NASA-CR-193062

JSC-08249

STS-37
SPACE SHUTTLE
MISSION REPORT

(NASA-CR-193062) STS-37 SPACE SHUTTLE MISSION REPORT (Lockheed Engineering and Sciences Co.) 32 p

N93-25956

Unclas

G3/16 0163535

May 1991

NASA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

NSTS-08249

STS-37

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke
Flight Requirements Section

Approved by

David W. Camp
Manager, Flight Data and
Evaluation Office

D. M. Germany
Manager, Orbiter and GFE Projects

Leonard S. Nicholson
Deputy Director, Space Shuttle Program

Prepared by
Lockheed Engineering and Sciences Company
for
Flight Data and Evaluation Office

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

May 1991

Table of Contents

List of Tables

INTRODUCTION

The STS-37 Space Shuttle Program Mission Report contains a summary of the vehicle subsystem activities during this thirty-ninth flight of the Space Shuttle and the eighth flight of the Orbiter vehicle Atlantis (OV-104). In addition to the Atlantis vehicle, the flight vehicle consisted of an External Tank (ET) (designated as ET-37/LWT-30), three Space Shuttle main engines (SSME's) (serial numbers 2019, 2031, and 2107 in positions 1, 2, and 3, respectively), and two Solid Rocket Boosters (SRB's) designated as BI-042.

The primary objective of this flight was to successfully deploy the Gamma Ray Observatory (GRO) payload. The secondary objectives were to successfully perform all operations necessary to support the requirements of the Protein Crystal Growth (PCG) Block II version, Radiation Monitoring Experiment-III (RME-III), Ascent Particle Monitor (APM), Shuttle Amateur Radio Experiment-II (SAREX-II), Air Force Maui Optical Site Calibration Test (AMOS), Bioserve Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA), and the Crew and Equipment Transfer Aids (CETA) payloads.

The sequence of events for this mission is shown in table I. The report also summarizes the significant problems that occurred in the Orbiter subsystems during the mission, and the official problem tracking list is presented in table II. In addition, each Orbiter subsystem problem is cited in the applicable subsystem discussion within the body of the report.

The crew for this thirty-ninth flight of the Space Shuttle was Steven R. Nagel, Colonel, USAF, Commander; Kenneth D. Cameron, Lt. Col., USMC, Pilot; Linda M. Godwin, Ph.D, Mission Specialist 1; Jerry L. Ross, Lt. Col., USAF, Mission Specialist 2; and Jerome (Jay) Apt, Ph.D., Mission Specialist 3. This was the third Shuttle flight for the Commander and Mission Specialist 2; and the first Shuttle flight for the Pilot, Mission Specialist 1, and Mission Specialist 3.

SUMMARY

The STS-37 mission was successfully launched from launch pad 39B at 095:14:22:44.988 G.m.t. (9:22:44.988 a.m. e.s.t.) on April 5, 1991, and all subsystems operated satisfactorily. Resumption of the countdown after the T-9 minute hold was delayed about 4 minutes 45 seconds because of two possible weather-condition violations of the launch commit criteria (LCC). The first concerned the ceiling being 500 feet less than the minimum of 8000 feet for a return-to-launch-site (RTLS) abort, and the second concerned the possible weather-condition (wind) effects on blast propagation. Both conditions were found acceptable and the launch countdown proceeded to a satisfactory launch on an inclination of 28.45 degrees. All SSME and redesigned solid rocket motor (RSRM) start sequences occurred as expected, and launch phase performance was nominal in all respects. First stage ascent performance was normal with SRB separation, entry, deceleration, and water impact occurring as expected.

Both SRB's were subsequently recovered and returned to KSC for disassembly and refurbishment. Performance of the SSME's, ET, and main propulsion system (MPS) was also normal with main engine cutoff (MECO) occurring at 095:14:31:17.72 G.m.t. At the completion of the orbital maneuvering subsystem (OMS) -2 maneuver, the Orbiter was in the planned circular orbit of approximately 243 n.mi.

During prelaunch operations, data indicated that the Z component of the backup flight system state vector was in error by 250 feet about 3 minutes after OPS 1 transition. The error in the Z component continued to increase to a maximum of 7700 feet during the prelaunch period. The normal update at T-11 seconds stopped the increase and reset the value to zero. This anomaly did not impact mission operations.

Flight day 1 activities included checkout of the remote manipulator system (RMS) and activation of the Gamma Ray Observatory (GRO) payload. Cabin pressure was reduced to 10.2 psia in preparation for the potential contingency extravehicular activity (EVA) on flight day 3 and the planned EVA on flight day 4.

Reaction control subsystem (RCS) thruster R1U failed at 095:14:31:49.87 G.m.t. (32 seconds after MECO). Thruster R1U remained deselected for the remainder of the mission.

Flight day 2 activities included an in-bay checkout of the GRO in preparation for its deployment during flight day 3. Also, the checkout of the three extravehicular mobility units (EMU's) was completed.

At 096:13:42 G.m.t., the Ku-Band antenna began exhibiting a track error while operating in the Auto and GPC Acquisition modes. This error caused a temporary loss of forward lock and occurred intermittently during nine revolutions (between revolutions 15 and 61) of the mission.

During the flight day 2 pre-sleep configuration activities, the power reactant storage and distribution oxygen manifold isolation valve 2 did not close when the onboard switch was placed in the closed position on three occasions. The crew closed the oxygen manifold 1 valve for the sleep cycle. The crew cycled the switch again at 098:09:21 G.m.t., (flight day 3) and the valve operated satisfactorily. The valve was kept closed for the remainder of the flight.

The GRO high gain antenna could not be deployed after the GRO was raised from the payload bay using the remote manipulator system (RMS) during flight day 3 activities. Numerous attempts were made to shake loose the antenna, but these were unsuccessful. As a result, a 3-hour 30-minute contingency EVA was performed. The antenna was released during the early portion of the EVA, and the crew then proceeded to perform some of the tasks that were planned to be performed during the flight day 4 EVA.

Also during the contingency EVA on flight day 3, no biomedical data were received from either EMU when operating on communications mode A. Following the EVA, compensations were made in the Mission Control Center to receive that data and these were successful.

The crew reported that it was not possible to recharge the EMU-1 battery following the EVA. The EMU-3 battery was topped off and installed in EMU-1 for the EVA.

Flight day 4 activities were primarily concerned with the planned EVA. The crew completed a 5-hour 47-minute EVA during which all remaining planned activities were completed. The RMS performed satisfactorily during the 6 hours and 35 minutes of operation.

The RCS hot-fire was completed on flight day 4 with all thrusters, except the failed R1U, operating satisfactorily. The flight control subsystem (FCS) checkout was also completed satisfactorily using APU 3.

The crew performed a series of maneuvers to achieve the desired re-rendezvous with the Gamma Ray Observatory.

Entry preparations were completed on flight day 5 and after a one revolution delay in the deorbit maneuver, the decision was made to delay landing one day because of high winds at the primary landing site, Edwards Air Force Base. Adequate consumables remained available for an additional two days, if required. A landing option was maintained for both KSC and Edwards Air Force Base on the first extension day (flight day 6). The first landing opportunity at KSC was waived because of fog, and the first opportunity at Edwards Air Force Base on lakebed runway 33 was accepted.

After completion of all entry preparations including stowage and payload bay door closure, the OMS deorbit maneuver was performed at 101:12:45:50.1 G.m.t., with a firing duration of 221.4 seconds and a differential velocity of 438.6 ft/sec. Entry interface occurred at 101:13:24:23 G.m.t., and because of the presence of Tracking and Data Relay Satellites (TDRS), communications were maintained for the majority of the entry period.

Main landing gear touchdown occurred at 101:13:55:29 G.m.t., on lakebed runway 33 at Edwards Air Force Base, CA. Nose landing gear touchdown occurred 6 seconds later with wheels stop at 101:13:56:25 G.m.t. The rollout was normal in all respects. The landing occurred on April 11, 1991, and the flight duration was 05:23:32:45.

