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STS-53 SPACE SHUTTLE MISSION REPORT

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which were designated BI-055. The lightweight RSRM's that were installed in each SRB were designated 360L028A for the left SRB, and 360L028B for the right SRB. The primary objective of this flight was to successfully deploy the Department of Defense 1 (DOD-1) payload. The secondary objectives of this flight were to perform the operations required by the Glow Experiment/Cryogenic Heat Pipe Experiment Payload (GCP); the Hand-Held, Earth-Oriented, Real-Time, Cooperative, User-Friendly, Location-Targeting and Environmental System (HERCULES); the Space Tissue Loss (STL); the Battlefield Laser Acquisition Sensor Test (BLAST); the Radiation Monitoring Equipment-III (RME-III); the Microcapsules in Space-1 (MIS-1); the Visual Function Tester-2 (VFT-2); the Cosmic Radiation Effects and Activation Monitor (CREAM); the Clouds Logic to Optimize Use of Defense Systems-1A (CLOUDS-1A); the Fluids Acquisition and Resupply Experiment (FARE); and the Orbital Debris Radar Calibration Spheres (ODERACS). 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. Listed in the discussion of each anomaly is the officially assigned tracking number as published by each Project Office in their respective Problem Tracking List. All times given in this report are in Greenwich mean time (G.m.t.) as well as mission elapsed time (MET).

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STS-53

SPACE SHUTTLE

MISSION REPORT

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INTRODUCTION

The STS-53 Space Shuttle Program Mission Report provides 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 the fifty-second flight of the Space Shuttle Program, and the fifteenth flight of the Orbiter vehicle Discovery (OV-103). In addition to the Orbiter, the flight vehicle consisted of an ET, which was designated as ET-49/LWT-42; three SSME's, which were serial numbers 2024, 2012, and 2017 in positions 1, 2, and 3, respectively; and two SRB's, which were designated BI-055. The lightweight RSRM's that were installed in each SRB were designated 360L028A for the left SRB, and 360L028B for the right SRB.

The STS-53 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 organization element supporting the program will report the results of their hardware evaluation and mission performance plus identify all related in-flight anomalies.

The primary objective of this flight was to successfully deploy the Department of Defense 1 (DOD-1) payload. The secondary objectives of this flight were to perform the operations required by the Glow Experiment/Cryogenic Heat Pipe Experiment Payload (GCP); the Hand-Held, Earth-Oriented, Real-time, Cooperative, User-Friendly, Location-Targeting and Environmental System (HERCULES); the Space Tissue Loss (STL); the Battlefield Laser Acquisition Sensor Test (BLAST); the Radiation Monitoring Equipment-III (RME-III); the Microcapsules in Space-1 (MIS-1); the Visual Function Tester-2 (VFT-2); the Cosmic Radiation Effects and Activation Monitor (CREAM); the Clouds Logic to Optimize Use of Defense Systems-1A (CLOUDS-1A); the Fluids Acquisition and Resupply Experiment (FARE); and the Orbital Debris Radar Calibration Spheres (ODERACS).

The sequence of events for the STS-53 mission is shown in Table I and the official Orbiter and GFE Projects Problem Tracking List is shown in Table II. The STS-53 mission was originally planned as a six-day mission, but subsequent mission planning changes led to a seven-day planned mission. Appendix A lists the sources of data, both formal and informal, that were used in the preparation of this document. Appendix B provides the definition of acronyms and abbreviations used in this 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. Listed in the discussion of each anomaly is the officially assigned tracking number as published by each Project Office in their respective Problem Tracking List. All times given in this report are in Greenwich mean time (G.m.t.) as well as mission elapsed time (MET).

The crew for this fifty-second Space Shuttle mission was David M. Walker, Capt., USN, Commander; Robert P. Cabana, Col., USMC, Pilot; Guion S. Bluford, Col., USAF, Mission Specialist 1; James S. Voss, Lt. Col., USA, Mission Specialist 2; and Michael R. Clifford, Lt. Col., USA, Mission Specialist 3. STS-53 was the fourth space flight for Mission Specialist 1; the third Space flight for the Commander; the second space flight for the Pilot and Mission Specialist 2; and the first space flight for Mission Specialist 3.

MISSION SUMMARY

The STS-53 vehicle was launched on a 57-degree inclination from Kennedy Space Center (KSC) launch complex 39A at 337:13:23:59.993 G.m.t. (8:24 a.m. e.s.t. on December 2, 1992), after a delay of 1 hour 25 minutes. The hold was required for ice on the launch vehicle that subsequently cleared, and for a wing load indicator A16L predicted violation. Analysis of the L-70 minute balloon data produced a value of 103 percent for wing load indicator A16L. The existing structural certification for the wing has at least a 5-percent positive margin to the load indicator redline. In addition, the ongoing aerodynamic verification program, based on OV-102 measured strain-gage responses, shows the aerodynamic baseline data are conservative. As a result of the conservatism in these areas, the 3-percent excess load prediction was determined to be acceptable, and the excess load condition was waived for flight.

Following a three-minute engine helium purge during the External Tank (ET) loading sequence, the Space Shuttle main engine (SSME) 3A 750-psi helium regulator outlet pressure began toggling above the 785-psi Launch Commit Criteria (LCC) upper limit. About 1 hour 20 minutes later, SSME 1B regulator pressure also exceeded the LCC upper limit. An LCC waiver was approved for these pressure excesses. Both pressures returned to within limits when the helium tanks were brought up to flight pressure (approximately 4400 psi) about 3 hours prior to launch. This behavior is a trait of the new -0006 regulators, and the LCC and Operations and Maintenance Requirements and Specifications Document (OMRSD) requirements will be reviewed in preparation for future flights.

This was the first flight of the OV-103 (Discovery) vehicle after major modifications were performed at KSC. The modifications included the installation of a drag chute, as well as extensive modifications to the nose wheel steering, landing gear, and hydraulics, as well as the addition of redundant fuel-cell cutoff circuits. Data indicate nominal performance from all these areas of installation/modification.

The direct ascent trajectory was nominal and no orbital maneuvering subsystem (OMS) 1 maneuver was required. The OMS-2 maneuver was performed at 337:14:00:53.8 G.m.t., and was 204.0 seconds in duration. The ΔV was 337.9 ft/sec, and the resultant orbit was 200.6 by 200.6 nmi.

A quick-look determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) determined for the time period between SRB separation and start of 3g throttling was 452.71 seconds as compared to an average main propulsion system (MPS) tag value of 452.92 seconds.

At 337:19:38 G.m.t. (00:06:14 MET), the reaction control subsystem (RCS) was used to perform a 19-second separation firing in the +X direction.

During flight day 1 operations, the crew reported a small amount of free water during the humidity separator water check. Approximately two hours later, the second humidity separator water check was performed, and the crew again reported a small amount of free water. The water carry-over may have been the result of operating the cabin temperature controller in the automatic position. The carry-over was well within specifications. The amount of water did not require any mop-up operations and the cabin humidity remained at 25 percent. The crew switched to humidity separator A as a precautionary measure due to the upcoming sleep period. An inspection during the post-sleep activities revealed that the area around the humidity separator was dry. The crew switched back to humidity separator B.

A check of humidity separator B for water carry-over after about six hours of operation revealed approximately 1 cc of water attached to the wires near the humidity separator. Due to the small amount of water, no mop-up of the water was required. However, the crew was requested to select humidity separator A again, and subsequent operations on humidity separator A were satisfactory. Engineering analysis indicates that humidity separator B was operating within design requirements and a small amount of carry-over may be expected when operating under the conditions discussed previously.

A decrease in the supply-water dump-nozzle temperature was observed during the first supply water dump. The nozzle temperature recovered and dumping proceeded nominally. The cause of the phenomenon is unknown, but was most likely a temporary loss of power to the nozzle heaters as occurred on STS-39. Future supply water dumps through the dump nozzle were performed as usual with no recurrence of the anomaly.

Evaluation of the data from the second through seventh supply water dumps revealed that the dump valve had expelled a small amount of water after being closed. This condition is similar to that noted on STS-44 and STS-48. A similar phenomenon occurred on all subsequent water dumps. This condition did not impact normal flight operations.

At 337:13:33 G.m.t. (00:09:45 MET), the speed brake flight control system (FCS) channel 3 position feedback data indicated 45 degrees (0 volts) for approximately 48 minutes, and then returned to the normal level of -1.9 degrees. The variable downlist in the flight software was reconfigured and aerosurface servo amplifier (ASA) 3 was powered up so that the flight-critical measurement could be monitored should the anomaly recur. The original occurrence was indicated only on the operational instrumentation (OI) measurement. Insufficient flight data were available to determine whether the anomaly was associated only with instrumentation or whether a real channel failure occurred. No recurrence of this anomaly was observed for the remainder of the flight. Postflight troubleshooting at KSC identified a faulty wire crimp on a bulkhead connector which carries the position feedback signal to the aerosurface servo amplifier.

The OMS 3 and OMS 4 single-engine maneuvers were completed satisfactorily. OMS 3 was performed with the left engine, and OMS 4 was performed with the right engine. As a result of these two maneuvers, the Orbiter was placed in a 177 by 174 nmi. orbit.

Following reconfiguration to the OMS/RCS interconnect mode, the left RCS primary oxidizer regulator on leg A indicated a small leak in the primary stage. The regulator pressure locked up at the secondary stage value of 261.5 psia. The system was switched to the B leg which operated properly.

