO activities. The evaluation of the alternate DAP mode as an operational program shows that approximately 25 lb of RCS propellant were saved while using this mode.

Orbital Maneuvering Subsystem

The OMS performed nominally during the three planned maneuvers (OMS-2, OMS-3, and deorbit maneuver). A total of 12,678 lb of propellants was consumed by the OMS during the three maneuvers and the two periods of interconnect operations with the RCS during which approximately 1.95 percent of OMS propellant was used by the RCS.

The only problem noted was that both the left and right forward fuel probes read high during the mission. The left probe has been failed for several missions as it indicates off-scale high. The right probe began indicating erroneously during the OMS-2 maneuver. The probe continued to provide an input into the totalizer during the deorbit maneuver when the forward compartment was empty. This caused a 16 to 18 percent offset in the right total fuel quantity after the deorbit maneuver. Both of these conditions were known prior to the mission and waivers had been written against the hardware.

Power Reactant Storage and Distribution Subsystem

The four-tank-set PRSD subsystem satisfactorily met all requirements throughout the mission. A total of 2186 lb of oxygen and 266 lb of hydrogen were consumed during the mission. The crew consumed 76.9 lb of oxygen. Adequate consumables (687 lb of usable oxygen and 79 lb of usable hydrogen) remained at the end of the mission for an additional 63 hours of operation at an average power level of 14.4 kW. Two anomalies were identified and are discussed in the following paragraphs.

At the end of the first sleep period (215:09:40 G.m.t.), the PRSD hydrogen tank 1 heater B failed off (Flight Problem STS-43-V-04). Pressure data verified that only heater A was operational, and troubleshooting showed that heater B would not operate in either the automatic or manual mode. This anomaly did not impact the mission. The cryogenics management plan was changed to deplete hydrogen tank 1 to a level that ensured a full mission duration should heater A in hydrogen tank 1 also fail. Postflight troubleshooting revealed an open 5-ampere fuse in the heater controller. In an effort to determine the cause of the open fuse, further troubleshooting is being performed.

During presleep preparations at 220:18:09 G.m.t., the PRSD hydrogen manifold 1 isolation valve failed to close when commanded by the crew, and the valve failed to respond on two subsequent attempts at closure (Flight Problem STS-43-V-09). Pressure data confirmed that the valve had failed in the open position. The valve had been successfully closed on five occasions earlier in the mission. The valve was left open for the remainder of the mission, and during postlanding operations the valve was cycled five times successfully. Leaving this valve open prevented fuel cell 1 from being isolated to tank 1, had a leak occurred. Tank 1 was intentionally depleted to a low quantity because of the heater B failure in that tank. This anomaly did not affect the mission.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed satisfactorily throughout the 213-hour mission. The fuel cells produced 3062 kWh of electricity at an average power level of 14.4 kW and load of 469 amperes. The fuel cells consumed 266 lb of hydrogen and 2109 lb of oxygen and produced 2375 lb of water in addition to the electricity produced.

One minor problem was noted during the mission. After the payload separation maneuver that followed the deployment of the TDRS-E payload, the pressure sensors on the fuel cell 2 alternate water line exhibited an increased reading simultaneous with a temperature rise to the 100 to 105 °F temperature range, both of which were indicative of some water from fuel cell 2 entering the alternate water line. This temperature signature could not be correlated with any events or equipment usage that would affect the local thermal environment of the sensor.

A postlanding incident occurred after the Orbiter had been moved to the Orbiter Processing Facility (OPF) when an emergency power down of the fuel cells was required. This resulted from Helium ingestion into fuel cells 2 and 3 from the ground support equipment (GSE). The Helium entered through the oxygen horizontal drain disconnect while the console operator was performing calibrations of the GSE back-pressure regulator. The GSE Helium pressure exceeded the 20-psid limit across the disconnect, and a severe voltage drop-off was observed in fuel cells 2 and 3.

As a result, an emergency power down of the fuel cells was performed at 224:22:11 G.m.t. This type of shutdown deactivates all heaters and pumps; however, the fuel cell can still produce power. Fuel cells 2 and 3 did not have enough voltage to drive their respective power connector motors, which remove and connect the fuel cells to the voltage bus. As a result, the fuel cells still had a load applied and may have produced water. Flooding of fuel cells 2 and 3 may have occurred because the hydrogen pumps that remove the water were not operating and there was no way to remove the water from the fuel cells. These two fuel cells were removed and sent to the fuel cell vendor for analysis.

Auxiliary Power Unit Subsystem

The APU subsystem met all demands placed upon the subsystem, but three anomalies and a number of other problems, none of which impacted the mission, were noted during the mission. The following table presents the cumulative run time and fuel consumption for the APU's during the STS-43 mission.

Flight Phase	APU 1 (S/N 305)		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	00:20:08	49	00:20:06	57	00:20:03	54
FCS checkout			00:11:04	26		
Entry	01:28:57	176	00:08:00	21	01:24:02	152
Total[a]	01:49:05	225	00:39:10	104	01:44:05	206

[a] The total includes 21 minutes 51 seconds of APU 1 and 3 operation and 1 minute 32 seconds of APU 2 operation after landing.

After APU 1 shutdown following ascent, the fuel pump/GGVM cooling system A displayed erratic water spray pulses. These longer pulses resulted in erratic APU fuel pump temperatures (Flight Problem STS-43-V-06). The controlling circuit has a timer that should limit water spraying to 1-second pulses; however, pulses as long as 9 seconds were observed in the data. These longer pulses were observed on at least six other flights of this vehicle with different APU's.

The second problem identified on APU 1 was indicated by the low temperature spikes seen in the data. These spikes are indicative of water spraying directly onto the fuel pump temperature sensor. This same temperature trace was observed on this APU when operating on another vehicle, and therefore is believed to be unique to this APU and its spray manifold.