Postlanding at 101:14:11 G.m.t., the pH sensor on fuel cell 3 indicated high pH. The presence of KOH was not confirmed by the common pH sensor that is downstream of the fuel cell 3 sensor, and all operational parameters indicated that the fuel cell was healthy. The high pH indication returned to normal after 10 minutes; however, fuel cell 3 was shut down as a precautionary measure.

Also, the APU 2 injector tube temperature sensor failed after landing; however, the failure did not impact the subsequent hydraulic load test. The hydraulic load test was performed and all indications were normal.

The last APU was shut down at 101:14:18:45.07 G.m.t., and the crew completed the required postflight reconfigurations and exited the vehicle at 101:14:54 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).

SOLID ROCKET BOOSTERS/REDESIGNED SOLID ROCKET MOTORS

All SRB systems performed as expected throughout ascent. The SRB prelaunch countdown was normal. RSRM propulsion performance was well within the required specification limits, and the propellant burn rate for each RSRM was normal. RSRM thrust differentials during the 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. No SRB or RSRM LCC or Operations and Maintenance Requirements Specification (OMRS) violations occurred during the launch countdown.

Power up of all case igniter, joint, and field joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. Ground purges maintained the case nozzle joint and flexible bearing temperatures within the required LCC ranges.

The flight performance of both RSRM's was well within the allowable performance envelopes. The SRB structural temperature responses were as expected during the flight. The postflight inspection of the recovered hardware showed that the SRB thermal protection system (TPS) performed properly during ascent with very little acreage ablation.

Separation subsystem performance was normal with all booster separation motors expended and all separation bolts severed. Nose cap jettison, frustum separation, and nozzle jettison occurred normally on each SRB.

Both SRB's were successfully separated from the ET near the proper time, and reports from the recovery area, based on visual sightings, indicated that the deceleration subsystems performed as designed. Both SRB's were observed during descent. The SRB's were towed to shore and taken to KSC for postflight inspection and disassembly.

One SRB anomaly occurred during the STS-37 flight. This anomaly (Flight Problem STS-37-B-1) was associated with the buckling of the left SRB forward skirt skin panel (aft end) on both sides of the systems tunnel (-Y axis). The structural damage was located between the aft ring of the forward skirt and the SRM connecting pins, and extended approximately 129 inches (105 °) around the SRB and centered about the -Y axis. The valley areas of the dimple measure approximately 0.75-inch deep. All of the forward-skirt TPS was intact with the exception of two pieces missing in the dimpled area. A crack was observed in the igniter heater cable feed-through cover, and an L-bracket had separated from the systems tunnel. Analysis and/or accelerometer data indicate that no buckling occurred during ascent or SRB separation. Consequently, the time of occurrence was confined to the periods of descent (parachute deployment sequence) or to the slap-down loads encountered in the heavy seas immediately following water impact.

Two RSRM anomalies occurred during the STS-37 flight. The first anomaly is a criticality 3 problem associated with an observation of missing cadmium plating up to the primary seal cushion on the right RSRM safe and arm (S&A) gasket (due to corrosive action of the right RSRM combustion products on the cadmium) as had been seen on several previous flights (Flight Problem STS-37-M-1). There was no evidence, nor has there ever been, of heat effects on the metal gasket or seal cushion material of the S&A's or igniters. Consequently, this problem is not considered to be a flight safety issue since it is attributed to corrosion rather than erosion.

The second anomaly (Flight Problem STS-37-M-2) was associated with a permanent inward deflection of the left RSRM forward segment case wall. The deflection appeared to be greatest from 320° through 0° to 80° along the aft cylinder of the forward segment, and the forward cylinder of the forward center segment.

There was a maximum inward deflection of 0.535 inch at 0°, and a maximum outward deflection of 0.480 inch at 50°. Also, there was no evidence of external collision or impact damage to the field joint. A structural assessment ruled out ascent phase loads as a potential cause because of the high margins of safety that exist. Tensile pressurization loads during ascent preclude any potential for buckling. The most likely cause of this case damage was the load that was experienced during slap-down, immediately following water impact. SRB data confirm that slap-down loads experienced by the SRB were the highest ever recorded (92 g's versus 12 - 40 g's historically recorded). This problem is not considered a safety-of-flight issue, but a refurbishment/reuse issue.

EXTERNAL TANK

All objectives and requirements associated with the support of the launch countdown and flight were successfully accomplished. ET propellant loading was completed as scheduled and all prelaunch thermal requirements were met. All ET electrical equipment and instrumentation performed satisfactorily. The operation of the ET heaters and purges was monitored and all performed properly. No LCC or OMRS violations were identified.

Only the normally expected ice/frost formations for the April environment were observed during the countdown. There was no frost or ice on the acreage areas of the ET. Normal quantities of ice or frost were present on the liquid oxygen and liquid hydrogen feedlines and on the pressurization line brackets. Frost was also present along the liquid hydrogen protruding air load (PAL) ramps. All of these observations were acceptable per Space Shuttle Program documentation. The ice/frost team reported that no anomalous TPS conditions were observed. The ET pressurization system functioned properly throughout engine start and flight. The minimum ullage pressure experienced during the period of ullage pressure slump was 13.9 psid.

ET flight performance was excellent. The ET tumble system was inactive for this flight. ET separation was normal, and main engine cutoff (MECO) occurred within the expected tolerances. ET breakup and entry were confirmed by many reports from Hawaii, as the ET provided a spectacular show when it disintegrated within the expected footprint.

SPACE SHUTTLE MAIN ENGINES

All SSME parameters appeared to be normal throughout the prelaunch coun comparing very well with prelaunch parameters observed on previous fli ts. The engine-ready indication was achieved at the proper time, and all L were met. Flight data indicate that SSME performance during engine start, thrust buildup, mainstage, throttling, shutdown, and propellant dump operations was well within specifications. All three engines started and operated normally. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures were normal throughout the period of engine operation. The SSME controllers provided proper control of the engines throughout powered flight. All on-orbit activities associated with the SSME's were accomplished successfully. No failures or significant problems were identified.

SHUTTLE RANGE SAFETY SYSTEM

Shuttle range safety system (SRSS) closed-loop testing was completed as scheduled during the launch countdown. The SRSS safe and arm devices were armed and all system inhibits were turned off at the appropriate times. All SRSS measurements indicated that the system performed as expected throughout the flight.

Prior to SRB separation, the SRB S&A devices were safed, and SRB system power was turned off as planned. The ET system remained active until ET separation from the Orbiter. The system signal strength remained above the specified minimum (-97 dBm) for the duration of the flight.

ORBITER SUBSYSTEMS

Main Propulsion System

The overall performance of the main propulsion system (MPS) was excellent. All pretanking purges were properly performed, and the liquid oxygen and liquid hydrogen loading was performed as planned with no stop flows or reverts. There were no OMRS or LCC violations.

The MPS helium system performed satisfactorily. Throughout the preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen level in the Orbiter aft compartment was 181 ppm, which compares very well with previous data for this Orbiter. There was also some indication of a small oxygen leak in the region of the aft compartment when the oxygen concentration reached 270 ppm, which is higher than previously observed on this Orbiter (Flight Problem STS-27-V-14). The absence of argon in the aft compartment indicated that air intrusion was not the cause of this elevated oxygen concentration. During replenish, the level dropped below 100 ppm. The LCC limit is 500 ppm.

A comparison of the calculated propellant loads at the end of replenish versus the inventory loads results in a loading accuracy of 0.05 percent for liquid hydrogen and 0.02 percent for liquid oxygen.

The gaseous oxygen flow control valves (FCV's) were shimmed to the high position of 85-percent open and a low position of 66-percent open as step 2 of the gaseous oxygen fixed orifice implementation plan was i peated. The gaseous oxygen pressurization system performed nominally throughout the flight.