The third on-orbit fuel cell purge was performed at 342:01:24 G.m.t. (04:12:00 MET) which was after 40 hours instead of the planned 48 hours between purges. The performance decay between purges was greater during this mission with the 0.2V-decay-limit, as established by the flight rules, being reached after 40 hours. The probable cause is slightly more than normal contaminants in the reactants (as indicated by the sample analysis), and this condition did not impact the mission.

The FCS checkout was performed using APU 1 at 342:16:09:21 G.m.t. (05:02:52:09 MET). APU 1 was operated for 8 minutes 45 seconds and approximately 26 lb of fuel was consumed. All aspects of the FCS checkout were nominal. Also, all aspects of the RCS hot-fire test which followed were nominal.

FCS checkout data showed that 1 minute 44 seconds of lubrication oil spray cooling occurred on APU 1 due to the long duration of the APU run. As a result, ice deposit on the water spray boiler (WSB) 1 vent nozzle was possible. Vent heater 1B was activated for ice removal prior to preparation for entry operations.

A single-engine (right-hand) OMS-5 maneuver was performed at 342:19:15:00.1 G.m.t. (05:05:51:00 MET). The firing duration was 10.8 seconds and the ΔV was 10.0 ft/sec.

An 8-second RCS maneuver was performed at 344:02:12 G.m.t. (06:12:48 MET) for orbital debris avoidance. The +X thrusters (L3A and R3A) were used for this 2 ft/sec maneuver.

The post-recovery inspection of the right SRB revealed a 3-inch by 1/8-inch by 1/2-inch deep gash in the cover of the aft center booster separation motor. Analysis of foreign material found embedded in the cork insulation revealed that the gash was most likely the result of contact from a piece of Orbiter tile material. An analysis of the potential Orbiter tile loss indicated that the impact on entry flight operations would be acceptable. Postflight video data of the Orbiter lower surface showed no areas of significant damage. Two tiles that had been impacted on the forward right-hand side of the Orbiter were identified as possible sources of the debris that impacted the BSM cover. These tiles were missing part of their tile identification markings. Samples of both tiles were analyzed, and the source of the tile impacts could not be positively determined based on the samples.

Both payload bay doors were closed nominally by 344:15:39:27 G.m.t. (07:02:15:27 MET). Weather conditions at the Shuttle Landing Facility (SLF) were deteriorating and predicted to be below minimum requirements at landing. As a result, the primary landing site was changed to Edwards Air Force Base (EAFB) on the orbit following the originally planned KSC landing.

The deorbit maneuver was performed at 344:19:43:20.1 G.m.t. (07:06:19:20.1 MET). The maneuver was approximately 150.6 seconds in duration and the ΔV was 294.0 ft/sec. Entry interface occurred at 344:20:12:12 G.m.t. (07:06:48:12 MET).

The forward RCS thruster F1L began leaking oxidizer at 344:19:55 G.m.t. (07:06:31 MET) following the forward RCS dump burn. Upon closure of the manifold isolation valves (normal procedure following the forward RCS dump), the manifold oxidizer pressure continued to decay from 275 psia to about 56 psia, confirming the leak. Postlanding, the ground crew confirmed a 1 ppm to 2 ppm concentration in the area of the F1L thruster. After nearly 2 hours of monitoring during which the level remained essentially the same, a fan was used to clear the area of fumes so that the crew could exit the vehicle.

Main landing gear touchdown occurred at EAFB, CA., on concrete runway 22 at 344:20:43:47 G.m.t. (07:07:19:47 MET) on December 9, 1992. Nose landing gear touchdown occurred 17 seconds after main gear touchdown with the Orbiter drag chute being deployed satisfactorily at 344:20:44:00.2 G.m.t. The drag chute was jettisoned at 344:20:44:24.9 G.m.t., with wheels stop occurring at 344:20:45:08 G.m.t. Preliminary indications are that the rollout was normal in all respects. The flight duration was 7 days 7 hours 19 minutes 47 seconds. All three APU's were powered down by 344:21:00:36.98 G.m.t. The crew completed the required postflight reconfigurations and after about a 1 1/2 hour delay because of the F1L thruster leak, exited the Orbiter at 344:23:05 G.m.t.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTER/REDESIGNED SOLID ROCKET MOTORS

All SRB/RSRM systems performed as expected with no SRB-related in-flight anomalies identified on this flight. No LCC or OMRSD violations were noted. The SRB prelaunch countdown was normal. 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 purge was used until T-15 minutes to inert the aft skirt area of any accumulation of hydrazine.

Prior to SRB separation, a +8 percent turbine speed specification limit violation occurred on the left-hand thrust vector control rock system during the nozzle null sequence. The turbine speed went to 78,000 rpm (77,760 rpm is specification limit). This excessive turbine speed is attributed to a combination of actuator null response characteristics and instrumentation tolerance. The excessive speed occurred when the actuator reached the null position thereby relieving the load on the system. Turbine speed control was maintained. A similar situation occurred on STS-41. The event is understood, is within the experience base, and is not a concern for future flights.

Hold-down post (HDP) 1 experienced a stud hang-up with associated broaching of the HDP bore. This verified the results of the analysis of Orbiter accelerometer data which indicated the probability of a stud hang-up. The broaching was within the experience base.

Three ordnance ring pins and retaining clips were missing from the left-hand SRB. Several clips in the area were bent out 90 degrees. Two clips were displaced from the pin heads, but the pins were still in place. This occurred during retrieval activities while untangling the left-hand 1 main parachute from the SRB.

Data indicate that the flight performance of both RSRM's was well within the allowable performance envelopes, and was typical of the performance observed on previous flights. There were no RSRM LCC violations nor in-flight anomalies identified. The mean bulk temperature was 68°F at lift-off. Performance data are shown in the following table.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 68°F		Right motor, 68°F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.13	64.67	65.29	64.53
I-60, 10^6 lbf-sec	173.84	173.51	174.18	173.14
I-AT, 10^6 lbf-sec	296.83	296.79	296.71	296.33
Vacuum Isp, lbf-sec/lbm	268.5	268.5	268.5	268.2
Burn rate, in/sec @ 60°F at 625 psia	0.3674	0.3660	0.3681	0.3659
Burn rate, in/sec @ 68°F at 625 psia	0.3695	0.3680	0.3702	0.3678
Event times, seconds				
Ignition interval[a]	0.232	N/A	0.232	N/A
Web time	110.5	111.2	110.2	111.5
Separation cue, 50 psia	120.3	121.1	120.0	121.2
Action time	122.4	123.1	122.1	123.3
Separation command, sec	125.2	126.5	125.2	126.5
PMBT, °F	68.0	68.0	68.0	68.0
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	2.6	2.8	2.6
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 357.2[b]	

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.

A 2.75-inch cut in the cork cover of the right-hand SRB triple booster separation motors (BSM's) was found. This cut penetrated the cork exposing the substrate. Laboratory analysis showed that the event occurred during the ascent phase. Residual material found in the cut matched samples of Orbiter tile. Photographic analysis of the launch films revealed five camera views that showed "objects" of unknown origin passing near (two views showing possible strikes) the right-hand aft BSM's.

The launch pad environment for the 10 hours prior to launch had a predominant wind from the West at an average of 6 knots and ambient temperatures ranging from 46°F to 52°F. Temperatures below 47°F and wind speeds below 5 knots were experienced at times prior to the opening of the launch window. With the ambient temperature and wind hovering near the lower LCC limit, the case remained well above the lower LCC limit (34°F) with a minimum temperature of 48°F.

Field joint heaters operated for 12 hours 43 minutes. Power was applied to the heating element 47 percent of the time to maintain the field joints in their normal operating temperature range. Igniter joint heaters operated for 19 hours 5 minutes with power being applied to the heating element 83 percent (highest percentage experienced) of the time to maintain igniter joints in their normal operating temperature range.

The flexible bearing temperatures were maintained above 60°F by intermittent activation of the aft skirt gaseous nitrogen purge. The purge was operated continuously during the last 14 hours 3 minutes of the countdown to maintain the nozzle-to-case joint above 75°F (minimum LCC temperature). To ensure that all hazardous gases were removed from the aft skirt compartment, the purge was operated at high-flow rate from T-15 minutes to launch. As a result of the purge operation, the flexible bearing mean bulk temperature was 75°F.

Both SRB's were successfully separated from the ET at lift-off plus 126.36 seconds, and reports from the recovery area, based on visual sightings, indicate that the deceleration subsystems performed as designed. Both SRB's were observed during descent, and were retrieved as planned and returned to KSC for disassembly and refurbishment.

EXTERNAL TANK

Overall ET performance was excellent. All objectives and requirements associated with 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 or in-flight anomalies were identified.

Typical ice/frost formations for the December atmospheric environment were observed on the ET during the countdown. Normal quantities of ice or frost were present on the liquid oxygen (LO_2) and liquid hydrogen (LH_2) feedlines and the pressurization line brackets, and some frost and ice was present along the LH_2 proturberance air load (PAL) ramps. All of the observations were acceptable per NSTS 08303.

Ice/frost formations were also present on the acreage of the LO_2 tank lower ogive and barrel and the LH_2 tank barrel, mainly in the +Y, +Z quadrant. This ice was judged by the Ice/Frost Red Team to exceed the 1/16-inch thickness in the debris zone, which was an LCC violation. Launch was delayed approximately 1 hour 25 minutes until the Sun melted the ice; the Ice/Frost Red Team reinspected the ET to verify that there were no longer any ET LCC violations.

The ET pressurization system functioned properly throughout engine start and flight. The minimum LO_2 ullage pressure experienced during the period of ullage pressure slump was 12.8 psid.

