NASA-TM-109867

NSTS-08287

NASA
N-16-TM
15683

STS-58 SPACE SHUTTLE MISSION REPORT

(NASA-TM-109867) STS-58 SPACE SHUTTLE MISSION REPORT (Lockheed Engineering and Sciences Co.) 40 p

N94-35251

Unclas

G3/16 0015683

JANUARY 1994

NASA
National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

NSTS-08287

STS-58

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke, Jr.
LESC/Flight Evaluation and
Engineering Office

Approved by

E. Michael Engle
STS-58 Lead Mission Evaluation Room Manager

David W. Camp
Manager, Flight Engineering Office

D. M. Germany
Manager, Orbiter and GFE Projects

Brewster H. Shaw
Director, Space Shuttle Operations

Prepared by
Lockheed Engineering and Sciences Company
for
Flight Engineering Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

January 1994

STS-58 Table of Contents

STS-58 Table of Contents (Concluded)

List of Tables

Appendixes

INTRODUCTION

The STS-58 Space Shuttle Program Mission Report provides a summary of the Payload activities as well as the Orbiter, External Tank (ET), Solid Rocket Booster (SRB) and Redesigned Solid Rocket Motor (RSRM), and the Space Shuttle main engine (SSME) subsystems performance during the fifty-eighth mission of the Space Shuttle Program, and the fifteenth flight of the Orbiter vehicle Columbia (OV-102). In addition to the Orbiter, the flight vehicle consisted of an ET (ET-57); three SSMEs which were designated as serial number 2024, 2109, and 2018 in positions 1, 2, and 3, respectively; and two SRBs which were designated BI-061. The lightweight RSRMs that were installed in each SRB were designated as 360L034A (lightweight) for the left SRB and 360W034B (welterweight) for the right SRB.

The STS-58 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirement as documented in NSTS 07700, Volume VIII, Appendix E. That document states that each major organizational element supporting the Program will report the results of its hardware evaluation and mission performance plus identify all related in-flight anomalies.

The primary objective of this mission was the successful performance of the operations of the Spacelab Life Sciences (SLS) -2 payload. The secondary objective of this flight was to perform the operations of the Shuttle Amateur Radio Experiment-II (SAREX-II) payload.

The sequence of events for the STS-58 mission is shown in Table I, the baselined Orbiter and GFE Projects in-flight anomalies are shown in Table II, and the official Marshall Space Flight Center (MSFC) In-Flight Anomaly List is shown in Table III. Appendix A lists the sources of data, both formal and informal, that were used in the preparation of this document. Appendix B provides the definitions of acronyms and abbreviations used in this document. All times given in this report are in Greenwich mean time (G.m.t.) as well as mission elapsed time (MET) where applicable.

The STS-58 mission was planned as a 14-day mission with two contingency days using the Extended Duration Orbiter (EDO) pallet for extra consumables. Fourteen major experiments comprised the SLS-2 payload operations conducted by seven crewmembers.

The crew for this fifty-eighth flight of the Space Shuttle Program was John E. Blaha, Col., USAF, Commander; Richard A. Searfoss, Lt. Col., USAF, Pilot; M. Rhea Seddon, M.D., Civilian, Payload Commander and Mission Specialist 1; William S. McArthur, Jr., Lt. Col., USA, Mission Specialist 2; David A. Wolf, M.D., Civilian, Mission Specialist 3; Shannon W. Lucid, Ph.D., Civilian, Mission Specialist 4; and Martin J. Fettman, D.V.M., Ph.D., Civilian, Payload Specialist. STS-58 was the fourth space flight for the Commander and Mission Specialist 4; the third space flight for Mission Specialist 1; and the first space flight for the Pilot, Mission Specialist 2, Mission Specialist 3, and the Payload Specialist.

MISSION SUMMARY

The countdown for the October 14, 1993, launch of STS-58, the second Spacelab mission that was dedicated to life sciences research, proceeded nominally up to the T-9 minute hold. The T-9 minute hold was lengthened to 2 hours because of unacceptable weather at the launch site. The weather became acceptable and the countdown was resumed for a launch at 12:53:00 p.m. e.d.t.; however, the countdown was stopped at T-31 seconds because of a Range Safety problem. Since the LO_2 drainback had begun at the time of the hold, the hold was limited to 4 minutes 51 seconds from the hold point. Range Safety was unable to correct the problem in that period of time, and the launch was scrubbed. The launch was rescheduled for 10:53 a.m. e.d.t. on October 15, 1993.

A problem was noted during the countdown for the first launch attempt, after supply tank A was drained and depressurized, when the supply water tank A quantity began increasing at a faster rate than should have occurred based on fuel cell water production. After the scrub, compressibility tests of supply water tank A and the galley showed that there was no gas in tank A, but apparently air had entered the galley hot water tank during the routine prelaunch water tank A depressurization and caused water to flow from the galley water supply into supply water tank A. The galley was isolated from the supply water for subsequent launch attempts to preclude this condition from recurring.

The second attempt to launch STS-58 occurred on October 15, 1993, but was scrubbed because the Orbiter S-band transponder 2 failed, and loss of this S-band transponder was a Launch Commit Criteria (LCC) violation. Also, it is unlikely that the launch would have occurred because of the unacceptable weather conditions at the launch site. As a result, an extended scrub turnaround was initiated to replace the S-band transponder and service the Spacelab experiments. The launch was rescheduled for October 18, 1993.

During the countdown for the third launch attempt, a 10-second hold was called at T-5 minutes because of an intruder aircraft in the Eastern Test Range. The countdown was resumed, and the STS-58 vehicle was launched successfully on a 39-degree inclination from launch complex 39B at 291:14:53:10.009 G.m.t. (10:53 a.m. e.d.t.) on October 18, 1993. All Orbiter subsystems operated satisfactorily throughout the ascent. At the completion of the OMS-2 maneuver, the Orbiter was in a 155 by 151 nmi. orbit.

Video tapes from three cameras monitoring the launch and the ascent phase showed a single white piece of debris near SSME 1 about 45 seconds after liftoff. Film analysis also showed a flexible, white object exiting the area between SSME 1 and 3 at the same time. The object fell aft into the plume and a flash in the plume was noted about 1 second after the object was sighted. Estimates of the object's size ranged from 14 by 15 inches to 26 by 11 inches. Analysis indicated that the object was probably a piece of the dome-mounted heat shield (DMHS) closeout blanket. This conclusion is based on past history of DMHS blanket damage and the object's apparent size, shape, color, and area of origin. A postlanding inspection showed portions of the DMHS around SSME 2 and 3 were missing.

A preliminary analysis of the main propulsion system (MPS) data from ascent showed that the SSME 1 GH_2 flow control valve exhibited a slow response time

(0.4 to 0.6 second vs. specification requirement of 0.3-second maximum). Also, the pressure decay after valve opening was not a step function as expected. The most probable cause was contamination in the poppet assembly, similar to the occurrence on this vehicle during the STS-28 mission. This condition did not impact tank repressurization.

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 3-g throttling was 452.3 seconds as compared to an MPS tag value of 452.96 seconds.

The orbital maneuvering subsystem (OMS) -3 orbit adjust maneuver was performed at 296:21:44:10 G.m.t. (05:06:21:00 MET) using the right OMS engine only. The firing lasted for 19.1 seconds, and the differential velocity was 14.8 ft/sec. All firing and subsystem parameters were nominal.

The flight control system (FCS) checkout was performed satisfactorily at 304:12:46:38.22 G.m.t (12:21:53:28.21 MET). Auxiliary power unit (APU) 3 was operated for 5 minutes 48.71 seconds during the FCS checkout, and all APU and FCS parameters were nominal.

The RCS hot-fire was performed at 304:13:43:00 G.m.t. (12:22:49:50 MET). All thrusters operated satisfactorily.

The crew completed all stowage requirements and prepared the vehicle for entry and landing. The payload bay doors were closed and latched by 305:11:23:46 G.m.t. (13:20:30:36 MET). The deorbit maneuver was performed at 305:14:05:30 G.m.t. (13:23:12:20 MET). The maneuver was 160.6 seconds in duration and the ΔV was 266.7 ft/sec.

Entry interface occurred at 305:14:34:23 G.m.t. (13:23:41:13 MET). DTO 250 - Forward RCS Test-Control Surface Effects - was successfully performed with the one planned programmed test input (PTI) completed between Mach 4.0 and Mach 2.6 during entry.

Main landing gear touchdown occurred on concrete runway 22 at Edwards Air Force Base at 305:15:05:42 G.m.t. (14:00:12:32 MET) on November 1, 1993. The Orbiter drag chute was deployed satisfactorily at 305:15:05:51 G.m.t., and nose landing gear touchdown occurred 3 seconds after drag chute deployment. The drag chute was jettisoned at 305:15:06:27 G.m.t. with wheels stop occurring at 305:15:06:42 G.m.t. The flight duration was 14 days 0 hours 12 minutes 32 seconds. All three APUs were powered down by 305:15:28:11 G.m.t.

PAYLOADS

The primary goal of the Spacelab Life Sciences-2 (SLS-2) mission was to conduct experiments in a variety of disciplines addressing important biomedical questions related to physiological responses to microgravity and the subsequent re-adaptation to gravity. The SLS-2 payload consisted of 14 experiments. Eight of the experiments used the astronaut crew as subjects and six used rats as subjects.

In addition to the 14 SLS-2 experiments, the payload included four middeck experiments. These were the Orbital Acceleration Research Experiment (OARE), the SAREX, the Inter Mars Tissue Equivalent Proportional Counter, and the Urine Monitoring System (UMS).

SPACELAB LIFE SCIENCES-2 EXPERIMENTS

The Spacelab Life Sciences-2 experiments were focused in four major areas: cardiovascular, regulatory, neurovestibular, and musculoskeletal systems. The results of the experiments are discussed in the following paragraphs.

