

STS-6 Space Shuttle Program Mission Report

May 1983



National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

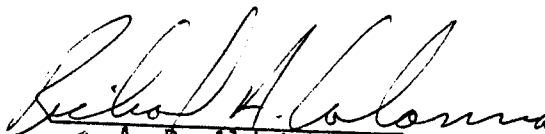
SPACE SHUTTLE PROGRAM

STS-6

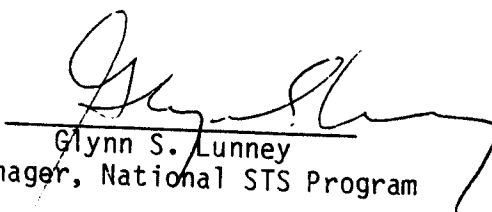
MISSION REPORT



Michael A. Collins, Jr.
Manager, Shuttle Data
and Evaluation Office



for A. D. Aldrich
Manager, Space Shuttle Projects Office



Glynn S. Lunney
Manager, National STS Program

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

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INTRODUCTION AND MISSION OBJECTIVES

The STS-6 Space Shuttle Program Mission Report provides a brief overview of the major activities, accomplishments, and findings of the second operational flight which was also the first flight of vehicle OV-099, the Challenger. The vehicle has been returned to Kennedy Space Center where preparations are continuing for the next flight (STS-7), scheduled for June 1983.

The primary mission objective of STS-6, as defined in the STS-6 Flight Requirements Document (JSC-17462-06), was to successfully deploy the TDRS (Tracking and Data Relay Satellite) and accomplish the functions of the CFES. To further this objective, a first-day deployment was incorporated into the flight design. An additional objective was to perform an EVA (extravehicular activity) as a result of the unsuccessful attempt on STS-5. The results of the EVA are also reported in summary form in this report.

MISSION SUMMARY

The STS-6 flight was launched on April 04, 1983, at 18:30:00.016 G.m.t. (12:30 p.m. c.s.t.) and landed April 09, 1983, at Edwards AFB, CA. The sequence of events for this flight is listed in Table I. The crew was Paul J. Weitz, Commander; Col. Karol J. Bobko, Pilot; and F. Story Musgrave, M.D., and Donald H. Peterson, Mission Specialists. Fifty-one of the 53 test objectives were accomplished. The two objectives that were not accomplished were DTO 0755 (auto-land to 5000 ft) and DTO 0805 (crosswind landing performance).

The ascent phase was normal in all aspects with all systems operating near predicted levels. The SRB (solid rocket booster) performance was satisfactory with the propellant burn rate about 0.2-percent lower than predicted. The action time was long by about 0.46 second on the right-hand motor and 0.96 second on the left-hand motor, resulting in SRB separation being delayed 0.75 second from predicted. All systems of the new lightweight ET (external tank) operated satisfactorily and the tank impacted only 5 nautical miles from the predicted point, well within the predicted footprint.

The main propulsion system operated normally with only minor problems. None of the problems had any impact on ascent operations. After main engine cutoff, the two orbital maneuvering system (OMS) maneuvers were conducted and the vehicle was placed in the planned 154-nmi. circular orbit.

During the first day of STS-6, the IUS/TDRS (interim upper stage/tracking and data relay satellite) was deployed at 95:04:31:58 G.m.t, followed about 19 minutes later by the OMS-3 (orbital maneuvering system) separation maneuver. The IUS did not successfully place the TDRS in the planned geosynchronous orbit and activities are still continuing at this writing to place the TDRS in the desired orbit. The Air Force and NASA have formed an investigation board to determine the cause of the IUS anomalous operations and a report of their findings will be published at a later date.

The experiment activities that were scheduled during this flight were all performed as planned. These activities were with the radiation monitoring experiment, the monodisperse latex reactor, the continuous flow electrophoresis system, the night/day optical survey of lightning, and the three getaway special experiment canisters.

The first day of the flight was completed in accordance with the flight plan and no significant anomalies were noted by the crew or ground personnel. The second day of flight was spent activating experiments and servicing the EMU's (extravehicular mobility units) in preparation for the EVA (extravehicular activity) which was conducted on the third day of the flight.