ET separation was confirmed. Radar from Bermuda confirmed that the ET did not tumble. Main engine cutoff (MECO) occurred within the expected tolerances, and ET entry and breakup occurred as predicted with the impact point being approximately 17 miles uprange of the preflight prediction.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters appeared to be normal throughout the prelaunch countdown, and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time, all LCC were met, and engine start and thrust buildup was normal.

Flight data indicate that SSME performance during mainstage, throttling, shutdown, and propellant dump operations was normal. The high pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within specification throughout engine operation. There were two in-flight anomalies noted. At 18.14 seconds after lift-off, channel B of SSME 1 HPOTP secondary seal cavity pressure was disqualified (Flight Problem STS-53-E-01). Spiking continued until 5 seconds after engine shutdown. This failure resulted in a loss of redline redundancy for this parameter. Analysis showed that the spiking was caused by transient contamination found in the pressure transducer, and the sensor was replaced. The contamination was most likely generated when a connector was replaced during the original fabrication. A similar failure was experienced on STS-39 (Flight Problem STS-39-E-01).

The second anomaly was the failure of the low-pressure fuel turbopump discharge temperature sensor on SSME 1 (Flight Problem STS-53-E-02). Channel A exhibited a single negative spike at 2.9 seconds after engine start. The sensor was replaced and failure analysis is in progress.

Following a three-minute engine fuel system helium purge during the ET loading sequence, the SSME 3A 750-psi helium regulator outlet pressure began toggling from 784 to 788 psia, violating the 785-psi LCC upper limit (Flight Problem STS-53-V-04). Within 30 minutes, the pressure rose one more bit-count to 792 psia. This was followed by a fuel system purge which dropped the outlet pressure to 772 psia, nominal performance during a fuel system purge. After the purge was concluded, the outlet pressure again rose to 788-792 psia and finally stabilized at 792 psia. One hour later, the fuel system purge was performed, and a similar signature was noted. During this three-hour time frame, the SSME 1B regulator outlet pressure exhibited similar pressures, starting at 780 psia and toggling twice to 788 psia. After MPS helium bottle pressurization occurred at Launch minus 3:20:00, all regulators showed a decrease in outlet pressure. Five minutes after the bottles reached flight pressure, another fuel system purge was performed. Steady-state pressure values after the purge were all less than or equal to 780 psia, and no more violations of the 785-psia limit were noted during the countdown. An LCC waiver was approved for these pressure excesses. This behavior is apparently a trait of the new -0006 regulators, and the LCC and OMRSD requirements are being re-evaluated in preparation for future flights.

The Orbiter MADS recorder failure prior to launch resulted in the loss of SSME vibration/accelerometer data during ascent. The loss of these data will impact the SSME hardware reuse program (removal and retest/acceptance of the HPOTP, and special inspections of the oxidizer preburner (OPB) faceplate flatness will be required).

Review of engine start films revealed a cold wall leak on SSME 2. This type of phenomenon has been observed on previous flights of the Space Shuttle. The nozzle will undergo leak isolation tests and repair at KSC.

The oxidizer preburner oxidizer valve (OPOV) skin temperature sensor 2 failed at 70 seconds after engine start on SSME 3. This measurement is used only during chill to detect liquid oxygen leakage downstream of the OPOV ball seal. The sensor was removed and replaced at KSC.

A spike in the HPFTP speed was observed at 1.6 seconds after engine cutoff on SSME 3. This measurement is used only during engine start as an ignition confirm indicator. This sensor will be removed for failure analysis and replaced with a spare.

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 PERFORMANCE

Main Propulsion System

The overall performance of the MPS was excellent. LO_2 and LH_2 loading was performed as planned with no stop-flows or reverts. There were no OMRSD violations; however, both the SSME 3A and SSME 1B MPS helium regulator outlet pressures violated the 785 psia maximum LCC limit, as discussed in the Space Shuttle Main Engine section of this report. Pneumatic regulator outlet pressures were also high. After pressurization of the helium bottles, the regulators performed well for the remainder of the countdown.

Throughout the period of preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment occurred shortly after the start of fast fill and was approximately 170 ppm, which compares favorably with previous data for this vehicle.

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 LH_2, which is within the required loading accuracy of 0.37 percent. The LO_2 loading accuracy was +0.10 percent for the LO_2, which is within the required loading accuracy for LO_2 of $\pm$0.43 percent.

The gaseous oxygen fixed orifice pressurization system performed as predicted. The gaseous helium pressurization system also performed nominally. Evaluation of the flow control valve data revealed no problems.

Ascent MPS performance appeared to be nominal. Data indicate that the LO_2 and LH_2 pressurization systems performed as planned, and that all net positive suction pressure (NPSP) requirements were met throughout the flight. The SSME 1 HPOTP secondary seal cavity pressure channel B failure is discussed in the Space Shuttle Main Engine Section of this report.

All MPS systems performed nominally during entry and landing. Helium consumption during entry was 59.1 lbm, which was within the flight history of OV-103.

Reaction Control Subsystem

The RCS supported and met all flight requirements, but two anomalies were noted during the mission. Consumption of propellants was nominal for the mission with 5063.4 lbm used from the forward and aft RCS. In addition, the RCS was interconnected to the OMS for two periods during which 4.87 percent of OMS propellants was used.

When the left RCS tank isolation valves were closed following left OMS interconnect, the left RCS oxidizer ullage and tank pressures increased above the primary stage lockup pressure of 255 psia to the secondary lockup pressure of 262 psia during the 15-hour OMS interconnect period (Flight Problem STS-53-V-06). The leakage was calculated to be 2500 scch and the OMRSD limit is 360 scch. A leak of approximately 300 scch was noted during prelaunch operations. The system was switched to the B leg which operated properly.

The forward RCS thruster F1L began leaking oxidizer at 344:19:55 G.m.t. (07:06:31 MET) following the completion of the forward RCS dump burn (Flight Problem STS-53-V-09). Upon closure of the manifold isolation valves (normal procedure following the forward RCS dump), the manifold oxidizer pressure continued to decay from 275 psia to about 56 psia, confirming the leak. Postlanding, the ground crew confirmed a 1 ppm to 2 ppm concentration in the area of the F1L thruster, and after nearly 2 hours of monitoring during which the level remained essentially the same, a fan was used to clear the area of fumes so that the crew could exit the vehicle.

Orbital Maneuvering Subsystem

The OMS performed nominally throughout this flight. Five OMS firings were completed as shown in the following table.

OMS firing	Engine used	Time, G.m.t./MET	Firing duration, sec	ΔV, ft/sec
2	Both	337:14:00:53.8 G.m.t. 00:36:53:8 MET	204.0	337.9
3	Left-hand	338:19:43:11.9 G.m.t. 01:06:19:11.9 MET	49.5	45.9
4	Right-hand	338:20:26:03.0 G.m.t. 01:07:02:03.0 MET	51.4	49.0
5	Right-hand	342:19:15:00.1 G.m.t. 05:05:51:00.1 MET	10.8	10.0
DOB	Both	344:19:43:20.1 G.m.t. 07:06:19:20.1 MET	150.1	294.1

The total burn time on the left OMS was 403.6 seconds and the right OMS was 416.3 seconds. Gaging system performance was nominal with three of the four systems operating properly. The left-hand fuel gage was biased high. Propellant consumption by the OMS was 16,455 lb including that used by the RCS during interconnect operations. During left OMS interconnect operations, 3.27 percent of the left OMS propellants were used by the RCS and during right OMS interconnect operations, 1.60 percent of the right OMS propellants were used.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed nominally throughout the mission. The vehicle was flown in the four-tank-set configuration. The PRSD subsystem supplied 1640.4 lb of oxygen and 206.6 lb of hydrogen to the fuel cells for the production of 2382.9 kWh of electrical energy. Based on lift-off and landing quantities, approximately 41.9 lb of oxygen was supplied to the environmental control system for crew breathing. An 83.1-hour mission extension at the average power level was possible with the reactants remaining in the PRSD subsystem at touchdown.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed nominally throughout the mission. During the 175.3-hour mission, the fuel cells produced 2382.9 kWh of electrical energy and 1847 lb of potable water from 1640.4 lb of oxygen and 206.6 lb of hydrogen. The average total Orbiter electrical power/load was 13.6 kW/444.2 amperes.

Fuel cells 2 and 3 were bus tied for 1 hour and 10 minutes to support the deployment of the DOD-1 payload on flight day 1. The actual fuel cell voltages at the end of the mission were 0.1-volt above the predicted for fuel cell 1 and 0.2-volt above the predicted for fuel cells 2 and 3.

Six purges were performed at approximately 20, 68, 108, 127, 141, and 166 hours MET. The flight rule for fuel cell purging was to purge every 48 hours or if a 0.2-volt degradation was reached since the previous purge by any fuel cell. Voltage decay of 0.2 volt was observed on all three fuel cells prior to the planned 48-hour purge interval as compared to a 0.1-volt decay over 48 hours observed on previous missions. The fuel cells were therefore purged based on the degradation limit of 0.2 volt for the last three purges. The increased decay was the result of the oxygen, although within specification, having a higher inert content than normally observed on previous missions.

The thermal performance of the fuel cell water relief, water line, and reactant purge systems was nominal. All heaters operated within their normal ranges except the fuel cell 1 water relief valve A heater that had very short heater cycles indicating a dithering thermostat that closed at the appropriate temperature, but opened too soon.

Auxiliary Power Unit Subsystem

The improved auxiliary power unit (IAPU) subsystem operated nominally throughout the mission. Fuel consumption and IAPU run times are shown in the following table.