Cardiovascular/Cardiopulmonary System

The three cardiovascular/cardiopulmonary system experiments were the In-flight Study of Cardiovascular Deconditioning (Experiment 066), Cardiovascular Adaptation to Zero Gravity (Experiment 294), and Pulmonary Function During Weightlessness (Experiment 198).

The cardiovascular experiments began on flight day 1 with central venous pressure measurements being obtained on the two crewmembers with the catheters inserted. Crewmembers participated in bicycle ergometer exercises. Heart rate, blood pressure, and cardiac output were determined for the payload crew member. All of the measurements scheduled for flight days 2, 4, 8, 12, and 14 were completed as planned.

Echocardiograms were also made on the crewmembers on flight days 1, 2, 8, and 12 of the mission. These images were accompanied by electrocardiograms that were used to record cardiac rhythm and electrical activity.

Pulmonary function tests were completed throughout the flight, although this experiment was to be utilized as a reserve activity. The crewmembers were able to accomplish extensive pulmonary function tests as additional science activity.

Neurovestibular System

A study of the human vestibular adaptation to weightlessness and the basis of space motion sickness was performed using a complement of experiments. The two experiments in the scientific discipline were a Study of the Effects of Space Travel on Mammalian Gravity Receptors (Experiment 238), and Vestibular Experiments in Spacelab (Experiment 072). All hardware associated with these experiments performed well. These experiments were comprised of the rotating dome, drop experiment, rotating chair, awareness of position, head movement and comparison test, and the head movement and symptom monitoring. These experiments required the crewmembers to wear the accelerometer recording unit (ARU) to record their head movements throughout the day and to record any symptoms in the daily log.

The rotating chair experiment was performed on flight days 4 and 10 and was completed. Drop data were also collected on flight days 5 and 11 as planned plus two additional subjects were tested on flight day 11. In addition, valuable ARU data were collected periodically throughout the flight by two of the crewmembers.

The rotating dome experiment was performed on flight days 2, 8, and 11 with all subjects completing the experiment. The Astronaut Science Advisor (ASA) was a computer-based intelligent assistant that was designed to help the astronauts work more efficiently and improve the quality of space science. The ASA was used to support the rotating dome experiment, and the program performed satisfactorily.

Regulatory Physiology

Investigations of regulatory physiology in space included studies of both the renal/endocrine and hematological systems. The experiments flown on SLS-2 in this discipline were the Fluid-Electrolyte Regulation During Spaceflight (Experiment 192), Regulation of Blood Volume During Spaceflight (Experiment 141), Regulation of Erythropoiesis in Rats During Space Flight (Experiment 012), and Influence of Spaceflight on Erythrokinetics in Man (Experiment 261).

Blood samples, urine samples, and saliva samples were collected on all crewmembers. These samples will be analyzed postflight for parameters that indicate changes in fluid, electrolyte, renal, and circulatory status of humans exposed to spaceflight. The blood samples were centrifuged in the rack-mounted centrifuge prior to refrigeration in the Life Science Laboratory Equipment (LSLE) refrigerator/freezers. The crewmember metabolic activities were carried out during the crew's postsleep periods on flight days 1-4, 6, 8, and 12-14 and were completed. The Iron Uptake and Hematology Experiment (Experiment 261) and Renal Function and Total Body Water Experiment (Experiment 192) were both supported by the activities performed for this discipline.

Musculoskeletal System

In microgravity, the body's bones and muscles are not used as extensively as on Earth. As a result, researchers have noted a decrease in the mass of both during spaceflight. The five experiments that were conducted in this discipline were Protein Metabolism During Spaceflight (Experiment 120); Effects of Zero Gravity on the Functional and Biochemical Properties of Anti-gravity Skeletal Muscles (Experiment 127); Effects of Microgravity on the Electron Microscopy Histochemistry and Protease Activities of Rat Hindlimb Muscles (Experiment 303); Pathophysiology of Mineral Loss During Spaceflight (Experiment 305); and Bone, Calcium and Spaceflight (Experiment 194).

The crewmembers were administered dual-stable isotopes of calcium, one orally and one intravenously throughout the flight in support of the Pathophysiology of Mineral Loss During Spaceflight experiment. Glycine tracers were also injected during the flight to support the Protein Metabolism During Spaceflight experiment. Urine, saliva, and blood samples were collected for postflight evaluation in conjunction with the Protein Metabolism experiment and Pathophysiology of Mineral Loss experiment.

The Effects of Zero Gravity on the Functional and Biochemical Properties of Skeletal Muscles (in rats) experiment was supported by the rodent dissection which achieved a space first. The rodent waste trays also provided data for the Bone, Calcium and Spaceflight experiment.

ORBITAL ACCELERATION RESEARCH EXPERIMENT

The OARE was performed successfully with all planned Orbiter operations in support of the OARE being completed. Included in the Orbiter operations were three sets of 360° vehicle rotations about each of the three body axes, a 60-minute maximum drag attitude test, and a 25-minute pitch-down drag test. In addition, the Orbiter was placed in the STS-74 United States Microgravity Laboratory (USML) -2 attitude for 15 hours to acquire OARE acceleration data to determine whether this is the best attitude for the USML-2 microgravity science.

The OARE acquired data throughout the orbital and entry phases. The raw sensor data were recorded on the payload recorder and dumped periodically to the ground. However, on flight day 10, the recorder failed. The loss of the recorder did not seriously impact the OARE, because real-time processed data were stored in the OARE's solid-state memory throughout the mission.

Preliminary reviews of the dumped data indicate nominal OARE operation except for erratic Z-axis data when the OARE was in its scale factor calibration mode. This condition is not expected to impact the final data processing because good calibration data can be obtained as a result of the 360° vehicle rotations, which were performed to obtain data for calculating the Orbiter's actual center of gravity as well as provide a backup to the OARE's self calibration.

SHUTTLE AMATEUR RADIO EXPERIMENT

The SAREX equipment operated very well throughout the mission. The SAREX payload operations were highly successful with a total of 17 school contacts completed. Sixteen United States schools had direct contacts with the Shuttle crew using SAREX. A bridge that used an amateur radio station in Australia was used for one contact with a school in France. Two school backup passes were required, one for a United States school and a second for the French school. In addition, a contact was arranged with the Russian Space Station MIR during the mission. The SAREX packet mode was also used very successfully with ground stations reporting several hundred contacts.

URINE MONITORING SYSTEM

The UMS operated nominally in the collection, volume measurement, and sampling of individual micturations in zero gravity.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTER

All SRB systems performed nominally with the exception of right-hand SRB main parachute 2. The SRB prelaunch countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specification Document (OMRSD) violations occurred.

Power-up and operation of all case, igniter, and field joint heaters was accomplished routinely. For the STS-58 mission, the low-pressure 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. At T-15 minutes, the purge was changed to high pressure to inert the SRB aft skirt.

Both SRBs were successfully separated from the ET at T + 123.8 seconds, and visual sightings in the recovery area indicated that the deceleration systems performed acceptably. Analysis of flight data indicates that the right-hand SRB main parachute 2 lagged into second stage. The parachute inflated initially but collapsed late in the first stage of inflation and remained collapsed through the first disreefing stage. The parachute began inflating shortly after the first disreef stage and was fully inflated prior to the second disreef. Right-hand main parachutes 1 and 3 remained fully inflated throughout the descent period. Both SRBs were recovered and returned to KSC for disassembly and refurbishment.

REDESIGNED SOLID ROCKET MOTOR

All RSRM temperatures were maintained within acceptable limits throughout the countdown. The RSRM propellant mean bulk temperature (PMBT) was 80°F at liftoff. No RSRM LCC or OMRSD violations occurred.

The field joint heaters operated for 11 hours 36 minutes during the launch countdown. The total activation time, which includes the scrubbed launch attempts, was 36 hours 53 minutes. Power was applied to the heating element an average of 19 percent of the time to keep the field joints within their normal operating temperature range.

Igniter joint heaters operated for 18 hours 11 minutes. The total activation time (including the scrubbed launch attempts) was 57 hours 3 minutes. Power was applied to the igniter heating elements an average of 38 percent of the time to keep the igniter joints within their normal operating temperature range.

The aft skirt gaseous nitrogen (GN_2) purge was operated for a total of 2 hours 36 minutes. The total activation time (including the scrubbed launch attempts) was 12 hours 38 minutes. To ensure all hazardous gases were removed from the aft skirt compartment, the purge was operated at high flow-rate from L-27 minutes to launch. As a result of the purge operation, the flex bearing mean bulk temperature was 81°F.

Data in the following table show that the performance of the RSRMs was well within the allowable performance envelopes and specification limits, and was typical of the performance observed on previous flights.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 80°F		Right motor, 80°F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.92	65.60	65.92	66.26
I-60, 10^6 lbf-sec	175.58	175.04	175.59	175.98
I-AT, 10^6 lbf-sec	296.83	295.10	296.58	296.30
Vacuum Isp, lbf-sec/lbm	268.60	267.10	268.60	266.30
Burn rate, in/sec @ 60°F at 625 psia	0.3672	0.3684	0.3674	0.3699
Burn rate, in/sec @ 66°F at 625 psia	0.3725	0.3737	0.3727	0.3740
Event times, seconds				
Ignition interval	0.232	N/A	0.232	N/A
Web time[a]	109.02	109.40	109.20	108.80
Separation cue, 50 psia	119.00	118.60	118.90	118.20
Action time	121.00	121.20	121.00	120.40
Separation command	123.90	123.70	123.90	123.70
PMBT, °F	80.00	80.00	80.00	80.00
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K), klbf-sec	2.80	3.10	2.80	3.00
Tailoff imbalance	Predicted		Actual	
Impulse differential,	N/A		501.4[b]	

Note:
[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).

