NSTS-08274

STS-42
SPACE SHUTTLE
MISSION REPORT

February 1992

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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MISSION REPORT

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INTRODUCTION

The STS-42 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem operations during the forty-fifth flight of the Space Shuttle Program and the fourteenth flight of the Orbiter vehicle Discovery (OV-103). In addition to the Discovery vehicle, the flight vehicle consisted of an External Tank (ET) designated as ET-52 (LWT-45); three Space Shuttle main engines (SSME's), which were serial numbers 2026, 2022, and 2027 in positions 1, 2, and 3, respectively; and two Solid Rocket Boosters (SRB's) designated as BI-048. The lightweight redesigned Solid Rocket Motors (RSRM's) installed in each one of the SRB's were designated as 360L020A for the left SRM and 360Q020B for the right SRM.

This report satisfies the Level II Space Shuttle Program requirement, as documented in NSTS 07700, Volume VIII, Appendix E, which requires each major organization supporting the Space Shuttle Program to report the results of its evaluation of the mission and identify all related in-flight anomalies.

The primary objective of the STS-42 mission was to complete the objectives of the first International Microgravity Laboratory (IML-1). Secondary objectives were to perform all operations necessary to support the requirements of the Gelation of Sols: Applied Microgravity Research (GOSAMR), Student Experiment 81-09 (Convection in Zero Gravity), Student Experiment 83-02 (Capillary Rise of Liquid Through Granular Porous Media), Investigation into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment-III (RME-III), and Get-Away Special (GAS) payloads carried on the GAS Beam Assembly.

The sequence of events for the STS-42 mission is shown in Table I, and the official Orbiter Problem Tracking List is presented in Table II. In addition, each Orbiter subsystem anomaly is discussed in the applicable subsystem section of the report, and a reference to the assigned tracking number is provided. Official ET, SRB, and SSME anomalies are also discussed in their respective sections of the report and the MSFC-assigned tracking number is also shown.

The crew for this forty-fifth Space Shuttle flight was Ronald J. Grabe, Col., USAF, Commander; Steven S. Oswald, Pilot; Norman E. Thagard, M.D., Mission Specialist 1 (Payload Commander); William F. Readdy, Mission Specialist 2; David C. Hilmers, Col., USMC, Mission Specialist 3; Roberta L. Bondar, Ph.D, Payload Specialist 1; and Ulf D. Merbold, Ph.D, Payload Specialist 2. STS-42 was the third flight for the Commander, the fourth flight for Mission Specialist 1 and Mission Specialist 3, the second flight for Payload Specialist 2, and the first flight for the remaining three crew members.

SUMMARY

The STS-42 mission was launched at 022:14:52:32.992 G.m.t. (9:52:32.992 a.m. e.s.t. on January 22, 1992) from launch complex 39A at KSC. STS-42 was the first flight of the Spacelab IML-1. The launch was delayed 59 minutes 33 seconds awaiting the resolution of a fuel cell 2 hydrogen-pump motor anomaly and also because of high readings from the KSC field mill network.

Approximately 7 hours 50 minutes prior to launch, a current change on ac bus 2 phases B and C occurred simultaneously with a fuel-cell hydrogen-pump motor-condition Launch Commit Criteria (LCC) violation. About six hours later, the phase C ac circuit breaker to the pump was cycled in an effort to gain a better understanding of the ac current and sensor data signatures and to clear any contamination from the circuit breaker contacts. In summary, there was no indication of an anomaly associated with the pump performance, inverter performance, or fuel cell performance, and as a result, the decision was made to proceed with the countdown to launch.

All SSME, RSRM, and SRB start sequences occurred as expected and the launch phase performance was satisfactory in all respects. First stage ascent performance was normal with SRB separation, entry, deceleration, and water impact occurring as anticipated. The ET, main propulsion system (MPS) and Orbiter performance was also normal with main engine cutoff (MECO) occurring at 510.1 seconds after lift-off. Both SRB's were successfully recovered.

With the successful completion of the orbital maneuvering subsystem (OMS) -2 maneuver, the Orbiter was inserted into the planned 163 nmi. circular orbit at an inclination of 57 degrees.

A waste collection system (WCS) anomaly occurred when the crew was attempting to reconfigure the WCS for commode use. The commode control handle became disconnected from the commode control valve linkage and, as a result, the crew was unable to open the WCS commode control valve. An in-flight maintenance (IFM) procedure was uplinked and implemented by the crew, and full WCS operation was restored. Later in the mission, the roll pin within the valve sheared on both sides and caused the valve/shaft to rotate freely. Another IFM procedure was performed that restored full WCS operation. The WCS remained operational for the remainder of the mission.

At 028:21:00:19 G.m.t., reaction control subsystem (RCS) thruster L3A was deselected by the redundancy management (RM) software because of an oxidizer leak which was confirmed by a decrease in the thruster injector temperature. At 029:02:40:00 G.m.t., the injector temperature began to recover, indicating the leak had stopped. The thruster was reselected at 029:07:49 G.m.t. and was placed in last priority. The thruster had not been fired prior to the leak and was not fired during the remainder of the mission.

Consumables usage remained below planned levels throughout the mission and, as a result, mission planning was changed to incorporate one additional day of flight with landing planned for January 30, 1992, at 10:07 a.m. c.s.t.

The flight control system (FCS) checkout was satisfactorily performed at 029:13:12:27.87 G.m.t. Auxiliary power unit (APU) 2 ran for 3 minutes 30 seconds during the checkout, and approximately 9 lb of fuel was used. No flight control system anomalies were noted.

Late in the mission, the crew reported what appeared to be venting from the aft compartment. No leaks were noted until multiplexer/demultiplexer (MDM) flight aft (FA) 4 was powered up, at which time thruster R4U was noted to have an oxidizer leak. The thruster was deselected by the RCS RM at 030:05:04:42 G.m.t. Spectacular pictures of the leak were documented with an onboard television camera and the leak rate was estimated to be approximately 4.8 lb/hr. The manifold (4) was later isolated for entry. This thruster also was not fired during the entire mission.

The RCS hot-fire test was performed at 030:10:20 G.m.t. All thrusters except L3A and R4U were fired during the RCS hot-fire test. A decision was made to not fire the L3A and R4U thrusters because of the leaks noted earlier in the mission.

The crew completed Spacelab operations, as well as entry preparations and stowage. The payload bay doors were satisfactorily closed at 30:12:34:56 G.m.t. The deorbit maneuver was performed at 030:15:05:03.4 G.m.t. The maneuver was approximately 178.2 seconds in duration and the differential velocity was 310.1 ft/sec. Entry interface occurred at 030:15:35:44 G.m.t.

Main landing gear touchdown occurred at Edwards Air Force Base concrete runway 22 at 030:16:07:17 G.m.t. Nose landing gear touchdown occurred 10 seconds later with wheels stop at 030:16:08:16 G.m.t. Preliminary indications are that the rollout was normal in all respects. The flight duration was 8 days 1 hour 15 minutes 43 seconds. The APU's were shut down by 030:16:24:13.5 G.m.t., and the crew completed the required postflight reconfigurations and departed the Orbiter landing area at 030:17:06 G.m.t.

VEHICLE PERFORMANCE

The vehicle performance section of this report contains a discussion of the operation and performance of each element (SRB, ET, SSME, and Orbiter) of the Space Shuttle vehicle.

SOLID ROCKET BOOSTERS/REDESIGNED SOLID ROCKET MOTORS

All SRB systems performed as expected. The SRB prelaunch countdown was normal, and no SRB or RSRM LCC or OMRSD violations occurred.

Power up and operation of all case, igniter, and field joint heaters were accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the heated ground purge in the SRB aft skirt was powered up and the case/nozzle joint and flexible bearing temperatures were maintained within the required LCC ranges.

The RSRM propulsion performance was well within the required specification limits, and the propellant burn rate for each RSRM was normal. RSRM thrust differentials during the buildup, steady-state, and tailoff phases were well within specifications. All SRB thrust vector control prelaunch conditions and flight performance requirements were met with ample margins. All electrical functions were performed properly. The SRB flight structural temperature response was as expected. Both SRB's were successfully separated from the ET at 127.8 seconds.

Postflight inspection of the recovered hardware indicated that the SRB thermal protection system (TPS) performed properly during ascent with very little TPS acreage ablation. Separation subsystem performance was normal with all booster separation motors expended and all separation bolts severed. Key RSRM propulsion performance parameters are presented in the table on the following page.