TABLE I.- STS-6 SEQUENCE OF EVENTS

Event	Planned G.m.t.	Actual G.m.t.
APU activation (1)		
(2)	94:18:24:57	94:18:25:10
(3)		94:18:25:12
SRB HPU activation command (4)		94:18:25:14
MPS start command (Engine 3)	94:18:29:32	94:18:29:32.7
SRB ignition command from GPC (lift-off)	94:18:29:53.4	94:18:29:53.5
Main engine throttledown to 81-percent thrust	94:18:30:00*	94:18:30:00
MPS throttleup to 104-percent thrust	94:18:30:29	94:18:30:30.4
Maximum dynamic pressure	94:18:31:01.3	94:18:31:02.5
SRB separation command	94:18:31:09.4	94:18:31:11
MPS throttledown for 3g acceleration	94:18:32:08.8	94:18:32:09.5
3g acceleration	94:18:37:19.8	94:18:37:22.8
Main engine cutoff (MECO) command	94:18:37:21	94:18:37:22.9
External tank separation	94:18:38:17	94:18:38:19.4
OMS-1 ignition	94:18:38:49.2	No Data
OMS-1 cutoff	94:18:40:29.0	94:18:40:19.7
APU deactivation	94:18:42:54	94:18:42:35
OMS-2 ignition	94:18:45:00	94:18:43:45
OMS-2 cutoff	94:19:14:39	94:19:13:37.7
Payload bay doors open	94:19:16:36	94:19:15:34.7
TDRS release		94:20:04:57.6
OMS-3 ignition	95:04:31:00	95:04:30:01
OMS-3 cutoff	95:04:43:24	95:04:50:53.3
OMS-4 ignition	95:04:43:33	95:04:51:14.3
OMS-4 cutoff	96:19:16:34	95:20:00:47.3
Close payload bay door	96:19:16:36	95:20:01:08.9
APU 1 activation		99:14:36:20
APU 2 and 3 activation	99:19:30:00	99:17:50:01
Deorbit maneuver ignition		99:18:10:30
Deorbit maneuver cutoff	99:19:39:46	99:17:55:00.1
Entry interface (400,000 ft)	99:19:42:07	99:17:57:25.2
End blackout	99:20:06:16	99:18:23:27
Terminal area energy management	99:20:23:00	99:18:31:23
Main landing gear contact	99:20:25:00	99:18:47:29
Nose landing gear contact	99:20:35:00	99:18:53:42
Wheels stop	99:20:35:00	99:18:53:54
APU deactivation completion	99:20:36:16	99:18:54:31
	99:20:38:00	99:19:08:55

*The lift-off time has been rounded from 94:18:30:00:016 G.m.t.

The EVA was begun by donning the EMU suits and entering the airlock for the 3-hour 30-minute prebreathing period. The outer hatch into the payload bay was opened at 97:21:05:00 G.m.t. and the first crewman exited the airlock moments thereafter. The crew performed all planned tasks of the EVA, but did experience some difficulty with releasing the EVA winch. The crew entered the hatch and the EVA was completed with hatch closure at 98:01:15:00 for a total EVA time of 4 hours 10 minutes.

All activities continued to be accomplished according to the flight plan. This mission demonstrated that the Shuttle flight planning process is near maturity.

Activities on the final day included stowage and all preparations for entry. The payload bay doors were closed without incident and a normal deorbit maneuver was performed. The Orbiter was guided to a smooth landing at Edwards AFB, CA., at 99:18:53:42 G.m.t. The wheels were stopped at 99:18:54:31 G.m.t., completing the second operational flight of the National Space Transportation System and the first flight of vehicle OV-099. The problems encountered during this first flight of Challenger were minimal and did not compromise any of the mission objectives. Challenger is ready to assume its role as the second operational vehicle.

CONSTRAINTS ON STS-7

There are no constraints to the STS-7 mission that resulted from the STS-6 mission. A list of the flight anomalies is provided in Appendix A. The final closure of all anomalies is performed by the PRCB (Program Requirements Change Board).

SOLID ROCKET BOOSTER ASSESSMENT

The thrust time history for the STS-6 SRM's (solid rocket motors) was well within the specification limits. The SRM's performed close to nominal. Evaluation shows that head pressures were lower than predicted by approximately 1.5 percent for both motors between 5 and 20 seconds. The propellant burn rate on both SRM's was approximately 0.2-percent lower than predicted. The action time was long by approximately 0.96 second for the left-hand motor and 0.46 second for the right-hand motor resulting in a later than predicted separation by approximately 0.75 second.