Minor pressure fluctuations were recorded on each motor. Using the agreed-upon method of calculating the pressure blip magnitudes, the blip on the left RSRM was 8.0 psi at 67 seconds, and 11.7 psi at 71 seconds on the right RSRM. Both of these values are within the RSRM experience base.

EXTERNAL TANK

ET performance was excellent, and 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 ET LCC or OMRSD violations were identified.

Typical ice/frost formations were observed on the ET during the countdown. No ice or frost was observed on the acreage areas of the ET. However, normal quantities of ice or frost were present on the liquid oxygen (LO_2) and liquid hydrogen (LH_2) feedlines and on the pressurization brackets. These observations were acceptable per NSTS-08303.

During the first launch attempt, the Ice/Frost "Red Team" reported one anomalous thermal protection system (TPS) condition. Two cracks were observed in the TPS on the -Y ET/SRB attach strut (one approximately 7 inches by 0.125 inch and the other approximately 14 inches by 0.125 inch). There was no ice/frost at the cracks, no venting, and no offset, indicating no debonded area existed. No other anomalous TPS conditions were reported by the team.

Also during the first launch attempt, the ET intertank oxygen concentration exceeded the LCC limit of 200 ppm (for the time period from start of cryogenics load to T-31 seconds) during an unscheduled hold at T-31 seconds. Analysis indicates that air intrusion can be expected after intertank purge termination at T-75 seconds. For the second and third launch attempts, an LCC waiver/deviation was processed to terminate monitoring of the LCC limit at T-75 seconds instead of T-31 seconds.

The newly implemented intertank heater control gain setting and reduced initial temperature control setpoint used during loading operations continued to be successful in providing a smoother temperature performance for the purge system and more margin for the intertank purge Interface Control Document (ICD) maximum temperature limit.

The ET pressurization system functioned properly throughout engine start and flight. The minimum LO_2 ullage pressure experienced during the ullage pressure slump was 14.7 psid.

ET separation was confirmed following a nominal main engine cutoff (MECO). ET entry and breakup occurred as expected. The ET impact point was approximately 19 nmi. downrange of the preflight prediction, well within the predicted footprint.

During postflight review of photography taken from the Orbiter umbilical well, one ET in-flight anomaly was identified. An ET intertank acreage TPS divot (24 inches by 4 inches) was noted as was the loss of TPS on each jack pad close-out (approximately 25 percent) (Flight Problem STS-58-T-01). An investigation team has been formed to determine the cause and corrective action for the loss of TPS.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters were normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. All tanking and prelaunch preparations were completed nominally. All monitored LCC parameters, ignition confirmation limits, and mainstage redline margins were satisfactory. All ICD start and shutdown transient requirements were met. Engine performance was nominal and as predicted with engine cutoff times of 521.92, 522.04, and 522.16 seconds for SSMEs 1, 2, and 3, respectively, as referenced to the start command. The Isp was rated as 452.3 seconds based on trajectory data. Block II controller and software performance was satisfactory.

Flight data indicate that the SSME performance during mainstage, throttling, shutdown and propellant dump operations was normal. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within the specification throughout engine operation. SSME cutoff occurred at T + 515.56 seconds (referenced to liftoff), and there were no failures or significant SSME problems identified.

Spiking was observed on both the SSME 2 HPFTP 0-degree and 186-degree flight acceleration safety cut-off system (FASCOS) accelerometers. Spiking was also observed on the SSME 3 HPFTP 0-degree FASCOS accelerometer. The modular auxiliary data system (MADS) recorder data are being reviewed to determine the level of spiking, and postflight troubleshooting is in progress.

The SSME 1 main combustion chamber (MCC) pressure drifted during ascent, and a postflight inspection for any contamination/obstruction will be made. The SSME 1 MCC hot-gas injection pressure did not respond to the 3-g throttle. This condition is common and is believed to be caused by frozen moisture in the sense line. Likewise, the SSME 2 MCC hot-gas injection pressure drifted 290 seconds into ascent. This also is a common occurrence that is believed to be caused by frozen moisture in the sense line.

SHUTTLE RANGE SAFETY SYSTEM

Analysis of the flight data indicates nominal performance of the Shuttle Range Safety System (SRSS). The 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 successful launch 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 the ET was separated from the Orbiter.

There was one new experience base data point established during the second launch attempt. The left-hand SRSS A battery open-circuit voltage was 31.68 Vdc just prior to SRSS power-up. The previous low experience base value for this measurement was 31.84 Vdc established on STS-57. The OMRSD lower limit is 31.60 Vdc.

The ET SRSS signal strength violated the LCC lower limit during a rain storm on the second launch attempt. The LCC specifies a preplanned contingency procedure to use the ground support equipment (GSE) radio frequency (RF) signal source to verify proper flight hardware function. This procedure was performed and the signal strength increased to 4.9 Vdc for the duration that the GSE RF signal was applied. The Air Force Flight Control Officer was notified of the results and concurred with the NASA conclusion that this was not a launch constraint. The launch was later scrubbed during the T-9 minute hold because of a failure of Orbiter hardware.

ORBITER SUBSYSTEMS

Main Propulsion System

The overall performance of the MPS was as expected. LO_2 and LH_2 loadings were performed as planned with no stop-flows or reverts. No OMRSD or LCC violations were noted during the countdown.

Throughout the period of preflight operations, no violation of hazardous gas concentrations was detected. The maximum hydrogen concentration level in the Orbiter aft compartment, which occurred after start of fast-fill, was approximately 138 ppm, which compares favorably with previous data for this vehicle.

LH_2 loading operations were normal through chilldown, slow-fill, fast-fill, topping and replenish. Based on the analysis of loading system data, the LH_2 load at the end of replenish was 231,891 lbm. Compared to the inventory (predicted) load of 231,853 lbm, this assessment yields a difference of +0.02 percent, which is within the required MPS loading accuracy of ± 0.37 percent.

LO_2 loading operations were normal through chilldown, slow-fill, fast-fill, topping and replenish. Based on the analysis of loading system data, the LO_2 load at the end of replenish was 1,388,232 lbm. Compared to the inventory (predicted) load of 1,387,828 lbm, this assessment yields a difference of +0.03 percent, which is within the required MPS loading accuracy of ± 0.43 percent.

Ascent MPS performance appeared to be normal. Data indicate that the LO_2 and LH_2 pressurization systems performed as planned, and all net positive suction pressure (NPSP) requirements were met throughout the flight.

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 Isp determined for the time period between SRB separation and start of 3-g throttling was 452.3 seconds as compared to an MPS tag value of 452.96 seconds.

The LO_2 and LH_2 pressurization and feed systems performed nominally, with one exception, and satisfied all tank ullage pressure and SSME inlet NPSP requirements. The exception was the SSME 1 GH_2 flow control valve which exhibited a slow opening response time (0.4 to 0.6 second vs. specification requirement of 0.3-second maximum) (Flight Problem STS-58-V-04). This slow opening response occurred from 2 seconds after liftoff to 224 seconds after liftoff. The valve was sluggish for 49 of the 59 cycles in that time period. The pressure decay after valve opening was not a step function as expected. During postflight analysis, contamination was found in the poppet assembly, similar to the occurrence on STS-28 on this vehicle.

The helium mass decay was nominal; however, the pneumatic regulator outlet pressure decay was faster than on previous flights, although the decay was still within the system specification. This condition may have been caused by an individual component being out-of-specification in its leakage, and as a result, a decay test was performed postlanding. The postlanding decay test showed the same results as the on-orbit data. Troubleshooting showed that CV23 (the SSME 3 LH_2 prevalve 3-way solenoid valve) was leaking 38 scims from its vent port when the vent port was deenergized (closed). The allowable leakage is 7.4 scims; consequently, the CV23 valve will be replaced. The helium system performed nominally during entry with 55.5 lbm of helium used.

Review of the STS-58 umbilical well film showed that one piece of the LO_2 lightning strip was missing after ET separation (Flight Problem STS-58-V-10). This condition has been noted on previous flights. A fix is underway to better secure the lightning strips to the ET. No safety issue exists with the lightning strip coming off. Additionally, the thin flexible structure will not impede umbilical door closure should the strip become lodged in the umbilical cavity.

Reaction Control Subsystem

The RCS performed nominally in support of the mission as well as Development Test Objective (DTO) 250 - Forward RCS Flight Control Surfaces Test - during entry. A total of 3,674.2 lbm of RCS propellants was consumed during the mission in addition to the 5.57 percent of OMS propellants used during interconnect operations.

RCS performance on-orbit was satisfactory. Because of the cold attitude and the necessity to fire the forward RCS thrusters in support of DTO 250 during entry, a concern existed that the forward RCS propellant temperatures might go below the Shuttle Operational Data Book (SODB) constraint of 70°F. A re-evaluation of this constraint resulted in the constraint being lowered to 53°F during the flight, and this temperature was not exceeded during the flight. The lowest temperatures observed on the forward pod was 61°F for the oxidizer, and 63°F for the fuel.

Orbital Maneuvering Subsystem

The OMS performed nominally. The total firing time was 284.9 seconds for the left engine and 303.5 seconds for the right engine. A total of 12,142 lbm of propellants was consumed during the three OMS firings and the two periods of RCS interconnect operations. The following table provides details of each OMS firing.

OMS firing	Engine used	Time, G.m.t./MET	Firing duration, sec	ΔV ft/sec
2	Both	291:15:35:04.8 G.m.t. 00:00:41:54.8 MET	125.4	197.1
3	Right	296:21:44:10.0 G.m.t. 05:06:51:00.0 MET	14.8	19.1
Deorbit	Both	305:14:05:30.0 G.m.t. 13:23:12:20.0 MET	160.6	266.7

The left OMS engine chamber pressure transducer failed off-scale low at 291:14:53:06.6 G.m.t., which was approximately three seconds after main engine ignition for launch (Flight Problem STS-58-V-03). The loss of this measurement did not affect OMS engine operation during the OMS-2 and deorbit maneuvers. Postflight troubleshooting isolated the failure cause to the signal conditioner/amplifier for this measurement.