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

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

Four MPS-related measurements were failed off scale. These were as follows:

a. GL0Q2009A - Facility liquid oxygen replenish flow rate;

b. MDBT1148A - Liquid oxygen bypass loop temperature;

c. V41R1115A1 - Engine 1 liquid hydrogen recirculation pump speed; an

d. GLHT4119A - Facility liquid hydrogen high-point bleed tempera

Reaction Control Subsystem

The performance of the reaction control subsystem (RCS) was nominal with two anomalies being noted. The RCS was also used to support development test objective (DTO) 0242 in which eight programmed test input (PTI) maneuvers were performed. A total of 5300 lb of propellant was consumed from the RCS propellants loaded onboard. Also, OMS/RCS interconnect operations provided additional propellants for RCS operation.

Thruster R1U failed off about 32 seconds after main engine cutoff (MECO) on the first attempted firing of the thruster (Flight Problem STS-37-V-01). Data show that the failure was similar to the R1U thruster failure experienced on STS-36 in that only the oxidizer poppet portion of the valve opened while both the poppet and main stage portions of the fuel valve opened. The chamber pressure reached only 10 psia, and this indicates low-level combustion because of an off-nominal mixture ratio. The thruster was removed and sent to White Sands Test Facility for testing.

For the re-rendezvous, an OMS/RCS interconnect test was performed because STS-38 data indicated low chamber pressure during left OMS interconnect operations. The RCS firings made during left interconnect operations showed no instances of low chamber pressure; however, low chamber pressure (20-psi low) was noted on thrusters L1U and L1L during right interconnect operations (Flight Problem STS-37-V-08). The left OMS-to-RCS interconnect was performed at 098:36:00 G.m.t., and the right OMS-to-RCS interconnect operations were initiated at 098:37:49 G.m.t. The data from these thrusters was similar to the low chamber pressure data from thrusters R1U, R3D, R4U, and R3R during left OMS interconnect operations on STS-38. The current understanding is that the low chamber pressure is a result of the data sampling rate, firing duration, and system pressure drops during interconnect operation. The low chamber pressure indication for an 80 millisecond firing is considered to be normal based on the three factors discussed previously.

Orbital Maneuvering Subsystem

The OMS performance was satisfactory for the three maneuvers and two periods of interconnect operation performed during the STS-37 mission. The OMS-2 maneuver (234.7 seconds and 372.1 ft/sec) and deorbit maneuver (221 seconds and 439.7 ft/sec) were both two-engine firings and the OMS-3 maneuver (9.44 sec and 8.7 ft/sec) was a one-engine (left-hand) firing. A total of 11,411 lb of oxidizer and 6859 lb of fuel was used during the mission. The gaging system performance was satisfactory except for the left forward fuel probe which has been failed for several missions and will be replaced on an opportunity basis. As stated in the discussion of the RCS, OMS propellants were fed to the RCS during left and right pod interconnect operations.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed nominally throughout the 143-hour mission, meeting all reactant supply requirements. The Orbiter was flown in a three-tank-set configuration, and a total of 1559 lb of oxygen (plus 75 lb used by crew) and 187 lb of hydrogen was used during the six-day mission for the production of 2165 kWh of electricity. Total reactants remaining at landing would have supported an additional 67 hours of mission operations at a 12.5 kW level.

During the flight day 2 pre-sleep configuration activities, the oxygen manifold isolation valve 2 did not close when commanded on three occasions (Flight Problem STS-37-V-03). The crew closed the oxygen manifold 1 valve for the sleep cycle. The crew cycled the switch again approximately 48 hours later at 098:09:21 G.m.t., (flight day 3) and the valve closed satisfactorily. The valve was kept closed for the remainder of the flight. This problem appeared to be a repeat of the same problem that occurred on STS-34 when this same valve did not close when first commanded.

A postlanding test was performed on the manifold valve during which the valve was cycled open three times to verify its operation on the ground. A 26 lb/hr flow rate of oxygen was established through the environmental control and life support system (ECLSS) for 10 minutes to chill the valve to cryogenic temperatures. The valve was cycled three times satisfactorily, thus indicating that the in-flight failure was not thermally induced.

Fuel Cell Powerplant Subsystem

The performance of the fuel cells was nominal throughout the mission with one anomaly occurring after landing. Total energy produced was 2165 kWh at an average power level of 15.1 kW. A total of 1627 lb of potable water was also produced.

During postlanding operations (about 15 minutes after landing), the fuel cell 3 (partial hydrogen)pH sensor began cycling rapidly on and off in 1- to 2-second intervals for a 10-minute period (Flight Problem STS-37-V-11), but the common water line pH sensor did not confirm the fuel cell 3 pH indication. A continuously "on" signal is a warning that fuel cell electrolyte (KOH) is exiting the fuel cell with the product water. The cyclic indication had not been observed in any previous fuel cell operation. The crew performed normal malfunction procedures for the possible loss of a fuel cell and these included tieing main busses A and C together. Although the fuel cell was operating properly after the anomaly, the decision was made by flight control personnel to shut down the fuel cell as a precautionary measure, and to leave the vehicle in a safe condition for the ground servicing personnel. Postflight analysis of the product water revealed no indications of KOH in the water, which indicates that the anomaly was a sensor malfunction.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performance was satisfactory with only one minor problem and one anomaly occurring during the mission. Neither of these conditions impacted the mission. The following table presents the cumulative run time and fuel consumption for each APU during the STS-37 mission.

Flight Phase	APU 1		APU 2		APU 3	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	00:20:36	51	00:20:36	55	00:20:36	54
FCS checkout					00:05:42	12
Entry	01:36:17	180	01:07:13	162	01:07:13	150
Total[a]	01:56:53	231	01:27:49	217	01:33:31	216

Note:
[a] The total includes 23 minutes 14 seconds of APU operation occurred after landing.

During entry operations, the APU 2 injector tube temperature sensor (V46T0274A) became erratic and failed off-scale low after landing (Flight Problem

STS-37-V-10b). Approximately 1 hour into the APU cooldown period after landing, the injector tube temperature measurement began responding nominally. Loss of this temperature measurement had no effect on postlanding operations.

The APU 1 exhaust gas temperature (EGT) sensor 1 (V46T0142A) failed off-scale low after APU shutdown following ascent. The measurement functioned properly during entry, but then failed during postlanding operations. Loss of EGT sensors has occurred on many missions with no effect on mission operations.

A discussion of the abnormal lubrication oil cooling on APU 2 during ascent and on APU 2 and 3 during entry is contained in the following section of this report.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler subsystem operation was nominal; however, four anomalous conditions were noted in the subsystem operation. A hydraulics load test was performed after landing and the data show excellent results.

During ascent, the water spray boiler (WSB) 2 core froze while operating on controller A and remained frozen until 2 minutes after MECO, causing an undercooling condition on the APU 2 lubrication oil (Flight Problem STS-37-V-02a). The temperature of the lubrication oil increased to 280 °F while on controller A (temperature should be maintained at 250 °F). Cooling was noted about 15 seconds prior to switching to controller B. Control was switched back to controller A about 45 seconds prior to APU shutdown and proper cooling was noted. A similar failure occurred on STS-38.

During entry, WSB 2 overcooled the lubrication oil on APU 2 by 61 °F for a period of 4.5 minutes before recovering (Flight Problem STS-37-V-02b). Also, WSB 3 undercooled APU 3 lubrication oil on two occasions by 20 and 40 °F before recovering (Flight Problem STS-37-V-12). Neither of these conditions impacted APU operations during the mission.

During entry, the hydraulics subsystem 2 priority valve opening was in excess of the 1-second specification as 4 seconds were required to respond (Flight Problem STS-37-V-15). This anomaly did not affect mission operations.

Pyrotechnics Subsystem

All pyrotechnics operated properly.