The SRB TPS (thermal protection system) performance was satisfactory. However, some problems were noted with the insulation covering three joints on the left motor. The aft center segment factory joint (station 1331.5) cork had fractured at the steel band edge and sooted along the fracture line, suggesting cork failure during entry.

The aft segment factory joint (station 1697.5) cork was mostly missing and there was a minimum of 8 inches free play in the metal band, suggesting that the band yielded. Cork was also missing from the forward center/aft center field joint (station 1171.5). No sooting was noted along the cork fracture lines at the joints at station 1171.5 or 1697.5.

Operation of both SRB TVC (thrust vector control) systems was normal. The accumulators functioned properly providing the expected system stability. The SRB actuators performed in a normal fashion. The maximum deflection observed was -2.9 degrees on the right-hand tilt actuator and the condition occurred at 10 seconds.

The deceleration subsystems on both SRB's performed normally and all parachutes were recovered. All booster separation motor covers were intact.

The left-hand SRB was tracked by radar and indications are that max q (maximum dynamic pressure) and splashdown velocities were within the expected values.

Recovery operations went smoothly.

EXTERNAL TANK ASSESSMENT

All ET (external tank) systems performed as expected and met all launch requirements except for failure of the liquid oxygen level sensor no. 1. Sensor no. 2 was substituted.

The prelaunch thermal environment was as expected with no launch commit violations. The TPS acreage experienced only minor ice/frost buildup in waived areas. A TPS crack 3 to 4 feet in length was observed on the intertank on the +Z side (away from the Orbiter). This is not in a critical area for flight. All prelaunch conditioning temperatures were well within requirements. All tank structural and attachment structure temperature differentials were within expected limits. The ascent environment was similar to previous flights.

Ninety-eight percent of the OI (operational instrumentation) measurements performed as expected. The only OI failure was the liquid oxygen 100-percent liquid level sensor no. 2 which failed during tanking operations.

Radar data from Antigua and Bermuda confirmed the ET tumbled. The preliminary estimate of the ET impact point was approximately 5 nmi uprange of the predicted nominal point and this is well within the predicted footprint.

MAIN PROPULSION SYSTEM ASSESSMENT

All aspects of the main propulsion system and main engines operation were satisfactory. The liquid oxygen and liquid hydrogen propellant loading was performed without any major problems or stoppages. The liquid oxygen overboard bleed test was normal with both switches indicating closed in less than 1 second.

The main engine flight data followed prelaunch predictions very closely with a specific impulse of 452.9 seconds, 0.3 second above preflight MPS assessment values. All aspects of the ascent were normal with no problems noted during start, mainstage, or cutoff operations. Engine controller performance was satisfactory and no hardware or software failures were noted.

Engine performance including throttling and operation at 104 percent were satisfactory. The total firing time from lift-off was 499.5 seconds. Neither the liquid oxygen nor liquid hydrogen engine cutoff sensors went dry as has occurred on previous missions. The temperature and pressure trends were all similar to those noted on previous flights.

Five minor anomalies occurred within the MPS during the flight. Two of these were transducer failures, plus the liquid oxygen 100-percent loading sensor no. 1 failed and the engine 1 gaseous hydrogen flow control valve failed to open completely on several occasions during the first 110 seconds of operation. Also, the no. 3 engine check valve (OV7) was leaking. None of these failures had any impact on flight.

PAYLOADS

INTERIM UPPER STAGE/TRACKING AND DATA RELAY SATELLITE

Interim Upper Stage

The interim upper stage (IUS)/tracking and data relay satellite (TDRS) combination was deployed on time at 95:04:30:01 G.m.t. The vehicle was very stable throughout the separation phase and the OMS maneuver to move to Orbiter a safe distance away from the IUS/TDRS vehicle.

The firings of the IUS to place the TDRS in a geosynchronous orbit were completed; however, problems developed with the IUS and the TDRS spacecraft was separated before reaching the desired orbit. The Air Force and NASA have named an investigation board to determine the cause of the IUS anomalies. A special report of the findings of this board will be published at a later date.

Tracking and Data Relay Satellite

The TDRS predeployment checkout was nominal. All systems were normal at the time of deployment.