The gaging system performance in the oxidizer tanks was satisfactory; however, both forward fuel probes exhibited anomalous behavior similar to that observed on the three previous missions that this pod has flown.

The OMS aft-fuselage center-crossfeed oxidizer-line heater-controller A appeared to be cycling in a higher-than-expected control band. This condition has been observed on previous OV-102 flights and did not impact STS-58 operations.

Data from OV-102 flights since STS-28 show that the temperature control band is higher when the RCS is configured for straight-feed operations than when configured for OMS interconnect (i.e., propellant flowing through the OMS crossfeed lines to the RCS manifolds). Data from other vehicles do not show a control band shift when interconnect operations data are compared with straight-feed data. The STS-58 configuration was straight-feed until flight day 6, while the configuration for the previous two OV-102 flights was primarily interconnect. After reconfiguring to interconnect on flight day 6, the control band shifted down and was consistent with previous OV-102 flights using interconnect operations.

Power Reactant Storage and Distribution Subsystem

The 16-tank power reactant storage and distribution (PRSD) subsystem performed satisfactorily in providing 4,208 lb of oxygen and 530 lb of hydrogen for electrical power generation, and 209 lb of oxygen for crew breathing. The EDO cryogenics pallet was used for the second time in addition to the normal PRSD tanks to provide the cryogenics for this long-duration mission. The tanks at liftoff contained 5766 lbm of oxygen and 672 lbm of hydrogen, and 1349 lbm of oxygen and 142 lbm of hydrogen remained at landing.

Data were collected for the On-Orbit PRSD Cryogenic Hydrogen Boiloff DTO (413), and the analysis of those data is presented in the Development Test Objectives section of this report.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed satisfactorily throughout the 14-day mission. A total of 6,085 kilowatt hours (kWh) of electrical energy was generated at an average power level of 18.1 kW and load of 594 amperes. In generating this energy, 530 lb of hydrogen and 4,208 lb of oxygen were consumed. A total of 4,738 lb of water was produced by the fuel cells. Seven fuel cell purges were performed during the course of the mission. The actual fuel cell voltages at the end of the mission were as predicted for fuel cell 1 and 0.1 volt above the predicted level for fuel cells 2 and 3.

The fuel cell 2 oxygen flow meter failed off-scale low just as it had done on STS-55 (Flight Problem STS-55-V-05). This flow meter will be repaired when the fuel cell is removed from the vehicle for refurbishment or to correct a more significant failure.

Auxiliary Power Unit Subsystem

The countdown for the October 14, 1993, launch attempt was stopped after APU start at the T-31 second point, and as a result, the APUs were shut down after approximately 10 1/2 minutes of operation.

Following the October 18 launch, early activation of the APU tank/fuel line H_2O system heaters was required after ascent (about 25 minutes early) to avoid violating the fault detection and annunciation (FDA) lower limit of 48°F. This condition also occurred on system 1 on the previous flight of this vehicle. The heaters operated nominally following activation. An evaluation to determine the possibility of lowering the FDA limit is being made.

The following table shows the APU run time, fuel consumption, and total running time for the mission.

Flight Phase	APU 1 (S/N 409)		APU 2 (S/N 403)		APU 3 (S/N 408)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Oct 14 Scrub[b]	10:25	36	10:26	36	10:27	34
Ascent	22:14	62	22:30	61	22:21	60
FCS checkout					05:48	12
Entry[a]	66:42	138	87:39	188	66:43	131
Total[a,b]	88:56	200	110:09	249	94:52	203

Notes:
[a] APU's 1, 2, and 3 ran for 22 minutes, 26 seconds after landing (touchdown).
[b] Totals include ascent, FCS checkout, and entry.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler (WSB) subsystem performed satisfactorily throughout the STS-58 mission. No in-flight anomalies were noted in the review and evaluation of the data.

WSB data indicate localized boiling may have occurred in each of the WSB cores during the first launch attempt when the APU's ran for approximately 10 1/2 minutes before the launch was scrubbed. This condition raised a concern about the vent plugs being popped off prematurely, allowing water to be dumped overboard. Video, as well as a visual inspection, revealed that the vent plugs remained seated; therefore, no water was lost.

No water spray boiler freeze-ups were noted during ascent as spray cooling was initiated nominally. A total of 13 circulation pump runs were completed for thermal conditioning with only one accumulator recharge occurring (WSB 3).

The DTO 414 - APU Shutdown Test (Sequence A) - was performed following ascent and the results of that DTO are presented in the Development Test Objective section of this report.

Hydraulic system 3 was exercised for flight control system checkout and performed nominally. WSB cooling was not required because of the short run-time of the APU. WSB heater operation was nominal.

Hydraulics and WSB operation was nominal for entry with satisfactory lubrication (lube) oil cooling throughout entry and landing. Postlanding, a hydraulics load test was performed with satisfactory results.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem operated nominally throughout the mission.

During the scrub of the first launch attempt at 287:17:16 G.m.t., the ground power system failed to assume the electrical load from fuel cell 2 when transferring to ground power. A remote sense test, fuel cell backfeed test, and cycling of vehicle and ground power contacts were performed, after which power was successfully transferred. Power transfer was nominal during the second scrub. All ground elements of the power transfer system checked out satisfactorily. Tests are being performed to determine if the aft power controller assembly (APCA) -5 is at fault.

Environmental Control and Life Support System

The Environmental Control and Life Support System (ECLSS) performed nominally throughout the mission.

The active thermal control system (ATCS) performance was satisfactory during the mission. The ammonia boiler system secondary A controller was operated for the first time since it was installed during the Orbiter Maintenance Down Period (OMDP). The controller operated satisfactorily and controlled freon coolant loop (FCL) temperatures to 34°F.

A special cooling test to determine if the payload bay purge air could maintain vehicle cooling while the FCLs were in radiator flow was performed after landing. Normally the vehicle is dependent on the ground cooling unit which interfaces with the FCLs through the GSE heat exchanger. The test unexpectedly occurred when both the primary and backup ground cooling units failed for approximately three hours. The purge air was maintained at 70°F with a 460-ampere load on the Orbiter. The evaporator outlet temperature stabilized at 78°F and began to drop when the purge air temperature was decreased to 65°F after the first hour and then again to 60°F after the second hour. No temperature limits were exceeded in the crew cabin or the freon coolant loops.

The supply and waste water subsystem performed satisfactorily. Seven supply water dumps and seven waste water dumps were performed during the mission. The supply water dumps were performed through the nozzle at an average rate of 1.56 percent/minute (2.58 lb/min), and the waste water dumps were performed at an average rate of 1.87 percent/minute (3.08 lb/min). The supply water dump line temperature was maintained between 77 and 107°F with the operation of the line heater, and the waste water dump line temperature was maintained between 55 and 80°F while the vacuum vent line temperature was between 59 and 75°F.

Data from the first launch attempt showed that the supply water tank A quantity was increasing at a faster rate than should occur, based on fuel cell water production calculations (Flight Problem STS-58-V-02). The condition, while a nuisance, was considered acceptable for flight and the countdown continued.

After the scrub, the galley was isolated and tank A was pressurized, and there was no compression of the tank A bellows. However, when the galley isolation valve was opened, the bellows did compress. It was concluded that air had entered the galley, but that no air was in supply tank A. When the air entered the galley water tank, it forced water back into tank A, and this caused the faster increase discussed in the previous paragraph.

The scenario for air entering the galley began with the nitrogen pressure being removed from tank A when the quantity was low (approximately 5 percent). The at-rest position of the bellows is approximately 66 percent. With no resisting nitrogen pressure the bellows tend to expand to the at-rest position, which creates a negative pressure in the water side of the tank and in the galley. The galley has two solenoid valves which may act as relief valves under this condition, allowing air flow in while preventing water flow out. As a result, a decision was made to isolate the galley for launch.

After launch, an in-flight maintenance (IFM) procedure was uplinked to allow the crew to purge the trapped air from the galley. The galley chilled water was flushed at 291:16:10 G.m.t. (00:01:17 MET). The galley hot water flush per the IFM procedure was completed at approximately 292:23:00 G.m.t. (01:08:07 MET). The crew reported bubbles in the flow for the first 5 percent of the supply tank A quantity decrease. The crew also stated that there was no taste of gas in the water taken after the flush. Following the flush, the supply and waste water tanks were dumped. The crew was asked whether they noticed air in the hot water dispensed from the galley. The crew stated that they had not noticed any air, but that they were getting inaccurate hot-water volumes dispensed when volumes greater than 1.5 ounces were selected. As a result, the crew selected hot water dispenses in 1.5-ounce increments to preserve accuracy of data being collected for the fluid and electrolyte study.

Later in the flight, the crew reported observing air mixed in the galley hot water dispenses. The presence of air affected the accuracy of dispenses, and as a result, the crew switched to cold water dispenses and heated the water as required using the oven. The galley water heaters were turned off.

The waste collection system (WCS) performed adequately throughout the mission. Likewise, the urine monitoring system was used satisfactorily throughout the mission.