The APU 1 drain line temperature appeared to change its set point immediately prior to switching to the B heaters, but it remained within acceptable limits. Operation was satisfactory on the B heaters.

The FCS checkout was performed at 222:07:13:56.79 G.m.t., using APU 2, and checkout was extended to 11 minutes to verify WSB 2 operation. The FCS checkout was satisfactory except that WSB 2 did not cool on either the A or B controller. The APU lubrication oil return temperature had reached 307 °F and the APU forward bearing temperature had reached 340 °F when the APU was shut down. A total of 26 lb of APU fuel was consumed during the FCS checkout. All other APU parameters were nominal. Although the lubrication oil and bearing temperatures were higher than usual, no limits were exceeded.

About 1 hour prior to the deorbit maneuver, the APU 2 drain pressure 1 exceeded the 25-psia fault detection annunciator (FDA) limit. A table maintenance block update (TMBU) was transmitted to raise the FDA limit to 27 psia. The drain pressure did not exceed the recently established limit during the remainder of the flight.

Because of the WSB 2 anomaly during ascent and FCS checkout, APU 2 was not activated until 223:12:16:57.71 G.m.t. (at the start of the TAEM phase about 7 minutes prior to landing). One procedural problem was noted during APU 2 shutdown when the controller was shut down prior to the completion of APU spin-down.

For about a 35-second period during entry, the APU 1 chamber pressure returned to a non-zero level after each pulse, indicating a possible leak in the pulse control valve (Flight Problem STS-43-V-12). Time between pulses became erratic and turbine speed decay rate during valve-closed periods appeared to decrease. Both chamber pressure and turbine speed recovered after about 35 seconds and remained nominal for the remainder of entry and landing operations.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem performance during the mission was acceptable; however, WSB 2 failed to provide cooling to APU 2 throughout the mission. Circulation pump operation was satisfactory on all three hydraulics systems.

Water spray boiler 2 did not cool lubrication oil using controller A following ascent (Flight Problem STS-43-V-02). The crew was requested to switch to the WSB controller B when APU 2 lubrication oil return temperature reached approximately 297 °F. Lubrication oil return temperature should be controlled to approximately 250 °F by the WSB's. The APU's were operated an additional

1.5 minutes while on the B controller, but no evidence of cooling was observed on APU 2 and the APU's were shut down. The APU 2 lubrication oil return temperature had reached 323 °F at APU shutdown.

An extended FCS checkout was performed at 222:07:13:56.79 G.m.t., using APU 2, and the checkout was extended to 11 minutes to verify WSB 2 operation. The FCS checkout was satisfactory except that WSB 2 did not cool on either the A or B controller. The lubrication-oil-return temperature had reached 307 °F and the forward bearing temperature had reached 340 °F when the APU was shut down. All WSB parameters were nominal. Although the lubrication oil and bearing temperatures were higher than usual, no limits were exceeded. Data analysis is underway and a failure of the lubrication oil spray valve (electrical or mechanical) is suspected. As a result, the flight rule which covers loss of a WSB and requires the associated APU not be activated until TAEM (about 7 minutes before landing) was followed.

Pyrotechnics Subsystem

The pyrotechnics subsystem operated satisfactorily throughout the mission with no anomalies identified.

Environmental Control and Life Support Subsystem

The environmental control and life support subsystem (ECLSS) performed satisfactorily throughout the mission with one prelaunch anomaly and one in-flight anomaly, neither of which impacted the completion of the mission in any manner.

The atmospheric revitalization subsystem (ARS) performance was nominal and all in-flight checkout requirements were completed satisfactorily. The air and water coolant loops performed nominally, and the carbon dioxide partial pressure was maintained below 3.6 mm Hg. The cabin air temperature and relative humidity peaked at 82 °F and 50 percent, respectively. The avionics bays 1, 2, and 3 air outlet temperatures peaked at 104 °F, 107 °F, and 89 °F, respectively, whereas the avionics bays 1, 2, and 3 water coldplate temperatures peaked at 88 °F, 90 °F, and 82 °F, respectively.

During the countdown for the anticipated August 1, 1991, launch, the T-9 minute hold in the countdown was extended because of the lack of a closed indication (barberpole indication remained) from the cabin vent valve when the cabin pressure check was completed (Flight Problem STS-43-V-01). The vent valve was cycled several additional times, but the closed indication was never received. A retest of the cabin pressure integrity verified that the cabin pressure vent valve was closed, and the vehicle was declared ready for launch. The lack of a closed indication was not a LCC violation since it was proven that the vent valve was actually closed.

Late in the mission, the partial pressure oxygen sensor C data began to drift lower by 0.02 psia every 3 to 6 minutes (Flight Problem STS-43-V-11). Until the drift was noted, the sensor had remained within 0.02 to 0.04 psia of the A and B sensors. The C sensor is a backup to the A and B sensors and its data can only been seen on the ground. The discrepancies in these data did not affect the successful completion of the mission.

Supply Water, Waste Water and Waste Collection Subsystems

The supply water and waste management subsystems performed normally throughout the mission. All of the associated in-flight checkout requirements were performed and satisfied by the end of the mission.

Supply water was managed through the use of the overboard dump system and the flash evaporator system. Two supply water dumps were performed at an average dump rate of 1.7 percent/minute (2.8 lb/min). The supply water dump line temperature was maintained between 66 °F and 93 °F throughout the mission with the operation of the line heaters.

Waste water was gathered at about the predicted rate. Four waste water dumps were performed at an average dump rate of 1.9 percent/minute. The waste water dump line temperature was maintained between 56 °F and 75 °F throughout the mission, while the vacuum vent line temperature was maintained between 58 °F and 76 °F.