EXPERIMENTS

Four experiments were carried on the STS-6 mission in the crew cabin area. In addition, three GAS canisters containing experiments were carried in the cargo bay. The experiments performed in the cabin area were the RME (radiation monitoring equipment), the MLR (mono-disperse latex reactor), the CFES (continuous flow electrophoresis system), and the NOSL (night/day optical survey of lightning).

- a. RME- The RME was conducted in accordance with the flight plan.
- b. MLR- The MLR performed normally for three of the four reactors. The fourth reactor did not go to completion, and therefore, the total growth was not achieved.
- c. CFES- The CFES samples were all processed in accordance with the flight plan. postflight removal of the samples indicated that the CFES refrigerator had been turned off. The cause of the condition was procedural as the ground switchlist called for opening the circuit breaker 12 1/2 hours early. The samples were acceptable.
- d. NOSL- Photographs were taken for the NOSL experiment in accordance with the flight plan.

ORBITER ASSESSMENT

PROPULSION AND POWER SUBSYSTEMS

Orbital Maneuvering Subsystem

The OMS (orbital maneuvering subsystem) performance was normal. Five dual-engine OMS maneuvers were performed for a total of 440 seconds of firing on each engine. Propellant supplied by the OMS right pod to the RCS (reaction control subsystem) totaled 254 lb with 228 lb directly to the engine and 26 lb to the RCS propellant tanks. No propellant was supplied to the RCS by the left pod.

Two minor problems were noted during the flight. The first was the left-hand engine feedline temperature measurement which operated intermittently, but this was expected as it had been observed during both flight readiness firings.

Also, at the end of the second maneuver, the right-hand engine oxidizer forward probe did not trigger the totalizer unengageable countdown. This problem was experienced on vehicle OV-102 flights and is a known problem.

On STS-5, buckling of the right OMS engine was noted during postflight examination. As a result, special cameras were installed for STS-6 launch. The STS-6 films revealed nozzle distortion during the main engine ramp-up process to 100 percent. Slight buckling and coating damage were noted during STS-6 postflight examinations; however, no cracks were noted. The nozzle does not require replacement for STS-7.

Reaction Control Subsystem

The RCS performance during STS-6 was satisfactory. The only significant problems involved engine valve leakage on primary thrusters R4U and L2D. The R4U thruster had an oxidizer leak early in the flight, but the leak rate was very small such that the thruster was not deselected by the RM (redundancy management). The leak stopped and did not recur during the flight, even when the thruster was fired during the hot fire test and during entry.

Thruster L2D had an intermittent fuel leak throughout the flight. It began leaking during the rendezvous no. 3 firing, but stopped about 4 hours later. The thruster was then fired during the RCS hot fire test and showed no indication of a leak. However, the thruster began leaking again during the rendezvous no. 4 firing, but it again stopped after about 22 hours. During this leakage period, the manifold 2 isolation valves were briefly closed so that a leak rate could be calculated from the pressure decay. This leak rate was found to be approximately 1.2 cc/min. The thruster remained deselected for the remainder of the mission.

Auxiliary Power Unit and Hydraulic Subsystems

The Orbiter APU's (auxiliary power units) performed well during the mission. The APU 1 gearbox was not pressurized to 10 psig prelaunch because the gearbox seal was leaking into the seal cavity drain. The seal held during the on-orbit period, but the lower initial pressure made the operating gearbox pressure low enough to activate the gearbox repressurization system. The repressurization system worked as designed and increased the gearbox pressure by approximately 2 psi.

The only anomalies experienced during the flight was a leak in all three APU seal cavity drains. The lowest pressure reached was 1 psia on APU 2. These pressure losses had no effect on the mission.

The Orbiter hydraulic subsystem performed satisfactorily during all mission phases with all data appearing the same as noted on previous flights. Water spray boiler 1 nitrogen regulator pressure decay was within specification, however, the relief valve will be cycled during servicing for STS-7 to eliminate the leakage. Seven temperature sensors in the elevon and body flap areas were found to be miswired or mislocated.

The landing gear isolation valve no. 2 did not open by computer command and had to be opened manually by the crew. The system 2 accumulator will be replaced due to a nitrogen leak.

