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SPACE SHUTTLE
MISSION REPORT

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STS-54

SPACE SHUTTLE

MISSION REPORT

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INTRODUCTION

The STS-54 Space Shuttle Program Mission Report is a summary of the Orbiter, External Tank (ET), Solid Rocket Booster/Redesigned Solid Rocket Motor (SRB/RSRM), and the Space Shuttle main engine (SSME) subsystems performance during this fifty-third flight of the Space Shuttle Program, and the third flight of the Orbiter vehicle Endeavour (OV-105). In addition to the Orbiter, the flight vehicle consisted of an ET, which was designated ET-51; three SSME's, which were serial numbers 2019, 2033, and 2018 in positions 1, 2, and 3, respectively; and two retrievable and reusable SRB's which were designated BI-056. The lightweight RSRM's that were installed in each SRB were designated 360L029A for the left SRB, and 360L029B for the right SRB.

The primary objectives of this flight were to perform the operations to deploy the Tracking and Data Relay Satellite-F/Inertial Upper Stage payload and to fulfill the requirements of the Diffuse X-Ray Spectrometer (DXS) payload. The secondary objective was to fly the Chromosome and Plant Cell Division in Space (CHROMEX), Commercial Generic Bioprocessing Apparatus (CGBA), Physiological and Anatomical Rodent Experiment (PARE), and the Solid Surface Combustion Experiment (SSCE).

The sequence of events for the six-day STS-54 mission is shown in Table 1 and the official Orbiter and GFE Projects Problem Tracking List is shown in Table II. Appendix A lists the sources of data, both formal and informal, that were provided to prepare this report. Appendix B defines the acronyms and abbreviations used in the document.

In addition to presenting a summary of subsystem performance, this report also discusses each Orbiter, ET, SSME, SRB, and RSRM in-flight anomaly in the applicable section of the report. The official tracking number for each in-flight anomaly, assigned by the cognizant project, is also shown. All times are given in Greenwich mean time (G.m.t.) and mission elapsed time (MET).

This STS-54 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirement, as documented in NSTS 07700, Volume VIII, Appendix E, which states that each major organizational element supporting the Program will report the results of their hardware evaluation and mission performance plus identify all related in-flight anomalies.

The crew for this fifty-third Space Shuttle mission was John H. Casper, Col., USAF, Commander; Donald R. McMonagle, Lt. Col., USAF, Pilot; Mario Runco, Jr., Lt. Cdr., USN, Mission Specialist 1; Gregory J. Harbaugh, Civilian, Mission Specialist 2; and Susan J. Helms, Major, USAF, Mission Specialist 3. STS-54 was the second space flight for the Commander, Pilot, Mission Specialist 1, and Mission Specialist 2, and the first space flight for Mission Specialist 3.

MISSION SUMMARY

The launch of the STS-54 vehicle occurred from KSC launch pad 39B at 13:13:59:29.989 G.m.t. (08:59:30 a.m. e.s.t. on January 13, 1993). The launch was delayed 7 minutes 30 seconds for resolution of a Launch Systems Evaluation and Advisory Team (LSEAT) violation. The vehicle was launched on a direct insertion trajectory with a 28.45-degree inclination. The launch phase was satisfactory in all respects.

After main engine cutoff (MECO), it was noted that water spray boiler (WSB) 3, while operating on controller A, was not cooling the lubrication oil of auxiliary power unit (APU) 3. At a lubrication oil return temperature of 295°F (lubrication oil return temperature is normally controlled to 250°F), WSB 3 was switched to controller B, but again no cooling was evident. As a result, when APU 3 bearing temperature 1 reached 335°F, the APU was shut down in accordance with flight rule 10-5A. Post-ascent data evaluation has shown approximately 35 seconds of cooling (water spraying) occurred about 40 seconds after APU 3 shutdown while operating on B controller. Analysis indicated that a freeze-up of the WSB occurred. WSB 3/APU 3 cooled normally on both controllers during the flight control system (FCS) checkout and during entry.

Supply pressures in hydraulic system 3 and 1 both showed anomalous pressure recovery immediately following the post-MECO APU shutdown, and this condition resulted in the early shutdown of APU 3. The system 3 pressure, following an initial drop from 3000 psia to 1600 psia over about 6 seconds, increased over the next 4 seconds to 2400 psia and remained there for more than 40 seconds. During the next 8 seconds, when the thrust vector control (TVC) isolation valves were closed in a 1, 2, and 3 sequence, system 3 again dropped to the 1600-psia range, sharply recovered to 2800 psia, and finally dropped to the expected reservoir pressure. Also, after APU 1 shutdown, hydraulic system 1 showed an unexpected transient pressure recovery. The pressure dropped normally during a postlanding test intended to recreate the problem. Also, the pressure dropped normally during a similar shutdown sequence on a previous flight of OV-105 (STS-47). Analysis of the STS-54 data showed that the pressure recovery in hydraulic system 3 was caused by back-driving speedbrake hydraulic motor 3, converting motor into a hydraulic pump which repressurized the shutdown system. Power to operated the back-driving pump was delivered through the differential gearbox that normally combines the outputs of the three speedbrake motors.

A 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 for the time period between SRB separation and start of 3-g throttling was 452.7 seconds as compared to an average main propulsion system (MPS) tag value 452.87 seconds.

The 143.8-second orbital maneuvering subsystem (OMS) -2 maneuver was performed as planned with a ΔV of 222 ft/sec, and the Orbiter was placed in a 162 by 160 nmi. orbit. The payload bay doors were opened satisfactorily at 13:15:41:11 G.m.t. (00:01:41:41 MET).

The Tracking and Data Relay Satellite (TDRS)/Inertial Upper Stage (IUS) payload was deployed nominally at 13:20:12:26 G.m.t. (00:06:12:56 MET). The TDRS satellite is the fifth in a configuration of satellites that form the space segment of the Tracking and Data Relay Satellite System (TDRSS). This systems was developed to provide user services to scientific and applications satellites in near-Earth orbit and to the Space Shuttle. The TDRS was boosted to geosynchronous orbit by the IUS.

At 13:20:27:26.1 G.m.t. (00:06:27:56.1 MET), the OMS 3 separation maneuver from the TDRS/IUS was initiated. The firing used the left engine only and was 33.7 seconds in duration (ΔV = 30.4 ft/sec). The firing resulted in a new orbit of 178.9 by 163.0 nmi. System operation during the firing was nominal.

The OMS-4 maneuver was completed nominally at 14:16:08:42.3 G.m.t. (01:02:09:12.3 MET). The OMS-4 maneuver was a right-engine-only firing that was 27.3 seconds in duration and provided a ΔV of 24.9 ft/sec.

A cabin depressurization to 10.2 psi was completed in preparation for the planned extravehicular activity (EVA) on flight day 5.

The waste collection system (WCS) commode fault light illuminated at 16:14:22:09 G.m.t. (03:00:22:39 MET). A review of data indicates that the compactor caused the fault light to illuminate during the retraction phase of the compaction cycle. A procedure, which was sent via the text and graphics system (TAGS), was performed by crewmembers and confirmed the fault, which disengages the motor. In-flight, the crew was told to power cycle the commode prior to use if the light was on, as this re-enables the motor. The WCS operated satisfactorily for the remainder of the mission. Postflight troubleshooting confirmed the problem to be the controller logic sensing the current-limit condition too quickly at the end of the cycle and shutting the compactor down.

The planned EVA was successfully initiated and the EVA crew egressed the Orbiter at 17:10:48 G.m.t. (03:20:49 MET). The EVA was satisfactorily completed and the official duration was 4 hours 27 minutes 50 seconds.

Fuel cell 2 was shut down as planned at 18:07:42:25 G.m.t. (04:17:42:55 MET). Fuel cell temperatures decreased as expected. The fuel cell was to remain shut down for 10 hours to meet the Development Test Objective (DTO). About 9 hours after shutdown, the fuel cell stack temperatures had decreased from 185°F to 135°F, and the environmental temperature was between 70°F and 80°F, based on the nitrogen system 2 tank 1 temperature. Fuel cell stack 2 temperatures were 130°F to 135°F at the time of the restart at 18:16:44 G.m.t. (05:02:45 MET). No anomalies were noted during startup, and the "Ready For Load" indication was received 7 minutes after the start command.

The FCS checkout was completed at 18:08:38:28.6 G.m.t. (04:18:38:58.6 MET). APU 3 and WSB 3 were used with APU 3 running for 14 minutes 47 seconds. All APU parameters were nominal, and the APU was operated until proper cooling was achieved on both A and B WSB controllers. Two and one-half minutes after spray initiation on the B controller, the A controller was selected. About 20 seconds later, a 28-degree over-cool condition was noted during which the lubrication oil return temperature went from 257°F to 227°F before recovering to a nominal 255°F where the temperatures stabilized and nominal operation was observed. This overcooling condition did not pose a flight impact.

The rudder speedbrake switching valve failed to switch to the standby position during each of the hydraulic system 3 circulation pump activations that occurred during the mission. During a special run of circulation pump 3, the MPS thrust vector control isolation valve was opened, increasing the differential pressure across the switching valve. This differential pressure caused the switching valve to move to the standby position. The switching valve performed as expected during FCS checkout and entry. KSC testing verified that the switching valve was operating nominally; however, under certain specific hydraulic balance conditions, the switching valve may require as long as 30 seconds to change state.

The reaction control subsystem (RCS) hot-fire was performed at 18:07:57 G.m.t. (04:17:57 MET), and primary thruster R1R failed off due to low chamber pressure (24.7 psia when it should have been 152 psia) on its first firing attempt. All other thrusters operated nominally. The chamber pressure was at 10 psia for the first 280 msec and then jumped to 25 psia prior to deselection at 320 msec. Injector temperature data indicated that both fuel and oxidizer flow had occurred. The most probable failure mode is failure of the oxidizer valve main stage to open due to nitrate contamination of the pilot stage.