The waste collection system (WCS) performed normally throughout the mission. The vacuum vent quick disconnect on the WCS was satisfactorily used to vent the lower body negative pressure device [detailed supplementary objective (DSO) 478] each time the device was used.

Smoke Detection and Fire Suppression Subsystems

The smoke detection system performance was nominal during the mission, and no use of the fire suppression system was required.

Airlock Support System

All airlock parameters remained nominal, indicating normal performance throughout the mission. The airlock was not used during the mission for other than a stowage area.

Avionics and Software Subsystem

The integrated guidance, navigation, and control system performed nominally throughout the mission. Three DTO's were performed using the integrated guidance, navigation, and control system. These were:

a. DTO 309 - Ascent Flutter Boundary Evaluation

b. DTO 798 - Alternate Mode Digital Autopilot Performance Evaluation

c. DTO 248 - Forward RCS Flight Test (8-second pulse)

To conserve fuel usage, a real-time decision was made to use the alternate mode digital autopilot (with 1 tail thruster only) as an operational tool. This configuration worked well and resulted in a forward RCS fuel savings of approximately 25 lb.

The inertial measurement units operated satisfactorily. The star tracker subsystem performance was satisfactory, although the -Z star tracker intermittently indicated star presence with the shutter closed (Flight Problem STS-43-V-15). The shutter is suspected of not being fully closed. The anomaly did not impact orbital operations, nor was it any hazard to the star tracker.

The data processing system/flight software performance was satisfactory. The electrical power and distribution control (EPDC) subsystem also operated satisfactorily. All data that was analyzed has shown nominal voltage and current signatures, and no specified limits were violated.

The displays and control subsystem met all operational requirements; however, an abnormal current reading (15 ampere increase in 3 to 4 seconds) was detected on the MPCA 3 bus during power-up of the payload bay floodlights. The current readings indicated a possible problem with either the mid-starboard or the aft port floodlight. As a result, a special payload bay floodlight test was performed at 222:06:45 G.m.t. The forward port and mid port floodlights flickered and never fully illuminated. The aft port floodlight came up to full illumination. The starboard floodlights were also turned on, with the forward and aft starboard floodlights fully illuminating. The mid-starboard light never came on and the RPC tripped at floodlight activation (Flight Problem STS-43-V-10). All lights were turned off at 222:06:56 G.m.t. At payload bay door closure, the mid-port floodlight did illuminate fully.

Communications and Tracking Subsystem

The communications and tracking subsystem performed acceptably; however, three anomalies and one problem were noted during the mission. The communications and tracking subsystem was used to successfully perform DTO 700-1 (TDRS S-Band Low Power) and DTO 799 (PGSC/PADM Air/Ground Communications Demonstration).

CCTV camera D was powered up, but no video output was noted (Flight Problem STS-43-V-05). Each time the camera was powered on, a camera over-temperature message was received. The crew performed a camera recovery procedure with no success, and the camera was declared inoperative for the remainder of the mission. This anomaly did not impact the mission.

CCTV camera A has the ground test pattern burned into the tube; this pattern was only visible during low-level light operations. This problem did not interfere with low-light operations nor the mission.

Power amplifier 2 exhibited a decreasing power output throughout the mission and PA1 was selected just before entry (Flight Problem STS-43-V-08). The traveling wave tube in PA2 was approaching its normal operating life of 2000 hours and was showing signs of degradation. At 221:19:00 G.m.t., S-Band PA2 began exhibiting erratic behavior.

The power output increased from about 99 watts to 108 watts, then decreased again to about 99 watts. A few minutes later, the output power increased to 117 watts. PA2 continued to oscillate between 99 watts and 117 watts. A decision was made by the flight controllers to switch from PA2 to PA1 at 223:10:22:05 G.m.t., approximately 2 hours prior to landing. The change to PA1 was made because of erratic communications and as a precautionary measure to ensure good communications during entry. This anomaly did not impact the mission.

At 216:13:07:29 G.m.t., the Ku-Band power output indication dropped from the nominal 31 watts to 7 watts, then 1 second later dropped to -22 watts (Flight Problem STS-43-V-07). The actual power output appeared to be satisfactory as the video being transmitted at that time showed no degradation. This same indication was present in three of the Ku-Band modes of operation. About 32 minutes after the initial indication, Ku-Band power returned to the normal level of 31 watts. The quality of TV transmission at the time of the low indications has remained good; therefore, the problem is not an indication of actual power degradation. This problem recurred two additional times later in the mission and neither indicated an actual decrease in output power. This anomaly is believed to be the result of a failing transducer.

The crew reported that the quality of voice on the flight deck speaker was very poor as compared to the middeck speaker. The crew reported that the speaker sometimes produced noises that were unintelligible. This speaker will be replaced during turnaround operations.

Operational Instrumentation

The operational instrumentation performed satisfactorily; however, one anomaly was identified. Following TDRS-E deployment, the PDI decommutator 2 ceased operating on format 7 and operations on decommutator 1 experienced intermittent dropouts, resulting in data processing problems for the SHARE II payload (Flight Problem STS-43-V-03). Processing of SHARE-II data was switched to decommutator 3, and the problem did not affect the SHARE-II data processing for the remainder of the mission.

Structures and Mechanical Subsystem

The structures and mechanical subsystem performed nominally except for the left inboard main landing gear tire which was worn through two cords. This wear was on the inboard side of the tire and appeared to be evenly spread around the circumference of the tire. This type of wear is not unusual for landings at KSC.

Main landing gear touchdown occurred at the Shuttle Landing Facility runway 15 at 223:12:23:25 G.m.t. (7:23:25 a.m. e.d.t. on August 11, 1991) at a ground speed of 203.4 knots, and 1986 ft from the runway threshold. Nose landing gear touchdown occurred 10 seconds later at a speed of 166.6 knots 5517 ft from the runway threshold. Wheels stop occurred at 223:12:24:24.96 G.m.t. The rollout was 9890 ft based on Orbiter data, and the rollout was normal in all respects.