Flight Phase	IAPU 1 (S/N 405)		IAPU 2 (S/N 406)		IAPU 3 (S/N 404)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	20:09	54	20:08	56	20:10	58
FCS checkout	8:45	26				
Entry[a]	61:09	130	82:14	176	61:10	146
Total[a]	90:03	210	102:22	232	81:20	204

Notes:
[a] The IAPU's ran for 16 minutes 50 seconds after landing.

The APU 1, 2, and 3 fuel service line temperatures cycled higher than expected requiring the upper FDA limit for these measurements to be changed by table maintenance block update (TMBU) to 140°F, 140°F, and 130°F, respectively. These temperature sensors had been relocated from the test line to the service line prior to the mission [during Orbiter maintenance down period (OMDP)] as a part of the APU smart-short heater modification. Since the service line has different thermal characteristics than the test line, the old FDA limit of 110°F should have been adjusted accordingly. This will be done before the next flight of this vehicle.

About 15 minutes after APU shutdown following ascent, the APU 1 test line temperature 1 (V46T0183A) reached 49°F, just above the 48°F FDA limit. This required the crew to activate the fuel/line/water system A heater system earlier than planned. Upon activation of the heater system, the temperatures returned to the normal heating range.

On the third day of the mission, the APU 3 drain line temperature 1 (V46T0386A) was changed by TMBU from 48°F to 45°F to prevent nuisance alarms. The drain line temperature had reached a minimum of 48°F at the heater cycle low point due to a vehicle attitude change.

The APU 1 fuel pump inlet pressure measurement (V46P0110A) failed off-scale high upon activation of the fuel isolation valves just prior to the preflight confidence run. APU 1 was approved to fly the mission without this instrumentation, and the transducer will be removed and replaced during postflight turnaround activities.

When the lubrication oil heaters were switched from the A to the B system following the FCS checkout per normal operations, the APU 1 lubrication oil B system heater did not cycle until the lubrication oil temperature (V46T0154A) reached 46°F approaching the lower FDA limit of 40°F. The thermostat set point was 51.9°F. The thermostat was relocated during OMDP to gain better access. The temperature at which the thermostat cycled is well within the tolerance of the instrumentation and location of the sensor with respect to the thermostat. There was no abnormal operation of the heater system.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/WSB subsystem performed nominally throughout all phases of the mission. The FCS checkout (performed using APU 1) was nominal with spray cooling beginning about 1 1/2 minutes prior to IAPU deactivation.

During prelaunch operations, the system 2 bootstrap accumulator experienced a rapid pressure decay (approximately 250 psi/hr). Pressure decay rates greater than 32 psi/hr are usually indicative of contamination in the unloader valve. Subsequent system 2 accumulator recharges indicated nominal performance during the prelaunch and on-orbit phases of the flight, and no action will be taken with the accumulator.

The WSB regulator pressure decayed from 29.1 psi to 23.7 psi throughout the on-orbit period. The decay rate was approximately 0.85 psi/day which is within specification (i.e., above the allowable exponential decay). The -1 valves assembly has a history of seals taking a set and leaking.

Because of the change in landing sites and the wave-off, longer-than-normal WSB operations for entry were required. During this period, WSB 1 steam vent B heaters displayed erratic performance. About 3 1/2 hours after WSB 1 heater activation for entry, the WSB 1 B steam vent temperature fell below the 130°F "WSB Ready" temperature. The WSB was switched from the B to the A controller and the heater operation recovered. Originally, data suggested that ice removal might be affecting the heater initial performance, and that the heater may not be failed. As a result, the WSB was switched back to B controller following the deorbit burn. Although subsequent operation was erratic, the B WSB controller/heaters operated and WSB 1 vent heating during entry was performed as scheduled on B controller. This occurrence was determined to be anomalous (Flight Problem STS-53-V-11) because of normal operations on the A controller. Also, the WSB's are not certified for entry with failed-off heaters.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performance was nominal with no problems identified. All data analyzed showed nominal voltage and current signatures, and no specified limits were violated. STS-53 was the first flight of OV-103 after major modifications were performed on the vehicle. The major modifications included the installation of a drag chute, improved nose wheel steering, landing gear changes, hydraulics changes and fuel cell redundant shutoff circuits. All electrical hardware related to these modifications/improvements performed nominally.

Pyrotechnics Subsystem

The pyrotechnics subsystem operated properly with all functions being performed as planned.

The postflight inspection revealed that all three ET/Orbiter separation devices (EO-1, -2, and -3) operated satisfactorily. All ET/Orbiter umbilical separation ordnance retention shutters were closed properly. No flight hardware was found on the runway below the umbilicals when the ET/Orbiter doors were opened.

Aft Fuselage Gas Sampling System

The data obtained during ascent by the Orbiter aft fuselage gas sampling system (AFGSS) were nominal for STS-53. The hydrogen concentration and oxygen concentration were well within the data base for all Shuttle vehicles. All six bottles contained excellent samples with less than 15-percent air in the sample. These six bottles were vacuum processed at a temperature of 275°F.

Environmental Control and Life Support Subsystem

The active thermal control system (ATCS) performance was nominal. The flash evaporator system (FES) was deactivated for several periods during the flight to support payload operations. The FES was used to perform several supply water dumps and performed nominally.

A temperature sensor on FES feedline A exceeded its FDA upper limit of 140°F at 340:10:10 G.m.t. (02:20:46 MET). The feedline had been stagnant for a long period of time and local hot spots were created. When the FES was pulsed momentarily, it caused a hot slug of water to travel down the feedline and that slug coincided with a peak in the heater duty cycle, and these conditions resulted in the sudden rise in temperature. No action was necessary as the heater cycled normally and the temperatures remained within their expected ranges.

The radiator coldsoak provided cooling during entry through touchdown plus 19 minutes, after which the ammonia system B was activated. After 44 minutes, system B was depleted and system A was activated. However, before system A was turned on, Freon cooling loop 2 was switched to bypass flow which had the effect of increasing the FES flowrate and temperature. This activity was performed to prevent ammonia system A from operating at less than the minimum control temperature of 32°F. The procedure accomplished its purpose and system A controlled to 36°F. System A was deactivated after 10 minutes of operation when ground cooling was connected.

The atmospheric revitalization system performance was normal throughout the mission. Humidity separator B had a few drops of water at its air outlet after being "slugged" with condensate water from the cabin heat exchanger. Separator A was used after flight day 2. Ground tests will determine if separator B requires replacement.

The supply water and waste management system performed adequately throughout the mission. Supply water was managed through the use of the overboard dump system and the FES. Seven supply water dumps were performed at an average dump rate of 1.42 percent/minute (2.35 lb/minute). The supply water dump line temperature was maintained between 62°F and 98°F throughout the mission with the operation of the line heater.

During flight day 1 operations, the crew reported a small amount of free water during the humidity separator water check. Approximately two hours later, the second humidity separator water check was performed, and the crew again reported a small amount of free water. The water carry-over may have been the result of operating the cabin temperature controller in the automatic position. The carry-over was well within specifications. The amount of water did not require any mop-up operations and the cabin humidity remained at 25 percent. The crew switched to humidity separator A as a precautionary measure due to the upcoming sleep period. An inspection during the post-sleep activities revealed that the area around the humidity separator was dry. The crew switched back to humidity separator B.

A check of humidity separator B for water carry-over after about six hours of operation revealed approximately 1 cc of water attached to the wires near the humidity separator. Due to the small amount of water, no mop-up of the water was required. However, the crew was requested to select humidity separator A again, and subsequent operations on humidity separator A were satisfactory. Engineering analysis indicates that humidity separator B was operating within design requirements and a slight amount of carry-over may be expected when operating under the conditions discussed previously.

A decrease in the supply water dump nozzle temperature was observed during the first supply water dump (Flight Problem STS-53-V-03). The nozzle temperature recovered and dumping proceeded nominally. The cause of the phenomenon is unknown, but was most likely a temporary loss of power to the nozzle heaters as occurred on STS-39. Future supply water dumps through the dump nozzle were performed as usual with no recurrence of the anomaly.

Waste water was gathered at approximately the predicted rate. Two waste water dumps were performed at a rate of 1.9 percent/minute (3.14 lb/minute). The waste water dump line temperature was maintained between 55°F and 98°F throughout the mission, while the vacuum vent line temperature was between 59°F and 83°F.

Flight data indicate internal leakage through the supply water dump valve after dumps 2 through 7 (Flight Problem STS-53-V-05). This expulsion (burping) phenomenon has been confirmed to have occurred on STS-48 and STS-44, and is suspected to have occurred on previous flights of OV-103 and OV-104. The valve was replaced after STS-48; however, testing on that valve has not repeated the phenomenon.

The waste collection system performed normally throughout the mission.

The pressure control system performance was satisfactory with the exception of partial pressure oxygen (PPO_2) sensor C which exhibited an erratic output during the entry phase of the mission (Flight Problem STS-53-V-10). No crew action was necessary for this failure, as this sensor was a monitor-only sensor and was not required for PPO_2 control.

Smoke Detection and Fire Suppression Subsystem

The smoke.detection subsystem performed normally throughout the flight, and use of the fire suppression subsystem was not required.

Airlock Support Subsystem

All airlock support subsystem parameters remained within expected ranges throughout the flight. Use of the airlock extravehicular activity (EVA) facilities was not required.

Avionics and Software Subsystem

The performance of the avionics and software subsystem was satisfactory throughout the mission.

The integrated guidance, navigation and control system performed satisfactorily.