Both payload bay doors were closed nominally by 19:10:04:14 G.m.t. (05:20:04:44 MET). The deorbit maneuver was performed at 19:12:38:10.1 G.m.t. (05:22:38:40.1 MET). The maneuver was approximately 153.4 seconds in duration and the ΔV was 292.9 ft/sec.

Main landing gear touchdown occurred at Shuttle Landing Facility on concrete runway 33 at 19:13:37:47 G.m.t. (05:23:38:17 MET) on January 19, 1993. Nose landing gear touchdown occurred 15 seconds after main gear touchdown with the Orbiter drag chute being deployed satisfactorily at 19:13:37:59.8 G.m.t. The drag chute was jettisoned at 19:13:38:22.6 G.m.t. with wheels stop occurring at 19:13:38:36 G.m.t. The rollout was normal in all respects. The flight duration was 5 days 23 hours 38 minutes 19 seconds. All three APU's were powered down by 19:13:56:56.10 G.m.t. The crew completed the required postflight reconfigurations and exited the Orbiter at 19:14:18 G.m.t.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTER/REDESIGNED SOLID ROCKET MOTOR

All SRB systems performed as expected. The SRB prelaunch countdown was normal. No SRB or RSRM Launch Commit Criteria (LCC) or Operations and Maintenance Requirements and Specifications Document (OMRSD) violations occurred.

Power-up and operation of all case, igniter, and field joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the heated ground purge in the SRB aft skirt was used to maintain the case/nozzle joint and flexible bearing temperatures within the required LCC ranges. The heated ground purge was also maintained in operation until launch minus 15 minutes to inert the aft skirt area of any accumulation of hydrazine.

Data indicate that the flight performance of both RSRM's was within the allowable performance envelope, and was typical of the performance observed on previous flights. The RSRM propellant mean bulk temperature (PMBT) was 70°F at lift-off. The RSRM performance is delineated in the table on the following page.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 70°F		Right motor, 70°F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.84	64.58	65.37	64.82
I-60, 10^6 lbf-sec	175.41	172.90	174.37	173.77
I-AT, 10^6 lbf-sec	296.92	296.27	296.75	296.91
Vacuum Isp, lbf-sec/lbm	268.50	267.80	268.50	268.50
Burn rate, in/sec @ 60°F at 625 psia	0.3690	0.3657	0.3676	0.3668
Burn rate, in/sec @ 68°F at 625 psia	0.3716	0.3683	0.3702	0.3694
Event times, seconds				
Ignition interval[a]	0.232	N/A	0.232	N/A
Web time[a]	109.50	110.90	110.20	110.80
Separation cue, 50 psia	119.50	120.60	120.00	120.00
Action time	121.30	122.70	122.00	122.60
Separation command, sec	125.44	125.96	125.44	125.96
PMBT, °F	70.00	70.00	70.00	70.00
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.80	2.70	2.80	3.50
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 707.30b	

Notes:

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

[b] Tailoff imbalance is equal to left motor minus right motor, and was calculated by Marshall Space Flight Center.

Postflight evaluation of the RSRM performance data revealed an unexpected perturbation in the chamber pressure measurements of the right RSRM approximately 67.5 seconds after lift-off (Flight Problem STS-54-M-1). The perturbation consisted of a pressure spike of approximately 13-psi maximum with an overall duration of 3 seconds. This pressure increase resulted in a thrust imbalance of 76.5 Klbf. The thrust imbalance approached but did not exceed the specification thrust imbalance limit of 85 Klbf. Pressure spikes of this nature have been observed in the past, but this spike is the largest seen during the Space Shuttle Program. Evaluation of this anomaly was continuing as the time of report publication.

RSRM field joint heaters operated for 11 hours and 23 minutes. Power was applied to the heating element 22 percent of the time during the prelaunch time period when the LCC was applicable. This amount of heat maintained the field joints in their normal operating temperature range. Igniter joint heaters operated for 18 hours 17 minutes. Power was applied to the left and right heating elements 42 and 56 percent of the time, respectively, to keep the igniter joints in their normal operating range.

The flexible bearing temperatures were maintained above 60°F by intermittent activation of the aft skirt GN_2 purge. The purge was operated for a total of seven hours 15 minutes to keep the nozzle-to-case-joint temperature above the minimum LCC temperature of 75°F. To ensure all hazardous gases were removed from the aft compartment, the purge was operated at high-flow rate from T-33 minutes to launch. As a result of the purge operation, the flexible bearing mean bulk temperature was 77°F.

Both SRB's were successfully separated from the ET at T-zero + 125.96 seconds, and reports from the recovery area, based on visual sightings, indicate that the deceleration subsystem performed as designed. Both SRB's were observed during descent, and were retrieved and returned to KSC for disassembly and refurbishment.

The postflight inspection of the igniter outer joint revealed a hair across the primary and secondary seal footprints of the aft gasket face on the right RSRM. The cause and corrective action for this condition are being resolved at this writing.

EXTERNAL TANK

The ET flight performance was excellent. All objectives and requirements associated with the ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation operated satisfactorily. ET purge and heater operations were monitored and all performed properly. No OMRSD violations were identified.

Propellant loading was nominal. The ullage pressures in all LO_2 and LH_2 tanks were within acceptable limits throughout loading, pressurization, and flight. The ET pressurization system functioned properly throughout engine start and flight. The minimum liquid oxygen ullage pressure experienced during the period of ullage pressure slump was a nominal 13.1 psid.

Typical ice/frost formations for the January atmospheric environment were observed on the ET during the countdown. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feed lines and on the pressurization line brackets. Also, some frost or ice was present along the liquid hydrogen protruding air load (PAL) ramps. These observations were acceptable per NSTS 08303. There was no observed ice or frost on the acreage of the liquid oxygen or liquid hydrogen tank barrel.

The intertank purge heater and temperature control system operated successfully. There were no LCC, OMRSD, or historical maximum temperature violations. The objective of the intertank purge was met with all temperatures inside the intertank being maintained within acceptable limits. Also, there were no hazardous gas violations in this area.

Development Test Objective 312 - ET Thermal Protection System Performance Photography - was performed following ET separation. Discussion of the results of the photographic evaluation are presented in the Development Test Objective section of this report.

ET separation was confirmed. Radar data from Bermuda confirmed that the ET (with tumble valve disabled) did not tumble after ET/Orbiter separation. The postflight impact point was within the expected footprint and about 37 miles from the predicted point.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters appeared normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights.

Engine "Ready" was achieved at the planned time, all LCC were met, and engine start and thrust buildup were normal. All Interface Control Document (ICD) start and shutdown transient requirements were met. Flight data indicate that SSME performance during start, mainstage, throttling, shutdown and propellant dump operations was as predicted and cutoff times for SSME 1, 2, and 3 were 516.29, 516.41, and 516.53 seconds, respectively. The Isp was rated as 452.68 seconds based on trajectory data. The high pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures were well within specification throughout engine operation. Two anomalies were identified and are discussed in the following paragraphs.

An increase in the SSME 1 HPOTP synchronous vibration amplitude of 1g rms (based on 11-point sliding average) was noted (Flight Problem STS-54-E-1). The amplitude increased to a maximum of 3.2g rms at 104 percent on accelerometer location 135-1. The average synchronous amplitude of the three HPOTP accelerometers reached the acceptance test specification of 3g rms. No bearing-related frequencies were evident at any time during the flight. The pump was disassembled after flight and no hardware anomalies were found. This is consistent with diagnostic disassemblies of pumps after ground tests that have exhibited synchronous vibrations of this magnitude.

A single negative spike of 0.6 psia was noted on the channel A (HPOTP) secondary seal cavity (SSC) pressure sensor on SSME 3 (Flight Problem STS-54-E-2). The spike occurred at engine start + 85.6 seconds. No other anomalies occurred during chill, mainstage, or the post-shutdown phases. The spiking was most likely caused by contamination in the pressure transducer. This pressure transducer had experienced six starts and 1,567 seconds of run time; however, this was the first flight for this sensor. The sensor was replaced. Failure analysis indicated contamination was present in the sensor; however, a particle capable of causing the failure was not identified.

SPACE SHUTTLE RANGE SAFETY SYSTEM

Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown. All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at the appropriate times. All SRSS measurements indicated that the system operated as expected throughout the countdown and flight.

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

ORBITER SUBSYSTEM

Main Propulsion Subsystem

The overall performance of the MPS was as expected. Liquid oxygen and liquid hydrogen loading was performed as planned with no stop flows or reverts. No OMRSD or LCC violations were identified.

Throughout the period of preflight operations, no significant gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment, which occurred shortly after the start of fast fill, was a corrected value of 135 ppm, and this value compares favorably with previous data for this vehicle. The oxygen concentration level was 25 ppm, and the helium concentration was initially 10,700 ppm, but it fell below the LCC maximum level of 10,000 ppm before the LCC limits became effective.

A comparison of the calculated propellant loads at the end of replenish, versus the inventory loads resulted in a loading accuracy of -0.004 percent for liquid hydrogen, and +0.04 percent for liquid oxygen. During loading of the helium supply for SSME 2, the helium pressure reached 4500 psia, which is the LCC upper limit; however, the pressure did not violate the LCC.