The sink rate at main gear touchdown was approximately 2.0 ft/sec, and the pitch rate at nose gear touchdown was 2.36 deg/sec. The Orbiter weight at landing was 196,046.5 lb.

The maximum brake pressures during rollout ranged from 840 to 936 psi on the left main gear and 780 to 1008 psi on the right main gear. Brake energies were 24.04 million ft-lb on the left-hand outboard brake, 27.21 million ft-lb on the left-hand inboard brake, 31.96 million ft-lb on the right-hand inboard brake and 27.62 million ft-lb on the right-hand outboard brake. Postflight data analysis showed that the right-hand outboard brake pressure 4 measurement was biased about 200 psi lower than the brake pressure 2 measurement (Flight Problem STS-43-V-14).

Aerodynamics and Heating

The overall aerodynamics performance of the Orbiter during STS-43 was satisfactory; however, the ascent trajectory flown provided a maximum dynamic pressure greater than 750 psf, which is higher than normally experienced. The entry aerodynamics were as expected. In general, the control surfaces responded as expected, and the angle of attack was as predicted. DTO 248 was performed during entry with two 8-second pulses being input to the system. The aerodynamics appeared nominal as a result of the inputs for DTO 248.

Ascent and entry aerodynamic heating was nominal based on heating calculations and the postflight inspection.

Thermal Control Subsystem

The performance of the thermal control subsystem was nominal during all phases of the mission. All temperatures were maintained within acceptable limits.

Aerothermodynamics

The aerothermodynamic performance of the vehicle was satisfactory. Acreage heating was nominal, and all structural temperatures remained within limits. The angle of attack was 39 degrees for a large portion of the trajectory and this value is within the experience base of the Space Shuttle Program. Local acreage heating was nominal with no tile melting indicated.

Thermal Protection Subsystem

The TPS performance was nominal, based on structural temperature response, and some tile surface temperature measurements. The overall boundary layer transition from laminar flow to turbulent flow was nominal-to-late, occurring between 1270 and 1290 seconds after entry interface. These times are the latest boundary layer transition times recorded on flights with available instrumentation (22 of 42 flights).

The KSC infrared imager was used to measure the surface temperatures in several areas of the Orbiter. At 84 minutes after landing, the Orbiter nose cap reusable carbon carbon (RCC) temperature was 113 °F, the right wing leading edge RCC panel 9 was 92 °F, and the right wing panel 17 was 91 °F.

Debris impact damage was minimal. The postflight inspection of the Orbiter revealed a total of 131 hits on the tile surface, 25 of which were greater than 1 inch. Four tile removals and replacements were identified as a result of debris impacts. The largest single damage site on the Orbiter lower surface occurred on the right-hand nose area below the forward RCS module. The damage site measured 18 in. by 1 in. by 1/8 in. (spanned six tiles) and was repairable. This damage may have resulted from the loss of TPS from the ET intertank area. Postflight analysis of ET post-separation photographs, taken by the crew for DTO 312, will be performed.

A cluster of 19 hits (seven larger than 1 in.) occurred immediately forward of the liquid oxygen ET/Orbiter umbilical cavity. Similar clusters of hits have been observed in this area on previous flights and have been attributed to ice from the liquid oxygen feedline bellows or support brackets. A second cluster of 12 hits (4 larger than 1 in.) occurred immediately aft of the liquid oxygen ET/Orbiter umbilical cavity and has been attributed to ice from the liquid oxygen ET/Orbiter umbilical during ET separation and/or damage from the purge barrier baggie and ice during ascent.

Inspection showed no significant heat intrusion past the thermal barriers around the ET doors. No TPS damage was attributed to material from wheels, tires, or brakes. Damage to the base heat shield tiles was less than average. The outer layer of the SSME 3 closeout blanket was peeled back along a 12-inch length at the 10 o'clock position. Minor fraying also occurred along a 12-inch length at the 9 o'clock position. The outer layer of the SSME 1 closeout blanket was frayed along a 12-inch length at the 8 o'clock location. The SSME 1 closeout blanket (approximately 40 inches in length) may have been the white object that was observed in films as falling aft of the Orbiter 43 seconds after launch.

Performance of the upper inboard elevon TPS material was excellent. The overall condition of the TPS on the OMS pods was good. White streaks were present on the right-wing leading edge RCC panels and appeared to be similar to the streaks observed on previous flights. The upper fuselage, payload bay doors, and upper wing TPS performance was nominal.

The nose landing gear door TPS was in good condition with only minor fraying. The forward RCS plume shield barriers showed evidence of damage. The left-hand barrier was protruding and severely frayed. A piece of thermal barrier approximately 8 inches in length was missing from between thrusters F2R and F4D on the right side of the forward RCS module. The barrier most probably came off late in the entry trajectory because no evidence is overheating was present.

The left-hand main landing gear door outboard thermal barrier was torn in the area adjacent to the forward hinge. The right-hand forward outboard corner tile was broken. The aft edge thermal barrier was protruding. The elevon-elevon gap tiles were in good condition, with minor gap filler degradation.

Overall, the RCC parts appeared nominal, except for the chin panel inspection that revealed internal damage to some lug areas of the panel and expansion seal. This damage was caused by a contact between clevis bolts and the panel. Although the drawing specifies a clearance of 0.10 inch between the bolt and RCC parts, contact between these parts occurred because of a discrepancy in the installation process (shim or spacer not installed).

The engine-mounted heat shield thermal curtain was damaged on SSME 1 with blanket batting missing between 4 and 6 o'clock. This material was probably the debris seen on the ascent films at 43 seconds into the flight. All other engine blankets exhibited normal flight damage.