The crew reported a small amount of fluid leaking around the odor/bacteria filter cover seal on the WCS (Flight Problem STS-58-V-05) and provided downlink video of the leakage. This leak was observed by the crew on three earlier occasions and was wiped up each time. The crew also stated that the first time this leak was observed was prior to the galley hot-water flush IFM procedure being performed. Liquid carry-over from fan separator 1 to the odor/bacteria filter line was suspected as the cause of the leak. Fan separator 2 was started at 291:23:56:35 G.m.t. (02:09:03:25 MET) and nominal start-up currents were observed. The crew reported that no fluid was observed around the odor/bacteria filter cover. Subsequent start-ups of fan separator 1 showed no signs of back leakage through the fan separator 1 check valves. The crew also reported that flow through the urinal hose had not changed since the flight began, indicating that the filter was probably not saturated with liquid. An IFM procedure was uplinked to remove and inspect the odor/bacteria filter and the procedure was completed at 294:17:53 G.m.t. (03:03:00 MET). The crew reported finding the filter wet but not saturated. The O-ring at the base of the filter was inspected and found properly installed and intact. Prior to the initiation of the IFM procedure, fan separator 1 was powered on in an attempt to remove as much fluid from the filter as possible. After completion of the IFM procedure, fan separator 2 was powered up and remained on until the crew went to sleep about 9 hours later. No more fluid leakage was noted when the crew went to sleep. Beginning on flight day 3, fan separator 2 was used for WCS operations. UMS operations were conducted using the fan separator 2 contingency procedure which provided steps for the crew to manually activate and deactivate the WCS for UMS operations.

All atmospheric revitalization system components operated properly throughout the mission. The CO_2 partial pressure was maintained below 2.88 mm Hg. Cabin air temperature and relative humidity peaked at 81.3°F and 48 percent, respectively. Avionics bays 1, 2, and 3 air outlet temperatures peaked at 102.4°F, 103.7°F, and 87.5°F, respectively. Avionics bay 1, 2, and 3 water coldplate temperatures peaked at 88.5°F, 91.5°F, and 80.0°F, respectively.

The atmospheric revitalization pressure control system (ARPCS) performed normally in the Spacelab preactivation and postactivation time periods. The Spacelab pressure control system was used during all other on-orbit periods. The redundant component check of the Orbiter pressure control system was performed and normal system operation was indicated for both systems.

During the regenerative carbon dioxide removal system (RCRS) reconfiguration to the system 2 controller, the crew reported that the OPER light on panel M051F failed to illuminate. The illumination of the OPER light is a visual indication that the selected controller is operational. Downlinked data indicate that the RCRS was operating nominally. The crew performed a lamp test of the RCRS system 2 controller OPER light and the lamp failed to illuminate. The crew pushed the OPER lamp assembly fully in and the OPER light illuminated. All RCRS indicator lights operated nominally for the remainder of the mission.

Smoke Detection and Fire Suppression

The smoke detection system showed no indications of smoke generation during the flight. Use of the fire suppression system was not required.

Airlock Support System

Use of the airlock support components was not required because no extravehicular activity (EVA) was planned or performed. All airlock system parameters remained within normal ranges throughout the flight.

Avionics and Software Support Subsystems

The integrated guidance, navigation, and flight control subsystems performed satisfactorily. The subsystems were used to perform DTO 250 - Forward RCS Flight Test-Control Surface Effects, and the data are being analyzed.

The inertial measurement units (IMUs) performed nominally throughout the flight, and the ship set is considered acceptable for the next flight of this vehicle. Maximum alignment errors at liftoff were 25 arc seconds in the A and B axes, and 125 arc seconds in the C axis. While on orbit, the IMU in slot 1 was moded to standby in accordance with the planned Group B power down at 291:15:52 G.m.t. (00:00:59 MET). The unit was returned to operate at 305:09:42 G.m.t. (13:18:49 MET).

Also, at 295:03:07:55 G.m.t. (03:12:14:45 MET) multiplexer/demultiplexer (MDM) FF2 shut down due to an inadvertent switching of the power. This condition in turn caused the IMU in slot 2 to mode to standby. The MDM was reset and the IMU returned to operate, and subsequently was aligned with the IMU in slot 3 six minutes after the MDM shutdown. The condition did not impact subsequent flight operations.

Likewise, the star tracker performance was satisfactory. The data processing system (DPS) hardware and flight software performance was excellent with no anomalies identified.

The displays and controls subsystem, with the exception of the floodlights, operated satisfactorily. The aft port and either the forward port or aft starboard floodlights had anomalous data traces during payload bay door closure activities. The postflight inspections showed evidence of arcing in the forward port and aft port floodlights.

Communications and Tracking Subsystems

The communications and tracking subsystems performed nominally except for the problems and anomalies discussed in the following paragraphs.

The second attempt to launch the STS-58 flight occurred on October 15, 1993, but was scrubbed because the Orbiter S-band transponder 2 failed (Flight Problem STS-58-V-01), and loss of this S-band transponder was a LCC violation. As a result, a scrub turnaround was initiated to replace the S-band transponder, and the launch was rescheduled for October 18, 1993.

The crew reported hearing a beeping sound when using the Spacelab wireless crew communications system (WCCS) audio interface unit (AIU) -D in both the intercommunciation (ICOM) and air-to-ground (A/G) modes (Flight Problem STS-58-V-06). The beeping sound could not be reproduced while using the same crew remote unit (CRU) with another wall unit, and battery replacement on the

CRUs communicating with AIU-D did not clear the problem. The crew also stated that the beeping tone did not sound like the battery-low warning. As a result of the AIU-D anomaly, a communication system reconfiguration procedure was performed. This procedure connected the Orbiter WCCS AIU-C on the middeck to the Pilot audio terminal unit (ATU) on the flight deck and enabled the Spacelab crew to utilize AIU-C and deactivate AIU-D.

Throughout most of the flight, frequency modulation (FM)transmitter 1 was used but showed a steady decrease in power output from 15 watts to 13.5 watts, which was still within specification limits. During the Operations Recorder dump on flight day 13 at 304:21:10:32 G.m.t. (13:06:16:52 MET), the output rapidly decayed to 6.5 watts, which is below the specification limit of 10 watts (Flight Problem STS-58-V-08). As a result, FM transmitter 2 was selected for the remainder of the flight. Postflight inspection verified that the transmitter had failed and it was replaced.

Performance of the thermal impulse printer system (TIPS) was nominal with the exception of a paper jam. The crew reported that the paper-fault indicator was illuminated and that paper had fed back on itself. It is believed that the paper was slightly misaligned. The crew was able to quickly clear the condition and the unit continued to operate nominally. A total of 362 pages were uplinked this mission via the Ku-band interface. The audio interface of the TIPS was not used this mission.

At 301:02:02 G.m.t. (09:11:09 MET), the payload recorder was recording on track 9 in the Serial Record B mode and the recorder percent-tape indicator read 96.77 percent. When the recorder reached the end-of-tape (EOT) and was performing its normal turnaround, the percent-tape reading went to 0 percent, the beginning-of-tape (BOT) and EOT indications were both present simultaneously in the data, and the track identification went to track 14 instead of track 10 (Flight Problem STS-58-V-07). This is a strong indication that the recording tape had broken in the payload recorder. The mission impact was the loss of the ability to record the raw OARE data; however, semi-processed OARE data were being saved in the OARE memory.

Structures and Mechanical Subsystems

All structural and mechanical subsystems performed satisfactorily with no problems or anomalies identified. The landing and braking data are presented in the following table.

The drag chute appeared to have functioned properly. All drag chute hardware was recovered and showed no signs of abnormal operation. Six damage sites were observed on the vertical tail stinger drain tile, and these were probably caused by the chute riser lines during deployment.

LANDING AND BRAKING PARAMETERS

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	3380	198.7	~2.0	n/a
Nose gear touchdown	6948	155.5	n/a	3.16

Braking initiation speed	129.9	knots (keas)
Brake-on time	42.8	seconds (sustained)
Rollout distance	9,640	feet
Rollout time	60.9	seconds
Runway	22	(concrete) at EAFB
Orbiter weight at landing	229,116	lb (landing estimate)

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	1176	Left-hand outboard	26.52
Left-hand inboard 3	1128	Left-hand inboard	27.29
Left-hand outboard 2	1092	Right-hand inboard	14.04
Left-hand outboard 4	1104	Right-hand outboard	16.26
Right-hand inboard 1	708		
Right-hand inboard 3	672		
Right-hand outboard 2	756		
Right-hand outboard 4	768		

Aerodynamics, Heating, and Thermal Interfaces

Ascent aerodynamics were nominal with no unexpected conditions noted. Two aerodynamic DTOs were performed (DTO-236 - Ascent Wing Aerodynamic Distributed Loads Verification on OV-102, and DTO-253 - Elevon Deflection Load Sensitivity Verification), and the preliminary results are presented in the Development Test Objectives section of this report.

Entry aerodynamics were nominal. Analysis showed that control surface positions and angle-of-attack compared well with preflight predictions. DTO 250 - Forward RCS Flight Test - was performed satisfactorily during entry at Mach 4 with no problems noted. Preliminary analysis of vehicle response compares well with the STS-45 flight when the same DTO was performed.

Data reflect nominal aerodynamic and plume heating during ascent and entry.

Thermal Control Subsystem

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

The OMS aft fuselage center crossfeed oxidizer line heater controller A appeared to be operating in a higher control band than expected. This condition has been observed on previous OV-102 flights and did not impact STS-58 operations.

Aerothermodynamics

Local heating during entry was nominal, although a leakage flow path may have existed around the right outboard main landing gear door. Some over-heating was noted in a 5-inch long by 0.6-inch deep area of tile damage on the lower midfuselage.

Acreage heating was within limits and the tempe ature rise was within the experience data base. TPS damage was also within the experience base.

Thermal Protection Subsystem

The TPS performed satisfactorily. Structural temperature response data show that the entry heating was average, and the TPS performed satisfactorily and prevented heating damage effectively throughout ascent and entry. The overall boundary layer transition from laminar flow to turbulent flow occurred 1150 seconds after entry interface on the forward centerline of the vehicle, and 1145 seconds after entry interface on the aft centerline of the vehicle.