Ascent MPS performance appeared to be completely normal. The GO_2 fixed orifice pressurization system performed as expected. The GH_2 pressurization system also performed nominally. Evaluation of the flow control valve data revealed normal operations. Preliminary data indicate that the liquid oxygen and liquid hydrogen pressurization systems performed as planned, and that all net positive suction pressure (NPSP) requirements were met throughout the flight. The gaseous hydrogen flow control valves for SSME 1 cycled 15 times, 57 times for SSME 2, and 0 times for SSME 3. Performance analyses of the propulsion systems during start, mainstage, and shutdown operations indicated that performance was nominal and all requirements were met. MECO occurred at lift-off plus 509.9 seconds.

The MPS propellant dump operations were nominal, and the MPS operations were nominal during entry and landing, and 55.6 lb of helium were consumed during entry.

Reaction Control Subsystem

The RCS met all mission requirements in a nominal manner. Propellant consumption during the six-day mission was 4910.5 lbm, which includes dumping the forward RCS to zero percent prior to landing.

The forward RCS thruster F3L fuel valve appeared to have a transient leak after its first firing when the fuel injector temperature dropped to 42°F. The temperature began recovering about 30 seconds after the firing. A second intermittent leak condition was noted about 30 seconds after the seventh firing of thruster F3L. Neither leak was of sufficient magnitude to cause the thruster to be failed by the redundancy management (RM) system. There was no other forward RCS manifold 3 thruster activity at the time of the leak indications. Data did not show any repeat of this intermittent leak condition during the remainder of the mission.

Primary thruster R1R failed off due to low chamber pressure (Flight Problem STS-54-V-05) on its first firing attempt at 18:07:58:02 G.m.t. (04:17:58:32 MET) during the RCS hot fire. The chamber pressure was 10 psia for the first 280 msec of the firing, and then jumped to 25 psia just before the thruster was deselected at 320 msec. All other thrusters operated nominally. The injector temperature data indicated that both fuel and oxidizer flow had occurred. The thruster remained deselected for the remainder of the mission. The most probable failure mode is failure of the oxidizer valve main stage to open due to nitrate contamination of the pilot stage.

Orbital Maneuvering Subsystem

The OMS performance was excellent. Four firings of the OMS engines were performed of which two were dual-engine firings and the other two were single-engine firings. The total firing time was 330.9 seconds for the left-hand engine and 323.5 seconds for the right-hand engine. Propellant consumption for the OMS was 12,587 lb with 7885 lb of oxidizer and 4702 lb of fuel used.

The gauging system performance was nominal throughout the mission, and all post-firing quantities were within one percent of calculated values. As a result, preliminary data indicate that the gauge values should be usable for loading purposes on the next OV-105 flight.

The following table presents the pertinent parameters for each firing.

OMS firing	Engine used	Time, G.m.t./MET	Firing duration, sec	ΔV, ft/sec
2	Both	13:14:38:23.4 G.m.t. 00:00:38:53.4 MET	143.8	222.0
3	Left-engine	13:20:27:26.1 G.m.t. 00:06:27:56.1 MET	33.7	30.4
4	Right-engine	14:16:08:42.3 G.m.t. 01:02:09:12.3 MET	27.3	24.9
Deorbit	Both	19:12:38:10.2 G.m.t. 05:22:38:40.2 MET	153.4	292.9

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed nominally throughout the mission. The vehicle was flown in a four-tank-set configuration, and a total of 1471.4 lb lb of oxygen and 176.9 lb of hydrogen was consumed during the mission. Of the oxygen amount used, 66.8 lb of oxygen was used by the crew for life support. The mission extension capability at an average power level of 14.4 kW was 111.5 hours.

The crew reported during the postflight crew debriefing that an attempt was made to close the oxygen tank manifold 1 isolation valve prior to the sleep period following flight day 4 activities. The switch was held on for 2 to 3 seconds, however the valve did not close. A second attempt was made during which the switch was held in position for 2 seconds, and the valve closed. This is a repeat of the anomaly experienced on this valve during STS-49 (Flight Problem STS-49-V-02). Failure analysis was performed on an OV-104 manifold valve which has shown similar behavior.

Fuel Cell Powerplant Subsystem

The fuel cells performed nominally in producing 2061.8 kWh of electricity. In producing this electricity, the fuel cells also produced 1581.5 lb of water.

The first attempt to wait 72 hours between fuel cell purges was shortened to 50 hours when the voltage decay reached the 0.2-volt limit. The voltage decay rate was higher than normal because of slightly higher nitrogen impurity levels in the oxygen. Reactant purity levels were well within specification, and the observed voltage decay rate had no mission impact. A total of six purges were performed at the following mission elapsed times: 27 hours; 77 hours; 98 hours; 111 hours (fuel cells 1 and 3 only); 123 hours; and 134 hours. The actual fuel cell voltage decay at the end of the mission was 0.1 V above the predicted for fuel cell 1 and 3, and 0.05 V above predicted for fuel cell 2. These decay rates had no effect on the mission.

Fuel cell 2 was shut down as planned at 018:07:42:25 G.m.t. (04:17:42:55 MET). Fuel cell temperatures decreased as expected. The fuel cell was to remain shut down for 10 hours to meet the DTO. About 9 hours after shutdown, the fuel cell stack temperatures had decreased from 185°F to 135°F, and the environmental temperature was between 70°F and 80°F, based on the nitrogen system 2 tank 1 temperature. Fuel cell stack 2 temperatures were 130°F to 135°F at the time of the restart at 018:16:44 G.m.t. (05:02:56:30 MET). No anomalies were noted during startup, and the "Ready For Load" indication was received 7 minutes after the start command. The fuel cell operated satisfactorily for the remainder of the mission.

During on-orbit operations, the temperature of the fuel cell 2 alternate water line was higher than normal, indicating water weeping past the fuel cell alternate water line check valve (Flight Problem STS-54-V-07). During entry at 19:13:30 G.m.t. (05:23:31 MET), the temperature of the fuel cell 3 alternate water line began rising and peaked at 127°F 30 minutes after landing (Flight Problem STS-54-V-07). The alternate water line temperature peaking at the same temperature as the primary water line indicates significant flow past the alternate water line check valve. Modified OMRSD check valve tests will be performed during turnaround.

Auxiliary Power Unit

The APU subsystem performed nominally throughout the mission, but some minor problems are discussed in the subsequent paragraphs. The following table presents the APU run times and fuel consumption by APU serial number and position.

Flight Phase	IAPU 1 (S/N 303)		IAPU 2 (S/N 401)		IAPU 3 (S/N 207)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	20:31	51	20:32	52	19:08	47
FCS checkout					14:47	31
Entry[a]	62:09	134	83:43	168	61:04	121
Total[a]	82:40	185	104:15	220	94:59	199

Notes:

[a] IAPU 1 ran for 18 minutes 28 seconds after landing (touchdown), IAPU 2 ran for 19 minutes 09 seconds after landing, and IAPU 3 ran for 17 minutes 24 seconds after landing. The lengthened running time was the result of special WSB checks that were run after landing.

APU 3 did not receive any hydraulic cooling during ascent (The Hydraulics/Water Spray Boiler Subsystem section of this report contains a detailed discussion of the WSB operation during ascent.) As a result of no cooling and prior to the early shutdown of APU 3, the APU lubrication oil outlet temperature reached 317°F (FDA limit = 305°F), lubrication oil return temperature reached 317°F (FDA limit = 290°F), gearbox bearing temperature 1 reached 340°F (FDA limit = 335°F), and gearbox bearing temperature 2 also reached 340°F (No FDA limit). None of these temperatures exceeded APU reuse limits. It is suspected that water had frozen on the WSB spray bar. APU 3 functioned normally during FCS checkout and during entry.

The APU 1, 2, and 3 fuel tank/line/water-system B heaters were activated about 15 minutes after post-ascent APU shutdown when the test line temperature for each system approached the lower FDA limit of 48°F. The temperatures returned to the normal range once heater cycling began. Activation was completed prior to violation of the FDA limit. This same situation occurred the previous two flights of OV-105 and is normal for the configuration of OV-105. Postflight analysis is continuing to determine an appropriate solution to this condition.

The APU 1 fuel pump/gas generator valve module (GGVM) heater system A shifted its on/off cycle points from about a 15° cycle band to a 10°F band about three days into the mission. The cycling was repeatable and showed no signs of degradation.

The APU 2 and 3 seal cavity drain pressure decreased while on orbit. APU 2 decreased from 15 psia to 8 psia over 5 1/2 days and APU 3 decreased from 18 psia to 3 psia over 2 days. The leakage was most probably from the drain relief valve, which will be tested during turnaround as a part of the normal OMRSD checks. The relief valves are the new design (-003). Leakage from the APU 2 seal cavity drain was noted on the previous flight of OV-105 (STS-47). This leakage did not impact normal flight operations.

The FCS checkout was completed at 18:08:38:28.6 G.m.t. (04:18:38:58.6 MET). APU 3 and WSB 3 were used with APU 3 running for 14 minutes 47 seconds. All APU parameters were nominal.

D ing entry at 19:13:27 G.m.t. (05:23:47 MET), the APU 3 bearing temperature was erratic for a period of 17 seconds (Flight Problem STS-54-V-10). The APU had been operating for about 35 minutes when the condition occurred. The APU recovered and operated nominally for the remainder of the mission and postlanding soakback.

Hydraulics/Water Spray Boiler Subsystem

Hydraulics/water spray boiler operation was acceptable during the STS-54 mission.

After MECO, it was noted that WSB 3, while operating on controller A, was not cooling the lubrication oil of APU 3 (Flight Problem STS-54-V-01). At a lubrication oil return temperature of 295°F (lubrication oil return temperature is normally controlled to 250°F), WSB 3 was switched to controller B, but again no cooling was evident. As a result, when the APU 3 bearing temperature 1 reached about 335°F, the APU was shut down in accordance with Flight Rule 10-5A. Post-ascent data evaluation has shown that while operating on B controller, approximately 35 seconds of cooling (water spraying) occurred about 40 seconds after APU 3 shutdown. Preliminary analysis indicates that a freeze-up of the WSB occurred.