No tiles, carrier panels, or other TPS materials were missing from the Orbiter that would explain the object observed on-orbit after the TDRS-E/IUS deployment. Frozen oxygen from the SSME area is the most likely explanation for that object.

Orbiter windows 3 and 4 exhibited heavy hazing with a few small streaks. Windows 1, 2, 5, and 6 had a slight hazing with several small streaks.

FLIGHT CREW EQUIPMENT

The flight crew equipment performed flawlessly throughout the STS-43 mission.

PAYLOADS

TRACKING AND DATA RELAY SATELLITE/INERTIAL UPPER STAGE

STS-43 deployed the fifth of six TDRS-E/IUS communications spacecraft into orbit. The TDRS-E is in geosynchronous orbit over the Pacific Ocean where it will provide telecommunications services for the Space Shuttle and unmanned satellites.

AURORAL PHOTOGRAPHY EXPERIMENT-B

The Auroral Photography Experiment (APE) -B objective was to provide photography for the study of the Earth's auroras. Five planned data takes were completed after performing an in-flight maintenance procedure to overcome a missing piece of hardware. A sixth data take was to be redundant photography of the Orbiter surfaces. The five data takes were considered to have fulfilled 100 percent of the mission requirements.

BIOSERVE-INSTRUMENTATION TECHNOLOGY ASSOCIATES MATERIALS DISPERSION APPARATUS

The Bioserve-Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA) objective was to grow large protein crystals in the weightless environment. The on-orbit processing activities of the BIMDA bioprocessing modules and material dispersion apparatus were accomplished with no problems, although some difficulties were experienced with cell syringe leakage. This leaking resulted in only non-toxic substances being spilled from all six syringes. In spite of the leakage difficulties, approximately 90 percent of the preflight scientific objectives of the experiment were accomplished.

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

The objective of the Investigations Into Polymer Membrane Processing (IPMP) experiment was to manufacture polymers in orbit. The IPMP payload required a minimum of 24 hours of operation before entry to meet its objectives. The experiment was powered on during flight day 6, approximately 96 hours prior to entry and was turned off before entry. Scientific results will be reported after the sponsor's evaluation.

AIR FORCE MAUI OPTICAL SITE

The objective of the Air Force Maui Optical Site (AMOS) experiment was for the Orbiter to serve as a calibration target for ground-based electro-optical sensors. No flight hardware was required for this payload. The AMOS payload accomplished all of its planned objectives on this flight: two passive Orbiter over-flights and two Orbiter RCS tests. All passes were very successful. The only problem encountered concerned an infrared sensor on the ground that was apparently not sensitive enough to acquire the Orbiter.

ULTRAVIOLET PLUME INSTRUMENT

The objective of the Ultraviolet Plume Instrument (UVPI) was to use the Orbiter as a calibration target for space-based ultraviolet sensors. No flight hardware was required for this payload. No UVPI observation opportunities were identified either preflight or in real-time for this payload.

PROTEIN CRYSTAL GROWTH-III

The objective of the Protein Crystal Growth (PCG)-III experiment was to grow crystals in the microgravity environment. The PCG payload was activated early on flight day 1 and operated for the entire mission (minimum on-orbit operation required was 4 days). The only anomaly involved a temperature variation on flight day 3, when the automatic temperature control allowed the PCG temperature to decrease to 18 °C. The temperature control was reset to the 23 °C position and satisfactory temperature control was maintained thereafter. The customer stated that this variation is not expected to significantly effect crystal growth. The scientific results will be known after the experiment's sponsor has evaluated the data.

SHUTTLE ACCELERATION MEASUREMENT SYSTEM

The objective of the Shuttle Acceleration Measurement System (SAMS) was to measure accelerations and disturbances in the weightless environment on-orbit. The SAMS payload operated throughout the entire mission, and for the first time, gathered data in the Orbiter middeck for its assigned objectives. The sensors on this flight were mounted on the Solid Surface Combustion Experiment (SSCE) and the PCG payloads and also on the treadmill. The amount of data lost during the flight day 8 data recording anomaly is uncertain, but in the worst case, it is expected to be only 4 or 5 hours.

SOLID SURFACE COMBUSTION EXPERIMENT

The objective of the SSCE was to investigate how materials burn in weightlessness. The SSCE payload objectives were successfully accomplished when the experiment was performed on flight day 6. The scientific results of this experiment will be known following postflight evaluation of the experiment results by the sponsors.

SPACE STATION HEAT PIPE ADVANCED RADIATOR ELEMENT II

The objective of the SHARE-II was to demonstrate microgravity thermal vacuum performance of a heat pipe radiator for heat rejection as a prelude to the development of a Space Station heat rejection system. The SHARE-II experiment was successfully operated with approximately 200 percent of the experiment's objectives being completed. Of the six data takes planned preflight, all were completely successful. In real-time, six additional data takes were arranged to further investigate the heat pipes capabilities under circumstances greatly exceeding nominal conditions. The evolving experiment plan provided extended opportunities to demonstrate microgravity thermal vacuum performance of the heat pipe radiators to the fullest extent.

SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET

The objective of the SSBUV payload was to calibrate ultraviolet sensors for TIROS-N and Nimbus-7 satellites. The SSBUV completed all planned objectives for the STS-43 mission: 33 orbits of earth viewing planned and accomplished (minimum of 24 required - 32 desired); and four solar views and four calibrations planned and accomplished (three required). All operations appear to be nominal. Scientific results will not be available until the sponsor evaluates the data.

OPTICAL COMMUNICATIONS THROUGH THE SHUTTLE WINDOW

The objective of the Optical Communications Through the Shuttle Window (OCTW) was to demonstrate fiber-optic communications onboard the Shuttle. A number of configuration problems were encountered during the initial setup for the payload. Once these were resolved, all four planned tests were accomplished for OCTW.