The entry and deceleration sequence was properly performed on both SRB's. RSRM nozzle jettison occurred after frustum separation, and subsequent parachute deployments were successfully performed. The aft ring cap on the left aft skirt was cracked during water impact. The right SRB forward access door was damaged during towback due to the sea conditions. Both SRB's were recovered and returned to KSC where disassembly was completed and refurbishment activities were initiated.

After removal of the left and right nozzle during the postflight disassembly and assessment of the RSRM nozzle-to-case joints, gas paths were observed through the polysulfide adhesive with erosion and sooting of the wiper O-rings (Flight Problem STS-42-M-1). Gas penetration on the left side at 57.6 degrees was more extensive as blow-by was observed at the wiper O-ring. The gas path measured 0.25-inch circumferentially minimum at the step and opened up to 4.2 inches

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 63 °F		Right motor, 63 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	64.63	63.75	64.72	64.09
I-60, 10^6 lbf-sec	172.75	171.91	172.92	171.85
I-AT, 10^6 lbf-sec	297.00	296.91	296.75	297.08
Vacuum Isp, lbf-sec/lbm	268.40	268.36	268.4	268.74
Burn rate, in/sec	0.3669	0.3648	0.3675	0.3648
Event times, seconds				
Ignition interval	0.232	N/A	0.232	N/A
Web time	111.4	112.2	111.2	112.0
Action time	123.4	124.8	123.1	124.5
Separation cue, 50 psia	121.3	122.7	121.0	121.6
PMBT, °F	62.0	63.0	62.0	63.0
Maximum ignition rise rate, psi/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	2.9	2.8	3.5
Tailoff imbalance Impulse differential, klbf-sec	Predicted N/A		Actual 566.7	

circumferentially just forward of the wiper O-ring. The gas path contained heat-affected polysulfide. The glass cloth phenolic (GCP) was also heat-affected along the fixed housing GCP wiper O-ring at 57 degrees. The heated area measured 4-inches circumferentially and 0.4-inch axially. Soot was observed up to the wiper O-ring from 45 to 77 degrees and past the wiper O-ring (downstream wall of the O-ring groove) intermittently from 52.2 to 68.4 degrees. Soot was also noted in the vent slots at 57.6 degrees and 64.8 degrees. No soot was observed on the primary O-ring. Erosion of the wiper O-ring was observed for 2.2-inches axially and 0.16-inch radially (centered at 57.6 degrees). The erosion depth was measured to be 0.02-inch maximum. A blow hole of this magnitude has never been experienced on a flight RSRM nozzle-to-case joint, and the investigation of this anomaly is continuing. However, blow-by that does not get through the wiper O-ring to the primary O-ring seal is not a safety-of-flight concern.

EXTERNAL TANK

All objectives and requirements associated with ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation performed satisfactorily. ET purge and heater operations were monitored and all performed properly. Propellant loading was completed as scheduled, and all prelaunch thermal requirements were met. No LCC or OMRSD violations were identified.

As expected, the normal ice/frost formations for the January atmospheric environment were observed during the countdown. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. A small amount of frost was also present on the liquid hydrogen protuberance air load (PAL) ramps. All of these observations were acceptable based on applicable NSTS documentation. The Ice/Frost Red Team reported that no visible anomalous TPS conditions existed.

The ET pressurization system functioned properly throughout engine start and flight. The minimum liquid oxygen ullage pressure experienced during the period of ullage pressure slump was 14.4 psid.

As usual, the ET tumble system was deactivated and radar reports from Bermuda confirmed that the ET did not tumble. ET separation was confirmed to have occurred properly, and based on MECO time, ET entry and breakup occurred within the planned footprint.

After ET separation from the Orbiter, the crew took pictures of the ET, and the photographs showed two possible divots in the intertank region (Flight Problem STS-42-T-1). The divots are estimated to be between 8 and 12 inches in diameter. The STS-42 ET utilized the two-gun spray method of insulating the intertank region. This was only the second tank flown that used the new TPS application/configuration. Analysis of this condition is continuing.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters were 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 were normal.

Preliminary flight data indicate that SSME performance at start up and 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 specification throughout engine operation. The SSME controllers provided the proper control of the engines throughout powered flight. Engine dynamic data generally compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully. No failures were identified from the flight data or postflight inspections of the engine.

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 performance was as expected throughout the flight.

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

ORBITER VEHICLE SUBSYSTEMS

Main Propulsion System

The overall performance of the MPS was excellent. All pretanking purges were properly performed, and liquid oxygen loading was performed as planned with no stop-flows or reverts. There was one liquid hydrogen stop-flow/revert that was initiated early in replenish. This was required because of a leaking liquid hydrogen replenish valve as evidenced by leak detector 27 indicating above 4 percent. The Ice/Frost Red Team retorqued the valve packing, thereby stopping the leak. Liquid hydrogen replenish flow was restored about 2 hours 30 minutes after the stop-flow/revert was initiated. No LCC or OMRSD violations occurred.

A failure in the data system at KSC resulted in the loss of 50 Kb data transmittal to the MSFC Huntsville Operations Support Center (HOSC) for a period of 3 hours and 21 minutes (022:08:01:00 to 022:11:22:00 G.m.t.) during propellant loading operations. The loss of these data resulted in MSFC providing preliminary propellant loading results based on manual calculations using low sample rate data provided in real time. Fifty Kb data again became available to MSFC at approximately Launch -2.5 hours. MSFC provided JSC with the Launch -1.75 hour projection which was used for the official prediction for launch.

Throughout the preflight operations, no significant hazardous gas concentrations were detected, and the maximum hydrogen level in the Orbiter aft compartment was 203 ppm (corrected), which compares well with previous data for this vehicle.

The MPS helium system performed satisfactorily. Prior to T-2 hours, data indicated that the helium concentration in the aft compartment peaked at 10,860 ppm, and later stabilized at 7,500 ppm. There was one momentary spike in the helium concentration to more than 10,000 ppm after T-2 hours. However, the level quickly decreased to 7,500 ppm; consequently, the spike was not an LCC violation. These helium concentrations are historically typical of the OV-103 vehicle.

The calculated propellant loads at the end of replenish versus the inventory loads shows a loading accuracy of -0.022 percent for the liquid hydrogen and +0.023 percent for the liquid oxygen.

Ascent MPS performance was completely normal. Preliminary data indicate that the liquid oxygen and liquid hydrogen pressurization systems performed as planned. Also, all net positive suction pressure (NPSP) requirements were met throughout the flight. Space Shuttle MECO occurred 510.1 seconds after lift-off. This flight was the second for the fixed orifice/flow control valve on OV-103 and the fifth flight for the Space Shuttle Program using this configuration. The postflight evaluation of actual performance versus predicted performance revealed no irregularities.

Entry and landing performance was nominal with 57.5 lb of helium consumed during entry. However, the liquid hydrogen topping valve open-position indicator did not come on when open power was applied at 5 minutes prior to entry interface (Flight Problem STS-42-V-09). The closed indicator did go off and the closed indicator came back on as planned later in entry when open power was removed.

Reaction Control Subsystem

The performance of the RCS was nominal except for primary thrusters L3A and R4U, which both exhibited oxidizer leakage during the flight. A total of 3739.3 lb of RCS propellant was consumed during the 8-day mission.

The Orbiter attitudes flown during this flight provided a hot environment for the RCS thrusters. During the bay-South attitude, the injector temperatures of the right RCS up-firing thrusters were predicted to reach 181 °F; in the bay-North attitude, the injector temperatures of the right RCS down-firing thrusters were predicted to reach 190 °F. Seven bay-South attitudes and four bay-North attitudes were flown. The maximum injector temperature for the right RCS up-firing thrusters was 165 °F. The maximum injector temperature for the right RCS down-firing thrusters was 173 °F. Later in the mission, three +Z axis local vertical (+ZLV) attitudes were flown, and this resulted in the forward RCS forward-firing thruster injectors reaching temperatures as high as 133 °F.

Because preflight analysis predicted a hot thruster environment, a flight rule annex change that clarified the Shuttle Operational Data Book (SODB) temperature constraints was processed prior to the flight. The thrusters can be operated up to a thruster valve seat temperature of 150 °F. Above that temperature, the closing of the thruster valve could "pound" the Teflon seat and increase the chance of leakage at colder temperatures. The non-operating thruster valve seat maximum temperature is 175 °F. Above this temperature, the Teflon seat would begin to degrade without a thruster firing. Since predictions indicated that the injector temperature would be 10 °F warmer than the valve seat temperature, the flight rule change allowed the injector temperatures to reach 160 °F under operational conditions and 185 °F under non-operational conditions. None of these revised temperature limits were exceeded.