The FCS performance was satisfactory for launch, FCS checkout, and entry, although one anomaly was noted and is discussed in the following paragraph.

The speedbrake channel 3 position feedback operational instrumentation (OI) measurement (V57H0252A) changed from the zero degree indication to 45° (0 volt position) during ascent and remained at that indication for approximately 48 minutes (Flight Problem STS-53-V-02). Prior to the transition to the on-orbit configuration, insufficient flight data were available to determine whether this was an OI measurement problem or a flight critical hardware problem. This anomaly did not recur during the remainder of the flight. Speed brake channel 3 performed nominally during FCS checkout and entry. Postflight troubleshooting at KSC identified a faulty wire crimp on a bulkhead connector which carries the position feedback transducer signal to the aerosurface servo amplifier. Had this intermittent condition occurred during a time when the flight control system was active, a failure of the flight control channel would have been annunciated. Mission rules invoke a minimum duration flight for a confirmed failure of this type.

The inertial measurement unit (IMU) and star tracker performance was nominal throughout the mission with no problems identified. Likewise, the performance of the data processing system hardware and flight software was nominal with no anomalies identified.

The displays and control (D&C) subsystem performed satisfactorily; however, during the FCS checkout, it was noted that there was a slight delay of the B pole on the panel 12 entry mode select switch to make contact. This is a four-pole, lever-locked switch. Switches of this type have been known to exhibit "switch teasing" characteristics. This occurrence was not considered a failure of the switch and did not impact the mission.

The operational instrumentation subsystem performed satisfactorily; however, the modular auxiliary data system (MADS) provided no usable data because it apparently failed due to an incorrect uplink command sequence prior to launch. The MADS recorder was commanded on per the normal uplink procedures prior to launch. This command was to be followed by a calibration command; however, a command to stop the recorder was inadvertently sent while the recorder was operating at 15 inches/second. This sequence can result in tape breakage in the 1-g vertical recorder position. Attempts to restart the recorder were unsuccessful, and no MADS data were recorded during the mission (Flight Problem STS-53-V-01).

Communications and Tracking Subsystems

Performance of the S-band, Ku-band, UHF, and FM communications equipment was satisfactory. Data evaluation is progressing in an effort to determine the cause of the noise on air-to-ground 1 about 2 hours before landing when the crew used the hand-held microphone (Flight Problem STS-53-V-12).

CCTV camera C was powered up in preparation for the ODERACS experiment deployment; however, the camera produced only colored horizontal lines and no discernible picture (Flight Problem STS-53-V-07). Camera B was substituted for camera C for the deployment. The deployment of the ODERACS experiment, however, was not successful.

At 341:09:24 G.m.t. (03:21:00 MET), the first page of the text and graphics system (TAGS) morning mail was sent and a jam occurred (Flight Problem STS-53-V-08). A page advance was sent, but the jam remained. Shortly after the crew awakened, one of the crew opened the front cover of the TAGS and noted that the booster roller, which should roll continuously, had stopped. The crew cycled the power to the TAGS, but was unsuccessful in regaining TAGS operation. As a result, the teleprinter was used for uplinking the morning mail. After further evaluation, the decision was made to leave the TAGS in the powered-down configuration because of the roller motor malfunction, and use the teleprinter and PADM for uplinking the mail for the remainder of the mission.

Structures and Mechanical Subsystems

All structures and mechanical subsystems equipment operated nominally throughout the mission. This included the vent doors, ET/Orbiter umbilical doors, payload bay doors, star tracker doors, Ku-band antenna deployment actuator, and air data probe system. Landing and braking data are contained 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	1268	212.4	~3.0	n/a
Nose gear touchdown	6345	144.9	n/a	1.9

Braking initiation speed	109.9	knots (keas)
Brake-on time	48.2	seconds (not sustained)
Rollout distance	10,696	feet
Rollout time	72.8	seconds
Runway	22	(concrete) at EAFB
Orbiter weight at landing	193,987	lb

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	515	Left-hand outboard	6.20
Left-hand inboard 3	489	Left-hand inboard	9.98
Left-hand outboard 2	502	Right-hand inboard	11.31
Left-hand outboard 4	489	Right-hand outboard	6.00
Right-hand inboard 1	621		
Right-hand inboard 3	793		
Right-hand outboard 2	555		
Right-hand outboard 4	621		

Tire location	Pressure, psia	Tire temperature, °F	Temperature decal, °F
Left-hand outboard	340.6	17.9	
Left-hand inboard	338.4	17.9	
Right-hand inboard	338.4	17.9	
Right-hand outboard	336.2	17.9	
Left-hand nose gear	347.3	52.7	
Right-hand nose gear	358.8	52.7	

Although the in-flight checkout requirement for dual motor drive-time of 63 seconds for the payload bay doors was exceeded by 2 seconds (actual drive time = 65 seconds), this longer drive-time was anticipated because the bending effects temperature (BET) was greater than 100°F by 5°F. Past flight data has shown that longer door-drive times can be expected for BET's that are greater than 100°F.

This flight marked the fifth use of the drag chute. The drag chute functioned satisfactorily and provided the desired slowing of the vehicle. During deployment, the drag chute rode to the left of the centerline in both the reefed and disreefed condition. All drag chute hardware was recovered and showed no signs of abnormal operation. Actual chute angle and heading angle determination is being completed using the photographic data.

Aerodynamics, Heating, and Thermal Interfaces

The ascent and entry aerodynamics were nominal; however, ascent was completed with a waiver of a potential violation of load indicator A16L. The predicted violation of wing load indicator A16L caused a hold in the countdown. Analysis of the L-70-minute balloon data produced a value of 103 percent for wing load indicator A16L. The existing structural certification for the wing has at least a 5-percent positive margin to the load indicator redline. In addition, the on-going aerodynamic verification program, based on OV-102 measured strain-gage responses, shows the aerodynamic baseline data are conservative. As a result of the conservatism in these areas, the 3-percent excess load prediction was determined to be acceptable and the potential excess load was waived for flight.

The aerodynamic and plume heating during ascent was nominal. Entry aerodynamic heating was within the thermal protection subsystem (TPS) limits; however, an unusual sideslip of 1 to 2 degrees was noted between entry velocities of 15,000 and 7,000 ft/sec. Analysis of this condition continues.

The thermal interface temperatures prior to launch were within interface control document (ICD) limits during all mission phases. Two concerns were expressed by evaluation personnel in that the adequacy of the LH_2 ET/Orbiter umbilical cavity purge cannot be determined because no direct measurement of this condition is available. Also, accurate temperature/wind speed data are difficult to obtain because of the lack of knowledge of which Orbiter instrumentation measurements to use for temperature and wind-speed indications. Additionally, no criteria exist to allow recovery after an LCC is violated.

Thermal Control Subsystem

The performance of the Orbiter thermal control subsystem (TCS) was nominal during all phases of the mission, and all subsystem temperatures were maintained within acceptable limits.

All three APU service line temperature 2 values cycled high and beyond the nominal on-orbit high value observed on previous missions of this vehicle. The upper FDA limit was raised from 110°F to 140°F to prevent alarms during the sleep periods. The temperature cycling time was about one hour and the peak values were near 130°F. These temperature sensors have been moved since the last flight of this vehicle. Subsequent analysis indicates these temperatures to be normal for the present configuration.

Aerothermodynamics

Acreage heating was nominal with all structural temperatures and structural temperature rise rates within limits and the experience base. Local acreage heating was normal and the postflight thermal protection subsystem (TPS) damage inspection results were within the experience base. The lack of MADS data will hamper some of the calculations normally performed in this area of concern.

Thermal Protection Subsystem

The Orbiter TPS performed nominally, providing the required protection of the Orbiter vehicle. Information to determine the time of boundary layer transition from laminar flow to turbulent flow was not available because of the failure of the MADS recorder.

The TPS sustained a total of 240 hits, of which 23 had a major dimension of one inch or greater. This total does not include the numerous hits on the base heat shield that are attributed to SSME vibration/acoustics and exhaust plume recirculation. A comparison of these statistics with those from 36 previous missions indicate that the overall number of hits was greater than average, and the number of hits one inch or larger was average.

The Orbiter lower surface sustained a total of 145 hits, of which 11 had a major dimension of one inch or greater and that number is less than average. The majority of this damage occurred on the right side of the vehicle and is primarily attributed to ice from the LO_2 feedline. A cluster of 56 hits, with two greater than one inch, was observed forward and outboard of the ET/Orbiter LO_2 umbilical opening. Similar clusters have been observed on previous flights and are attributed to ice/debris impacts at ET separation.

The post-recovery inspection of the right SRB revealed a 3-inch by 1/8-inch by 1/2-inch deep gash in the cover of the aft center booster separation motor (BSM). Analysis of foreign material found embedded in the cork insulation at the gash was identified as Orbiter tile material, and was of no concern for entry. During the postflight evaluation, two impacted tiles on the forward right-hand side of the vehicle were identified as possible sources of the debris which impacted the BSM cover. These tiles were missing part of their tile identification markings. Samples were taken from these impacted tiles and analyzed, and the source of the tile impacts could not be determined based on the analyzed samples. However, the amount of material missing from the tiles could not have caused the observed SRB damage.

No TPS damage was attributed to material from the wheels, tires, or brakes. The main landing gear tires were considered to be in excellent condition for a landing on a concrete runway.

The left-hand reinforced carbon-carbon (RCC) panel 9 exhibited a 4-inch by 2.5-inch area of coating that was bubbling and spalling. Left-hand RCC panel 6, right-hand RCC panel 13, and left-hand RCC T-seals 8, 14, and 16 all exhibited smaller areas of coating bubbling and spalling.