The FCS checkout was completed using WSB 3 with APU 3 running for 14 minutes 47 seconds. The APU was operated until proper cooling was achieved on both A and B WSB controllers. Two and one-half minutes after spray initiation on the B controller, the A controller was selected. About 20 seconds later, a 28-degree over-cool condition was noted during which the lubrication oil return temperature went from 257°F to 227°F before recovering to a nominal 255°F where the temperatures stabilized and nominal operation was observed. This overcooling condition did not pose a flight impact.

Supply pressures in hydraulic system 3 and 1 both showed anomalous pressure recovery immediately following the post-MECO APU shutdown, and this condition resulted in the early shutdown of APU 3. The system 3 pressure, following an initial drop from 3000 psia to 1600 psia over about 6 seconds, increased over the next 4 seconds to 2400 psia and remained there for more than 40 seconds (Flight Problem STS-54-V-08). During the next 8 seconds, when the thrust vector control (TVC) isolation valves were closed in a 1, 2, and 3 sequence, system 3 again dropped to the 1600-psia range, sharply recovered to 2800 psia, and finally dropped to the expected reservoir pressure. Also, after the normal APU 1 shutdown, hydraulic system 1 showed an unexpected transient pressure recovery. The pressure dropped normally during a postlanding test intended to recreate the problem. Also, the pressure dropped normally during a similar shutdown sequence on a previous flight of OV-105 (STS-47).

Analysis of the STS-54 data showed that the pressure recovery in hydraulic system 3 was caused by back-driving speedbrake hydraulic motor 3, converting the motor into a hydraulic pump which repressurized the shutdown system. Power to operate the back-driving pump was delivered through the differential gearbox that normally combines the outputs of the three speedbrake motors. Additionally, the APU 2 and 3 data showed an abrupt 8-horsepower increase during the 40-second period, and this closely correlated with the 8.4 horsepower required in system 3 to pump the estimated 6 gallons per minute quiescent flow to the observed 2400 psia.

Two concurrent conditions must exist for back-drive to occur; that is the speedbrake must have the hard-closed command present, and the supply pressure in one of the hydraulic supplies must have declined to a threshold range for an adequate dwell time (> 2 seconds). The conditions leading to the observed pressure recovery are a previously unrecognized characteristic of the rudder/speedbrake system, rather than a failure of system components. A detailed assessment of the effects of this condition on the ascent and entry flight performance indicate that the systems can withstand this condition, although it is undesirable.

Electrical Power Distribution and Control

The electrical power distribution and control (EPDC) subsystem performed satisfactorily throughout the mission. Performance of the EPDC components of the drag chute system performed satisfactorily.

Fuel cell 2 was shut down for 9 hours in support of DTO 0412. The fuel cell was successfully restarted with the ready-to-load indications received seven minutes after the start command.

During the crew debriefing, the crew reported having difficulty sleeping because of the excessive acoustical noise generated by the extravehicular mobility unit (EMU) power supply and battery charger (Flight Problem STS-54-V-11). A request to obtain acoustical data on STS-57 is being recommended so that the proper corrective action can be taken.

Environmental Control and Life Support Subsystem

The active thermal control system (ATCS) performed nominally throughout the mission with the exception of one failure that occurred prior to launch. The flash evaporator system (FES) high-load duct temperature measurement, located on the outboard zone, did not rise at its normal rate when heater string A was activated. Troubleshooting conducted on redundant heater strings B and C verified that both strings were functioning properly. Heater string B was selected for launch and operated within its control band for the remainder of the mission.

FES temperature oscillations were noted during ascent and , also during the deorbit preparations. The oscillations were similar to those experienced on the two previous flights of this vehicle. This condition did not impact operations. No oscillations were seen with the primary B controller used for entry.

The radiator cold soak provided cooling for 4 minutes after landing. The ammonia boiler system (ABS) primary B was operated for 35 minutes, and the primary A was operated for 20 minutes before ground cooling was connected and operational.

The atmospheric revitalization system (ARS) performance was nominal throughout the mission with no problems identified. The CO_2 partial pressure was maintained below a nominal level of 3.50 mm Hg. The cabin air temperature and relative humidity peaked at 80°F and 56 percent, respectively. The avionics bays 1, 2, and 3 air outlet temperatures peaked at 104.°F, 105°F, and 87°F, respectively. The avionics bays 1, 2, and 3 water coldplate temperatures peaked at 89°F, 90°F, and 79°F, respectively.

The pressure control system parameters all remained within anticipated ranges throughout the mission. The pressure control system was used in support of the cabin depressurization to 10.2 psia on flight day 3, the airlock and cabin repressurizations on flight day 5.

Based on nitrogen consumption (1.8 lbm/day vs. 4.5 lbm/day), an unusually low cabin pressure leakage was noted throughout the mission. Additionally, odors were noted by the crew in the area of the volume F. These two factors indicate that adequate venting was not being provided to the volume F wet trash. Postflight checks by KSC personnel revealed a dynatube adapter plug in the opening of the wet trash to vacuum. (This problem was initially defined as Flight Problem STS-54-V-06; however, a decision was made to delete this item as an anomaly and transfer it to KSC as an action item to be corrected.)

The supply water and waste management system performed normally throughout the mission. By the completion of the mission, all of the associated in-flight checkout requirements were performed and satisfied. The FES operated satisfactorily in performing all supply water dumps. The supply water dump line temperature was maintained between 70°F and 104°F throughout the mission with the operation of the line heater.

Waste water was gathered at the predicted rate with one waste water dump being performed at an average dump rate of 1.81 percent/minute (3.0 lb/min). The waste dump line temperature was maintained between 54°F and 78°F while the vacuum vent line temperature was maintained between 57°F and 81°F.

At approximately 14:12:59 G.m.t. (00:23:00 MET), the ac bus 1 currents indicated that the commode fan was still on after a commode use three hours earlier. Evaluation showed that the commode lid microswitch had probably not closed and switched the commode fan off after the last use, and that fully closing and latching the commode lid would switch the fan off. Instructions were given to the crew who verified that the commode fan was running. The crew then cycled the commode lid and the fan switched off. To prevent future occurrences of this condition, the crew was instructed to ensure that the lid was fully closed and latched after each use. This condition is not considered a problem, and it did not impact the flight.

The Extended Duration Orbiter (EDO) waste collection system (WCS) operated successfully throughout the mission on its first flight. At approximately 016:14:22:09 G.m.t. (03:00:22:39 MET), the WCS commode fault light illuminated (Flight Problem STS-54-V-03). A review of data indicated that the compactor caused the fault light to illuminate during the retraction phase of the compaction cycle. A procedure was performed and confirmed the fault, which disengages the motor. In-flight, the crew was told to power cycle the commode prior to use if the light was on, as this re-enables the motor. Postflight troubleshooting confirmed the problem to be the controller logic sensing the current-limit condition too quickly at the end of the cycle and shutting the compactor down. The commode fault disengages the motor. The WCS operated satisfactorily for the remainder of the mission.

Smoke Detection and Fire Suppression

All smoke detection system parameters remained within normal ranges throughout the flight. The use of the fire suppression system was not required.

Airlock Support System

The airlock system was used to support the extravehicular activity on flight day 5. All airlock system parameters remained within anticipated ranges.

Avionics and Software Subsystems

The integrated guidance, navigation and control subsystem performance was nominal throughout the flight. During ascent, elevon load relief occurred at approximately Mach 0.9. This was nominal but not a predicted condition because the phenomenon has been observed only two previous times during the Space Shuttle Program. These two occurrences were on the last two flights of the OV-105 vehicle (STS-47 and STS-49).

The flight control system performed nominally throughout the flight. The rudder speedbrake secondary switching valve failed to switch to the standby position at normal circulation pump pressure (TVC isolation valve closed) and nominal return pressure (Flight Problem STS-54-V-04). During a special run of circulation pump 3, the MPS TVC isolation valve was opened by increasing the differential pressure across the switching valve to 470 psia. This differential pressure caused the switching valve to move to the standby position. The switching valve performed as expected during FCS checkout and entry. The preliminary analysis has indicated a sticky switching valve.

The inertial measurement unit (IMU) and star tracker performed satisfactorily throughout the mission. The data processing system (DPS) hardware and software also performed very well with no anomalies or problems noted.

The displays and controls subsystem performed nominally; however, an anomaly was noted in that three payload bay floodlights did not operate properly (Flight Problem STS-54-V-09). The forward starboard and mid starboard floodlights failed to illuminate during the EVA. The mid port floodlight did not illuminate for about 1 hour after switch activation.

The operational instrumentation performed nominally with no anomalies or problems reported.

Communications and Tracking Subsystem

The performance of the communications and tracking subsystem was nominal. The tactical air navigation (TACAN) 2 was not able to maintain good bearing lock during much of the countdown period, but the unit operated satisfactorily during ascent and entry.

Payload Operations reported a total of five occurrences of Communications Security (COMSEC) equipment hangup when the uplink commands were not authenticated due to a known characteristic of the particular COMSEC unit. Each time the hangup occurred, uplink modulation was removed and reapplied to recover the command capability. There is a potential for the COMSEC to hang up and quit processing commands when there is a momentary interruption of data to the COMSEC. This condition is a known characteristic of the COMSEC equipment.