Environmental Control and Life Support Subsystem

The environmental control and life support subsystem performed nominally throughout the STS-37 mission. The Orbiter cabin total pressure was maintained between 14.52 and 14.8 psia and the oxygen partial pressure (PPO2) was maintained between 2.96 and 3.3 psia using the automatic pressure control system. During the EVA periods, manual operation of the cabin pressure valve maintained the total pressure between 10.05 and 10.5 psia and PPO2 between 2.64 and 2.92 psia.

Following the EVA, automatic control of cabin pressure was again selected to repressurize the crew module to 14.7 psia and maintain cabin pressure at that level for the remainder of the mission.

The waste collection system performed normally throughout the mission.

The supply water and waste management subsystems performed normally throughout the mission. By the completion of the mission, all of the associated supply water in-flight checkout requirements were completed satisfactorily.

Supply water was managed through the use of the overboard dump system and the flash evaporator system. Supply water dumps were performed at an average rate of 1.6-percent per minute (2.64 lb/min), and the supply water dump line temperature was maintained between 66 °F and 93 °F using the line heater.

Waste water was gathered at a rate greater than predicted. A waste water dump was performed at a rate of 1.94-percent per minute. The waste water dump line was maintained between 57 and 74 °F throughout the mission, while the vacuum vent line temperature was maintained between 56 and 76 °F.

Smoke Detection and Fire Suppression Subsystem

The smoke detection subsystem operated properly throughout the mission. The fire suppression subsystem was not required during the STS-37 mission.

Airlock Support Subsystem

The airlock support subsystem operated properly while providing support to the two crew members who performed the EVA's. The airlock provided access to the payload bay in support of the contingency EVA and the planned EVA. The airlock depressurization valve was used to depressurize the cabin to 10.2 psia in support of the EVA prebreathe protocol.

Avionics and Software Subsystem

The performance of the avionics and software subsystem was nominal with five anomalies noted during prelaunch and mission operations.

Between OPS 101 transition and navigation initialization at T-11 seconds during the final portion of the launch countdown, the backup flight system (BFS) navigation error diverged at a rate greater than 1 ft/sec (Flight Problem STS-37-V-09). The divergence reached 7700 ft when navigation initialization took place at T-11 seconds. Data analysis and Shuttle Avionics Integration Laboratory (SAIL) testing show that the anomaly was due to incorrect navigation initialization code and was not an in-flight navigation issue. During investigation of the BFS navigation anomaly, numerous runs were made in the SAIL facility which showed the cause of the prelaunch anomaly; however, the data also showed another problem. When transitioning between OPS 0 and OPS 3, the GPC on numerous occasions would hang in the wait state. A workaround procedure was developed should this problem occur during the flight, but the problem did not occur.

The integrated guidance, navigation and control performance during ascent and on-orbit was nominal; however, during landing operations, the touchdown was much slower (156.6 knots), shorter (-537 ft to runway threshold) and harder (4 ft/sec sink rate) than usual. A wind shear of approximately 80 knots was encountered between 14,000 ft and 9000 ft above ground level. This shear was outside the Edwards Air Force Base 3 sigma data base and may have contributed to the above landing conditions, although the energy level was low earlier while flying the heading alignment circle.

The flight control system hardware as well as the inertial measurement unit (IMU) hardware performed nominally throughout the mission. Star tracker performance was also nominal; however, the -Z axis star tracker failed self-test (Flight Problem STS-37-V-16). This problem did not affect star tracker performance.

General purpose computer (GPC) 2 was inadvertently brought out of the sleep mode. This condition apparently occurred when the crew was placing a switch guard over the GPC switches. The problem was not noticed for about 24 hours until the thermal data showed greater heat input to the avionics bay where GPC 2 is located.

The electrical power distribution and control subsystem operated nominally during all mission phases. The displays and controls operated nominally; however, two floodlights in the payload bay failed during the mission. During the contingency EVA, the payload bay forward bulkhead floodlight failed (Flight Problem STS-37-V-5A). An attempt to light the floodlight by cycling the switch was unsuccessful. Loss of this light did not significantly impact EVA operations.

While preparing to close the payload bay door before the planned entry on flight day 5, the mid-port floodlight was noted to be out (Flight Problem STS-37-V-5b). The loss of the light did not hamper any payload bay activities.

Communications and Tracking Subsystem

Communications and trackings subsystem performance was nominal with two anomalies and two problems identified.

Closed circuit television (CCTV) camera D was noted to have some kind of debris that appeared to be floating inside the lens and within the field of view. This small object did not degrade the image significantly and the camera remained usable throughout the mission.

The Ku-Band system failed the self-test on two occasions. This occurrence was a repeat of the same condition that occurred on a previous flight. The Ku-Band also had an angle tracking anomaly on nine occasions between revolutions 8 and 61 (Flight Problem STS-37-V-04). In each case the tracking error increased until loss of lock occurred. After the last occurrence on revolution 61, the antenna operated properly for the remainder of the mission.

During the contingency EVA on flight day 3, biomedical data that were transmitted on communications channel A were not recoverable in the Mission Control Center (Flight Problem STS-37-V-07). A real-time evaluation of this condition showed that the UHF transceiver had experienced a frequency shift that could be corrected by adjusting the ground equipment. This adjustment was made and data were received during the second EVA.

During postflight debriefings, the crew reported that the aft flight deck speaker was over-driving with poor sound quality (Flight Problem STS-37-V-18). An evaluation of this speaker is being performed.

Operational Instrumentation Subsystem

The operational instrumentation subsystem (OIS) operated nominally with three instrumentation failures. The body flap lower skin temperature sensor (V09T1026A) operated erratically (Flight Problem STS-37-V-10a). The APU 2 injector tube temperature sensor (V46T0274A) also failed (Flight Problem STS-37-V-10b). During postlanding operations, the fuel cell 3 pH sensor (V45X0430E) intermittently indicated high levels of pH. This intermittent indication resulted in fuel cell 3 being shut down prematurely as a precautionary measure.

Structures and Mechanical Subsystems

All mechanical subsystems operated nominally. Postflight data showed that the right-hand outboard brake pressure 4 was approximately 100 psia below brake pressure 2 (Flight Problem STS-37-V-17).

Remote Manipulator System

The remote manipulator system (RMS) performance was nominal, and all mission objectives were accomplished. No RMS anomalies occurred during the mission. The primary mission objective for the RMS was the unberthing and release of the Gamma Ray Observatory (GRO). At 34,527 lb, the GRO was the heaviest payload that the RMS has maneuvered on any flight.

A nominal RMS checkout using standard procedures was performed on flight day 1. The only problem concerned the end effector backup release time requiring more time than was shown in the procedures. The specified time shown in the Flight Data File had not been updated from an expected value of 10 seconds to the expected value of 15 seconds. Following the successful checkout and prior to the RMS power down, an in-bay CCTV survey was performed using the end-effector camera. On flight day 3, the arm was powered and positioned for GRO release operations. About 1 hour after positioning the arm, the payload was grappled in the payload bay and about an hour after that, the maneuver to the GRO release position was initiated. At the release position, two GRO solar relays were deployed; however, the GRO high gain antenna did not deploy as expected. After setting the brakes on the RMS arm, the Orbiter RCS thrusters were fired in an attempt to shake the high gain antenna in such a manner that it would release from its stowed position. Following the unsuccessful attempt at antenna release with the RCS, the RMS was used in another unsuccessful attempt to shake the GRO antenna loose. As a result, a contingency EVA was initiated, and the RMS lowered the GRO so that the antenna area was accessible from the payload bay during EVA operations. The extravehicular crewman was able to release the antenna in a very short period of time, after which the GRO was maneuvered back to the release position where release from the RMS occurred at 097:22:36:47 G.m.t.