Tile damage on the base heat shield was typical. Four dome-mounted heat shield (DMHS) closeout blanket sacrificial panels were nearly detached from the 1:30 to 4:30 o'clock position on SSME 2, exposing the inner blanket layer. This layer was eroded/missing in a number of places revealing the underlying batting material. The outer layer of the DMHS splice at the 6 o'clock position on SSME 1 exhibited minor fraying. All of the remaining DMHS blankets were in excellent condition.

The were no obvious indications of the SSME 2 nozzle cold wall fire that was observed during the postlaunch film review. Tiles on the trailing edge of the body flap immediately underneath SSME 2 were discolored (milky white). This discoloration may have resulted from the nozzle fire.

The tiles on the left-hand OMS pod leading edge suffered more damage than usual. Access to this area was not possible at the Dryden Flight Research Facility (DFRF); consequently, the number of impact sites and dimensions are approximate. Orbiter windows 3 and 4 exhibited typical hazing and streaking. Only a very light haze was present on the other forward-facing windows (1, 2, 5, and 6). Surface wipes were taken from windows 1 through 6 for laboratory analysis. A total of 33 hits with one greater than one inch were noted on the perimeter tiles around windows 1 through 6. Most all of these hits were small and shallow in depth and may have been caused by room temperature vulcanizing (RTV) used to bond paper covers to the forward RCS engine nozzles, exhaust products from the SRB booster separation motors, ice/TPS debris from the ET LO_2 tank, or any combination of these three.

A Cyclops infrared spot radiometer was used to measure the surface temperatures on several areas of the Orbiter in accordance with OMRSD requirements. Two hours and twenty-seven minutes after landing, the nosecap Orbiter RCC was 105°F. The right-hand wing leading edge RCC panel 9 was measured immediately following the nosecap measurement and the temperature was 73°F, and the temperature of panel 17 was 72°F. These temperatures were taken much later than usual after touchdown because of the oxidizer leak.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The crew was unable to find the Commander's eating utensils. The actual stowage location was determined and reported to the crew the evening of flight day 1. The crew reported during the technical debriefing that the Commander's utensils were found the morning of the flight day 2 in the stowage location that was given them the previous day.

The crew noted that the battery adapter was missing from the 16-mm Arriflex camera the first time the camera was unstowed. The adapter is held in place by a thumb screw. The camera should have been stowed with the adapter attached. An in-flight maintenance (IFM) procedure was approved to power up the camera using the IFM breakout box.

CARGO INTEGRATION

Cargo integration hardware and systems operated nominally throughout the mission. No new mission-unique hardware was provided for this mission. The major effort during the mission was in support of the ODERACS experiment which was inoperative because of a dead battery as discussed in the following section of the report.

PAYLOADS

DEPARTMENT OF DEFENSE -1

The DOD -1 payload was deployed on the first flight day at 337:19:18 G.m.t. (00:05:54 MET).

ORBITAL DEBRIS RADAR CALIBRATION SPHERES

The six ODERACS spheres were planned for deployment on orbit 31 to calibrate ground radars and optical telescopes. However, a dead gas control decoder (GCD) battery prevented the get away special (GAS) canister door from opening. No method was available to recharge the battery from the crew compartment. Time did not permit the development of an engineering solution to perform an EVA to recharge the battery. As a result, the spheres were not deployed, but the experiment has been manifested for STS-56.

GLOW EXPERIMENT/CRYOGENIC HEAT PIPE EXPERIMENT

Overall, the Glow Experiment (GLO)/Cryogenic Heat Pipe Experiment (CRYOHP) payload (GCP) was a non-standard hitchhiker payload mounted on the starboard sidewall of the payload bay. The experiment was used to observe Orbiter and air glow, RCS maneuvers, water dumps, and FES operations. The GCP was very successful, even though the orbital darkness required for GLO did not occur until flight day 6. A total of 20 of 23 planned premission requirements for the GLO were met. A total of eight cycles for the CRYOHP were successfully completed, with only five planned premission.

CLOUD LOGIC TO OPTIMIZE THE USE OF DEFENSE SYSTEMS

The objective of the cloud logic to optimize the use of defense systems (CLOUDS) military man in space experiment was to quantify the variation in apparent cloud cover as a function of the angle at which clouds are viewed from orbit. Data from CLOUDS will be stored in a high resolution data base for use by the meteorological community and various defense meteorological satellite program initiatives. Although the batteries stowed in the CLOUDS data pack were dead, the flight crew was able to change the batteries, initialize the data pack, and successfully complete the CLOUDS data gathering objectives for this mission. Fourteen targets were uplinked to the crew during the mission.

FLUID ACQUISITION AND RESUPPLY EXPERIMENT

The fluid acquisition and resupply experiment (FARE) investigated the dynamics of fluid transfer in microgravity. The orientation of liquids in weightlessness is highly unpredictable because the liquid may locate in any area within the container and may encapsulate large gas bubbles.

The FARE also experienced a battery failure before operations began. The cassette data tape recorder (CDTR) internal clock is powered by an Everready 357BP watch battery. The failure of the battery was not mission critical since an alternative method existed. However, the flight crew found a replacement battery and was able to complete all eight of the FARE tests planned.

MICROCAPSULES IN SPACE

The Microcapsules in Space (MIS) was recently developed and the objective of MIS was to increase the knowledge of microencapsulated drug technology. Crew members performed two experiments to produce time-released antibiotic microcapsules. The antibiotic ampicillin was microencapsulated with a biodegradable polymer. Scientists have reason to believe that microcapsules made in weightlessness have properties vastly superior to microcapsules made on Earth.

The MIS was activated for 4.5 hours and deactivated as planned. During the mission, the crew reported MIS temperatures daily with the range being 74°F to 78°F which is nominal.

RADIATION MONITORING EQUIPMENT-III

The Radiation Monitoring Equipment-III (RME-III) measured the exposure of the Orbiter to ionizing radiation. The dose rate and total accumulated radiation dose of the crew member was measured simultaneously. The RME-III operated nominally during the mission. The crew also performed memory module changes as planned.

SPACE TISSUE LOSS

The Space Tissue Loss (STL) hardware operated without any anomalies during the STS-53 mission. The Walter Reed Army Institute of Research was the development organization for the experiment hardware and the evaluation of the results.

VISUAL FUNCTION TESTER

The model II Visual Function Tester (VFT-2) was used to perform a series of vision performance experiments on the crew members aboard the Orbiter to assess the effect of microgravity on visual function. All VFT tests were performed as planned.

BATTLEFIELD LASER ACQUISITION SENSOR TEST

The Battlefield Laser Acquisition Sensor Test (BLAST) demonstrated the technology associated with using a space-borne laser receiver to detect laser energy from ground-based test locations. A total of 20 targets of opportunity were available for use of the BLAST hardware, and of the 20 targets, only two were successfully completed, and these were over Malabar and over the AMOS site. A total of 18 could not be completed. Nine could not be completed because of inclement weather; four could not be completed because of ground site hardware problems; one could not be completed because of an unidentified aircraft in the air space; and four could not be completed for unknown reasons.

HAND-HELD, EARTH-ORIENTED, REAL-TIME, COOPERATIVE, USER-FRIENDLY, LOCATION-TARGETING AND ENVIRONMENTAL SYSTEM

The Hand-Held, Earth Oriented, Real-Time, Cooperative, User-Friendly, Location-targeting and Environmental System (HERCULES) was developed was developed by scientists to enable the Shuttle crew member to point a camera at an interesting feature on the Earth, record the image, and determine the latitude and longitude of the feature within two nautical miles. Approximately 78 pictures were reported to have been taken by the flight crew. Premission planning included 48 sites of which 25 were required (15 acquired) to meet 100-percent of the experiment objectives. The remaining exposures were of alternate targets of opportunity.

COSMIC RADIATION EFFECTS AND ACTIVATION MONITOR

The Cosmic Radiation Effects and Activation Monitor (CREAM) collected data on the cosmic ray energy loss spectra, neutron fluxes and induced radioactivity. The data were collected by both active and passive monitors placed at specific locations in the crew compartment. CREAM data were collected from the same locations as the RME-III so that a correlation between these data could be attempted.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

A total of 11 development test objectives (DTO's) and 12 detailed supplementary objectives (DSO'S) were assigned to the STS-53 mission. Five of the 11 DTO's were completed. The remaining six were not completed because these were data-only DTO's which required data from the MADS recorder for successful completion. The MADS recorder was lost before lift-off because of a ground controller error.

All 12 of the planned DSO's were completed.

DEVELOPMENT TEST OBJECTIVES

DTO 301D - Ascent Structural Capability Evaluation - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 305D - Ascent Compartment Venting Evaluation - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 306D - Descent Compartment Venting Evaluation - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 307D - Entry Structural Capability - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 308D - Vibration and Acoustics Evaluation - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 319D - Shuttle/Payload Low Frequency Environment - This was a data-only DTO and loss of the MADS recorder resulted in this DTO not being completed.

DTO 312 - ET TPS Performance-Method 3 - This DTO was completed as planned with both magazines of film exposed (72 photographs) taken using a Nikon F4 camera body with a 300 mm lens and a 2X converter. The ET after the separation from the Orbiter appeared to be in good condition. The normal ET TPS charring and SRB separation burn scars were observed.

The preliminary analysis of the 72 photographs from magazine 19 and 27 are given in the following paragraphs.