TANK PRESSURE CONTROL EXPERIMENT

The objective of the Tank Pressure Control Experiment (TPCE) was to determine the effectiveness of jet mixing for controlling tank pressures and equilibrating fluid temperatures. The TPCE payload is assumed to have operated completely nominally. The TPCE was activated by a baroswitch during ascent and was deactivated after approximately 49 hours of operation (36 hours required to perform the 38 sequential test runs). The desired attitudes were also planned and accomplished. The scientific results will not be known until the sponsor evaluates the data.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

LAUNCH VIDEOS AND FILMS

On launch day, all 25 of the expected video were screened. Three significant observations were made. A discoloration was noted in the SSME 2 plume shortly after engine start. Also, a debonding of a beta blanket around SSME 2 was noted during engine start. The third observation was a piece of debris that was seen on several long-range tracking cameras falling aft of the vertical stabilizer at approximately 43 seconds after lift-off.

In addition, all 71 of the expected launch films were reviewed. Significant observations included the same observations as noted in the videos plus a stud hang-up on holddown post M7 of the left SRB at lift-off.

Eight discolorations were noted in the SSME 2 plume Mach diamond prior to lift-off. The color of the plume appeared to change from blue to an orange tint. A similar discoloration was observed in the STS-32 photography. Analysis of these discolorations continues.

A beta blanket around SSME 2 was noted to be debonded. The debonded area was 10.85 inches circumferentially and 1.81 inches in length. The debonded blanket was oscillating back and forth during the start sequence. After landing, the postflight inspection revealed that the outer layer of the SSME 2 closeout blanket was frayed along a 12-inch length at the 8 o'clock position.

At 43 seconds mission elapsed time, five cameras recorded a large light-colored piece of debris that appeared to originate above the SSME 2 and traveled around the RCS stinger, then along the SSME nozzle, after which the debris fell aft of the vehicle. Trajectory plots were made of the debris. Analysis of the debris continues.

LANDING VIDEOS AND FILMS

Eight videos of landing operations plus NASA Select were screened. No significant observations can be made from this screening and no anomalies were noted.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

Twelve DSO's were assigned to the STS-43 mission and all were accomplished.

DEVELOPMENT TEST OBJECTIVES

Ascent

DTO 301D - Ascent Wing Structural Capability Evaluation - Data were collected for this DTO, and the data are being evaluated by the sponsor.

DTO 309 - Ascent Flutter Boundary Evaluation - Data were collected for this DTO, and the data are being evaluated by the sponsor.

DTO 312 - ET TPS Performance (Method 2) - Photographic data, consisting of 17 hand-held 70 mm pictures of the ET, were collected for this experiment and the data are being evaluated by the sponsor. Five of the views which image the left side of the ET were very good. For the STS-43 mission, DTO 312 is considered to be partially accomplished with usable pictures of the ET.

On-Orbit

DTO 645 - Combustion Products Analyzer (Configuration 1) - Data were collected for this DTO and are being analyzed by the sponsor.

DTO 652 - Vibration Recordings on the Shuttle Treadmill Using an Accelerometer - Data were collected for this DTO, and the data are being analyzed.

DTO 700-1 - TDRS S-Band Forward Link RF Power Level Evaluation - This DTO was performed and good results were obtained. The data are being evaluated by the sponsor.

DTO 798 - Alternate Mode DAP Performance Evaluation - This DTO was performed with satisfactory results. In addition, a real-time decision was made to use the alternate mode DAP much earlier in the mission to conserve forward RCS propellant. The use resulted in significant fuel savings.

DTO 799 - PGSC/PADM Air/Ground Communications Demonstration - The Payload General Support Computer (PGSC)/Portable Audio Data Modem (PADM) Air/Ground Communications Demonstration DTO was performed with satisfactory results. The data are being evaluated by the sponsor.

DTO 1208 - Space Station Cursor Control Device Evaluation II and Advanced Applications - This DTO was performed successfully with electronic mail (e-mail) being sent and received by the crew. Some very useful data were obtained that will aid in the design of Space Station Freedom computer cursor control devices.

Entry/Landing

DTO 248 - Forward RCS Flight Test (8-Second Pulse) - This DTO was performed during entry and the data are being evaluated by the sponsor.

DTO 805 - Crosswind Landing Performance - This DTO was not performed as winds at the time of landing were very low and not from a direction that could be used for this DTO.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 0476 - In-Flight Aerobic Exercise - The treadmill operated properly. The sponsor will report the results after the flight crew has been evaluated.

DSO 0478 - In-Flight Lower Body Negative Pressure - All required runs were completed and the data are being evaluated by the sponsor.

DSO 0601 - Baroflex Function - Data were collected for this DSO and are being evaluated by the sponsor.

DSO 0602 - Blood Pressure Variability During Spaceflight - Blood pressure data were collected from the crew members for this DSO and are being evaluated by the sponsor.

DSO 0603 - Orthostatic Function During Entry, Landing and Egress - Data were collected for this DSO and are being evaluated by the sponsor.

DSO 0604 - Visual/Vestibular Integration as a Function of Adaptation - Data were collected for this DSO and are being evaluated by the sponsor

DSO 0605 - Postural Equilibrium Control During Landing/Egress - Data were collected for this DSO and are being evaluated by the sponsor.

DSO 0613 - Changes in the Endocrine Regulation of Orthostatic Tolerance Following Spaceflight - Data were collected for this DSO and are being evaluated by the sponsor.

DSO 0614 - Head and Gaze Stability During Locomotion - Data were collected for this DSO and are being evaluated by the sponsor.

DSO 0901 - Documentary Television - All of the video collected on this flight will be evaluated by the sponsor of this DSO.

DSO 0902 - Documentary Motion Picture Photography - Motion picture data were collected throughout this mission for this DSO and will be evaluated by the sponsor.