The RMS was used to support the planned EVA on flight day 4. During the first portion of the EVA, the arm was positioned above the payload bay so that the elbow camera could be used to observe crewmen performing crew equipment translation aid (CETA) activities (DTO 1202). The manipulator foot restraint (MFR) was later grappled and a crewman was positioned to perform DTO 1205 that measured the arm stiffness in two different positions. An EVA crewman then rode the RMS arm at standard and enhanced rates to subjectively evaluate manipulator translation rates. The RMS was also placed in the limp mode so that a crewman could evaluate the capability to position the end effector manually. The crew comments and evaluation will be used as an input in developing future positioning devices. Because the flight was extended 1 day, power-down procedures were initiated to conserve consumables and the RMS heaters were turned off. The RMS low temperature limit was dropped from 0 °F to -10 °F in a successful attempt to prevent alarms from waking the crew during the sleep period.

Aerodynamics

The ascent and entry aerodynamics were satisfactory. During entry, the alpha was as expected and the control surfaces responded as expected. The aerodynamics were evaluated for DTO 0242 during which 8 programmed test inputs (PTI's) were performed. The initial evaluation shows the DTO was successful.

Thermal Control Subsystem

The thermal control subsystem heater performance was nominal with all temperatures maintained within acceptable limits. Three temperature sensors failed during the mission. These failures are discussed in the Operational Instrumentation section as well as the applicable subsystem section of the report. The body flap bottom skin temperature sensor operated erratically and intermittently indicating off-scale low values. This problem did not impact the mission.

Aerothermodynamics

The aerothermodynamics were nominal. The angle of attack was satisfactory, and the aerothermal was satisfactory for the forward c.g. schedule that was flown. The PTI's performed for DTO 0242 all appeared nominal.

Thermal Protection Subsystem

The thermal protection subsystem (TPS) performance was nominal, based on structural temperature response data and some tile surface temperature measurements. The overall boundary layer transition from laminar to turbulent flow was nominal, occurring 1210 seconds after entry interface.

As a result of the detailed inspection at Dryden Flight Research Facility, the TPS appeared to be in good-to-excellent condition with a nominal amount of debris-impact damage to the TPS. The Orbiter TPS sustained a total of 113 hits, of which 10 had a major dimension of one inch or greater. This total does not include the small number of hits found on the base heat shield.

The Orbiter lower surface had a total of 91 hits, of which 7 had a major dimension of one-inch or greater. A comparison of these numbers with statistics from 25 previous missions of similar configuration indicates that the total number of hits on the lower surface was greater than average, but the number of hits with a major dimension greater than one inch was less than average.

A cluster of 12 hits (none larger than one inch) occurred immediately aft of the liquid hydrogen ET/Orbiter umbilical opening. Similar clusters of hits have been observed in this area on previous flights and have been attributed to ice/debris impacts during ET separation and/or damage from the purge barrier baggie and ice during ascent. An unusual cluster of eight hits (one larger than one inch) was observed immediately forward of the liquid oxygen ET/Orbiter umbilical opening. No TPS damage was attributed to material from the wheels, tires, or brakes.

Overall, the reusable carbon carbon (RCC) parts looked good. The chin panel-to-nose cap gap filler, which was repaired prior to this flight, was in good condition with no additional degradation. The panel will fly its third consecutive flight on the next flight. The nose landing gear door thermal barrier was in excellent condition with no noted tears or debonded areas. The forward RCS thermal barrier was in excellent condition. The right main landing gear door thermal barrier was damaged on the forward outboard corner, and the adjacent TPS tiles (doors and structure) were damaged. The left main landing gear door thermal barrier was in good condition. The ET door thermal barriers were in good condition with evidence of a flow path in the left forward outboard section (approximately 6 in.). The elevon-elevon gap tiles were in good condition. The engine-mounted heat shield thermal curtains were in fair condition with a tear noted in the engine 2 blanket.

All Orbiter windows were moderately hazed with a few small streaks. Overall, the upper surface TPS was in good condition with minor blanket damage. The OMS pod TPS was in good condition, except for a protruding carrier plate that produced damage to the blanket on the right pod. The carrier panel protrusion was attributed to an improper panel installation.

The KSC thermal imager was used to measure the TPS surface temperatures on several areas of the Orbiter. Twenty-seven minutes after landing, the Orbiter nosecap temperature was 101 °F, the right-hand wing leading edge panel was 65 °F, and the right-hand wing panel was 65 °F. These temperatures were lower than usual because of the lower ambient temperature and the high winds.

During the postflight runway inspection, a lightning protection contact fell to the runway upon opening the liquid hydrogen ET/Orbiter umbilical door (Flight Problem STS-37-V-13). This contact, approximately 17.5 inches long by 2.5 inches wide, is part of the ET portion of the liquid hydrogen umbilical and should have remained with the ET upon separation.

EXTRAVEHICULAR ACTIVITY EVALUATION

During the GRO deployment on flight day 3, an unscheduled EVA was required to assist in the deployment of the high gain antenna on the GRO satellite while the satellite was still connected to the RMS. Following the successful deployment of the antenna by the EV1 crewman, both EV crewmen proceeded to perform several of the EVA Developmental Flight Experiment (EDFE) tasks while the GRO checkout was being conducted.

During the 3-hour 30-minute contingency (first) EVA, the real-time data system experienced a complete loss of data from the EV1 crewman while in communications channel A. At the same time, the EV2 crewman was operating in communications channel B, and experiencing a high data dropout rate (Flight Problem STS-37-V-07). During the latter half of the first EVA, data were received from the EV1 crewman after switching from communications channel A to communications channel B. Data from the EV2 crewman, operating in communications channel A, were no longer being received. A real-time investigation revealed that the biomedical data stream from the Orbiter on communications channel A had a voltage offset of approximately two volts. Ground personnel were able to compensate for this offset in the signal processing hardware located in the Mission Control Center.

Following the unscheduled EVA, and while performing the EMU maintenance recharge operations, EMU 1 failed to go into the battery charge mode (Flight Problem STS-37-V-06). This condition posed no constraint to the use of EMU 1 for the second EVA. A workaround was performed in which the battery for use in EMU 1 was charged using the charge circuit in EMU 3.

The scheduled EDFE EVA was performed on flight day 4. During this 5-hour 47-minute EVA, both EMU's performed well and both EVA crewmen were pleased with all aspects of EMU operation. Comments were made by the EV1 crewman on the 5000 series gloves which were being worn for an evaluation. Real-time data were received from both EMU's for the entire duration of the EVA. The post-EVA maintenance and recharge operations were modified to perform only the overnight battery charge.

The EV2 crewman reported during postflight debriefings that following the second EVA and after removal of the gloves, the right-hand index finger had an abrasion about 3/4 inch behind the metacarpal knuckle. The postflight inspection of the right-hand glove revealed that the palm bar was penetrating through the restraint and glove bladder into the index finger side of the glove approximately 3/8 inch (Flight Problem STS-37-V-19). The glove leakage rate with the palm bar in the failed position was 3.8 sccm of air as compared with the specification rate of 8.0 sccm. Had the palm bar come out of the hole during the EVA, the leak rate would not have been great enough to activate the secondary oxygen pack. The primary oxygen system would have maintained satisfactory suit pressure, and would also have displayed a high oxygen usage rate indication.

The official total time for the two EVA's was 9 hours 17 minutes, although the crewmen were in a vacuum environment in the suit for a total of 10 hours 23 minutes during the two EVA's.

FLIGHT CREW EQUIPMENT

The overall performance of the flight crew equipment was satisfactory with only one recorded anomaly. The crew reported, at 099:09:40:00 G.m.t., that the Linhoff camera was not operating properly and the blown fuse indication light was illuminated. The 1.0-ampere fuse in the magazine drive circuit of the Linhoff camera failed. The crew replaced the 1.0-ampere fuse with a 1.5-ampere fuse, but the same indication was again received. The ground advised the crew to replace the 1.5-ampere fuse with a 2.0-ampere fuse and satisfactory operation of the camera was achieved. Subsequent fuse replacements resulted in the camera operating properly for the remainder of the mission.