The magazine 19 film consisted of 36 good quality frames (views) of the ET. The first picture was acquired approximately 5 minutes 36 seconds after ET separation, and the last frame was acquired approximately 8 minutes 34 seconds after ET separation. Items of interest noted were three divots in the ET aft dome. Two of the divots were on the -Z side and one was on the +Z side of the ET. Possible venting was also noted coming from the ET liquid hydrogen umbilical. In addition, two probable divots were observed on the liquid hydrogen tank/intertank interface on the ET +Y axis, and two possible divots were seen below the ET ground umbilical carrier plate (GUCP) in the liquid hydrogen tank/intertank interface TPS on the -Y axis.

Magazine 27 contained 36 excellent quality photographs using the Nikon hand-held camera with a 300-mm lens and 2X extender. A focusing problem was evident at the beginning and end of the film. The first frame of this magazine was taken approximately 10 minutes and 39 seconds after ET separation, and the last frame was taken approximately 12 minutes after ET separation. The only item of interest was a possible divot on the ET liquid hydrogen tank/intertank interface below the antenna to the left of the forward bipod.

DTO 521 - Evaluation of Drag Chute System - The Orbiter drag chute was deployed at the initiation of derotation as planned, and the drag chute operated nominally.

DTO 653 - Evaluation of MKI Rowing Machine - The evaluation of this rowing machine was completed as planned.

DTO 656 - PGSC Single Event Upset Monitoring - Monitoring was completed in conformance with the requirements established during premission briefings.

DTO 663 - Acoustical Noise Evaluation - This evaluation was performed by the crew and the data are being analyzed by the sponsor. A separate report will be published by the DTO sponsor.

DTO 805 - Crosswind Landing Performance - The crosswinds were not strong enough to meet the requirements of this DTO.

DETAILED SECONDARY OBJECTIVES

DSO 469 - Radiation Dose Distribution - Data for this DSO were collected and are being evaluated by the sponsor.

DSO 472 - Intraocular Pressure - Measurements were made as planned of the intraocular portion of the eye.

DSO 474 - Retinal Photography - All requirements of this DSO were met and the data are being evaluated by the sponsor.

DSO 479 - Hypersomatic Fluid Countermeasure - The requirements of this DSO were completed, and the data and results are being evaluated by the sponsor.

DSO 603B - Orthostatic Function During Entry, Landing, and Egress - All requirements of this DSO were completed and the data are being evaluated by the sponsor.

DSO 604 - Visual Vestibular Integration as a Function of Adaption - The in-flight requirements of this DSO were met and the data are being evaluated by the sponsor.

DSO 605 - Posture Equilibrium Control During Landing and Egress - Measurements for this DSO were made and are being evaluated by the sponsor.

DSO 608 - Effects of Space Flight on Aerobic and Anaerobic Metabolism During Exercise - The requirements of this DSO were met and are being evaluated by the sponsor.

DSO 901 - Documentary Television - The requirements of this DSO were met and the data are being evaluated by the sponsor.

DSO 902 - Documentary Motion Picture Photography - The requirements of this DSO were met and the photography is being evaluated by the sponsor.

DSO 903 - Documentary Still Photography - The requirements of this DSO were met and the photography are being evaluated by the sponsor.

PHOTOGRAPHIC AND TELEVISION ANALYSES

LAUNCH DATA ANALYSIS

The STS-53 launch videos (24) were reviewed and no anomalous conditions were noted. Also, launch films (54 of 55) were reviewed, and two possible anomalous conditions were observed in footage from launch pad camera E-9. The conditions noted were a bolt hangup at hold down post M-1 at lift-off and orange vapor at hatband 9 on SSME 2. Both conditions were later verified to be no problem.

ON-ORBIT DATA ANALYSIS

Late in the mission during the post-recovery inspection of the right SRB, a 3-inch by 1/8-inch by 1/2-inch deep gash was found in the cover of the aft center booster separation motor. Analysis of foreign material found embedded in the cork insulation revealed that the gash was most likely the result of contact from a piece of Orbiter tile material. As a result, the launch films of the right SRB aft skirt were rescreened for indication of debris that may have been related to this finding. No evidence of any problem could be found in the films. An analysis of the potential Orbiter tile loss indicated that the impact on entry flight operations would be acceptable. Postflight video data of the Orbiter lower surface showed no areas of significant damage.

LANDING DATA ANALYSIS

Six landing videos including the NASA Select were received and reviewed approximately four hours after landing. No anomalous conditions were noted in the landing videos.

Video coverage of the drag chute deployment and jettison was also reviewed. The deployment of the drag chute appeared as expected. The drag chute appeared to drift to the left of the Orbiter centerline (longitudinal axis) as the vehicle slowed down prior to drag chute release.

TABLE I.- STS-53 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	337:13:19:10.38
	APU-2 GG chamber pressure	337:13:19:11.33
	APU-3 GG chamber pressure	337:13:19:12.40
SRB HPU activation	LH HPU system A start command	337:13:23:32.36
	LH HPU system B start command	
	RH HPU system A start command	337:13:23:32.36
	RH HPU system B start command	
Main propulsion System start	Engine 3 start command accepted	337:13:23:53.44
	Engine 2 start command accepted	337:13:23:53.56
	Engine 1 start command accepted	337:13:23:53.66
SRB ignition command (lift-off)	SRB ignition command to SRB	337:13:23:59.993
Throttle up to 100 percent thrust	Engine 1 command accepted	337:13:24:04.06
	Engine 3 command accepted	337:13:24:04.08
	Engine 2 command accepted	337:13:24:04.08
Throttle down to 73 percent thrust	Engine 1 command accepted	337:13:24:28.06
	Engine 3 command accepted	337:13:24:28.08
	Engine 2 command accepted	337:13:24:28.08
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	337:13:24:53
Throttle up to 104 percent thrust	Engine 1 command accepted	337:13:25:01.18
	Engine 3 command accepted	337:13:25:01.20
	Engine 2 command accepted	337:13:25:01.20
Both SRM's chamber pressure at 50 psi	RH SRM chamber pressure mid-range select	337:13:26:01.07
	LH SRM chamber pressure mid-range select	337:13:26:01.19
End SRM action	RH SRM chamber pressure mid-range select	337:13:26:03.32
	LH SRM chamber pressure mid-range select	337:13:26:03.60
SRB separation command	SRB separation command flag	337:13:26:06
SRB physical separation	LH rate APU A turbine speed LOS	337:13:26:06.35
	RH rate APU A turbine speed LOS	337:13:26:06.35
Throttle down for 3g acceleration	Engine 1 command accepted	337:13:31:29.19
	Engine 2 command accepted	337:13:31:29.21
	Engine 3 command accepted	337:13:31:29.21
3g acceleration	Total load factor	337:13:31:29.11
Throttle down to 67 percent thrust	Engine 1 command accepted	337:13:32:27.11
	Engine 2 command accepted	337:13:32:27.13
	Engine 3 command accepted	337:13:32:27.13
Engine Shutdown	Engine 1 command accept	337:13:32:33.31
	Engine 2 command accept	337:13:32:33.33
	Engine 3 command accept	337:13:32:33.33
MECO	Command flag	337:13:32:34
	Confirm flag	337:13:32:35

TABLE I.- STS-53 SEQUENCE OF EVENTS (Continued)

Event	Description	Actual time, G.m.t.
ET separation	ET separation command flag	337:13:32:52
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-1 GG chamber pressure	337:13:39:18.79
	APU-2 GG chamber pressure	337:13:39:20.72
	APU-3 GG chamber pressure	337:13:39:22.48
OMS-2 ignition	Right engine bi-prop valve position	337:14:00:53.8
	Left engine bi-prop valve position	337:14:00:53.8
OMS-2 cutoff	Right engine bi-prop valve position	337:14:04:17.8
	Left engine bi-prop valve position	337:14:04:18.0
Payload bay door open	PLBD right open 1	337:15:05:23
	PLBD left open 1	337:15:06:41
DOD-1 Deploy	Voice call	337:19:18
OMS-3 ignition	Right engine bi-prop valve position	Not applicable
	Left engine bi-prop valve position	338:19:43:11.9
OMS-3 cutoff	Right engine bi-prop valve position	Not applicable
	Left engine bi-prop valve position	338:19:44:01.9
OMS-4 ignition	Right engine bi-prop valve position	338:20:26:03.0
	Left engine bi-prop valve position	Not applicable
OMS-4 cutoff	Right engine bi-prop valve position	338:20:26:54.6
	Left engine bi-prop valve position	Not applicable
Flight control system checkout		
APU start	APU-1 GG chamber pressure	342:16:16:09.21
APU stop	APU-1 GG chamber pressure	342:16:24:54.14
OMS-5 ignition	Right engine bi-prop valve position	342:19:15:00.1
	Left engine bi-prop valve position	Not applicable

TABLE I.- STS-53 SEQUENCE OF EVENTS (Concluded)