Closed circuit television (CCTV) camera D did not have a scene image (Flight Problem STS-54-V-02A). The downlink video also did not have any scene image; however, random streaks were noted across the image area. Analysis of the CCTV camera D problem has shown that on flight day 1, CCTV camera D originally produced normal, good-quality video of payload bay scenes. Approximately 5 hours into the flight, it was discovered that the camera temperature had reached 54 °C after the camera had remained in operation for an extended period of time. The 54 °C temperature is 9 degrees above the redline temperature at which the caution and warning system should sound an alarm. However, the alarm had been disabled to permit use of the camcorder on the downlink. Although the camera should not have experienced a failure solely due to reaching 54 °C, the high temperature most likely contributed to the failure. CCTV camera D was checked later in the mission and the quality of the video was normal, however the camera continued to produce unusable video on an intermittent basis.

During the EVA, CCTV camera B was being used in the split-screen mode and a synchronization problem occurred between camera B and the CCTV system (Flight Problem STS-54-V-02B). After the camera was cycled, split-screen operations were nominal, and the camera continued to operate nominally. Analysis indicates that the problem was caused by camera B and not the video switching unit. Camera B video will be examined postflight to determine if further testing and repair is requested.

Momentary red and green horizontal lines were noted near the lower quarter of the image that was seen from downlinked CCTV camera A video (Flight Problem STS-54-V-02C). This condition was noted on several of the separate downlinks of camera video. Downlink video will be examined during postflight activities to determine the need for further testing and repair.

The crew reported that when using CCTV camera C on-orbit, only the brightest stars were visible in a low-light scene (Flight Problem STS-54-V-02D). This condition was indicative of a high-gain circuit problem. The camera was removed and sent to Johnson Space Center (JSC) for evaluation.

Structures and Mechanical Subsystems

All mechanically actuated subsystems performed nominally. STS-54 was the sixth flight of the drag chute system. The drag chute was deployed as planned prior to nose landing gear touchdown and all operations were nominal. The drag chute was jettisoned 22.8 seconds after deployment.

Five pieces of black tile, the largest of which measured 8 inches by 1.25 inches by 0.75 inch were found in the vicinity of the pilot chute at the 6200-foot marker. These tile fragments originated from the vertical stabilizer "stinger" and were dislodged by contact with the drag chute riser lines during deployment. Aside from this usual damage to the vertical stabilizer "stinger", the drag chute functioned normally. All drag chute hardware was recovered, appeared to be in good condition, and showed no signs of abnormal operation.

The landing and braking data are presented in the following table.

LANDING AND BRAKING PARAMETERS

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	1536	211.5	~2.0	n/a
Nose gear touchdown	6247	148.9	n/a	2.68

Braking initiation speed	109.6	knots (keas)
Brake-on time	25.0	seconds (not sustained)
Rollout distance	8,723	feet
Rollout time	49.2	seconds
Runway	33	(concrete) at KSC
Orbiter weight at landing	197,470	lb (landing estimate)

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	1248	Left-hand outboard	16.21
Left-hand inboard 3	1272	Left-hand inboard	17.90
Left-hand outboard 2	1284	Right-hand inboard	12.77
Left-hand outboard 4	1092	Right-hand outboard	10.96
Right-hand inboard 1	1116		
Right-hand inboard 3	1044		
Right-hand outboard 2	948		
Right-hand outboard 4	936		

Aerodynamics, Heating, and Thermal Interfaces

The ascent aerodynamics were nominal with elevon load relief being commanded at approximately Mach 0.9. This load relief was not predicted; however, it has been seen on the previous two flights of OV-105 (STS-47 and STS-49). Although the cause of the load relief is not fully understood, the relief was transient and the system responded as designed. The STS-47 postflight data evaluation was unable to identify a cause for the load relief on that flight.

The descent aerodynamics were nominal with the control surfaces responding generally as expected. The angle of attack varied 1 to 2 degrees from predictions between Mach 9.0 and 4.0, but it did not impact the descent in any manner.

The integrated heating (aerodynamic and plume) was nominal during ascent and heating to the SSME nozzles was nominal.

Thermal Control Subsystem

The performance of the thermal control subsystem (TCS) was nominal throughout the mission with only one heater failure occurring prior to launch. All Orbiter subsystem temperatures were maintained within acceptable limits during all phases of the mission.

The FES high-load duct outboard zone heater system A failed off prior to launch. This failure did not impact the mission.

Thermal data were obtained on fuel cell/environment decay rates during the performance of DTO 312 - Fuel Cell Shutdown and Restart on Orbit. These data were gathered in support of the long-duration Orbiter requirements.

The starboard main landing gear brake line temperature increased to 244°F following activation of the heaters during deorbit preparation. This condition has been noted on previous flights and is being corrected by the investigation involving flight problem STS-52-V-18.

Aerothermodynamics

The acreage heating during entry was nominal with all structural temperatures remaining within limits, and all structural temperature rise rates remaining within the experience base. The local heating was also within normal limits.

Thermal Protection Subsystem

The thermal protection subsystem (TPS) performed satisfactorily throughout the mission, based on structural temperature response data. The overall boundary layer transition from laminar to turbulent flow was symmetric. Transition occurred at 1220 seconds after entry interface on the forward side of the vehicle (X/L = 0.3), and at 1215 seconds after entry interface on the aft portion of the vehicle (X/L = 0.6).

The inspection of the Orbiter TPS following landing revealed that the TPS had sustained a total of 131 hits, of which 14 had a major dimension of one-inch or greater. Debris impact damage, however, was less than average. A comparison of these numbers to statistics from previous missions of similar configuration indicates that the number of hits larger than one inch is less than average.

The Orbiter lower surface sustained 80 hits of which 14 had a major dimension of one inch or greater. The distribution of hits on the lower surface does not suggest a single source of ascent debris, but it does indicate a shedding of ice and TPS debris from random sources. The Orbiter upper surface had a total of 34 hits and none had dimensions greater than one inch. The right side had five hits, the left side had none, the right OMS pod had 10, the left OMS pod had two, and none of these hits had a major dimension greater than one inch.

No TPS damage was attributed to material from the wheels, tires, or brakes. Damage to the base heat shield tiles was much less than average. The SSME dome mounted heat shield (DMHS) closeout blanket sacrificial panels were partially detached and some material was missing from 9:00 to 9:30 o'clock on SSME 3. The outer edge of the SSME 2 panels from 2:30 to 3:30 o'clock were detached and the underlying batting was exposed. Some of the sacrificial panel and batting was missing. The outer blanket edge from 5:30 to 7:00 o'clock on SSME 1 was frayed. All of the remaining DMHS blankets were in excellent condition.

The Orbiter windows 3 and 4 exhibited moderate hazing with several streaks. Only a very light haze was present on the other forward-facing windows. Surface wipes were taken from windows 1 through 9 for laboratory analysis.

A sweep of the runway after landing revealed the remains of a bird at the 6400-foot marker; however, no evidence of contact or damage to the Orbiter from striking the bird was found. Unexpected flight hardware found on the runway consisted of three Q-felt plugs that were located 8 feet from the runway centerline at the 5800-foot marker.

A portable Shuttle thermal imager (STI) was used to measure the surface temperatures of three areas of the Orbiter. Twenty-one minutes after landing, the Orbiter reinforced carbon carbon (RCC) nosecap was 243°F. Twenty-eight minutes after landing, the right-hand wing leading edge RCC panel 9 was 186°F, and panel 17 was 182°F.

EXTRAVEHICULAR ACTIVITY

On flight day 4, the crew performed the extravehicular mobility unit (EMU) checkouts while at a cabin pressure of 10.2 psia. Both units performed as expected, and no anomalies were noted. Following the EMU checkout, the units remained attached to the airlock adapter plates in preparation for the planned EVA on flight day 5 in support of DTO 1210.

The planned EVA was performed on flight day 5 following nominal EMU donning and a 40-minute prebreathe period. During the EVA, both units performed as expected and both extravehicular crew members were pleased with the EMU. Real-time data were received from both units throughout the EVA with the exception of the time when the S-band communications link was inoperative. Following the EVA, the units were recharged with oxygen and the batteries were placed on overnight recharge.

Total EVA time for this flight is officially recorded as 4 hours, 27 minutes, 50 seconds. This is the time interval between placing the units on internal battery power and the beginning of airlock repressurization at the end of the EVA.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government furnished equipment/flight crew equipment performed as designed throughout the mission.

PAYLOADS

TRACKING AND DATA RELAY SATELLITE/INERTIAL UPPER STAGE SPACECRAFT

The TDRS satellite is the fifth in a configuration of satellites that form the space segment of the Tracking and Data Relay Satellite System (TDRSS). This systems was developed to provide user services to scientific and applications satellites in near-Earth orbit and to the Space Shuttle. The TDRS was boosted to geosynchronous orbit by the IUS.

The TDRS/IUS was successfully deployed from the Orbiter cargo bay at 13:19:13 G.m.t. (00:06:13 MET). Prior to the IUS solid rocket motor-2 (SRM-2) burn, the B-side stage 1 battery failed. This removed power from the entire B-side and also failed redundant inertial measurement unit (RIMU) channel 3, causing a memory fault on the A-side. Although the A-side took control, it voted itself not-okay because of the memory fault. In addition, the spacecraft experienced attitude perturbations that are believed to have been caused by venting from the failed battery. These perturbations were compensated for by the IUS and the A-side provided the correct mission sequencing for the SRM-2. The TDRS spacecraft successfully separated from the IUS at 14:02:10 G.m.t. (00:13:10 MET). The TDRS spacecraft remains healthy and was in the initial phase of testing as this report was being written. The TDRS drifted at about 3 to 5 degrees per day to its checkout position at 150 degrees West longitude, where 5 to 6 weeks of detailed equipment calibration began.

DIFFUSE X-RAY SPECTROMETER

The DXS payload was sponsored by Goddard Space Flight Center and collected data on X-ray radiation from diffuse sources in deep space. The DXS was designed to determine the wavelength and intensity of the strongest X-ray lines emitted by the hot stellar gases released by supernovas.