The EV1 crewman reported that the communications through the right earphone were lost during airlock depressurization (Flight Problem STS-37-V-20A). The EV2 crewman reported that communications through the left earphone were lost during airlock depressurization (Flight Problem STS-37-V-20B). Both of these losses of communications are being evaluated.

PAYLOADS

GAMMA RAY OBSERVATORY

The Gamma Ray Observatory (GRO) was successfully deployed on revolution 37 at 097:22:36:47 G.m.t. The deployment was completed three revolutions later than planned because the GRO high gain antenna would not deploy. Multiple RCS firings and RMS movements all were unsuccessful in releasing the antenna from the stowed position. As a result, a contingency EVA was performed and the antenna was deployed by the EV1 crewman laterally shaking the antenna boom. All other GRO activities were normal.

The GRO consists of four major scientific instruments: Energetic Gamma Ray Experiment telescope; Oriented Scintillation Spectrometer Experiment; Imaging Compton Telescope; and Burst and Transmit Source Experiment. The goal of these experiments is to enhance the understanding of the spectra and scale of gamma ray and associated galactic activity by gathering information about phenomena occurring in galaxies, quasars, pulsars, supernova and black holes.

AIR FORCE MAUI OPTICAL SITE CALIBRATION TESTS

The Air Force Maui Optical Site Calibration (AMOS) tests on revolution 17 were successful with good data acquired. During the revolution 48 pass, good data were also acquired; however, only fair data were acquired on the revolution 63 pass.

The AMOS uses ground-based infrared and optical sensors to obtain imagery and calibration data, and observe plume phenomena during overflights of the Hawaiian island of Maui.

BIOSERVE-INSTRUMENT TECHNOLOGY ASSOCIATES MATERIALS DISPERSION APPARATUS

The Bioserve-Instrument Technology Associates Materials Dispersion Apparatus (BIMDA) was activated at 095:20:07 G.m.t. The 15-minute, 1-hour, and 12-hour samples were taken from the cell syringes. The 12-hour, 24-hour, 1/3 pre-stow (approximately 92 hours) samples were taken from the bio-processing modules. The materials dispersion apparatus (MDA) block 1 and 2 samples were active in microgravity for about 92 hours. The MDA 3 1/3 and MDA 4 samples were active less than 1 hour. An anomaly with MDA 4 was corrected with an uplinked data entry procedure with no loss of science.

The BIMDA is three experiments within a refrigerator/incubator module consisting of four MDA mini-laboratories, six bio-processing modules, six cell syringes, and a temperature recorder.

PROTEIN CRYSTAL GROWTH-BLOCK II

Crystal growth continued throughout the mission. Temperature adjustments were made on day 1 and 2, and all processing was nominal. The payload demonstrated techniques for producing crystals of sufficient size to permit molecular analysis by diffraction techniques.

RADIATION MONITOR EXPERIMENT III

The radiation monitor experiment (RME) III was activated early in the mission. All changeouts were made within the constrained time limits and dosage measurements were taken. The RME III experiment measures the ionizing radiation in the Orbiter cabin and calculates exposure in rad-tissue equivalent.

SHUTTLE AMATEUR RADIO EXPERIMENT

The Shuttle amateur radio experiment (SAREX) -II enables the crew to make voice contact with all the scheduled schools as well as the crewmember's families. The fast-scan and slow-scan television was also demonstrated. Voice contact with the Russian Space Station (Mir) was unsuccessful. The SAREX-II uses a two-meter band handheld transceiver to enable the crew to contact amateur radio operators in one of four transmission modes: voice; data; slow-scan television; and fast-scan television.

ASCENT PARTICLE MONITOR

The ascent particle monitor (APM) was active during ascent. The closed circuit television (CCTV) survey of the payload bay verified that the APM door was closed as designed. Postflight analysis of the data is required to verify operation of the experiment.

CREW EQUIPMENT TRANSLATION AID

The crew equipment translation aid (CETA) was exercised during the planned EVA on flight day 4. All CETA tasks were completed with the exception of data recovery on the outrigger handrail. No data were collected because the portable data acquisition package (PDAP) did not operate properly. Evaluation by the crew of the manual, mechanical, and electrical carts, as well as the tethered shuttle went exceptionally well, and better than ground-based testing.

The CETA consisted of a length of track, a track-mounted truck, and three carts. The EVA crewmen evaluated the concept and candidate techniques/equipment for propelling the carts, for restraining the crewman on the carts, for restraining the CETA truck on the CETA track, and measuring translation dynamics including translation rates and crew loads induced in the carts, truck, and track.

PHOTOGRAPHIC AND TELEVISION ANALYSIS

On launch day, 25 videos (out of 29 expected) were screened. No anomalies were observed on any of the video items. Cloud cover obscured the view of the vehicle on several of the tracking cameras.

In addition to the video films, 65 of the 71 launch films were reviewed and no major anomalies were detected. Also, no Castglance film of the SRB recovery was acquired.

The damage to the left SRB forward skirt was not visible in the launch day camera films or from the videos. Eight post-SRB recovery photographs of the left SRB forward skirt were sent to JSC for analysis.

Excellent quality handheld post-separation photographs of the ET were acquired. A total of 12 views of the ET were taken. The views are, for the most part, clear and sharp with good exposure and focus. The data back, however, was not turned on and no timing data are available. The photographs are looking nearly directly at the left (-Y) tank axis. Very little rotation of the ET was noted in the series of photographs. There were no umbilical cameras on STS-37. For this mission, development test objective (DTO) 312 was at least partially accomplished with usable handheld pictures of the ET.

DEVELOPMENT TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

Eighteen development test objectives (DTO's) were scheduled for the STS-37 mission and 17 of these were accomplished. Nine detailed supplementary objectives (DSO's) were scheduled for the STS-37 mission and all were accomplished. The available information on the DTO's and DSO's at the time of this publication is presented in the following paragraphs.

DEVELOPMENT TEST OBJECTIVES

DTO 242 Entry Aerodynamic Control Surface Test (Part 4) - All eight programmed test inputs (PTI's) were performed and the data are being evaluated by the sponsor.

DTO 301 Ascent Structural Capability Evaluation - This was a data only DTO and required no crew participation. The data were collected and are being analyzed by the sponsor.

DTO 307 Entry Structural Capability - This was a data only DTO and required no crew participation. The data were collected and are being evaluated by the sponsor.

DTO 309 Ascent Flutter Boundary Evaluation - This was a data only DTO and required no crew participation. The data were collected for this DTO and are being analyzed by the sponsor.

DTO 312 ET TPS Performance (Method 2) - The crew took several high quality photographs of the ET. These photographs provided the sponsors with good data on the ET thermal protection system performance during ascent. The photographs are being analyzed.

DTO 331 Direct ET Insertion - Good data on the direct insertion trajectory were received from all tracking sites. The data are being analyzed by the sponsor.

DTO 519 Carbon Brake System Test (Condition 4) - This DTO was successfully performed by the crew during landing rollout. The preliminary analysis indicates that the carbon brakes performed flawlessly with very little wear.

DTO 623 Cabin Air Monitoring - This DTO was performed successfully by the crew, and the data are being analyzed by the sponsor.

DTO 633 Video Tape Recorder Demonstration - The crew reported problems when powering up the commercial video tape recorder (VTR) being evaluated as part of this DTO. The crew was able to free the jammed switch and power up the VTR. Subsequent operation of the VTR was controlled using a circuit breaker because of the switch difficulties.

The VTR worked well in flight. Eight tapes (out of a total of 11 available) were used. Because of the unscheduled EVA, the crew did not have time to downlink the video from the VTR. The VTR was, however, used as a video source for the Orbiter CCTV system, thus proving that the VTR would interface with the Orbiter system.