At 028:21:00:19 G.m.t., RCS thruster L3A was deselected by the RM software because of an oxidizer leak that was confirmed by a decrease in the thruster injector temperature to less than 30 °F (Flight Problem STS-42-V-05). At 029:02:40:00 G.m.t., the injector temperature began to recover, indicating the leak had stopped. After the thruster temperature recovered to 90 °F, the thruster was reselected and was placed in last priority. The thruster had not been fired at any time up to the deselection nor was it fired at any time following the reselection.

Late in the mission, the crew reported venting from the aft compartment. Data showed no leaks until MDM FA 4 was powered up at which time data confirmed that thruster R4U had an oxidizer leak (Flight Problem STS-42-V-06). MDM FA4 was powered off during the mission along with MDM's flight forward (FF) 2 and FF 4 as part of the group B power down to conserve cryogenics. The thruster was deselected by the RCS RM at 030:05:04:42 G.m.t. The oxidizer leak was documented with an onboard television camera and the leak rate was estimated to be approximately 4.8 lb/hr. Manifold 4 was later isolated for entry since the leak did not recover, and the oxidizer quantity had leaked down to approximately 4 percent lower than the fuel quantity at that time. This thruster also had not been fired up to the time of the deselection and the thruster was never reselected. A postflight review of the oxidizer quantity data indicated that the leak had started at approximately 030:02:53 G.m.t.

Data during entry revealed that the RCS thruster F1D fuel injector temperature reached 245 °F for about 5 minutes during entry, and this is the highest temperature ever recorded for this measurement. The SODB constraint is 230 °F for 1 hour on the valve seat with a differential pressure of 175 to 300 psid across the valve. Since the differential pressure across the valve was 155 psid, the SODB constraint was not violated. This irregularity continues to be evaluated in an effort to understand the temperature increase.

Vernier thruster F5L was deselected as "failed leak" three times during the mission. The thruster was deselected each time by the RM when the oxidizer injector temperature dropped below the leak detection limit of 130 °F. The deselection in each case was not caused by a propellant leak, but rather was caused by the Orbiter attitude and the thruster F5L low duty cycle that allowed the thruster to cool. In each case, the thruster was reselected, and the thruster leak detection was inhibited. After the thruster was fired and the injector temperatures were above 130 °F, the leak detection was reenabled.

The aft RCS oxidizer manifold 1 temperature exceeded 100 °F, which is the certification limit for the RCS bulk propellant. Temperatures as high as 123 °F were observed. However, the SODB allows the distribution system temperature to reach but not exceed 150 °F to protect the operating limit of the thruster valve seats.

Orbital Maneuvering Subsystem

The OMS performance was nominal with no discrepancies noted during the two maneuvers (OMS-2 and deorbit). Both firings were performed with both engines in the straight-feed mode, and the total firing time was 337.4 seconds on each engine. Propellant usage for the two firings was 8,134 lb of oxidizer and 4,914 lb of fuel.

The left-hand and right-hand fuel quantity gaging system indicated high during prelaunch operations and have exhibited irregular behavior during the last three missions that the pods were flown. The left-hand and right-hand oxidizer gaging systems operated nominally throughout the mission.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was nominal throughout the mission with no discrepant operation noted. The vehicle was flown in the four-tank-set configuration. The PRSD subsystem supplied 2310 lb of oxygen and 291 lb of hydrogen to the fuel cells for the production of electrical energy. Based on the lift-off and landing indicated quantities, approximately 81 lb of oxygen was supplied to the environmental control and life support subsystem (ECLSS) for crew breathing. A 31-hour mission extension at the average power level of 17.2 kW was possible with the cryogenics remaining in the PRSD subsystem at landing.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed nominally from lift-off through landing; however, an anomaly occurred during prelaunch operations. The total energy produced during the mission was 3317 kWh at an average power level of 17.2 kW and 567 amperes. The fuel cells produced at total of 2,601 lb of water during the mission.

During prelaunch activities at approximately 022:07:02 G.m.t., a fuel cell 2 hydrogen-pump motor-condition LCC violation occurred simultaneously with a current change on ac bus 2 phases B and C (Flight Problem STS-42-V-01). Fuel cell 2 hydrogen pump motor condition increased from 0.6 V to 1.48 V for approximately 6 seconds. The LCC limit is 1.0 V. The ac bus 2 phase C current decreased about 0.16 ampere, and phase B increased about 0.25 ampere. All other fuel cell 2 parameters were reading nominal. There was no noticeable change in the phase A current. The pump-motor condition was nominal (0.52 - 0.56 Vdc) from fuel cell 2 activation until this anomaly, and performance was nominal (0.56 - 0.60 Vdc) thereafter for the remainder of the flight.

An inverter problem was ruled out because no ac bus voltage fluctuations were observed, and the main engine controllers did not indicate a phase shift or voltage violation. Orbiter data indicated a possible intermittent high resistance path to phase C of the motor. The rationale for waiving the LCC violation was based on a worst-case condition of an open circuit to one phase of the hydrogen and coolant pump motors. This would result in the hydrogen and coolant pump motors running on two phases. The pump motors would not be affected since they are certified to operate on two phases.

Postflight laboratory testing and data analysis led to the following conclusions. An ac bus 2 inverter phase angle change did not occur; a hydrogen pump motor anomaly did not occur; a power factor change could not have caused the anomaly. The most probable cause was the high resistance condition that existed in the phase C circuit path to the fuel cell pump package. The possible causes of the condition were believed to be an intermittent connection of a connector pin/socket; panel L4 circuit breaker contamination; or relay failures within the fuel cell. Troubleshooting is being performed on the Orbiter to isolate the cause of the anomaly.

Auxiliary Power Unit Subsystem

The APU subsystem operated nominally throughout the mission. Fuel consumption and run time are shown in the following table.

Flight Phase	APU 1 (S/N 310)		APU 2 (S/N 301)		APU 3 (S/N 312)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	18:54	51	18:54	51	18:55	49
FCS checkout			03:30	9		
Entry	84:04	174	61:18	139	61:19	151
Total[a]	102:58	225	83:42	199	80:14	200

[a] The total includes 16 minutes 54 seconds of APU operation after landing.

The APU 1 EGT 2 measurement became erratic about 24 minutes after the APU was started for entry, and then the measurement failed off-scale low shortly thereafter. The sensor will be removed and replaced during turnaround operations.

The second irregularity was noted when the APU 3 seal-cavity drain-line pressure slowly decayed from 19 psi to 14 psi over a 30-minute period during entry. The gear box pressure rose from 7.5 psi to 11.0 psi during the last 20 minutes of APU operation, and the APU lubrication oil outlet pressure rose from 40 to 50 psi during the same time period. A hydrazine leak into the gear box was caused by this change in pressure.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem operated nominally throughout the mission. Excellent water spray boiler (WSB) vent heater operation was observed throughout the prelaunch period. Steam vent temperature 2A was the highest (normally low and causing loss of APU ready condition on this vehicle) of the three vent temperatures during the prelaunch period, and none of the three ready indications were lost prior to APU start.

Reservoir quantities during ascent did not decrease significantly. Also, reservoir pressure stayed relatively constant except for the initial expected decrease resulting from decreasing atmospheric pressure during ascent. WSB water usage was nominal with systems 1, 2, and 3, using approximately 1.6 lb, 0.9 lb, and 1.0 lb of water, respectively, during ascent. Spray initiation for system 1, 2, and 3 occurred at 245 °F, 260 °F, and 256 °F, respectively, which was within specification.

Throughout the on-orbit period, reservoir quantities, pressures, and temperatures tracked each other, and there was no evidence of hydraulic fluid leakage. Seven circulation pump runs (six for hydraulic system 1 and one for hydraulic system 3) occurred for thermal circulation early in the flight. However, about one day into the flight, the vehicle attitude was changed to top-Sun, which provides 100-percent sunlight to the payload bay, and no more circulation pump runs were required.

WSB vent heater operation on the A controller was normal. WSB 1 required 55 minutes and WSB 3 required approximately 42 minutes to increase the vent temperatures above 122 °F, while WSB 2 required only 18 minutes. The delays in WSB 1 and 3 were postulated to be due to ice removal from the vent areas. All WSB core temperatures exceeded the upper limit of 60 °F as specified by the in-flight performance requirement. These high temperatures are believed to be caused by the extended warm attitude of the vehicle for this flight and not due to core heater malfunctions.