Event	Description	Actual time, G.m.t.
OMS-5 cutoff	Right engine bi-prop valve position	342:19:15:11.3
	Left engine bi-prop valve position	Not applicable
Payload bay door close	PLBD left close 1	344:15:37:32
	PLBD right close 1	344:15:39:27
APU activation for entry	APU-1 GG chamber pressure	344:19:59:25.67
	APU-2 GG chamber pressure	344:19:38:21.53
	APU-3 GG chamber pressure	344:19:59:26.92
Deorbit maneuver ignition	Left engine bi-prop valve position	344:19:43:20.1
	Right engine bi-prop valve position	344:19:43:20.2
Deorbit maneuver cutoff	Left engine bi-prop valve position	344:19:45:50.7
	Right engine bi-prop valve position	344:19:45:50.8
Entry interface (400K)	Current orbital altitude above reference ellipsoid	344:20:12:12
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	344:20:37:35
Main landing gear contact	LH MLG tire pressure	344:20:43:47
	RH MLG tire pressure	344:20:43:47
Main landing gear weight on wheels	LH MLG weight on wheels	344:20:43:47
	RH MLG weight on wheels	344:20:43:47
Drag chute deploy	Drag chute deploy 1 CP Volts	344:20:44:00.2
Nose landing gear contact	NLG tire pressure	344:20:44:04
Nose landing gear weight on wheels	NLG WT on Wheels -1	344:20:44:04
Drag chute jettison	Drag chute jettison 1 CP Volts	344:20:44:24.9
Wheels stop	Velocity with respect to runway	344:20:45:08
APU deactivation	APU-1 GG chamber pressure	344:21:00:34.77
	APU-2 GG chamber pressure	344:21:00:35.65
	APU-3 GG chamber pressure	344:21:00:36.98

TABLE II.- STS-53 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-53-V-01	MADS Recorder Did Not Start When Commanded	337:13:08 G.m.t. (Prelaunch) IM 53RF01 INS-3-16-0622	The initial on command was satisfactory. However, the second command inadvertently commanded the recorder to Standby/Off 11 seconds later. Recorder would not restart. Suspect broken tape due to abnormal command sequence in one g. KSC: Remove and replace MADS recorder. No ferry impact.
STS-53-V-02	Speedbrake FCS Channel 3 Position Feedback Anomaly	337:13:34 G.m.t. IPR 56V-0002	The OI position feedback measurement (V57H0252A) indicated 45 degrees (0 volt position) for approximately 48 minutes, then returned to normal. No visibility of flight critical measurement (V57H0203C). Variable downlist established to monitor FCS measurement for possible recurrence. Anomaly did not recur during FCS checkout or entry. Insufficient flight data available to isolate anomaly to instrumentation only. KSC: Postflight troubleshooting plan developed.
STS-53-V-03	Supply Water Nozzle Temperature Drop	337:23:16 G.m.t. IPR 56V-0012 PR DDC-2-14-0055	The supply water dump nozzle temperature dropped approximately 50°F in one minute during dump and subsequently recovered. Suspect intermittent heater power loss. Recurrence of previous OV-103 anomaly (STS-39 UA). Line, valve, and nozzle removed and replaced after STS-48 due to valve leakage. No ferry impact. KSC: Postflight troubleshooting required. Continuity checks and wiggle tests of suspected areas.
STS-53-V-04	MPS Helium Regulators 3A and 1B Exceeded LCC Limits	Prelaunch IPR 53V-0184 IM 53RF05	Prior to bringing MPS helium tanks to flight pressure, both regulators exceeded the 785-psia LCC upper limit. Attributed to known characteristic of new -0006 regulator design. LCC and OMRSD to be reviewed. LCN 378 under review. No ferry impact. KSC: No action required.
STS-53-V-05	Supply Water Dump Valve Leakage.	339:10:14 G.m.t. IPR 56V-0014	Valve expelled (burped) some water following the second supply water dump. Changed procedure to bake out nozzle to 250°F following dumps, but anomaly recurred on all subsequent dumps. This phenomena has occurred previously on OV-103 (STS-48) and OV-104 (STS-44). Suspect ice formation in valve. No ferry impact. KSC: Inspect heater installation around dump valve. Possible drawing change required.
STS-53-V-06	Left RCS Oxidizer A Leg Regulator Leaked through Primary Stage	339:01:00 G.m.t. IM53RF02 IPR 56V-0003	When RCS tank isolation valves were closed after left OMS interconnect, the left RCS oxidizer ullage and tank pressures increased past the primary stage lockup pressures to the secondary lockup pressure of 261.5 psia. Leakage calculated to be 2500 scch (OMRS limit = 360). Approximately 300 scch was noted during prelaunch activities. Suspect particulate contamination in poppet area. KSC: Normal OMRSD turnaround activities. No ferry impact.
STS-53-V-07	Camera C Failed.	339:10:47 G.m.t.	Crew reported that CCTV camera C video consisted of only bright-colored lines when powered up. KSC: Remove camera and ship to JSC.
STS-53-V-08	TAGS Jam (GFE)	341:09:24 G.m.t. COM 3-16-0209	TAGS jammed on first page of transmission. Crew reported booster roller was stopped. KSC: Removed TAGS at Dryden and shipped to JSC.

TABLE II.- STS-53 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-53-V-09	RCS Thruster F1L Oxidizer Leak During Entry	344:19:55 G.m.t. IM 53RF03 IPR 56V-0005	RCS thruster F1L began leaking oxidizer following the forward RCS dump burn. Ferry flight impact. Drain manifold and apply 20 psig nitrogen pad pressure. Manifold ISO VLV 1 (OX and FUEL) were the only ones closed. KSC:
STS-53-V-10	PPO2 Sensor C Erratic	344:20:12 G.m.t. IM 53RF04 IPR 56V-0013	PPO2 sensor C experienced erratic output. Shifts noted of up to 1.2 psi. New style sensor. Postlanding inspection showed sensor to be loose in amplifier. KSC: Sensor removed at Dryden for shipment to vendor. KSC troubleshooting also required.
STS-53-V-11	WSB 1B Steam Vent Temperature Erratic	344:18:47 G.m.t.	About 2 1/2 hours after WSB 1 heater activation for entry, the WSB 1B steam vent temperature became erratic and fell below the 130°F WSB Ready temperature about 1 hour later. Switched to A controller and heater recovered. Following deorbit maneuver, switched back to B controller and heaters worked, although still erratically. Troubleshooting should include 4 hours on B controller with high data rate, and 4 hours of A controller with high data rate.
STS-53-V-12	Poor Quality Audio on A/G	344:17:10 G.m.t.	During deorbit preparation, the crewman using the MS ATU and hand-held microphone was low in volume with a buzzing noise. Postflight troubleshooting in progress.

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this STS-53 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.

AFGSS	Aft Fuselage Gas Sampling System
APU	auxiliary power unit
ASA	aerosurface actuator
ATCS	Active thermal control system
BET	bending effects temperature
BLAST	Battlefield Laser Acquisition Sensor Test
BSM	booster separation motor
CCTV	closed circuit television
CDTR	cassette data tape recorder
CLOUDS	Clouds Logic to Optimize Use of Defense Systems-1A
CREAM	Cosmic Radiation Effects and Activation Monitor
CRYOHP	Cryogenic Heat Pipe Experiment
D & C	Displays and Controls
DFRF	Dryden Flight Research Facility
DMHS	dome-mounted heat shield
DOD-1	Department of Defense payload
DSO	Detailed Supplementary Objective
DTO	Development Test Objective
ΔV	differential velocity
EAFB	Edwards Air Force Base
EO	ET/Orbiter
EPDC	electrical power distribution and control subsystem
ET	External Tank
EVA	extravehicular activity
FARE	Fluids Acquisition and Resupply Experiment
FCS	flight control system
FDA	fault detection and annunciation subsystem
FES	flash evaporator system
FM	frequency modulation
GCD	gas control decoder
GCP	Glow Experiment/Cryogenic Heat Pipe Experiment Payload
GFE	Government furnished equipment
GLO	Glow Experiment
G.m.t.	Greenwich mean time
GUCP	ground umbilical carrier plate
HDP	hold down post
HERCULES	Hand-Held, Earth-Oriented, Real-Time, Cooperative, User-Friendly, Location-Targeting and Environmental System
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
IAPU	improved auxiliary power unit
ICD	interface control document
IFM	in-flight maintenance
IMU	inertial measurement unit
Isp	specific impulse

KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LESC	Lockheed Engineering and Sciences Company
LH_2	liquid hydrogen
LO_2	liquid oxygen
LWT	lightweight
MADS	modular auxiliary data system
MECO	main engine cutoff
MET	mission elapsed time
MIS	Microcapsules in Space
MPS	main propulsion system
NPSP	net positive suction pressure
OAFGSS	Orbiter Aft Fuselage Gas Sampler System
ODERACS	Orbital Debris Radar Calibration Spheres
OI	operational Instrumentation Subsystem
OMDP	Orbiter Maintenance Down Period
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPB	oxidizer preburner
OPOV	oxidizer preburner oxidizer valve
PADM	portable audio data modem
PAL	protuberance air load
PGSC	payload
PMBT	propellant mean bulk temperature
PRSD	power reactant storage and distribution
PPO2	partial pressure oxygen
RCC	reinforced carbon carbon
RCS	reaction control subsystem
RME	Radiation Monitoring Experiment
rpm	revolutions per minute
RSRM	Redesigned Solid Rocket Motor
RTV	room temperature vulcanizing
S&A	safe and arm
SLF	Shuttle Landing Facility
S/N	serial number
SRB	Solid Rocket Booster
SRSS	Shuttle Range Safety System
SSME	Space Shuttle main engine
STI	Shuttle thermal imager
STL	Space Tissue Loss
TAGS	text and graphics system
TCS	thermal control system
TMBU	table maintenance block update
TPCE	Tank Pressure Control Experiment
TPS	thermal protection system/subsystem
UHF	ultrahigh frequency
USA	U. S. Army
USAF	U. S. Air Force
USMC	U. S. Marine Corps
USN	U. S. Navy
V	volt
VFT	Visual Function Tester
WSB	water spray boiler

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SD24/D. A. Rushing
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