DTO 639 Advanced 5000 Series Glove Evaluation - The 5000 series gloves were evaluated by the EV1 crewman. The preliminary evaluations indicate that this glove is not recommended as a future replacement for the glove currently used.

DTO 640 Hydrazine Monitor - This DTO was completed and the data are being evaluated by the sponsor.

DTO 645 Combustion Products Analyzer - This DTO was not performed.

DTO 650 VTR Demonstration Enhancement - The Pulnix camera and the color LCD monitor were successfully evaluated by the crew. The Pulnix camera was slightly out of focus and the crew did not have time to refocus the camera (involved resetting a set screw on the lens). The color LCD monitor was very useful and the crew liked having an additional monitor to complement the standard Orbiter monitor.

DTO 822 Mid-Range Targeted Stationkeeping (Test Condition 4) - This DTO was successfully performed using the deployed Gamma Ray Observatory as a target. The detailed data are still being evaluated by the sponsor.

DTO 1202 Space Station Freedom (SSF) EVA Translation Evaluation - The requirement to have one crew member translate along the sill/handrails while the other crew member holds on to his own portable life support system (PLSS) was deleted preflight due to safety concerns. Otherwise, all the objectives were accomplished and the recorded data are still being analyzed and evaluated by the sponsor.

DTO 1203 SSF EVA Crew Loads Instrumented Pallet (CLIP) - All objectives of this DTO were accomplished and the recorded data are being evaluated by the sponsor.

DTO 1204 SHARE II Middeck Priming Experiment - Although som[illegible] difficulties were encountered with the bubble management article that req[illegible] the crew to implement a workaround procedure to induce liquid "priming", [illegible] of the indications are that the design functioned as expected. Detailed data analysis is still in work.

DTO 1205 TRAC Application For RMS Alignment/Deflection Measurements Evaluation - Astronauts L. Godwin (RMS operator) and EV2 crewmember successfully completed this DTO. The crewmembers reported that TRAC alignment was easily accomplished and that the RMS was acceptable as a work platform. The video data are being evaluated by the sponsor

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 0469 Radiation Dose Distribution (Configuration 2) - Data were collected for DSO 0469 and are being evaluated by the sponsor.

DSO 0477 Muscle Performance - Data were collected for DSO 0477 and are being evaluated by the sponsor. These data are required to support future extended duration Orbiter flights.

DSO 0479 Hyperosmotic Fluid Countermeasure - Data were collected for DSO 0479 and are being evaluated by the sponsor. These data are required to support future extended duration Orbiter flights.

DSO 0603 Orthostatic Function During Entry, Landing, and Egress - Data were collected for DSO 0603 and are being evaluated by the sponsor. These data are required to support future extended duration Orbiter flights.

DSO 0607 Lower Body Negative Pressure Following Space Flight - The data for DSO 0607 were collected during postflight testing at KSC, and the data are being evaluated by the sponsor. The data for this DSO are required to support future extended duration Orbiter flights.

DSO 0613 Change in the Endocrine Regulation of Orthostatic Tolerance Following Space Flight - Data for this DSO were collected and are being evaluated by the sponsor. The data for this DSO are required to support future extended duration Orbiter space flight.

DSO 0901 Documentary Television - Data for this DSO were collected and are being evaluated by the sponsor.

DSO 0902 Documentary Motion Picture Photography - Data for this DSO were collected and are being evaluated by the sponsor.

DSO 0903 Documentary Still Photography - Data for this DSO were collected and are being evaluated by the sponsor.

TABLE I.- STS-37 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	095:14:17:58.07
	APU-2 GG chamber pressure	095:14:17:58.92
	APU-3 GG chamber pressure	095:14:17:58.69
SRB HPU activation	LH HPU system A start command	095:14:22:17.208
	LH HPU system B start command	095:14:22:17.368
	RH HPU system A start command	095:14:22:17.528
	RH HPU system B start command	095:14:22:17.688
Main propulsion System start	Engine 3 start command accepted	095:14:22:38.422
	Engine 2 start command accepted	095:14:22:38.542
	Engine 1 start command accepted	095:14:22:38.662
SRB ignition command (lift-off)	SRB ignition command to SRB	095:14:22:44.988
Throttle up to 104 percent thrust	Engine 3 command accepted	095:14:22:48.768
	Engine 2 command accepted	095:14:22:48.883
	Engine 1 command accepted	095:14:22:48.875
Throttle down to 87 percent thrust	Engine 3 command accepted	095:14:23:03.098
	Engine 2 command accepted	095:14:23:03.124
	Engine 1 command accepted	095:14:23:03.115
Throttle down to 67 percent thrust	Engine 3 command accepted	095:14:23:13.499
	Engine 2 command accepted	095:14:23:13.525
	Engine 1 command accepted	095:14:23:13.516
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	095:14:23:36
Throttle up to 104 percent thrust	Engine 3 command accepted	095:14:23:44.060
	Engine 2 command accepted	095:14:23:44.087
	Engine 1 command accepted	095:14:23:44.076
Both SRM's chamber pressure at 50 psi	LH SRM chamber pressure mid-range select	095:14:24:44.748
	RH SRM chamber pressure mid-range select	095:14:24:43.908
End SRM action	LH SRM chamber pressure mid-range select	095:14:24:47.218
	RH SRM chamber pressure mid-range select	095:14:24:46.508
SRB separation command	SRB separation command flag	095:14:24:50
SRB physical separation	SRB physical separation	
	LH APU A turbine speed LOS*	095:14:24:50.208
	LH APU B turbine speed LOS*	095:14:24:50.208
	RH APU A turbine speed LOS*	095:14:24:50.208
	RH APU B turbine speed LOS*	095:14:24:50.208
Throttle down for 3g acceleration	Engine 3 command accepted	095:14:30:18.640
	Engine 2 command accepted	095:14:30:18.639
	Engine 1 command accepted	095:14:30:18.648
3g acceleration	Total load factor	095:14:30:18
MECO	MECO command flag	095:14:31:18
	MECO confirm flag	095:14:31:19
ET separation	ET separation command flag	095:14:31:36

* = loss of signal

TABLE I.- CONTINUED

Event	Description	Actual time, G.m.t.
OMS-1 ignition	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
OMS-1 cutoff	Left engine bi-prop valve position	N/A
	Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
APU deactivation	APU-1 GG chamber pressure	095:14:38:33.63
	APU-2 GG chamber pressure	095:14:38:35.43
	APU-3 GG chamber pressure	095:14:38:35.70
OMS-2 ignition	Left engine bi-prop valve position	095:15:04:28.0
	Right engine bi-prop valve position	095:15:04:28.1
OMS-2 cutoff	Left engine bi-prop valve position	095:15:08:23.4
	Right engine bi-prop valve position	095:15:08:23.3
Gamma Ray Observatory Deployment	Voice call	097:22:36:47
Flight control system checkout		
APU start	APU-3 GG chamber pressure	099:10:29:34.00
APU stop	APU-3 GG chamber pressure	099:10:35:16.30
OMS-3 ignition	Left engine bi-prop valve position	099:15:19:13.1
	Right engine bi-prop valve position	099:15:19:13.1
OMS-3 cutoff	Left engine bi-prop valve position	099:15:19:23.1
	Right engine bi-prop valve position	099:15:19:23.1
APU activation for entry	APU-1 GG chamber pressure	101:12:42:26.31
	APU-2 GG chamber pressure	101:13:11:30.75
	APU-3 GG chamber pressure	101:13:11:31.78
Deorbit maneuver ignition	Left engine bi-prop valve position	101:12:45:50.1
	Right engine bi-prop valve position	101:12:45:50.2
Deorbit maneuver cutoff	Left engine bi-prop valve position	101:12:49:31.5
	Right engine bi-prop valve position	101:12:49:31.5
Entry interface (400k)	Current orbital altitude above reference ellipsoid	101:13:24:23
Blackout	Data locked at high sample rate	No blackout because of TDRS