Hydraulic/WSB performance during the FCS checkout was normal. No spray cooling was required because lubrication oil temperatures remained below 250 °F due to the limited APU run duration of 3 1/2 minutes.

Reservoir quantities, temperatures, and pressures as well as WSB steam vent heater operations were normal during entry. All three hydraulic systems performed nominally with hydraulic fluid temperatures never exceeding a nominal 220 °F by APU shutdown. WSB water usage for entry cooling was 32.8 lb for system 1, 12.1 lb for system 2, and 19.9 lb for system 3.

Environmental Control and Life Support Subsystem

The atmospheric revitalization system (ARS) performed nominally throughout the mission. No carry-over of water from humidity separator A or B was noted.

The ARS air and water coolant loops performance was normal. The carbon dioxide partial pressure was maintained below 4.35 mmHg throughout the mission. Cabin air temperature and relative humidity peaked at 84.5 °F and 54.5 percent, respectively. Avionics bays 1, 2, and 3 air outlet temperatures peaked at 110 °F, 110 °F, and 94 °F, respectively. The avionics bays 1, 2, and 3 water coldplate temperatures peaked at 93.5 °F, 95 °F, and 84.5 °F, respectively.

The Orbiter air revitalization pressure control system (ARPCS) performed normally throughout the period of control with both systems being used to satisfy turnaround checkout requirements. One irregularity in system performance occurred during ascent when several high cabin-pressure alarms were annunciated. The cabin pressure increase was the result of a combination of the following conditions: a slightly high cabin pressure (14.86 psia) initially at launch; seven crew members breathing on the launch/entry suit oxygen supply; and the normal cabin pressure increase due to cabin temperature increase during ascent. All of these conditions were nominal; however, the generic cabin pressure backup flight system (BFS) calibration curve was 0.32-psi higher than the actual OV-103 pressure calibration curve, and this was the major contributor in the BFS-computed cabin pressure being at the alarm value of 15.0 psia.

The supply water performed satisfactorily throughout the mission. By the completion of the mission, all of the supply water in-flight checkout requirements and all but one of the waste water requirements had been performed.

Supply water was managed through the use of the flash evaporator system (FES). No supply water dumps were performed due to the vehicle cooling requirements. The supply water dump line temperature was maintained between 65 °F and 94 °F with the operation of the line heater.

Waste water was gathered at approximately the predicted rate. Two waste water dumps were performed. The first dump had an average dump rate of 1.96 percent/minute (3.24 lb/minute), while the second dump had a degraded flow.

The second water dump consisted of four segments over a 1-hour 7-minute period during which the waste tank quantity was dumped from 87.9 percent to 42.6 percent. The dump rate during the first segment degraded from an initial rate of 1.9 percent/minute to a final rate of 1.5 percent/minute, violating the OMRSD lower limit of 1.6 percent/minute (Flight Problem STS-42-V-08). The remaining three segments had a dump rate of 1.6 percent/minute. The dump rates for the second dump were still within the experience band of past flights. These lower dump rates remained within the range in which it was considered safe to continue dumping, if required to support an extension of the mission. The cause of this degradation is under evaluation.

The waste water dump line temperature was maintained between 58 °F and 84 °F throughout the mission, while the vacuum vent line temperature was between 60 °F and 83 °F.

The waste management system performed its functions acceptably; however, one significant anomaly occurred. A WCS anomaly occurred when the crew was attempting to reconfigure the WCS for commode use. The commode control handle became disconnected from the commode control valve linkage and, as a result, the crew was unable to open the WCS commode control valve (Flight Problem STS-42-V-03). An IFM procedure was uplinked and implemented by the crew, and full WCS operation was restored. Later in the mission, the roll pin within the valve sheared on both sides and caused the valve/shaft to rotate freely. Another IFM procedure was performed that allowed the crew to visually identify the appropriate valve positions. The WCS remained operational for the remainder of the mission.

Performance of the active thermal control system (ATCS) was normal for the duration of the mission. The radiators were deployed and restowed without incident.

Smoke Detection and Fire Suppression Subsystem

The smoke detection subsystem performed normally throughout the mission. Use of the fire suppression subsystem was not required.

Airlock Support System

Use of the airlock support system was not required during this mission as no extravehicular activity (EVA) was planned or performed. The tunnel adapter system was used to support Spacelab access and no anomalies were noted.

Avionics and Software Subsystems

Performance of the integrated guidance, navigation, and control subsystem was nominal during all phases of the flight. Likewise, the performance of the flight control system was nominal with no irregularities noted. Also, the inertial measurement unit (IMU), star tracker, and flight software performance was satisfactory. All displays and controls operated nominally.

An irregularity was noted in that a single input/output (I/O) error was logged against FA 1 MDM prom sequence C at 026:08:02 G.m.t.; however, no bypass occurred. If two consecutive errors had occurred, a bypass would have occurred. The bite status read after landing was clear of any errors. The MDM will be monitored during turnaround processing for any recurrence of this event.

The performance of the electrical power distribution and control subsystem was nominal throughout the flight, but one anomaly was noted prior to lift-off. This anomaly (Flight Problem STS-42-V-01) is discussed in the Fuel Cell Powerplant Subsystem section of this report.

Communications and Tracking Subsystem

Communications and tracking subsystem performance was acceptable, but five anomalies and one irregularity in subsystem performance were noted.

At 022:16:48 G.m.t. while over the Indian Ocean Station, the S-band FM hemi antenna switched to the upper antenna without a command being given, and subsequently, the antenna did not switch when commanded. Approximately 1.5 hours later over the Oak Hangar Station, a command was again sent, but no response was observed. Following a switch to manual antenna control, the antenna switching worked correctly. Control of the S-band FM hemi antenna was returned to the general purpose computer and no repeats of the uncommanded switching were noted. S-band FM hemi antenna switching will be monitored on subsequent flights for recurrences of this irregularity.

Early in the mission, closed circuit television (CCTV) camera D was powered up for Earth observations, and the downlinked signal was severely degraded (Flight Problem STS-42-V-02a). In all camera modes, the automatic light control (ALC) cycled from full bright to dark and then back again. The video appeared to stop cycling when a mode switch occurred and the light level was within a narrow band. However, when the light level went outside this narrow band, the ALC began cycling again. This camera is a -508 type that had been modified to prevent blooming problems. The camera was not used for the remainder of the mission. Postflight testing will be performed.

On at least two occasions, the CCTV camera A color wheel became stuck and then later became free (Flight Problem STS-42-V-02b). In each case, the camera again began operating properly.

On flight day 6, contamination of the imaging tube was noted on CCTV camera C, which rendered camera C unusable for the remainder of the mission (Flight Problem STS-42-V-02c).

The TAGS telemetry measurement indication on the ground changed for no known reason and did not correlate with other onboard TAGS indications (Flight Problem STS-42-V-04). A power cycle of the TAGS was performed in an effort to clear the telemetry irregularities. Following the power cycle, the TAGS experienced several false jam indications and the crew performed the TAGS jam malfunction procedure. One additional false jam occurred after the malfunction procedure was performed and was cleared. No further false jams occurred; however, in the mode 1 uplink, the TAGS hardcopier did not produce an image. During troubleshooting, a mode 2 image was sent with the crew reporting that the image was very faint.

Later in the mission, the TAGS was powered up for a test transmission on mode 4. Mode 4 is a high-resolution gray scale mode that requires between 16 and 17 minutes per page to develop an image. The TAGS operated properly during the mode 4 test and it was determined that the TAGS was available for transmission of photographs. At 29:06:10:00 G.m.t., a TAGS mode 3 uplink transmission was executed since it had not been used previously. The crew commented on the transmission, describing the page as "washed out a little bit" and "it may be difficult to read." In an attempt to increase the image intensity, the scanner gain was set to 3, and another transmission was made. The crew commented that the page was still a little washed out and the small fonts were illegible, but the crew did agree that the mode 3 transmissions could be used to supplement the teleprinter message.