Videos from three cameras monitoring the launch and the ascent phase showed a single white piece of debris near SSME 1 about 45 seconds after liftoff (Flight Problem STS-58-V-09). Film analysis showed a flexible, white object exiting the area between SSME 1 and 3 at the same time. The object fell aft into the plume and a flash in the plume was noted about 1 second after the object was sighted. Estimates of the object's size ranged from 14 by 15 inches to 26 by 11 inches. Analysis indicated that the object was probably a piece of the DMHS closeout blanket, based on past history of DMHS blanket damage and the object's apparent size, shape, color, and area of origin. A postlanding inspection showed the SSME 3 DMHS blanket was badly torn from 8 o'clock to 10 o'clock. Much of the blankets outer cover and batting was missing, but the inner fabric was intact. The SSME 2 DMHS blanket was also torn at the 3 o'clock positions, but its outer cover was still intact.

Overall debris damage was above average with the Orbiter TPS sustaining a total of 155 hits of which 26 had a major dimension of one inch or greater. Of the total hits, 78 were on the lower surface, 43 were on the upper surface, 19 were on the right side, 3 were on the left side, and 12 were on the OMS pods. No TPS damage was attributed to material from the wheels, tires, or brakes.

One large damage site (5 inches by 2 inches by 0.6 inch deep) was located just forward and outboard of the right-hand ET door. The tile was fractured through to the strain isolation pad (SIP). The exposed tile substrate was melted, and the tile coating was curled and peeled at the aft portion of the damage area. The tile was non-destructively removed from the vehicle for analysis. Inspection of the removed tile indicated that a small section of the SIP, approximately one-half inch in diameter, was yellowed because of over-temperature conditions at that location. The discoloration was located below the molten portion of the tile. The aft edge of the SIP was also discolored, indicating that the damage allowed flow to penetrate beyond the gap filler and continue between the SIP and the filler bar. A slightly orange-red discoloration was noted on a portion of the unmelted exposed tile substrate.

The primary nose landing gear door (NLGD) thermal barrier was in good condition overall, with several frayed patches noted. A large portion (6 inch by 4 inch) of the inboard aft corner tile on the right-hand NLGD was broken off, and the tile, although fractured, was still intact. Similar damage to this tile has occurred on past missions.

All three ET/Orbiter separation devices appeared to have functioned properly. The ET/Orbiter umbilical ordnance retention shutters were closed properly, and no flight hardware was found on the runway below the ET doors.

All Orbiter windows exhibited typical hazing with window 3 having the most haze.

The thermal imager was used to measure surface temperatures on several areas of the Orbiter. At 20 minutes after landing, the Orbiter nosecap reusable carbon-carbon (RCC) temperature was 170°F, the right wing leading edge RCC panel 9 temperature was 88°F, and the panel 17 temperature was 78°F.

FLIGHT CREW EQUIPMENT/GOVERNMENT FURNISHED EQUIPMENT

The flight crew equipment and Government furnished equipment (GFE) performed nominally throughout the mission with no problems reported.

CARGO INTEGRATION

All cargo integration hardware operated satisfactorily throughout the mission.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

A total of 16 development test objectives (DTOs) and 19 detailed supplementary objectives (DSOs) was assigned to the STS-58 mission. Preliminary analysis indicates that data were collected for all DTOs and DSOs.

DEVELOPMENT TEST OBJECTIVES

The preliminary results of the 16 DTOs are presented in the following subparagraphs.

DTO 236 - Ascent Wing Aerodynamic Distributed Loads Verification on OV-102 - STS-58 was the last in a series of eight OV-102 flights on which DTO 236 was performed. Wing loads data (external pressures and internal strains) were collected during ascent. The trajectory flown included a negatively biased angle-of-attack profile during the high dynamic pressure portion (Mach = 0.8 to 1.8). Preliminary indications are that all DTO objectives for this flight were accomplished. The data collected during this eight-flight program will be used to update the ascent aerodynamic loads database, which will be baselined in November, 1994. The results of the analysis will be reported in separate documentation.

DTO 250 - Forward RCS Flight Test - Control Surface Effects - Data were recorded for this DTO during ascent. The data have been given to the sponsor and the results of the evaluation will be reported in separate documentation.

DTO 253 - Elevon Deflection Load Sensitivity Verification for OV-102 - The STS-58 flight is the first, last, and only flight in support of DTO 253. For this flight, an off-nominal ascent elevon schedule was flown. The schedule flown was more consistent with the 6.0 Loads Certification schedule and should result in decreased wing loads with slightly larger elevon hinge moments. Both inboard and outboard elevon schedules were modified. The ascent wing loads flight measurements will be evaluated against the existing data base to verify accuracy of elevon load sensitivity. Based on the results of this flight, a modified elevon schedule will be considered for future flights. The results of the evaluation will be reported in separate documentation.

DTO 301D - Ascent Structural Capability Evaluation - Data were collected during ascent for this DTO. The data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DTO 307D - Entry Structural Capability - Data were collected during entry and were recorded on the MADS recorder. The data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DTO 308D - Payload Bay Acoustic Evaluation - Data were recorded on the MADS recorder, and these data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 312 - ET TPS Performance (Methods 1 and 3) - Photography of the ET was acquired with the Nikon camera, 300 mm lens, and the 2X extender by the Payload Commander (Mission Specialist 1). A total 38 good-quality photographs were taken of the ET, and all sides of the ET were adequately photographed except the +Z side (side facing the Orbiter). The first pictures were taken approximately 15 minutes after liftoff, and the last picture was taken four minutes later. Several light-colored marks on the TPS were noted on the -Z side of the ET TPS during the screening. These marks were compared with the launch film and videos and found to have occurred after launch. None of the marks were of such significance to cause any concern for the ascent operations.

In addition to the hand-held photography of the ET, two 16 mm motion picture films and sixty 35 mm still frames were taken from the LH_2 and LO_2 umbilical wells. The 16 mm motion picture films were well focused and showed the left SRB and ET separations along with the normal venting and debris associated with these events. None of the films or photographs revealed any significant activity that would be of concern to ascent operations.

DTO 319D - Orbiter/Payload Acceleration and Acoustics Environment Data - Data were recorded for this DTO, and these data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 413 - On-Orbit PRSD Cyrogenic H_2 Boiloff - This DTO was performed to measure the pressure rise in the tanks on-orbit when the tanks were not supplying reactant. This was accomplished by operating one or two tanks between 240 and 275 psia and allowing the other tanks to increase in pressure for several hours as a result of the heat leak. Quantity boiloff for hydrogen tank 3 was also monitored for an extended period while the tank heaters were turned off.

Data were collected for seven days, and the preliminary analysis shows that the actual boiloff rate is 45 percent less than the predicted values. These results compare well with the STS-50 results, which mean that the 90-day on-orbit capability has nearly been attained. There was no significant difference between the Orbiter and pallet-tank boiloff rates.

DTO 414 - APU Shutdown Test (Sequence A) - This DTO was performed to aid in determining why an anomalous hydraulics system 3 supply pressure hang-up of about 40 seconds was observed when APU 3 was shut down early during ascent on STS-54. It was theorized that the hang-up was due to back-driving the system 3 rudder speedbrake power drive unit (PDU) motors.

The APU shutdown sequence after ascent was 1, 3, and 2; however, the planned shutdown sequence was 3, 1, 2. Data analysis indicates that the spindown was nominal and no back-driving of the PDU motor resulted from the altered shutdown sequence. The results will be reported in separate documentation.

DTO 521 - Orbiter Drag Chute System (Special Test Condition) - The Orbiter drag chute was deployed during derotation. Five ribbons had been removed from the chute prior to flight. The results of this test will be reported in separate documentation.

DTO 523 - Cabin Air Monitoring - Data were collected for this DTO throughout the flight, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DTO 663 - Acoustical Noise Dosimeter Data - Data were collected for this DTO and are now being evaluated by the sponsor. The results of that evaluation will be reported in separate documentation.

DTO 665 - Acoustical Sound Noise Level Data - Data were collected using the Spacelab sound level meter. These data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 667 - Portable In-Flight Landing Operations Trainer - The Portable In-Flight Landing Operations Trainer (PILOT) was operated several times on-orbit by several of the crewmembers. The preliminary data results are positive. A complete assessment will be made following the postflight analysis of the PILOT data.

DTO 910 - OEX Orbital Acceleration Research Experiment - The OARE was powered from the cabin power bus. The results of this DTO are presented in the Payloads section of this report.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 314 - OV-102 Acceleration Data Collection - High resolution accelerometer package (HiRAP) data were collected to measure vehicle accelerations resulting from on-orbit operations. Twenty periods of HiRAP data were recorded encompassing crew exercise on the ergometer, crew push-off force measurement tests, crew presleep and sleep, FCS checkout, RCS hot-fire test, lower body negative pressure (LBNP) preparations, seat installation, and general crew activities. The telemetry indicated nominal recording of all data acquisition periods.

DSO 325 - Dried Blood Method for In-Flight Stowage (Protocol 1 and 2) - Both protocols for this DSO were completed as planned. Serum filling was accomplished through the back part of the card when the front filter failed. The results of the analysis will be reported in separate documentation.

DSO 326 - Window Impact Observation - The required observations were made during the flight, and the results of those observations have been given to the sponsor. The sponsor will report the analysis in separate documentation.

DSO 485 - Inter Mars Tissue Equivalent Proportional Counter - The Inter Mars Tissue Equivalent Proportional Counter (ITEPC) operated nominally in gathering data on the radiation environment within the Space Shuttle Orbiter. The purpose of this DSO was to gather data on the radiation environment, and demonstrate the ability of the hardware to withstand the radiation environment. The data have been given to the sponsor. The results of the evaluation will be published in a separate document.