DSO 0903 - Documentary Still Photography - Still photography data were collected for the general activities of the flight and will be evaluated by the sponsor.

TABLE I.- STS-43 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	214:14:57:09.82
	APU-2 GG chamber pressure	214:14:57:12.49
	APU-3 GG chamber pressure	214:14:57:16.55
SRB HPU activation	LH HPU system A start command	214:15:01:32.17
	LH HPU system B start command	214:15:01:32.33
	RH HPU system A start command	214:15:01:32.49
	RH HPU system B start command	214:15:01:32.65
Main propulsion System start	Engine 3 start command accepted	214:15:01:53.461
	Engine 2 start command accepted	214:15:01:53.546
	Engine 1 start command accepted	214:15:01:53.698
SRB ignition command (lift-off)	SRB ignition command to SRB	214:15:01:59.986
Throttle up to 104 percent thrust	Engine 3 command accepted	214:15:02:03.942
	Engine 2 command accepted	214:15:02:03.906
	Engine 1 command accepted	214:15:02:03.939
Throttle down to 84 percent thrust	Engine 3 command accepted	214:15:02:24.263
	Engine 2 command accepted	214:15:02:24.226
	Engine 1 command accepted	214:15:02:24.259
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	214:15:02:50.4
Throttle down to 67 percent thrust	Engine 3 command accepted	214:15:02:51.945
	Engine 2 command accepted	214:15:02:51.906
	Engine 1 command accepted	214:15:02:51.900
Throttle up to 104 percent thrust	Engine 3 command accepted	214:15:02:59.145
	Engine 2 command accepted	214:15:02:59.106
	Engine 1 command accepted	214:15:02:59.100
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	214:15:04:00.186
	RH SRM chamber pressure mid-range select	214:15:04:00.146
End SRM action	LH SRM chamber pressure mid-range select	214:15:04:02.568
	RH SRM chamber pressure mid-range select	214:15:04:02.334
SRB separation command	SRB separation command flag	214:15:04:05
SRB physical separation	SRB physical separation	214:15:04:05.55
Throttle down for 3g acceleration	Engine 3 command accepted	214:15:09:30:327
	Engine 2 command accepted	214:15:09:30.310
	Engine 1 command accepted	214:15:09:30.308
3g acceleration	Total load factor	214:15:09:30.9
MECO	MECO command flag	214:15:10:25.9
	MECO confirm flag	214:15:10:26.9
ET separation	ET separation command flag	214:15:10:44.9
OMS-1 ignition	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown

TABLE I.- STS-43 SEQUENCE OF EVENTS (CONTINUED)

Event	Description	Actual time, G.m.t.
OMS-1 cutoff	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
APU deactivation	APU-1 GG chamber pressure	214:15:17:17.70
	APU-2 GG chamber pressure	214:15:17:19.24
	APU-3 GG chamber pressure	214:15:17:20.01
OMS-2 ignition	Left engine bi-prop valve position	214:15:41:50.9
	Right engine bi-prop valve position	214:15:41:50.9
OMS-2 cutoff	Left engine bi-prop valve position	214:15:44:14.1
	Right engine bi-prop valve position	214:15:44:13.9
Payload bay door open	PBD right open 1	214:16:29:50.7
	PBD left open 1	214:16:31:09.9
TDRS/IUS Deployment	Voice call	214:19:16:00
Flight control system checkout		
APU start	APU-2 GG chamber pressure	222:07:13:56.79
APU stop	APU-2 GG chamber pressure	222:07:25:01.45
Payload bay door close	PBD left close 1	223:08:41:45.9
	PBD right close 1	223:08:43:07.7
APU activation for entry	APU-1 GG chamber pressure	223:11:16:17.23
	APU-2 GG chamber pressure	223:12:16:57.71
	APU-3 GG chamber pressure	223:11:38:54.57
Deorbit maneuver ignition	Left engine bi-prop valve position	223:11:21:15.17
	Right engine bi-prop valve position	223:11:21:14.97
Deorbit maneuver cutoff	Left engine bi-prop valve position	223:11:23:53.77
	Right engine bi-prop valve position	223:11:23:53.57
Entry interface (400k)	Current orbital altitude above reference ellipsoid	223:11:51:51.50
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	223:12:16.52.00
Main landing gear contact	LH MLG tire pressure	223:12:23:25.00
	RH MLG tire pressure	223:12:23:25.00
Main landing gear weight on wheels	LH MLG weight on wheels	223:12:23:25.97
	RH MLG weight on wheels	223:12:23:24.96
Nose landing gear contact	NLG tire pressure	223:12:23:34.96

TABLE I.- STS-43 SEQUENCE OF EVENTS (CONCLUDED)

Event	Description	Actual time, G.m.t.
Nose landing gear weight on wheels	NLG WT on Wheels -1	223:12:23:35.97
Wheels stop	Velocity with respect to runway	223:12:24:24.96
APU deactivation	APU-1 GG chamber pressure	223:12:45:15.08
	APU-2 GG chamber pressure	223:12:24:57.22
	APU-3 GG chamber pressure	223:12:45:16.85