The crew reported that multiple anomalies had occurred with the onboard communications crew equipment (Flight Problem STS-42-V-07). The anomalies enumerated by the crew included the following:

a. The C wall unit had a constant beeping noise, regardless of which leg unit was being used for transmission (Flight Problem STS-42-V-07B);

b. Channel 1 of the wall unit A that was located in the Spacelab failed for a period of 20 minutes on flight day 5. Channel 2 operated properly. Channel 1 recovered for a short period, but then failed for the remainder of the mission (Flight Problem STS-42-V-07B);

c. One Orbiter leg unit failed to transmit, but it could receive. Postflight troubleshooting isolated the failure to the transmit synthesizer (Flight Problem STS-42-V-07A);

d. The leg units were not marked with identification numbers;

e. Some of the leg units drained their batteries in as little time as 2 hours, whereas other batteries lasted as long as 2 days. The battery lifetime was irrespective of the procedures used by the crew to activate the batteries (Flight Problem STS-42-V-07C); and

f. The volume level from the speaker unit in the Spacelab was so low that the unit was inadequate as a communications device.

Operational Instrumentation

The operational instrumentation operated satisfactorily throughout the mission with one failure. During entry, the APU 1 EGT 2 measurement became erratic and eventually failed to the lower limit. The EGT sensors have recorded failures on a number of previous missions and the loss of this measurement does not impact the mission.

Structures and Mechanical Subsystems

All structures and mechanical subsystems operated satisfactorily. Braking was initiated at 134.8 knots and continued for 37.3 seconds. The maximum brake pressure on each braking mechanism as well as other brake data are presented in the following two paragraphs.

The left inboard brake 1 pressure was 872 psi, and the right inboard brake 1 pressure was 912 psi. The left inboard brake 3 pressure was 859 psia, and the right inboard brake 3 pressure was 938 psia. The left outboard brake 2 pressure was 912 psi and the right outboard brake 2 pressure was 952 psi. The left outboard brake 4 pressure was 833 psi and the right was 991 psi.

The brake energies were 27.95 million ft-lb on the left-hand outboard brake, 28.03 million ft-lb on the left-hand inboard brake, 30.32 million ft-lb on the right-hand inboard brake, and 30.83 million ft-lb on the right-hand outboard brake.

The sink rate at main gear touchdown was approximately 2 ft/sec, and the pitch rate at nose gear touchdown was 3.68 ft/sec. The Orbiter weight at landing was 218,130 lb. The rollout distance was 9811 feet. Winds were 2 knots from 300 degrees true at the time of touchdown. The main landing gear tires were in good condition for a concrete runway landing.

During the postlanding inspection, the entire exterior surface (flexible insulation blanket and thermal barrier) of the Orbiter right-hand vent door 7 exhibited a yellow-orange discoloration. The surrounding Orbiter sidewall was not discolored. Wipes were taken of the outer door area where the irregularity existed as well as from the structure inside the door and a chemical analysis was performed on these samples. Analysis of the wipe samples indicated the presence of tin, which is associated with room temperature vulcanizing (RTV) material. The vent door blanket has been removed and samples of the blanket are being analyzed at KSC, JSC, and Rockwell-Downey.

At 029:13:23 G.m.t., the crew heard a loud noise. The crew stated that the noise sounded like a "pop" and was accompanied by a vibration that was likened to a tremor. Data analyzed from that period did not show any irregularities. This noise was also heard on STS-9, the first Spacelab flight, and strain gage data from the instrumented transfer tunnel indicated movement of the joints at the attachment point of the Spacelab tunnel to the Orbiter primary structure.

Aerodynamics

The ascent and entry aerodynamic responses were nominal. During entry, the control surfaces and angle-of-attack were as expected; however, the elevon schedule was slightly off of the predicted values because of the more forward center-of-gravity. The entry aerodynamic control surfaces test was performed during entry with all programmed test inputs (PTI's) being completed. The manual body flap maneuver was not performed.

Thermal Control Subsystem

The performance of the thermal control subsystem (TCS) was nominal during all phases of the mission with all temperatures being maintained within acceptable limits. The high beta angles (up to -75 degrees) and resulting 100-percent sunlight conditions resulted in the most extreme thermal environments of the Space Shuttle Program for several subsystems. These subsystems include the primary RCS thrusters, injectors, and valve seats, the OMS main engine fuel and oxidizer lines, and the aft primary RCS oxidizer manifold line in the starboard RCS stinger.

One irregularity was noted when a fault detection annunciator (FDA) alarm was received on the APU 2 fuel test line temperature 2 when the temperature dropped to 48 °F approximately 3 minutes after MECO. The conditions resulted from the line temperature being just above the heater "on" thermostat set point at lift-off. The ground support equipment (GSE) power to the heater was lost at lift-off and the heater is usually not enabled until 1 hour after lift-off. However, because of the lower temperature, the heater was enabled about 20 minutes into the mission.

Instrumentation irregularities that were noted included the oxidizer tank temperature measurement on the starboard OMS pod that was inoperable during the mission and has been inoperable during the previous two flights of this vehicle, STS-39 and STS-48.

As reported in the Auxiliary Power Unit subsection of this report, the EGT 2 sensor on APU 1 failed during entry. The EGT sensors have failed on a number of APU's during previous flights.

The starboard OMS engine oxidizer feedline temperature reached 126 °F, exceeding the operating constraint of 125 °F, but not the non-operating limit of 150 °F.

Thermal Interfaces and Aerothermodynamics

All prelaunch thermal interface temperatures were maintained within limits; however, the start of ET tanking was delayed 1 hour to avoid the potential of violating the LCC. No anomalies or irregularities were noted during prelaunch activities in the area of thermal interfaces.

Acreage heating was as expected during entry. Analysis of aerothermodynamic data is continuing.

Thermal Protection Subsystem

The TPS performed satisfactorily and the general condition of the TPS tiles was very good, except for the higher than usual number of hits with a major dimension greater than 1 inch. The overall boundary layer transition from laminar to turbulent flow was symmetric, occurring at 1215 seconds after entry interface.

During the postflight inspection, a total of 209 hits were noted and 44 of these had a major dimension greater than 1 inch. A comparison of these statistics with previous missions shows that this mission had a greater than average number of hits. The Orbiter lower surface sustained a total of 159 hits of which 38 had a major dimension greater than 1 inch and 14 of these had a major dimension greater than 3 inches. None of the TPS damage was attributed to material from wheels, tires, or brakes.

The chin area tiles and gap fillers looked very good; however, five tiles on the left-hand nose landing gear door had broken edges. This area of the vehicle also sustained approximately 17 hits with a major dimension greater than 1 inch.

Three seals in the left-hand leading edge of the wing and one seal from the right wing have a degraded coating. The right-hand ET door had five tiles damaged. The ET doors thermal barriers experienced normal heating, and no main landing gear door (MLGD) tiles were damaged. However, the right-hand MLGD outboard thermal barrier was breached at the forward corner, and the MLGD left inboard thermal barrier was frayed and protruding.

The engine-mounted heat shield blankets were in good condition except for a two-foot long split in the outer cover of SSME 3 and a frayed cover near the bottom of SSME 1. The base heat shield peppering was nominal, and all other areas of the vehicle looked nominal.

Windows 3 and 4 had a heavy haze, and a light haze was present on all of the other windows. Streaking was noted on windows 2 and 3. Slight periphery tile damage was noted on windows 2, 4, and 5, and the captive gap filler between windows 4 and 5 was breached.

The ascent integrated heating was nominal from both the aerodynamic and plume heating standpoint. Analysis of the heating inputs to the Orbiter continues. Entry heating was also within nominal limits. Analysis based on postflight inspection and data review has shown nominal operation.

FLIGHT CREW EQUIPMENT/GOVERNMENT FURNISHED EQUIPMENT

Overall, the flight crew equipment performed satisfactorily; however, two anomalies were noted, neither of which had any impact on the mission.

At 024:21:53 G.m.t., the crew reported that the amount of water dispensed by the galley rehydration station did not correspond to the selected water quantity. The condition was remedied by cycling power to the galley control electronics. During the postflight debriefing, the crew stated that these erratic dispenses were common occurrences throughout the flight. Early in the flight, cycling power to the electronics did alleviate the problem; however, as the flight progressed, cycling the electronics power became less and less effective in correcting the dispensed amount. Evaluation indicates that this condition was most likely caused by electromagnetic interference (EMI) and can normally be corrected by resetting the control electronics. This particular galley unit historically has been the most susceptible to EMI and is scheduled to be removed from OV-103 during the next flow and modified into the repackaged galley. This modification includes improved EMI shielding.

An attempt to remove the sleep station lower panel for cabin air filter cleaning was initially unsuccessful. The crew reported that the sleep station panel was jammed in place. Analysis determined that the panel could be pried open should mandatory cleaning of the filter be required. Later in the mission, the crew performed a detailed inspection of the area and found that the sliding portion of the door was not fully open, a condition that prevented the lower panel from being removed. Access to the cabin filter was gained and the filter was cleaned.