The DXS payload was activated soon after the payload bay doors were opened at about 13:15:30 G.m.t. (00:01:30 MET). The DXS began scanning operations on revolution 7. On revolutions 10 and 11, the starboard and port instruments, respectively, experienced problems with high counts causing the high voltage to automatically shut down. It was theorized that these problems were caused by a time lag (very small) of the internal high voltage turn-off logic during the high radiation regions of the South Atlantic Anomaly (SAA), and this time lag allowed formation of hydrocarbon deposits on the high-voltage anode wires in the detectors. A bakeout procedure in which the internal heaters were commanded to a higher temperature followed by a vigorous P-10 gas purge significantly improved the results on the port instrument. The starboard instrument continued to receive these bakeout procedures throughout the mission, enabling it to capture some useful data.

Because of these problems, 15 extra orbits of data-taking opportunities were planned of which 12 were used for scanning, and three for an additional bakeout procedure on both instruments. DXS completed its data takes on revolution 90 followed by deactivation and instrument relatch on revolution 91.

The port instrument obtained 48,915 seconds of confirmed good data of the planned 55,220 seconds. The starboard instrument obtained 31,200 seconds of confirmed good data of the planned 32,850 seconds.

CHROMOSOME AND PLANT CELL DIVISION IN SPACE

The objective of the Chromosome and Plant Cell Division in Space (CHROMEX) was to investigate reproductive abnormalities which apparently occur in plants exposed to microgravity.

The CHROMEX activity was monitored by the crew on a daily basis and no anomalies were noted.

COMMERCIAL GENERIC BIOPROCESSING APPARATUS

The objective of the Commercial Generic Bioprocessing Apparatus (CGBA) experiment was to perform biological sample processing and stow it for return to Earth for evaluation.

All 24 fluid processing apparatus (FPA) sets, containing a total of 192 individual FPA's were successfully processed. One set was inadvertently deactivated early, but the science was recovered with a workaround procedure. Another FPA set was terminated late with no significant loss of scientific data.

PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT

The objective of the Physiological and Anatomical Rodent Experiment (PARE) was to investigate physiological and anatomical changes in rodents exposed to microgravity.

The crew observed the animals and the animal enclosure module as planned throughout the mission. Temperatures were much as expected and the ground controls also functioned as expected.

SOLID SURFACE COMBUSTION EXPERIMENT

The objective of the Solid Surface Combustion Experiment (SSCE) was to measure flame-spread rate, solid-phase temperature, and gas-phase temperature for flames. Data will be used to validate flame-spread models to improve the safety of space travel. The two SSCE burn operations planned for the mission were completed satisfactorily, and no problems were encountered.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

Fourteen development test objectives were assigned to the STS-54 mission. Of these, 12 were accomplished and are discussed in the following paragraphs.

DTO 301D - Ascent Structural Capability Evaluation - Data were collected and recorded on the modular auxiliary data system (MADS) recorder for this data-only DTO. The data have been processed and given to the sponsor for evaluation, and the results will be presented in separate documentation.

DTO 305D - Ascent Compartment Venting Evaluation - Data were collected and recorded on the MADS recorder for this data-only DTO. The data have been processed and given to the sponsor for evaluation, and the results will be presented in separate documentation.

DTO 306D - Descent Compartment Venting Evaluation - Data were collected and recorded on the MADS recorder for this data-only DTO. The data have been forwarded to the sponsor for evaluation and reporting.

DTO 307D - Entry Structural Capability - Data were collected and recorded on the MADS recorder for this data-only DTO. The data have been forwarded to the sponsor for evaluation and reporting.

DTO 312 - ET Thermal Protection Subsystem Performance - Two full rolls and one partial roll of 35-mm film were taken with a Nikon F4 camera equipped with a 300-mm lens and a 2x extender which together provide an effective 600-mm focal length lens. Magazines 27 and 28 each contained 37 photographs with excellent exposure. The first frame was taken on magazine 27 at 13:14:13:45 G.m.t. (00:00:14:15 MET) and the last frame was taken at 13:14:15:33 G.m.t. (00:00:16:03 MET). The first frame taken from magazine 28 at 13:14:16:37 G.m.t. (00:00:17:07 MET), and the last frame was taken 4 minutes 12 seconds later. The seven additional frames that were obtained on magazine 36 were exposed between 3 minutes and 5 minutes after magazine 28. The duration of ET acquisition was 12 minutes 9 seconds.

Magazine 27 viewed the nose cone/ogive and the right side (+Y axis) of the ET. Magazine 28 showed the aft dome and the left side (-Y/+Z axis).

In addition to the photography taken from the flight deck, 60 good quality frames of the ET were taken on magazine 51 with the 35-mm umbilical well camera. These frames provided views of the LH_2 tank TPS acreage (+Z side), the aft dome, and the ET nose. Data were also obtained on magazine 52 from the 16-mm camera with a 5-mm lens that was also located in the umbilical well. These data were used to perform the analysis presented in the following paragraphs.

Magazine 57 of the 16-mm film taken from the umbilical well during SRB and ET separation and the early portion of the on-orbit phase showed a small metallic-appearing disk-shaped object with a probable hollow center shortly after ET separation (Flight Problem STS-54-I-01). This object was visible for almost 200 frames of the 16-mm film. At about the same time, a small metallic-appearing rod-shaped object with possibly a hollow end was noted, and it was shown in almost 400 frames of the film (Flight Problem STS-54-I-01). The third item noted was a flexible tape-like object, and it was noted in 187 frames (Flight Problem STS-54-I-01).

Relative measurements of the three metallic appearing objects were also made. The actual size of these objects could not be determined because no adequate reference was available in the field of view for comparative scaling. The scale is not linear with trajectory because the 5 mm camera lens does not have flat optics and the objects are not near the center of the field of view.

The disk-shaped object was seen between 8 minutes 59 seconds and 9 minutes 0 seconds MET (first observed 11.335 seconds after ET separation). The ratio of the outside diameter to the height of the disk-shaped object was determined to be 4.2 to 1 (frame 7511). The ratio of the outside diameter to the inner diameter of this object was 3.2 to 1 (frame 7461).

The rod-shaped debris was seen between 8 minutes 59.5 seconds and 9 minutes 5.7 seconds MET (first observed at 11.65 seconds after ET separation). The ratio of the major axis to the diameter was determined to be 16.2 to 1. The measurements of the rod-shaped object was made on frame 7448.

The tape-like debris was seen between 9 minutes 1.6 seconds and 9 minutes 02.4 seconds (first seen 13.63 seconds after ET separation). The longest dimension of the tape-like object was 13.6 analyzer units (frame 7935) and the width of the object is 2.5 analyzer units (frame 7913). The thickness of the thin dimension was 1.2 analyzer units (frame 7936).

DTO 412 - Fuel Cell On-Orbit Shutdown/Restart - Fuel cell 2 was successfully shut down and restarted. Temperature data were collected and have been given to the sponsor for evaluation. The Fuel Cell Powerplant Subsystem section of this report contains a detailed discussion of this activity.

DTO 520 - Edwards Lakebed Runway Bearing Strength and Rolling Friction Assessment for Orbiter Landings - This DTO was not accomplished as the landing occurred at KSC.

DTO 521 - Orbiter Drag Chute System - The Orbiter drag chute was deployed during the derotation and the drag chute operated satisfactorily. Details are contained in the Structures and Mechanical subsystem section of this report.

DTO 648 - Electronic Still Photography Test - The electronic still camera was operated and no problems were reported. The photography has been given to the sponsor for evaluation.

DTO 656 - PGSC Single Event Upset Monitor - This DTO was accomplished and the data have been given to the sponsor for evaluation.

DTO 662 - Extended Duration Orbiter WCS Evaluation - The evaluation of the Extended Duration Orbiter (EDO) WCS was completed very satisfactorily with only one minor problem. The data have been given to the sponsor for evaluation. The Environmental Control and Life Support Subsystem section of this report contains a detailed discussion of EDO WCS operations and problems.

DTO 700-3 - Atmospheric Effects on Star Tracker Performance - Data were taken on three orbits and have been given to the sponsor for evaluation and reporting in separate documentation.

DTO 805 - Crosswind Landing Performance - This DTO was not accomplished as crosswinds did not meet the minimum requirements for this DTO.

DTO 1210 - EVA Operation Procedures/Training - This DTO was accomplished with a 4 hour 27 minute 50 second EVA. A discussion of the EVA is contained in the Extravehicular Activity section of this report.

DETAILED SUPPLEMENTARY OBJECTIVES

Twelve Detailed Supplementary Objectives (DSO's) were assigned to the STS-54 mission and all 12 were accomplished. Each one is discussed in the following paragraphs.

DSO 316 - Bioreactor/Flow and Particle Trajectory in Microgravity - The two planned tests were completed and the data have been given to the sponsor for evaluation and documenting in separate publications.

DSO 321 - Frequency Interference Measurement - This DSO was completed and the data have been given to the sponsor for evaluation and reporting. The results will be presented in separate documentation.

DSO 322 - Human Lymphocyte Locomotion in Microgravity - This DSO operated as planned and the data and hardware have been given to the sponsor for evaluation. The sponsor will provide the results in separate documentation.

DSO 476 - In-Flight Aerobic Exercise (Rower) - This was an EDO buildup medical evaluation DSO. All exercise sessions were completed, and the data have been given to the sponsor for evaluation and reporting.

DSO 487 - Immunological Assessment of Crew Members - Data for this DSO were gathered during preflight and postflight operations only. The sponsor has the data and will report in separate documentation after data evaluation.

DSO 603 - Orthostatic Function During Entry, Landing, and Egress - This was an EDO buildup medical evaluation DSO. Data were collected for this DSO and have been given to the sponsor for evaluation and reporting in separate documentation.