TABLE II.- STS-43 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-43-V-01	Cabin Vent Valve Failed to Indicate "Closed"	213:14:20 G.m.t. IPR 44V-0001 IM 43RF01	After the vent down from the cabin leak test for August 1 launch attempt, no closed indication was received from the cabin vent valve. Subsequent cabin leak test verified valve was closed. Fly as-is for this mission. KSC troubleshooting verified bad microswitch. Valve removed and replaced.
STS-43-V-02	No cooling on Water Spray Boiler 2 on Ascent	214:15:11 G.m.t. IPR 44V-0015 IM 43RF02	No cooling was noted when operating on Water Spray Boiler 2 controllers A and B. Data indicate freeze-up. Tests during FCS checkout verified no cooling on either controller. Changeout lube oil and hydraulic spray valves. Valves in failure analysis.
STS-43-V-03	Payload Data Interleaver (PDI) Decommuntation Problems	214:16:50 G.m.t. IPR 44V-0014	Decom 2 dropped in and out of lock on format 7 SHARE data and lost lock completely for 1 minute. A reload of format and source was unsuccessful. Went to backup decommutator (1) which experienced drops in data. Successfully processed data on decom 3 for remainder of mission. PDI will be removed and replaced. Replacement PDI having intermittent MTU IRIG B toggle fail hits.
STS-43-V-04	PRSD Hydrogen Tank 1 Heater B Failed Off	215:09:30 G.m.t. IM 43RF03 IPR 44V-0008	After several dual heater cycles, heater B appeared to fail off. A subsequent manual activation of heater B verified the failed off condition. Normal KSC troubleshooting verified blown 5 ampere fuse in cryo control box. Fuse removed and replaced and heater worked nominally. Failure analysis shows mechanical failure of fuse. Not related to STS-40 cryogenic heater failure.
STS-43-V-05	CCTV Camera D Inoperative	214:17:48 G.m.t. FIAR-BCFE-029-F038 IPR 44V-0004	Crew reported that when camera D was powered up, there was no video . output. Each time the camera was powered, a "S76" camera over-temperature message occurred. Crew tried to repower the camera on flight day 2 with no success. Problem repeated during KSC trouble-shooting. Camera A put in D slot and functioned normally.
STS-43-V-06	APU 1 Fuel Pump/Gas Generator Valve Module Overcooling	214:15:32 G.m.t. IPR 44V-0003 IM 43RF04	After APU shutdown on ascent, the fuel pump/gas generator valve module (FP/GGVM) cooling system A for APU 1 displayed excessive, erratic water spraying resulting in overcooling of the fuel pump. Fly timer box as is.
STS-43-V-07	Low Ku-Band Power Indication	216:13:07 G.m.t. IPR 44V-0006 IM 43RF05	Ku-Band power output (V74E2511A) dropped from 31 W to ~22 W and recovered in 22 minutes. TV in progress was good. Similar occurrences at 216:16:40 G.m.t., 218:15:10 G.m.t. and 218:15:29 G.m.t. Troubleshooting could not duplicate problem. Fly as-is.
STS-43-V-08	S-Band Power Amplifier Degradation	216:21:30 G.m.t. IPR 44V-0005 IM 43RF06	S-Band power amplifier 2 has shown a slow power degradation throughout the flight. Switched to PA1 just before entry after communications erratic with PA2. Removal and replacement of PA2 has been completed.
STS-43-V-09	PRSD Hydrogen Manifold Valve 1 Failed Open	220:18:09 G.m.t. IPR 44V-0007 IM 43RF07	Valve failed to open when commanded closed. Crew cycled switch twice and no operation was visible. Further valve closures were not be attempted in flight. Valve closed five times previously on this flight. KSC troubleshooting after detanking; valve cycled 5 times successfully. Wire wiggles inconclusive. Will splice in instrument-ation to valve command circuit for next flight.

TABLE II.- STS-43 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-43-V-10	Floodlight failure Mid-Starboard RPC Trip	219:17:13 G.m.t. IM 43RF08 IPR 44V-0013	When payload bay floodlights were powered, mid Main C amps increased 15 amps for 3 - 4 seconds, Subsequent testing confirmed mid-starboard floodlight failed. Light flickering during troubleshooting. Remove and replace light.
STS-43-V-11	Partial Pressure Oxygen Sensor C Failed	223:02:32 G.m.t. IM 43RF09 IPR 44V-0016	Sensor C began diverging downward for sensors A and B valves. All three sensors removed and sent to vendor in dedicated canisters. Troubleshooting shows no Orbiter contribution to this problem.
STS-43-V-12	APU 1 Anomalous Chamber Pressure During Entry	223:11:58 G.m.t. IM 43RF10	For approximately 35 seconds, the APU 1 chamber pressure returned to a non-zero level after each pulse. indicating a possible leak in the pulse control valve. Remove and replace APU 1.
STS-43-V-13	MPS Liquid Hydrogen 4 inch Disconnect-Portion of Seal Stuck in Flapper	Postlanding PR MPS-4-10-0795 IM 43RF11	Postlanding operations revealed a pressurization leak in the MPS. Visual inspection showed that a portion of the PD3 flapper seal had come loose and was lodged in the flapper. Seal removed and replaced and failure analysis is in progress.
STS-43-V-14	Right-Hand Outboard Brake Pressure Bias	Rollout IPR 44V-0028	The right-hand outboard brake pressure 4 (V51P0744A) appeared biased approximately 200 psi lower than right-hand outboard brake pressure 2. Ground troubleshooting on August 14 could not duplicate. Similar phenomenon, to a lesser extent, seen on previous flights of OV-104 d (IFA STS-37-V-17). Further troubleshooting week of 9/11. Look for funnies in brake skid control - If no repeat, remove and replace servo module and antiskid control box.
STS-43-V-15	-Z Star Tracker/Light Shade Shutter Light Leak	222:12:27 G.m.t. IPR 44V-0029	Star tracker exhibited intermittent star presence while pointed at the Sun with the shutter closed. This condition indicates shutter is not closed. No repeat during troubleshooting. Fly as-is.
STS-43-V-16	Right Main Engine Repressurized to 33 psia During Entry	223:12:23 G.m.t. IPR 44V-0020 IM 43RF14	During entry, the right engine liquid oxygen inlet pressure (V41P1330C) tracked the manifold pressure during repressurization. Initial KSC troubleshooting showed no leakage in prevalve. Tests and X-rays showed CV 35 stuck open. Replacement of valve will be made.

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