The crew initially reported that the Orbiter cabin air cleaner power-on light was on, but the fan did not come up to speed. The next day, the crew reported that the cleaner was operating properly. This irregularity is being evaluated.

During the postflight inspection, three unfired pyrotechnics were found in the Orbiter aft fuselage gas sampling system (OAFGSS) (Flight Problem STS-42-V-10). Two pyrotechnics are attached to each of the six bottles in the OAFGSS and these pyrotechnics are normally fired during ascent. The right gas sampler assembly experienced a failure during flight. The bottle 2 fire-closed pyrotechnic did not fire and the bottle 3 fire-open and fire-close pyrotechnics did not fire. All other bottle pyrotechnics fired as expected. The electronics/battery hardware was shipped to the Flight Equipment Processing Contractor for failure analysis. The pyrotechnics and bottles that did not function will undergo further verification of the malfunction at KSC, and then the hardware will be shipped to JSC. The initial theory is that the gas sampler system lost power during flight between the fire-open and fire-close signals on bottle 2. The four bottles that functioned properly have been analyzed for hydrogen and oxygen content and the levels are nominal in three of the four bottles, well within the non-flammability region. Bottle s/n 1374, however, leaked in a significant amount of air postflight and the samples is considered unusable.

PAYLOADS/EXPERIMENTS

The STS-42 mission payloads consisted of the IML -1 (Spacelab long module), which encompassed nine materials science experiments and seven life science experiments in microgravity; five middeck payloads; and nine GAS experiments that were located on the GAS bridge assembly in the payload bay.

Activation of the Spacelab began about 2 hours 20 minutes after lift-off, with the crew entering the Spacelab module about 3 hours 37 minutes after launch. With the mission progressing very smoothly and consumable usage being less than planned, the mission was extended for one additional day during which both the life sciences and materials science investigations benefited. Spacelab systems performed almost flawlessly. The Orbiter provided a trouble-free and stable platform to conduct the IML science activities. More than 100 percent of the premission planned science activities were completed. In addition, well over 100 hours of television were downlinked, and approximately 70 video tapes were recorded. More than 100 crystals, billions of cells, and hundreds of plants were returned. After more than 7 days and 14 hours of operations, the Spacelab was deactivated for entry.

All cargo integration hardware, which includes the Spacelab utility kit, aft flight deck wiring, and retention hardware functioned nominally. The crew did report hearing a loud "pop" that has been attributed to the Spacelab transfer tunnel. This sound was also heard on STS-9 and in both cases is believed to be a normal characteristic of the Spacelab transfer tunnel which contracts and expands due to the solar-induced thermal environment.

The IMAX camera system was flown on IML-1 to obtain footage for use in a film on the human and robotic exploration of the cosmos. The working title of the film is "Destiny in Space." The IML-1 interior shots were chosen to document human adaptation to the microgravity environment, while the exterior shots focused on high-latitude Earth shots that are not available on most missions.

SPACELAB EXPERIMENTS

All of the Spacelab experiments worked well and provided good results. The preliminary results of each Spacelab experiment are as follows:

a. Fluid Experiment System - The objective of this experiment was to study crystal growth and fluid behavior in microgravity conditions. More than 11 runs were made to solidify crystals of triglycine sulfate (metal modeling salts), and nearly 300 holograms were made. Also, over 15 hours of crystal growth were obtained in cell 1 and more than 900 holograms were obtained from cells 1 and 2.

b. Vapor Crystal Growth System - This experiment was first flown on Spacelab 3. Periodic monitoring of the seed crystal early in the mission revealed polycrystalline growths on the faces of the crystal. Temperature adjustments were made that etched these growths from the seed crystal, and the mercury iodide crystal began to grow. preliminary reports indicate a crystal approximately 16 by 16 by 8 mm in size, which is the largest space-grown crystal.

c. Mercuric iodide crystal growth - this objective of this experiment was to grow mercuric iodide crystals. the experiment was previously flown on Spacelab 1 and Spacelab 3. six mercuric iodide crystals were grown in six different cartridges.

d. Organic Crystal Growth Experiment - This experiment used the organic crystal growth facility to grow large single crystals of superconducting organic chemicals.

e. Cryostat - This experiment used two separate thermostatic chambers, one in a stabilizer mode and the other in a freezer mode, to grow protein crystals under different thermal conditions.

f. Protein Crystal Growth - This experiment has been flown on four previous Space Shuttle missions: STS-26, STS-29, STS-32, and STS-37. All experiment equipment worked well with 15 types of protein crystals being grown in the 120 chambers.

g. Space Acceleration Monitoring System - This system measured on-orbit Shuttle accelerations in support of other microgravity experiments.

h. Critical Point Facility - The objective of this experiment was to measure material properties at the critical point. The crew reported that an interesting behavior was noted in the fluid when it passed through the critical point.

i. Gravitational Plant Physiology Facility - The objective of this experiment was to perform a biological investigation of plants during space flight. Initial data indicate that the oat and wheat seedlings grew faster and larger than expected.

j. Biorack - The objective of this experiment was to perform a biological investigation of various life forms during spaceflight. This experiment was also flown on the D-1 Spacelab mission. Preliminary results indicate that, in microgravity, bacteria have thicker cell walls that would reduce the effectiveness of antibiotics.

   Fly data were obtained for two days; however, over the course of the mission all of the flies died. The science team suspects that trace amounts of the hardware sterilization fluid used during ground preparations may have remained in the containers, since the ground control populations also had a high death rate.

k. Space Physiology Experiments - The objective of this experiment was to investigate human space adaptation and motion sickness. During one of the experiment runs, an umbilical cable was caught in a sled rail, and a few ball bearings were released into the laboratory. All of the bearings were collected and the experiment continued to operate properly throughout the mission.

l. Microgravity Vestibular Investigations - The objective of this experiment was to study space motion sickness. An overspeed limiting device (pendulum) stopped the chair operations during its first run. The Spacelab Microgravity Vestibular Investigation (MVI) had completed a sinusoidal run and was about 6 seconds into a ramp run when the 20-ampere circuit breaker tripped. The circuit-breaker tripping incident on the MVI was evaluated for Orbiter impacts. A review of fuel cell currents at the time of the tripping showed that the currents were normal and no current spike was indicated. The circuit breaker was reset, but continued to trip during MVI pitch operations. The irregularity was traced to an out-of-balance pendulum sensor within the experiment and was not the result of actual overcurrent conditions.

   An in-flight maintenance procedure was performed to limit the movement of the pendulum, since it was found to be more sensitive in zero g than in 1 g. The helmet interface box vents were cleaned to eliminate thermal conditions that were degrading experiment video. The science team reported that a substantial amount of data that quantified the human vestibular function in the microgravity environment had been collected.

m. Biostack - The objective of this experiment was to investigate space radiation effects on biological materials. Four Biostack radiation detectors were installed in a Spacelab rack and under the laboratory floor, where they operated throughout the mission. The data will be used to determine the biological impact of cosmic radiation and aid in the design of better radiation protection for spacecraft.

n. Mental Workload and Performance Evaluation - The objective of this experiment was to test human performance of computer tasks in zero-g. The data collected during this experiment will be used to design workstations that are the most comfortable and efficient for humans to use, and to plan future Space Station operations.

o. Radiation Monitoring Container/Dosimeter - The objective of this experiment was to measure the effect of space radiation on biological materials. The data are being evaluated by the sponsor.

MIDDECK PAYLOADS

Five payloads were flown on the middeck. These were:

a. Gelation of Sols: Applied Microgravity Research (GOSAMR) - The objective of this experiment was to investigate processing of gelled Sols in microgravity. All experiment operations were nominal.

b. Student Experiment SE 83-2 - The objective of this experiment was to study zero gravity capillary rise of liquid through granular porous media. All experiment operations were nominal.

c. Student Experiment SE 81-9 - The objective of this experiment was to study convection in zero gravity. All experiment operations were nominal.

d. Investigation into Polymer Membrane Processing - The objective of this investigation was to manufacture polymers in orbit. All experiment operations were nominal.

e. Radiation monitoring equipment (RME-III) - The objective of this experiment was to measure radiation environment while on orbit. The data are being evaluated by the experiment sponsor.