DSO 603 - Orthostatic Function During Entry, Landing, and Egress - Data were collected for this DSO, and the data have been given to the sponsor for analysis. The results of the analysis will be published in separate documentation.

DSO 604 - Visual-Vestibular Integration as a Function of Adaptation - Data were collected during the preflight and postflight periods as expected. The data have been given to the sponsor for evaluation, and the results of the evaluation will be published in separate documentation.

DSO 605 - Postural Equilibrium Control during Landing/Egress - Data were collected for this DSO during the postlanding period. The data have been given to the sponsor for analysis, and the evaluation results will be reported in a separate documentation.

DSO 611 - Air Monitoring Instrument Evaluation and Atmosphere Characterization (Microbial Air Sampler) - Data were collected for this DSO, and the data were given to the sponsor for evaluation. The results of the evaluation will be published in separate documentation.

DSO 612 - Energy Utilization - This DSO was completed as planned, and the data have been given to the sponsor for evaluation. The results of that evaluation will be published in separate documentation.

DSO 614 - Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion - Data were collected for this DSO, and the data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DSO 620 - Physiological Evaluation of Astronaut Seat Egress Ability at Wheels Stop - Data were collected from the crew during the postlanding time-frame and these data have been given to the sponsor for evaluation. The results of the evaluation will be published in separate documentation.

DSO 623 - In-Flight LBNP Test of Countermeasures and End-of-Mission Countermeasure Trial - All of the planned data were collected on one subject, and partial data were collected on the second subject. These data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DSO 624 - Preflight and Postflight Measurement of Cardiorespiratory Responses to Submaximal Exercise - The preflight and postflight activities were completed and the data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 626 - Cardiovascular and Cerebrovascular Responses to Standing Before and After Space Flight - Data were collected for this DSO during the preflight and postflight periods, and the data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 802 - Educational Activities (Objective 1) - All planned educational activities were completed and all objectives were met. Data were given to the sponsor for evaluation and reporting in a separate report.

DSO 901 - Documentary Television - Video tapes were made of all planned documentary television, and all objectives of this DSO have been met. The tapes have been returned to the sponsor for evaluation and reporting.

DSO 902 - Documentary Motion Picture Photography - All planned documentary motion picture photography objectives were completed. The film has been given to the sponsor for evaluation. The results of that evaluation will be reported in a separate document.

DSO 903 - Documentary Still Photography - All planned documentary still photography objectives were completed. The film has been processed and given to the sponsor for evaluation. The results will be published in separate documentation.

DSO 904 - Assessment of Human Factors (Configuration A) - Data were collected in support of this DSO. These data are being evaluated by the sponsor, and the results of that evaluation will be reported in separate documentation.

PHOTOGRAPHY AND TELEVISION ANALYSES

LAUNCH PHOTOGRAPHY AND VIDEO ANALYSIS

On launch day, 24 videos of launch were screened. Following launch, 55 films were reviewed, one of which produced no usable data. One anomaly was noted at 45 seconds after liftoff when a white piece of debris was observed to fall from the aft heat shield area into the SSME plume. Postflight inspections revealed a piece of the dome mounted heat shield was missing from the circumference of SSME 3.

The umbilical well camera revealed that the lightning strip from the LO_2 umbilical was missing.

ON-ORBIT PHOTOGRAPHY AND VIDEO ANALYSIS

No on-orbit photographic or video analysis requirements existed for this mission. However, a detailed discussion of the DTO-312 photography is presented in the Development Test Objective section of this report.

LANDING PHOTOGRAPHY AND VIDEO ANALYSIS

A total of eight videos of landing plus NASA Select were screened on landing day. No anomalies were noted during the screening process. Drag chute operations were taped and all operations appeared to be normal.

TABLE I.- STS-58 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
	LAUNCH SCRUB - OCTOBER 14, 1993	
APU activation	APU-1 GG chamber pressure	287:16:48:09.71
	APU-2 GG chamber pressure	287:16:48:11.12
	APU-3 GG chamber pressure	287:16:48:12.57
APU deactivation	APU-1 GG chamber pressure	287:16:58:34.80
	APU-2 GG chamber pressure	287:16:58:36.84
	APU-3 GG chamber pressure	287:16:58:38.53
	LAUNCH - OCTOBER 18, 1993	
APU activation	APU-1 GG chamber pressure	291:14:48:21.26
	APU-2 GG chamber pressure	291:14:48:22.91
	APU-3 GG chamber pressure	291:14:48:24.26
SRB HPU activation[a]	LH HPU system A start command	291:14:52:42.199
	LH HPU system B start command	291:14:52:42.349
	RH HPU system A start command	291:14:52:42.519
	RH HPU system B start command	291:14:52:42.669
Main propulsion system start[a]	Engine 3 start command accepted	291:14:53:03.448
	Engine 2 start command accepted	291:14:53:03.585
	Engine 1 start command accepted	291:14:53:03.685
SRB ignition command (lift-off)	SRB ignition command to SRB	291:14:53:10.009
Throttle up to 100 percent thrust[a]	Engine 1 command accepted	291:14:53:13.925
	Engine 3 command accepted	291:14:53:13.928
	Engine 2 command accepted	291:14:53:13.945
Throttle down to 67 percent thrust[a]	Engine 1 command accepted	291:14:53:36.005
	Engine 3 command accepted	291:14:53:36.009
	Engine 2 command accepted	291:14:53:36.025
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	291:14:54:00
Throttle up to 104 percent thrust[a]	Engine 1 command accepted	291:14:54:11.045
	Engine 3 command accepted	291:14:54:11.049
	Engine 2 command accepted	291:14:54:11.066
Both SRM's chamber pressure at 50 psi[a]	RH SRM chamber pressure mid-range select	291:14:55:08.169
	LH SRM chamber pressure mid-range select	291:14:55:08.929
End SRM action[a]	RH SRM chamber pressure mid-range select	291:14:55:10.669
	LH SRM chamber pressure mid-range select	291:14:55:11.429
SRB separation command	SRB separation command flag	291:14:55:13.61
SRB physical separation[a]	LH rate APU A turbine speed LOS	291:14:55:13.649
	RH rate APU A turbine speed LOS	291:14:55:13.649
Throttle down for 3g acceleration[a]	Engine 1 command accepted	291:15:00:46.088
	Engine 3 command accepted	291:15:00:46.095
	Engine 2 command accepted	291:15:00:46.112

[a]MSFC supplied data

TABLE I.- STS-58 SEQUENCE OF EVENTS (Continued)

Event	Description	Actual time, G.m.t.
3g acceleration	Total load factor	291:15:00:47.9
Throttle down to 67 percent thrust[a]	Engine 1 command accepted	291:15:01:39.208
	Engine 3 command accepted	291:15:01:39.216
	Engine 2 command accepted	291:15:01:39.233
Engine Shutdown[a]	Engine 1 command accept	291:15:01:45.608
	Engine 3 command accept	291:15:01:45.616
	Engine 2 command accept	291:15:01:45.633
MECO	Command flag	291:15:01:46
	Confirm flag	291:15:01:47
ET separation	ET separation command flag	291:15:02:05
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	291:15:10:35.49
	APU-3 GG chamber pressure	291:15:10:45.20
	APU-2 GG chamber pressure	291:15:10:53.00
OMS-2 ignition	Right engine bi-prop valve position	291:15:35:05.0
	Left engine bi-prop valve position	291:15:35:05.0
OMS-2 cutoff	Right engine bi-prop valve position	291:15:37:10.2
	Left engine bi-prop valve position	291:15:37:10.4
Payload bay door open	PLBD right open	291:16:23:35
	PLBD left open	291:16:24:56
OMS-3 ignition	Right engine bi-prop valve position	296:21:44:11.2
	Left engine bi-prop valve position	Not applicable
OMS-3 cutoff	Right engine bi-prop valve position	296:21:44:30.2
	Left engine bi-prop valve position	Not applicable
Flight control system checkout		
APU start	APU-3 GG chamber pressure	304:12:46:38.23
APU stop	APU-3 GG chamber pressure	304:12:52:26.94
Payload bay door close	PLBD left close	305:11:20:54
	PLBD right close	305:11:22:53

[a]MSFC supplied data

TABLE I.- STS-58 SEQUENCE OF EVENTS (Concluded)

Event	Description	Actual time, G.m.t.
APU activation for entry	APU-2 GG chamber pressure	305:14:00:32.47
	APU-1 GG chamber pressure	305:14:21:26.95
	APU-3 GG chamber pressure	305:14:21:28.73
Deorbit maneuver ignition	Left engine bi-prop valve position	305:14:05:30.2
	Right engine bi-prop valve position	305:14:05:30.2
Deorbit maneuver cutoff	Left engine bi-prop valve position	305:14:08:10.6
	Right engine bi-prop valve position	305:14:08:10.6
Entry interface (400K)	Current orbital altitude above reference ellipsoid	305:14:34:23
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	305:14:59:36
Main landing gear contact	LH MLG tire pressure	305:15:05:42
	RH MLG tire pressure	305:15:05:42
Main landing gear weight on wheels	LH MLG weight on wheels	305:15:05:42
	RH MLG weight on wheels	305:15:05:42
Drag chute deploy	Drag chute deploy 1 CP Volts	305:15:05:51.4
Nose landing gear contact	NLG tire pressure	305:15:05:53
Nose landing gear weight on wheels	NLG WT on Wheels -1	305:15:05:53
Drag chute jettison	Drag chute jettison 1 CP Volts	305:15:06:24.6
Wheels stop	Velocity with respect to runway	305:15:06:44
APU deactivation	APU-1 GG chamber pressure	305:15:28:08.93
	APU-2 GG chamber pressure	305:15:28:10.66
	APU-3 GG chamber pressure	305:15:28:12.21