DSO 604 - Visual-Vestibular Integration - Both OI-1 and OI-3 - This was an EDO buildup medical evaluation DSO. These investigations were completed and the data were given to the sponsor for evaluation and reporting.

DSO 605 - Postflight Recovery of Postural Equilibrium Control - This was an EDO buildup medical evaluation DSO, and data were collected during the preflight and postflight periods only. The sponsor is in possession of the data and will report the results in separate documentation after completion of the evaluation.

DSO 802 - Educational Activities - The crew performed the live downlink with four schools that were planned. In addition, several other sessions were taped for use after completion of the flight.

DSO 901 - Documentary Television - Data were collected for this DSO and have been given to the sponsor for evaluation and reporting in separate documentation.

DSO 902 - Documentary Motion Picture Photography - Data were collected for this DSO and have been given to the sponsor for evaluation and reporting.

DSO 903 - Documentary Still Photography - Data were collected for this DSO and have been given to the sponsor for evaluation and reporting.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHIC AND VIDEO DATA ANALYSIS

On launch day, 24 of the 24 expected videos were received and reviewed. Following launch day, but during the mission, 54 of 55 expected launch films were also reviewed. The review produced no evidence of in-flight anomalies.

ON-ORBIT PHOTOGRAPHIC AND VIDEO DATA ANALYSIS

The results of the ET tank analysis are presented in the Detailed Test Objectives section of this report.

In addition, onboard video coverage of the six batteries associated with the TDRS payload in the aft Orbiter payload bay area was examined as well as two prelaunch closeout pictures of the six batteries. The analysis of the video data was performed to determine if any postlaunch damage to the batteries could be detected.

A visual comparison of the closeout views with the onboard video views showed no obvious signs of damage to any of the six batteries or associated structures. The edges of the battery boxes appeared straight, and the covers to the battery boxes appeared intact (similar to the closeout views). The multilayer insulation wrapping on the batteries was not torn, discolored, or misshapen at the level of detail present in the videos. The multilayer insulation covering over the individual batteries had a wrinkled appearance that was consistent with the prelaunch closeout photography. No indications of liquid or vapors were detected in the onboard video views. An analysis of the video from each camera follows:

a. Camera A - A discoloration was present on the white cover of the port forward battery, but this discoloration was determined to be caused by shadowing when viewed over a period of time. The cabling going to the middle group of batteries appeared to be positioned normally. The wrinkling of the multilayer insulation on the starboard forward battery did not appear to be excessive when compared to the prelaunch closeout photography.

b. Camera B - Wrinkling of the multilayer insulation covering the port rear and center rear batteries was visible. The covering over the top of these two batteries appeared intact.

c. Camera C - The visible portion of the starboard aft battery appeared in very good condition. The right side of the forward and aft center batteries were uneven in appearance, and this may have been due to wrinkling of the multilayer insulation. The tops of the two batteries had a normal appearance. The tape-like stripping material between the two center batteries had an uneven appearance, but it could not be confirmed to be abnormal because of the lighting and viewing angle.

LANDING PHOTOGRAPHIC AND VIDEO DATA ANALYSIS

Nine landing videos were received and reviewed on the day of landing. The following items of interest were noted during the post-landing review of the video views. None of the observations were considered anomalous.

A light discoloration of the tiles was noted on the upper side of the body flap on both the left and right sides. Also, a portion of the dome mounted heat shield (DMHS) around SSME 2 was torn. Discolorations were noted on the inside of the LO_2 umbilical well door.

TABLE I.- STS-54 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	13:13:54:42.21
	APU-2 GG chamber pressure	13:13:54:42.83
	APU-3 GG chamber pressure	13:13:54:43.56
SRB HPU activation[a]	LH HPU system A start command	13:13:59:02.169
	LH HPU system B start command	13:13:59:02.329
	RH HPU system A start command	13:13:59:02.489
	RH HPU system B start command	13:13:59:02.649
Main propulsion System start[a]	Engine 3 start command accepted	13:13:59:23.448
	Engine 2 start command accepted	13:13:59:23.561
	Engine 1 start command accepted	13:13:59:23.685
SRB ignition command (lift-off)	SRB ignition command to SRB	13:13:59:29.989
Throttle up to 104 percent thrust[a]	Engine 2 command accepted	13:13:59:34.001
	Engine 1 command accepted	13:13:59:34.006
	Engine 3 command accepted	13:13:59:34.008
Throttle down to 72 percent thrust[a]	Engine 2 command accepted	13:13:59:56.882
	Engine 1 command accepted	13:13:59:56.886
	Engine 3 command accepted	13:13:59:56.888
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	13:14:00:23
Throttle up to 104 percent thrust[a]	Engine 2 command accepted	13:14:00:26.483
	Engine 1 command accepted	13:14:00:26.486
	Engine 3 command accepted	13:14:00:26.489
Both SRM's chamber pressure at 50 psi[a]	RH SRM chamber pressure mid-range select	13:14:01:29.669
	LH SRM chamber pressure mid-range select	13:14:01 30.909
End SRM action[a]	RH SRM chamber pressure mid-range select	13:14:01:32.869
	LH SRM chamber pressure mid-range select	13:14:01:32.879
SRB separation command	SRB separation command flag	13:14:01:36
SRB physical separation[a]	LH rate APU A turbine speed LOS	13:14:01:35.949
	RH rate APU A turbine speed LOS	13:14:01:35.949
Throttle down for 3g acceleration[a]	Engine 3 command accepted	13:14:07:02.292
	Engine 2 command accepted	13:14:07:02.295
	Engine 1 command accepted	13:14:07:02.332
3g acceleration	Total load factor	13:14:07:06.1
Throttle down to 67 percent thrust[a]	Engine 1 command accepted	13:14:07:53.492
	Engine 2 command accepted	13:14:07:53.498
	Engine 3 command accepted	13:14:07:53.534
Engine Shutdown[a]	Engine 1 command accept	13:14:07:59.932
	Engine 3 command accept	13:14:07:59.936
	Engine 2 command accept	13:14:07:59.974
MECO	Command flag	13:14:08:00
	Confirm flag	13:14:08:01

[a] MSFC supplied data.

TABLE I.- STS-54 SEQUENCE OF EVENTS (Continued)

Event	Description	Actual time, G.m.t.
ET separation	ET separation command flag	13:14:08:19
OMS-1 ignition	Left engine bi-prop valve position	Not performed - direct insertion trajectory flown
	Right engine bi-prop valve position	
OMS-1 cutoff	Left engine bi-prop valve position	
	Right engine bi-prop valve position	
APU deactivation	APU-3 GG chamber pressure	13:14:13:50.24
	APU-1 GG chamber pressure	13:14:15:12.66
	APU-2 GG chamber pressure	13:14:15:14.21
OMS-2 ignition	Right engine bi-prop valve position	13:14:39:23.4
	Left engine bi-prop valve position	13:14:39:23.6
OMS-2 cutoff	Right engine bi-prop valve position	13:14:41:47.2
	Left engine bi-prop valve position	13:14:41:47.4
Payload bay door open	PLBD right open 1	13:15:39:52
	PLBD left open 1	13:15:41:11
TDRS/IUS Deploy	Voice call	13:20:13:00
OMS-3 ignition	Right engine bi-prop valve position	Not applicable
	Left engine bi-prop valve position	13:20:27:26.1
OMS-3 cutoff	Right engine bi-prop valve position	Not applicable
	Left engine bi-prop valve position	13:20:27:59.8
OMS-4 ignition	Right engine bi-prop valve position	14:16:08:42.3
	Left engine bi-prop valve position	Not applicable
OMS-4 cutoff	Right engine bi-prop valve position	14:16:09:09.6
	Left engine bi-prop valve position	Not applicable
Airlock Depressuri-ization	Airlock differential pressure 1	17:10:45:22
Airlock Repressuri-	Airlock differential pressure 1	17:15:17:42
Fuel Cell 2 Shutdown	Fuel cell 2 ready	18:07:46:40
Flight control system checkout		
APU start	APU-3 GG chamber pressure	18:08:23:42.55
APU stop	APU-1 GG chamber pressure	18:08:38:28.64
Fuel Cell 2 Startup	Fuel cell 2 oxygen valve open	18:16:30:31

TABLE 1.- STS-54 SEQUENCE OF EVENTS (Concluded)

Event	Description	Actual time, G.m.t.
Payload bay door close	PLBD left close 1	19:10:02:22
	PLBD right close 1	19:10:04:14
APU activation for entry	APU-2 GG chamber pressure	19:12:33:09.41
	APU-1 GG chamber pressure	19:12:54:02.62
	APU-3 GG chamber pressure	19:12:54:03.74
Deorbit maneuver ignition	Right engine bi-prop valve position	19:12:38:10.2
	Left engine bi-prop valve position	19:12:38:10.3
Deorbit maneuver cutoff	Right engine bi-prop valve position	19:12:40:43.6
	Left engine bi-prop valve position	19:12:40:43.7
Entry interface (400K)	Current orbital altitude above reference ellipsoid	19:13:06:59
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	19:13:31:37
Main landing gear contact	LH MLG tire pressure	19:13:37:47
	RH MLG tire pressure	19:13:37:49
Main landing gear weight on wheels	LH MLG weight on wheels	19:13:37:49
	RH MLG weight on wheels	19:13:37:49
Drag chute deploy	Drag chute deploy 1 CP Volts	19:13:37:59.8
Nose landing gear contact	NLG tire pressure	19:13:38:02
Nose landing gear weight on wheels	NLG WT on Wheels -1	19:13:38:03
Drag chute jettison	Drag chute jettison 1 CP Volts	19:13:38:22.6
Wheels stop	Velocity with respect to runway	19:13:38:36
APU deactivation	APU-3 GG chamber pressure	19:13:55:11.16
	APU-1 GG chamber pressure	19:13:56:15.62
	APU-2 GG chamber pressure	19:13:56:56.10