GET-AWAY SPECIAL PAYLOADS

In addition to the Spacelab and middeck experiments, nine GAS payloads were flown in 12 canisters that were connected to the GAS Bridge Assembly in the payload bay. The nine GAS payloads were as follows:

a. G-086 - Effects of Microgravity on Cysts Hatched in Space; Thermal Conductivity and Bubble Velocity of Air in Water - This experiment operated nominally.

b. G-140 - Marangoni Convection in a Floating Zone - This experiment operated nominally.

c. G-143 - Glass Bubbles in Glass Melt - Preliminary data indicate that this GAS payload operated nominally.

d. G-329 - Solidification Phenomena of Metal Alloys - This experiment operated nominally.

e. G-336 - Measurement of Diffuse Zodiacal and Galactic Emissions at B, R, and V Standard Astronomical Wavelengths - This experiment operated nominally.

f. G-337 - Performance of Thermoacoustic Refrigerator Under Microgravity - This experiment operated nominally.

g. G-457 - Gas-Liquid Separation Under Microgravity - It is assumed that the payload operated nominally during ascent; however, a status check during on-orbit operations indicated a malfunction and it is believed to have been caused by low battery voltage.

h. G-609 and G-610 - Ultraviolet Observations of Deep Space - During the third observation, video confirmed that the motorized door assembly did not open, thus preventing the payload from taking data. Successive attempts to restart the payload in a more thermally benign Orbiter attitude were unsuccessful.

i. G-614 - Motion of Debris Under Microgravity Conditions; Low-Melting Point Materials Processing - This experiment operated nominally.

In addition to these GAS experiments, ballast was flown in two of the canisters.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

A total of 15 Development Test Objectives (DTO) and nine Detailed Supplementary Objectives (DSO) were planned for this mission.

DEVELOPMENT TEST OBJECTIVES

DTO 0242 - Entry Aerodynamic Control Surfaces Test (Part 6) - All PTI's were performed and evaluation of the data is being performed by the sponsor.

DTO 0301D - Ascent Wing Structural Capability Evaluation - The data were collected for this experiment and are being evaluated by the sponsor.

DTO 0305D - Ascent Compartment Venting Evaluation - The data were collected for this experiment and are being evaluated by the sponsor.

DTO 0306D - Descent Compartment Venting Evaluation - The data were collected for the experiment and are being evaluated by the sponsor.

DTO 0307D - Entry Structural Evaluation - The data were collected for this experiment and are being evaluated by the sponsor.

DTO 0308D - Vibration and Acoustic Evaluation - The data were collected for this experiment and are being evaluated by the sponsor.

DTO 0312 - ET TPS Performance (Method 2) - In the performance of this DTO, a total of 29 images of the ET were acquired by the crew using the hand-held Hasselblad camera with the 250mm lens. Excellent views of the ET after separation were also acquired with the 16mm Arriflex hand-held motion picture camera.

Review of the ET photography, both 70mm and 16mm, taken by the crew at approximately 15 minutes into the mission revealed two 8 to 12-inch bright regions on the ET intertank between the left bipod attachment point and the forward attachment point to the left SRB. Prelaunch closeout photographs are being reviewed to determine if these bright regions are foam repairs or regions of damage caused during ascent.

DTO 0319D - Shuttle/Payload Low Frequency Environment - The data were collected for this experiment and are being evaluated by the sponsor.

DTO 0623 - Cabin Air Monitoring - All activities were completed in support of this DTO. The data are being evaluated by the sponsor.

DTO 0635 - Eyewash Demonstration - The eyewash demonstration was successfully completed on flight day 5.

DTO 0641 - Spacelab CO2 Control - Activities for this DTO were initiated on flight day 2 at 22 hours 6 minutes mission elapsed time and were successfully terminated on flight day 6 at 5 days 12 hours 27 minutes mission elapsed time. The DTO was completed with the Spacelab Lithium Hydroxide (LiOH) cartridges not being changed out throughout the flight. During the DTO period, the Orbiter cabin partial pressure CO_2 was maintained below 4.0 mmHg and the Spacelab cabin below 5.5 mmHg, both of which are well below the upper limit of 7.6 mmHg CO_2.

DTO 0648 - Electronic Still Photography Test (Test 3 without downlink) - There was not downlinked from this test; however, it is believed that the DTO was completed.

DTO 0651 - EDO Cycle Ergometer Hardware Evaluation - The extended duration Orbiter (EDO) cycle ergometer was the primary exercise device used during this flight. The crew reported that the modifications to improve the vibration level were successful. In-flight video and data from the Space Acceleration Measurement System will be used to evaluate the effectiveness of the cycle as an exercise device and its compatibility with microgravity experiments.

DTO 0653 - Evaluation of MK I Rowing Machine - The rower was used for several exercise sessions and reported to be quiet, but uncomfortable. The comfort problems were similar to those experienced on the ground. Preliminary results indicate that the use of the rowing machine resulted in less "g" disturbances to the vehicle than the cycle ergometer.

0805 - Crosswind Landing Performance - Cross winds were not of the magnitude required for this DTO.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 0466 - Variations in Supine and Standing Heart Rate, Blood Pressure, and Cardiac Size - This DSO was performed only during preflight and postflight operations. Data are being evaluated by the sponsor.

DSO 0469 - In-Flight Radiation Dose-Distribution [Tissue Equivalent Proportional Counter (TEPC) only] - The DSO was completed and data are being evaluated by the sponsor.

DSO 0470 - The Relationship of Space Adaptation Syndrome to Middle Cerebral Artery Blood Velocity Measured In-Flight By Doppler - This DSO was performed and the data are being evaluated by the sponsor.

DSO 0603B - Orthostatic Function During Entry, Landing, and Egress - Data were collected during entry and postlanding and are being evaluated by the sponsor.

DSO 0611 - Air Monitoring Instrument Evaluation and Atmospheric Characterization (Configuration 1 and 2) - Archival organic sampler data were successfully recorded and microbial air sampler data were also successfully recorded with an additional day of data collected. Data are being analyzed by the sponsor.

DSO 0613 - Changes in the Endocrine Regulation of Orthostatic Tolerance Following Space Flight - Data were collected for this DSO during preflight and postflight operations and are being evaluated by the sponsor.

DSO 0901 - Documentary Television - Over 100 hours of video were downlinked during the mission.

DSO 0902 - Documentary Motion Picture Photography - This DTO was successfully accomplished and the photographic data are being evaluated by the sponsor.

DSO 0903 - Documentary Still Photography - This DTO was successfully accomplished and the photographic data are being evaluated.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

On launch day, 25 videos were reviewed. During the mission, 69 films of the expected 69 were reviewed. The detailed review revealed no anomalies or irregularities.

Seven videos of landing were transmitted to JSC for review and analysis. Additionally, seven unprocessed films were received the day after landing, and review of these films began on February 3, 1992. No anomalies or irregularities were noted during the film and video analysis.

TABLE I.- STS-42 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	022:14:47:48.54
	APU-2 GG chamber pressure	022:14:47:49.95
	APU-3 GG chamber pressure	022:14:47:51.16
SRB HPU activation	LH HPU system A start command	022:14:52:05.172
	LH HPU system B start command	022:14:52:05.332
	RH HPU system A start command	022:14:52:05.492
	RH HPU system B start command	022:14:52:05.652
Main propulsion System start	Engine 3 start command accepted	022:14:52:26.435
	Engine 2 start command accepted	022:14:52:26.569
	Engine 1 start command accepted	022:14:52:26.703
SRB ignition command (lift-off)	SRB ignition command to SRB	022:14:52:32.992
Throttle up to 100 percent thrust	Engine 3 command accepted	022:14:52:37.316
	Engine 2 command accepted	022:14:52:37.329
	Engine 1 command accepted	022:14:52:37.344
Throttle down to 75 percent thrust	Engine 3 command accepted	022:14:53:00.196
	Engine 2 command accepted	022:14:53:00.210
	Engine 1 command accepted	022:14:53:00.224
Throttle up to 104 percent thrust	Engine 3 command accepted	022:14:53:31.877
	Engine 2 command accepted	022:14:53:31.891
	Engine 1 command accepted	022:14:53:31.905
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	022:14:53:39
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	022:14:54:35.002
	RH SRM chamber pressure mid-range select	022:14:54:35.672
End SRM action	RH SRM chamber pressure mid-range select	022:14:54:37.672
	LH SRM chamber pressure mid-range select	022:14:54:38.152
SRB separation command	SRB separation command flag	022:14:54:40
SRB physical separation	LH rate APU A turbine speed LOS	022:14:54:40.832
	RH rate APU A turbine speed LOS	022:14:54:40.832
Throttle down for 3g acceleration	Engine 3 command accepted	022:14:59:57.967
	Engine 2 command accepted	022:14:59:57.981
	Engine 1 command accepted	022:14:59:57.955
3g acceleration	Total load factor	022:14:59:58.91
MECO	MECO command flag	022:15:01:02
	MECO confirm flag	022:15:01:03
ET separation	ET separation command flag	022:15:01:21
OMS-1 ignition	Left engine bi-prop valve position	N/A Not performed -
	Right engine bi-prop valve position	direct insertion trajectory flown
OMS-1 cutoff	Left engine bi-prop valve position	N/A Not performed -
	Right engine bi-prop valve position	direct insertion trajectory flown