TABLE II.- STS-58 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-58-V-01	S-Band Transponder 2 Uplink Failure No Ferry Flight Impact	288:11:58 G.m.t. IM 58RF01 PR COM-A0036	At approximately 288:11:58 G.m.t., during the second launch attempt, uplink lock was lost on the S-band PM system. Transponder 2 was being used at the time and troubleshooting indicated that this transponder (S/N 301) had failed. Note that the downlink was operating properly through transponder 2. The launch attempt was scrubbed and the failed transponder was removed and replaced with S/N 309.
STS-58-V-02	Air Ingestion into Galley Transferred to GFE Office For Resolution No Ferry Flight Impact	Prelaunch IPR 62V0002	After the L-4 hour drain of the potable water tank A (first launch attempt) the tank quantity rise rate was higher than the fuel cell water production rate, indicating gas in the water system. After the scrub, the galley supply valve was closed and tank A repressurized. No significant change was seen in tank A quantity indicating no gas in the tank. The galley valve was then reopened, and a quantity decrease was noted, indicating gas in the galley. It is speculated that a leak in the galley allowed air ingestion and subsequently allowed the backflow of water in supply tank A. The galley is currently scheduled for removal postflight.
STS-58-V-03	Left OME Pressure Transducer Failed Off-Scale Low No Flight Ferry Impact	291:14:53:10 G.m.t. IPR 62V0003	At liftoff, the left OME chamber pressure (V43P4649C) failed off-scale low. The chamber pressure indication remained off-scale low during during OMS-2 and the deorbit maneuver. The crew reported that the cockpit Pc meter did not work during OMS-2.
STS-58-V-04	Engine 1 GH_2 Flow Control Valve Sluggish	291:14:53:30 G.m.t. IPR 62V0004 IM58RF02	Main engine 1 GH_2 flow control valve exhibited a sluggish response during ascent. The pressure decay after valve opening was not a step function as expected. The most probable cause is contamination in the poppet assembly.
STS-58-V-05	Fluid Found on WCS Odor/Bacteria Filter Lid No Ferry Flight Impact	293:22:35 G.m.t. PR ECL0936 IM 58RF03	At approximately 293:22:35 G.m.t., the crew reported that a small amount of fluid was found on the WCS Odor/Bacteria filter lid. The crew also reported that fluid was found in this location on three earlier occasions, the first instance occurring before the galley hot water flush to the WCS was performed. (See IFA STS-58-V-02.) Liquid carryover from fan separator 1 to the odor/bacteria filter line is one of the suspected causes. Fan separator 2 was started and the crew reported that no additional fluid was observed around the Odor/Bacteria cover seal. Recent startup of fan separator 1 have shown no signs of back-leakage through Fan Separator 1 check valves. The crew has reported that air flow through the urinal hose has not changed since the flight began, indicating that the filter is probably not saturated with liquid. The WCS will be removed from the vehicle postflight.

TABLE II.- STS-58 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-58-V-06	WCCS AIU-D Tone Problem (Beeping) Transferred to GFE Office (GA2) for Resolution No Ferry Flight Impact	296:21:20 G.m.t.	At 296:21:20 G.m.t, the crew called down that they consistently got a 1 Hz beep on wall unit D (in the laboratory) whether configured for ICOM or Air-to-Ground. The crew changed batteries to no avail. The crew also tried one of the other crewmembers headsets with wall unit D also go beeping, Did not get beeping on wall unit E.
STS-58-V-07	Payload Recorder Tape Broke	301:02:02 G.m.t. PR INS1017	At 301:02:02 G.m.t., the payload recorder was performing a Serial Record B record on track 9. When the recorder performed its normal turnaround at end of tape (EOT), the percent tape readings went to 0 percent and the recorder indicated both EOT and beginning of tape (BOT). This is indicative of a broken tape.
STS-58-V-08	S-Band FM System 1 Power Output Degraded Level III Closure No Ferry Flight Impact	On-orbit IM 58RF04 IPR 62V-0007	The FM transmitter 1 power steadily degraded throughout the flight, then dropped to 6.5 watts on flight day 13 (specification is 10 watts). Switched to transmitter 2 for the remainder of the flight.
STS-58-V-09	Engine 1 and 2 Dome-Mounted Heat Shield Closeout Blanket Damage No Ferry Flight Impact	Ascent	During ascent, (about 45 seconds after liftoff), a piece of white debris was observed exiting the area between SSME 1 and 3. Postlanding inspections showed damage to the engine 2 and engine 3 dome-mounted heat shield (DMHS) blankets. Engine 3 had significant damage to the blankets at the 9 o'clock position. Engine 2 had a small blanket cover panel at the 3 o'clock position detached on three sides.
STS-58-V-10	LO_2 Umbilical Lightning Strip Detached	291:15:02:05 G.m.t.	Postlanding review of the umbilical well film revealed that the lightning strip across the forward portion of the LO_2 umbilical was missing.

TABLE III.- MSFC ELEMENTS STS-58 PROBLEM TRACKING LIST

Problem/Title	Element	Description	Comments/Status
STS-58-T-01 ET Intertank Acreage Divot and Jackpad Closeouts	External Tank (MMMSS)	During postflight review of the STS-58 (ET-57) umbilical well camera film, three areas along the ET intertank acreage exhibited a loss of TPS. One ET intertank acreage divot and the two jackpad closeouts were identified as the TPS locations effected.	A long divot (approximately 24 in. long by 4 in. wide) was observed on the + Z axis of the intertank acreage, directly under the Orbiter nose. The remaining two areas of missing intertank TPS were identified as major portions of each jackpad closeout (two total). which are located between the intertank bipod attach fittings (+Z axis also). For clarity, the following in-flight anomaly discussion has been divided based on the two noted issues. A. Jackpad Closeouts STS-58 is the sixth documented occurrence of jackpad-related anomalies. Complete and/or partial loss of the jackpad closeout has been previously observed on STS-32R (ET-32), STS-50 (ET-50) (tracked as IFA STS-50-T-01), STS-52 (ET-55), STS-54 (ET-51), and STS-55 (ET-56). The evaluation attributed the failures to cryopumping of a substrate void in the PDL material. When the LH_2 level dropped below the closeout region and aeroheating warmed this area, the PDL closeout popped loose. B. Intertank Divot In the case of divots along the ET intertank acreage, seven occurrences have been documented. Five instances have been identified with the old two-tone SOFI intertank configuration, and two have now been identified with the new two spray gun method of intertank TPS application (effectivity of ET-51 and subsequent). These may be respectively investigated on IFA tracking numbers STS-32-T-1, STS-35-T-1, STS-42-T-1, STS-50-T -1, STS-47-T-1, STS-56-T-1, and STS-58-T-1). The problem investigation is currently in progress.

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this 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
15. Shuttle Operational Data Book

ACRONYMS AND ABBREVIATIONS

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

A/G	Air-to-Ground
AIU	audio interface unit
APCA	aft power controller assembly
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARU	accelerometer recording unit
ASA	Astronaut Science Advisor
ATCS	Active thermal control system
ATU	audio terminal unit
BOT	beginning of tape
CRU	crew remote unit
DMHS	dome-mounted heat shield
DPS	data processing system
DSO	Detailed Supplementary Objective
DTO	Development Test Objective
ΔV	differential velocity
EAFB	Edwards Air Force Base
ECLSS	Environmental Control and Life Support System
EDO	Extended Duration Orbiter
e.d.t.	eastern daylight time
EOT	end of tape
EPDC	electrical power distribution and control subsystem
ET	External Tank
EVA	extravehicular activity
FASCOS	flight acceleration safety cut-off system
FCL	freon coolant loop
FCS	flight control system
FDA	fault detection and annunciation
FM	frequency modulation
g	gravity
GFE	Government furnished equipment
GH_2	gaseous hydrogen
G.m.t.	Greenwich mean time
GN_2	gaseous nitrogen
GSE	ground support equipment
H_2O	water
HIRAP	High Resolution Accelerometer Package
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
ICD	Interface Control Document
ICOM	intercommunications
IFM	in-flight maintenance
IMU	inertial measurement unit
Isp	specific impulse
ITEPC	Inter Mars Tissue Equivalent Proportions Counter
JSC	Johnson Space Center

keas	knots estimated air speed
kWh	kilowatt hours
LBNP	lower body negative pressure
LCC	Launch Commit Criteria
LESC	Lockheed Engineering and Sciences Company
LH_2	liquid hydrogen
LO_2	liquid oxygen
LSLE	Life Science Laboratory Equipment
MADS	modular auxiliary data system
MCC	main combustion chamber
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
MPS	main propulsion system
MSFC	George C. Marshall Space Flight Ce...er
NASA	National Aeronautics and Space Administration
NLGD	nose landing gear door
NPSP	net positive suction pressure
OARE	Orbital Acceleration Research Experiment
OMDP	Orbiter maintenance down period
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
PDU	power drive unit
PILOT	Portable In-Flight Landing Operations Trainer
PMBT	Propellant mean bulk temperature
PRSD	power reactant storage and distribution
PTI	programmed test input
RCC	reusable carbon carbon
RCRS	regenerative carbon dioxide removal system
RCS	reaction control subsystem
RF	radio frequency
RSRM	Redesigned Solid Rocket Motor
SAREX	Shuttle Amateur Radio Experiment
S&A	safe and arm
SIP	strain isolation pad
SLS-2	Spacelab Life Sciences - 2
SODB	Shuttle Operational Data Book
SRB	Solid Rocket Booster
SRSS	Shuttle Range Safety System
SSME	Space Shuttle main engine
STS	Space Transportation System
TIPS	Thermal Impulse Printer System
TPS	thermal protection subsystem/system
UMS	urine monitoring system
USA	U. S. Army
USAF	U. S. Air Force
USML	U. S. Microgravity Laboratory
WCCS	wireless crew communications system
WCS	Waste Collection System
WSB	water spray boiler