TABLE I.- CONTINUED

Event	Description	Actual time, G.m.t.
Terminal area energy management	Major mode change (305)	101:13:48:47
Main landing gear contact	LH MLG tire pressure	101:13:55:29
	RH MLG tire pressure	101:13:55:29
Main landing gear weight on wheels	LH MLG weight on wheels	101:13:55:29
	RH MLG weight on wheels	101:13:55:31
Nose landing gear	NLG tire pressure	101:13:55:35
Nose landing gear weight on wheels	NLG WT on Wheels -1	101:13:55:36
Wheels stop	Velocity with respect to runway	101:13:56:25
APU deactivation	APU-1 GG chamber pressure	101:14:18:43.04
	APU-2 GG chamber pressure	101:14:18:44.19
	APU-3 GG chamber pressure	101:14:18:45.07

TABLE II.- STS-37 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-37-V-01	Thruster R1U Failed Off	095:14:31 G.m.t. IM 37RF-01 IPR 43V0005	Occurred on first firing attempt after ET separation. Suspect only pilot valve opened on oxidizer side. Removed and replaced thruster on 5/11 and sent failed thruster to White Sands Test Facility for testing.
STS-37-V-02	A. Water Spray Boiler 2A Temporary Spray Bar Freeze-up During Ascent	095:14:30 G.m.t. IM-37RF-02	A. Lubrication oil temperature reached 280 °F after MECO. Switched to B controller, but temperature was already going down. Switched back to A controller, and operations were normal.
	B. Water Spray Boiler 2A Lubrication Oil over-cooling during entry	101:13:24 G.m.t. IM 37RF-15	B. Five minutes into spray mode during entry, lubrication oil over-cooling was observed for about 4.5 minutes. Minimum over-cool temperature observed was 189 °F. WSB 2 will fly as-is. No hot flush performed.
STS-37-V-03	PRSD Oxygen Manifold Valve 2 Failed to Close	096:22:00 G.m.t. IM37RF-03 IPR 43V0004	Recurrence of in-flight anomaly STS-34-12, which was an unexplained anomaly. Valve successfully closed on flight day 3. Unable to duplicate problem on ground. Suspect bulkhead connector. Rewired through different connector and successfully tested.
STS-37-V-04	Ku-Band Antenna Erratic In Auto Mode	096:13:42 G.m.t. IM 37RF-04	Track error increased until loss of lock. Designate mode operated properly. Suspect control circuit problem. Antenna worked properly after revolution 61. Unable to reproduce on the ground. Small metallic chips found on dish. (Apparent drilling debris.)
STS-37-V-05	A. Forward Bulkhead Flood Light Out B. Mid-Port Payload Bay Flood Light Out	097:18:48 G.m.t. IM 37RF-05 100:09:00 G.m.t. IM 37RF-06	EVA crew reported light not working. Switch cycled off for 10 minutes, then back on. Light did not come on. Troubleshooting at KSC. Light operated properly on both EVA's. Light flickered when turned on for payload bay door closure. Previous deferred unexplained anomaly. Will reroute through new bulkhead payload bay connector during STS-44 flow.
STS-37-V-06	EMU-1 Failed To Charge Battery (Post First EVA)	098:00:13 G.m.t.	Crew reported that it was not possible to charge EMU-1 battery. Suits shipped from Dryden Flight Research Center to Flight Equipment Processing Facility. Unable to reproduce in ground tests. Suspect problem with power mode switch. Transceiver removed and replaced.
STS-37-V-07	Temporary Loss of EMU Suit Parameters in Comm Mode A	097:11:33 G.m.t.	Lost data from both suits during first EVA. Ground data systems adjusted to compensate for time shift in A. Suspect the FM discriminator in the Orbiter UHF transceiver.
STS-37-V-08	Low chamber pressure on Thrusters L1U and L1L During Interconnect	099:15:40 G.m.t. IM 37RF-07	Low chamber pressure (20 psi low) noted while using right OMS to left RCS interconnect. Data review from other flights show this is a normal characteristic of interconnect operation. Non-problem.
STS-37-V-09	Prelaunch Backup Flight System Navigation Anomaly	095:13:51 G.m.t.	Backup flight system Z runway position diverged to 7700 ft in OPS 101. No effect to flight. To be corrected with OI-22 software release.

TABLE II.- STS-37 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-37-V-10	Instrumentation		
	A. Body Flap Lower Skin Temperature (V09T1026A) Failed.	On-orbit IM 37RF-08	A. Exhibited cold bias and intermittent off-scale low indication. Found damaged solder sleeve at body flap interface.
	B. APU 2 Injector Tube Temperature (V46T0274A) Sensor Failed	101:14:19 G.m.t. IM 37RF-09	B. Sensor reading became erratic during entry and then failed off-scale low after landing. Rewired to backup measurement.
STS-37-V-11	Fuel cell 3 pH High Indication Postlanding	101:14:11 G.m.t. IM 37RF-10	Fuel cell 3 pH sensor indication was high on an intermittent basis for approximately 10 minutes. The common water line pH sensor did not confirm the fuel cell 3 pH sensor indication. All fuel cell 3 performance parameters were nominal. Water sample at DFRC nominal. Fuel cell removal and replacement initiated on 4/25.
STS-37-V-12	Water Spray Boiler 3A Over-Cooling During Entry	101:13:25 G.m.t. IM 37RF-11	During entry, two instances of over-cooling were observed. The minimum lubrication oil return temperature seen was 211 °F. Hot oil flush planned.
STS-37-V-13	Liquid Hydrogen ET Umbilical Forward Lightning Contact Strip Debonded	Postflight IM 37RF-12	Strip found on runway after ET door open g. Suspect faulty bonding.
STS-37-V-14	Abnormal Oxygen Concentration in Aft Fuselage	Prelaunch IM 37RF-13	Reached 220 ppm (outside experience base). LCC limits is 500 ppm. Postflight analysis of aft air sample bottles showed no anomaly. Possible ground fill and drain hardware leak. No Orbiter troubleshooting required.
STS-37-V-15	Hydraulic System 2 Priority Valve Lagged During Entry	101:13:11:55 G.m.t. IM 37RF-14	Priority valve took 4 seconds to open to equalize accumulator pressure with main pump pressure when NORM PRESS was commanded. Equalization should require no more than 1 second. Valve removal and replacement completed.
STS-37-V-16	-Z Star Tracker Failed Self Test	096:03:00 G.m.t. IPR 43V0009 CAR 37RF16	Star tracker failed first self-test, passed second. Anomaly repeated during KSC ground tests. Data analysis indicates a probable hardware problem within the star tracker that could affect normal star tracker operations. Star tracker removed and replaced.
STS-37-V-17	Right-hand Outboard 4 Brake Pressure Low	Landing rollout 101:13:55 G.m.t. IPR 43V0008	Data show brake pressure 4 was approximately 100 psia below brake pressure 2. Did not repeat during troubleshooting.
STS-37-V-18	Aft Flight Deck Speaker Had Poor Sound Quality	On-orbit	Crew reported that the aft flight deck speaker was over-driving with poor sound quality. Quality on the ground during testing was satisfactory.

TABLE II.- STS-37 PROBLEM TRACKING SUMMARY

Number	Title	Reference	Comments
STS-37-V-19	EVA Glove Palm Bar Penetrated Restraint and and Glove Bladder	Second EVA	Following second of two EVA's, the EV2 crewman noted cut on right hand. Postflight inspection revealed glove palm bar was penetrating through restraint and bladder about 3/8 inch into index finger side of glove. Stitches added to prevent palm bar movement.
STS-37-V-20	A. EV1 Right Earphone Lost Communications		EV1 reported loss of communications during airlock depressurization. Postflight tests revealed the earphone was 10 dB below specification.
	B. EV2 Left Earphone Lost Communications		EV2 reported loss of communications during airlock depressurization.