TABLE I.- STS-42 SEQUENCE OF EVENTS (CONCLUDED)

Event	Description	Actual time, G.m.t.
APU deactivation	APU-1 GG chamber pressure	022:15:06:43.21
	APU-2 GG chamber pressure	022:15:06:44.45
	APU-3 GG chamber pressure	022:15:06:45.66
OMS-2 ignition	Left engine bi-prop valve position	022:15:28:41.0
	Right engine bi-prop valve position	022:15:28:41.0
OMS-2 cutoff	Left engine bi-prop valve position	022:15:31:20.7
	Right engine bi-prop valve position	022:15:31:20.6
Payload bay door open	PLBD right open 1	022:16:19:25
	PLBD left open 1	022:16:20:44
Flight control system checkout		
APU start	APU-2 GG chamber pressure	029:13:12:27.87
APU stop	APU-2 GG chamber pressure	029:13:15:57.94
Payload bay door close	PLBD left close 1	030:12:32:56
	PLBD right close 1	030:12:34:56
APU activation for entry	APU-1 GG chamber pressure	030:15:00:07.30
	APU-2 GG chamber pressure	030:15:22:53.90
	APU-3 GG chamber pressure	030:15:22:55.12
Deorbit maneuver ignition	Left engine bi-prop valve position	030:15:05:03.4
	Right engine bi-prop valve position	030:15:05:03.4
Deorbit maneuver cutoff	Left engine bi-prop valve position	030:15:08:01.7
	Right engine bi-prop valve position	030:15:08:01.7
Entry interface (400K)	Current orbital altitude above reference ellipsoid	030:15:35:44
Blackout ends	Data locked at high sample rate	No blackout
Terminal area energy management	Major mode change (305)	030:16:00.53
Main landing gear contact	LH MLG tire pressure	030:16:07:18
	RH MLG tire pressure	030:16:07:17
Main landing gear weight on wheels	LH MLG weight on wheels	030:16:07:18
	RH MLG weight on wheels	030:16:07:17
Nose landing gear contact	NLG tire pressure	030:16:07:27
Nose landing gear weight on wheels	NLG WT on Wheels -1	030:16:07:27
Wheels stop	Velocity with respect to runway	030:16:08:16
APU deactivation	APU-1 GG chamber pressure	030:16:24:11.14
	APU-2 GG chamber pressure	030:16:24:12.37
	APU-3 GG chamber pressure	030:16:24:13.50

TABLE II.- STS-42 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-42-V-01	a) Fuel Cell 2 Hydrogen Pump Motor Condition Spike/AC Bus 2 Phase Current Anomaly	022:07:02 G.m.t. Prelaunch IPR-53V-0001 IM 42RF01	A spike in the fuel cell 2 hydrogen pump motor condition was noted with a maximum value of 1.48 (LCC limit = 1.00). At the same time, AC 2 phase B showed a 0.25 ampere increase and phase C showed a 0.16 ampere decrease. Off-line testing duplicated the problem, most likely failure cause is intermittent high resistance in power circuitry. KSC: Resistance test and wire wiggle between panel L4 and fuel cell 2 interface. Visual check of associated phase C connectors pins/sockets.
STS-42-V-02	a) CCTV Camera D Degradation (GFE)	023:06:58 G.m.t. a) FIAR BFCE 029-F044	a) In all camera modes, the automatic light control (ALC) circuitry cycles from full bright to dark and back again. It appears to stop cycling when a mode switch occurs and the light level is within a narrow band. When the light level goes outside this band, the ALC circuitry begins cycling again.
	b) CCTV Camera A Color Wheel Stuck	b) FIAR BFCE 029-F047	b) On a couple of occasions and at various temperatures, the camera A color wheel became stuck and later unstuck.
	c) Camera C Degradation	c) FIAR BFCE 029-F048	c) When camera C was used for downlink of payload bay views, the camera appeared to have delamination or some type of film on the faceplate. KSC: Remove cameras and deliver to Flight Equipment Packing Facility.
STS-42-V-03	WCS Commode Control Handle Linkage Failure	024:16:10 G.m.t. CAR 42RF02 PR ECL-3-15-0859	During an attempt to configure the WCS for commode use, the commode control handle became disconnected from the commode control valves. The crew performed an in-flight maintenance (IFM) procedure and regained use of the commode. At 027:17:19 G.m.t., the pin inside the the WCS ball valve sheared due to extra torque from the IFM. Caused loss of hardstops on ball valve. Further IFM provided initial hardstop starting point and visual stopping point. WCS again functional. Linkage removed at DFRC on February 3. Verified single shear dowel pin failure where handle linkage mates to the vacuum valve shaft caused initial problem. Later, double shear of roll pin near the valve caused loss of hardstops. KSC: Redesign in work for STS-50 and subsequent. Will manifest IFM tools for flights prior to STS-50.
STS-42-V-04	TAGS Telemetry and Imaging Problems.	026:04:10 G.m.t. JSC-EE-0668	Telemetry on ground changed inexplicably and did not correlate with the onboard TAGS indications. TAGS was power cycled, after which false jams were indicated. After false jams were cleared, pages could pass through, but were not imaged in mode 1 or mode 2. Faint images were received in mode 3. Mode 4 transmissions were nominal. KSC: Remove TAGS and deliver unit to Flight Equipment Packing Facility.

TABLE II.- STS-42 PROBLEM TRACKING LIST

Number	Title	Reference	Comments
STS-42-V-05	Left Aft RCS Thruster L3A Failed Leak	028:21:00 G.m.t. CAR 42RF03 IPR 53V-0005	At 028:21:00 G.m.t., aft RCS thruster L3A (ser. no. 116) was deselected by RM when the oxidizer injector temperature dropped below 30 °F. No thruster firings in process at that time. A review of the data indicates an oxidizer valve leak. Thruster rewarmed itself indicating the leak stopped. No leak postlanding KSC: Remove and replace thruster L3A.
STS-42-V-06	Thruster R4U Oxidizer Leak	030:03:07 G.m.t. CAR 42RF04 IPR 53V-0004	Crew downlinked video of fluid leak from aft of vehicle. Power up of MDM FA4 verified R4U oxidizer leak. Leak also visible via tank quantity decrease. Right manifold 4 closed for entry. No leak postlanding. KSC: Remove and replace thruster R4U.
STS-42-V-07	Wireless Communications Equipment a) Two CRU's bad b) Wall units A & C were Degraded c) Low Battery Life	027:06:30 G.m.t. a) FIAR BFCE 029-F045 and 029-F046	The crew reported that two CRU's had failed, one in the Orbiter and one in the Spacelab. Also wall unit C had a constant beeping, and wall unit A was scratchy and quit working on flight day 5 for 20 minutes. Some of the leg units drained batteries in as little as 2 hours. KSC: Remove all affected units and deliver to FEPC.
STS-42-V-08	Degraded Waste Dump Flow Rate	023:15:08 G.m.t. IM 42RF05 IPR 53V-0008	During waste dump 2, the dump flowrate degraded from an initial rate of 1.9 percent/minute to a final rate of 1.5 percent/minute on the first segment. The remaining three segments had a dump rate of 1.6 percent/minute. Postflight urine solids filter removed and replaced - looked okay. Data analysis of KSC flow testing continuing.
STS-42-V-09	Liquid Oxygen Topping Valve Open Indication Missing	030:15:30 G.m.t. IM 42RF06 IPR-53V-0009	Open indication did not appear when valve was commanded open during entry. Closed indication was lost. Closed indication came back when when valve commanded closed. KSC: Verified bad microswitch. Valve removed and replaced.
STS-42-V-10	OAFGSS Pyrotechnics Did Not Fire (GFE)	Ascent - Discovered in Postlanding Inspection FIAR BFCE-029-F006	Right side bottle 2 "close" pyrotechnic did not fire, and no pyrotechnics fired on bottle 3. All other bottle pyrotechics operated properly.

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