TABLE II.- STS-54 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-54-V-01	WSB 3 No Cooling	013:14:14 G.m.t. IM 54RF01 PR HYD-5-04-0104	During ascent, WSB 3 failed to initiate cooling of the APU 3 lube oil while operating on controller A. WSB 3 was switched to controller B. Again, no cooling was evident. Approximately 40 seconds after APU 3 shutdown, WSB 3 began spraying on controller B. APU 3/WSB 3 was used for FCS checkout and performance was nominal on both controllers. The performance was also nominal during entry. Preliminary analysis indicates a freeze-up occurred. KSC: Troubleshooting plan has been developed for KSC. Will load WSB core with 4.4 lb of water (nominal is 3.5 lb).
STS-54-V-02	Camera Anomalies a. CCTV Camera D - No Image (Intermittent) b. CCTV Camera B Problem During Split Screen Operations c. CCTV Camera A Momentary Red and Green Lines d. CCTV Camera C High-Gain Anomaly	017:17:50 G.m.t. a)DR BH330019 b)DR BH330018 c)DR BH330055 d)DR BH330054	a. Camera D image was intermittent, sometimes producing normal quality picture and sometimes out-of-focus picture. Camera will be removed and returned to JSC for evaluation. b. During the EVA, camera B was being used in the split screen mode and a synchronization problem occurred between camera B and the CCTV system. After cycling the camera power, split-screen operations were nominal. Analysis indicates that the problem was caused by Camera B and the video switching unit (VSU). Camera will be removed and returned to JSC for evaluation c. Unexpected red and green lines were noted on camera A. Camera will will be removed and sent to JSC for evaluation. d. It was reported in-flight that only the brightest stars could be seen when looking at low-light scene. Possible high-gain circuit problem. Camera will be removed and sent to JSC for evaluation.
STS-54-V-03	EDO WCS Commode Fault Light On	016:14:22:09 G.m.t. IM 54RF02 IPR 57V-0006	The WCS compactor caused the fault light to illuminate during the retraction phase of the compaction cycle. Postflight, the vendor could not duplicate the problem, but did note a difference in the results from the troubleshooting current signature in comparison to the ATP data. The plan is to replace the snubber (foam) to further dampen the end of travel current spike. Will rework snubber at vendor, then reinstall and retest the unit.
STS-54-V-04	Rudder Speedbrake Switching Valve Indication	016:21:06 G.m.t. IPR 57V-0012	The rudder speedbrake switching valve indication (V58X1001E) failed to show that hydraulic system 3 was selected while hydraulic circulation pump 3 was operating at nominal pressure. Troubleshooting in-flight indicates that with additional pressure, the valve will switch to the the proper position. KSC: Test at 500 psi completed and data analysis in progress.
STS-54-V-05	RCS Thruster R1R Failed Off	018:07:58 G.m.t. IM 54RF03 PR RP04-11-0353	During the RCS hot-fire test, thruster R1R failed off and was deselected by RCS RM. Both oxidizer and fuel injector temperature trends were nominal indicating that there was at least partial flow into the chamber. Failure most likely a failure of the oxidizer main stage valve to open. KSC: Remove and replace thruster. Spare available at KSC.

TABLE II.- STS-54 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-54-V-06	Low Nitrogen Leak Rate/ Odor from Wet Trash (Volume F) TRANSFERRED TO KSC	018:19:51 G.m.t. IM 54RF04 PR ECL-5-04-0293	Nitrogen usage was unusually low (approximately 1.8 lbm/day, should be be 4.5 lbm/day) coupled with crew report of odor coming from the wet trash (Volume F). These factors indicate that adequate venting was not being provided to the volume F wet trash. KSC: Reported that a dynatube adapter plug was in the opening of the wet trash to vacuum. No hardware troubleshooting required. Will remove cap and correct procedure to preclude recurrence of problem.
STS-54-V-07	Fuel Cell 2 and 3 Alternate Water Lines Temperature Increasing	019:13:30 G.m.t. IM54RF05	Leakage was indicated past the fuel cell alternate water line check valves for fuel cell 2 and 3. KSC: Perform modified OMRSD check valve checks. Chit to be written specifying the test plan.
STS-54-V-08	Hydraulic System 3 Pump Outlet Pressure High Post-Ascent APU Shutdown	013:14:14 G.m.t. IPR 57V-0008 IM54RF09	Following the early APU 3 shutdown after MECO because of the APU 3 bearing over-temperature, the hydraulic supply pressure failed to decay as expected. The pressure initially dropped to about 1600 psia, then increased and stayed locked up at about 2400 psia for more than 40 seconds following APU 3 shutdown. The pressure bled off when the SSME/TVC isolation valves were closed. Post-landing troubleshooting did not repeat the condition seen during ascent. KSC: Test partially completed and data analysis in progress.
STS-54-V-09	Floodlight Failures a) Forward Starboard b) Mid Starboard c) Mid Port	017:10:38 G.m.t. IM54RF06 IM54RF07 IM54RF08 IPR 57V-0010 a. PR DDC-5-04-0040 b. PR DDC-5-04-0041 c. PR DDC-5-04-0042 FEA: PR FEL-5-04-0772	a and b) During payload bay floodlight power up, the forward starboard and mid starboard floodlights did not come on. b) The midport floodlight came on approximately one hour after switch activation. There were indications of arcing on all three floodlights. All three of the floodlights plus the FEA 2 have been removed and replaced for planned testing.
STS-54-V-10	APU 3 Bearing Temperature Erratic	019:13:27 G.m.t. IPR 57V-0007	During entry, approximately 35 minutes after APU start, the APU 3 gearbox bearing temperature 2 (V46T0362A) became erratic for a period of about 17 seconds. It then recovered and operated nominally throughout the remainder of the mission and postlanding soakback. KSC: Troubleshooting at KSC did not repeat the problem.
STS-54-V-11	EMU Battery Charger Noisy	IM54RF10	The EMU power supply/battery charger was reported postflight as exhibiting excessive audible noise. Will ask for DTO on STS-57 to measure noise, so the necessary corrective actions can be performed. KSC: No KSC activity required.

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this STS-54 Mission Report, the following list is provided.

1. Flight Requirements Document
2. Public Affairs Press Kit
3. Customer Support Room Daily Reports
4. MER Daily Reports
5. MER Mission Summary Report
6. MER Quick Look Report
7. MER Problem Tracking List
8. MER Event Times
9. Subsystem Manager Reports/Inputs
10. MOD Systems Anomaly List
11. MSFC Flash Report
12. MSFC Event Times
13. MSFC Interim Report
14. Crew Debriefing comments

ACRONYMS AND ABBREVIATIONS

The following is a list of the acronyms and abbreviations and their definitions as these items are used in this document.

ABS	ammonia boiler system
APU	auxiliary power unit
ARS	Atmospheric revitalization system
ATCS	Active thermal control system
CCTV	closed circuit television
CGBA	Commercial Generic Bioprocessing Apparatus
CHROMEX	Chromosome and Plant Cell Division in Space
COMSEC	Communications Security
CO_2	Carbon dioxide
DMHS	dome-mounted heat shield
DPS	data processing system
DSO	Detailed Supplementary Objective
DTO	Development Test Objective
ΔV	differential velocity
DXS	Diffuse X-ray Spectrometer
EDO	Extended Duration Orbiter
EMU	Extravehicular Mobility Unit
EPDC	electrical power distribution and control subsystem
ET	External Tank
EVA	extravehicular activity
FCS	flight control system
FDA	fault detection and annunciation subsystem
FES	flash evaporator system
FPA	fluid processing apparatus
GFE	Government furnished equipment
GG	gas generator
GGVM	gas generator valve module
GH_2	gaseous hydrogen
G.m.t.	Greenwich mean time
GN_2	gaseous nitrogen
GO_2	gaseous oxygen
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
HPU	hydraulic power unit
IAPU	improved auxiliary power unit
ICD	Interface Control Document
IMU	inertial measurement unit
Isp	specific impulse
IUS	Inertial Upper Stage
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LESC	Lockheed Engineering and Sciences Company
LH_2	liquid hydrogen
LO_2	liquid oxygen

LSEAT	Launch System Evaluation and Advisory Team
MADS	modular auxiliary data system
MECO	main engine cutoff
MET	mission elapsed time
MLG	main landing gear
MPS	main propulsion system
MSFC	George C. Marshall Space Flight Center
NLG	nose landing gear
NPSP	net positive suction pressure
NSTS	National Space Transportation System
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
PAL	protuberance air load
PARE	Physiological and Anatomical Rodent Experiment
PLBD	payload bay door
PMBT	propellant mean bulk temperature
ppm	parts per million
PRSD	power reactant storage and distribution
RCC	reinforced carbon carbon
RCS	reaction control subsystem
RIMU	redundant inertial measurement unit
RM	redundancy management
rms	root mean square
RSRM	Redesigned Solid Rocket Motor
SAA	South Atlantic Anomaly
S&A	safe and arm
SRB	Solid Rocket Booster
SRM	solid rocket motor
SRSS	Shuttle Range Safety System
SSC	secondary seal cavity
SSCE	Solid Surface Combustion Experiment
SSME	Space Shuttle main engine
STI	Shuttle thermal imager
TACAN	Tactical Air Navigation
TAGS	text and graphics system
TCS	thermal control system
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TPS	thermal protection system/subsystem
TVC	thrust vector control
USAF	U. S. Air Force
USN	U. S. Navy
V	volt
WCS	Waste Collection System
WSB	water spray boiler