Fuel Cells and Power Reactant Storage and Distribution Subsystems

The Orbiter fuel cells and power reactant storage and distribution subsystems performed very well. Two anomalies were reported concerning the fuel cells. The fuel cell no. 2 hydrogen flowmeter failed at 98:02:34 G.m.t. During postlanding shutdown, the fuel cell no. 1 coolant pump differential pressure talkback stayed on.

AVIONICS SUBSYSTEMS

Communications and Tracking

The communications and tracking system provided excellent command, data, and voice. The S-band network and payload communications, CCTV system, and the NAVAID equipment performance was satisfactory.

The DTO (detailed test objective) to analyze the performance of the S-band switched-beam antennas (DTO 0707) was successfully conducted and data obtained. Likewise, a tape recording of crewman voice was made for DTO 0721 during the mission. Postmission evaluation of the tape indicates a successful recording was made. The recorded voice will be used for speech recognition and voice command system development.

The capability to zoom-out the CCTV (closed-circuit television) camera "D" lens was temporarily lost. A crewman jiggled the zoom switch on three separate occasions during the flight to restore the zoom function.

A voice echo with a delay of one-half to one second was heard on the ground on air-to-ground 1 during EVA preparations and EVA. The echo was never heard onboard the Orbiter or by the EVA crewmen. The echo was not heard during post-EVA tests in the Orbiter.

The pilot reported that WCCU (wireless crew communications unit) unit A went dead and unit B was very noisy. Replacing batteries did not rectify the problem and the pilot used a headset cable for the rest of the mission.

The teleprinter stayed in the high power (print) mode after a ground station pass twice during the flight. After the second occurrence, the "paper low" light was also on. Since the teleprinter was no longer needed, it was powered off.

The crew reported that the TV pictures on both the CCTV monitors were degraded in contrast and fuzzy. The monitors have been removed for examination and testing.

Ascent Guidance, Navigation and Control

GN&C (Guidance, Navigation and Control) Performance Evaluation: The ascent GN&C system performance was normal. Examination of downlist/downlink vehicle data in combination with trajectory reconstruction using six degree-of-freedom dynamic simulations revealed the following:

- a. The first stage trajectory was slightly depressed (about 2000 feet low at SRB staging).
- b. MECO conditions were near normal.

Prelaunch/Lift-Off Clearance: The SSME (Space Shuttle Main Engine) commands were patched during the T-minus-9-minute hold to compensate for actuator drift which had exceeded the 2-degree limit. At APU start, the maximum transient from the actual position to the patched commanded position was 0.5 degree. A manual LPS procedure to disable the actuator FDI (failure detector indicator) will be used for STS-7 and subsequent flights. This will eliminate the need for this type of software patch. The APU power-up transients will be minimized by redefining the initial ME (main engine) commands to be consistent with ME position drift observed on previous flights.

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The SRB nozzle/support-post clearance was measured using extensio-meters and the resultant data will be used in clearance assessment for future launch configurations at VAFB (Vandenberg AFB, CA.). No useful clearance data were obtained from the sonar-type measurement devices which were also installed for STS-6.

First-Stage Performance: The following table gives the SRB staging conditions. The pitch attitude error history was similar to that observed on flights 3, 4, and 5. Low SRB performance is the consistent anomaly throughout these flights and a major contributor to the observed positive pitch attitude error. SRB burnout occurred about 0.5 second later than predicted.

SRB STAGING CONDITIONS

Parameters	Flight	Simulated*
Mission elapsed time, sec	129.31	128.88
Altitude, ft	150938.	154547.
Velocity, ft/sec	4388.1	4411.6
Relative flight-path angle, deg	27.13	27.32

*Predicted SRB thrust with PMBT = 65 deg

Second-Stage Performance: The second stage performance was close to preflight predictions with the exception of a slightly larger than expected pitch attitude error during the last minute of flight. This resulted in a small flight path error at MECO (0.02 degree). The OV-099 thrust structure deformation was similar to OV-102. Thrust structure deformation is reflected by a steady-state value on the trim integrators.

The following table gives the MECO conditions.

MECO ZERO THRUST CONDITIONS

Parameters	Flight	Predicted/target
Mission elapsed time, sec	506.38	504.58
Radius vector, ft	21273285.	21272079.
Initial velocity, ft/sec	25672.8	25670.0
Initial flight path angle, deg	0.633	0.650

Transition DAP

No unusual behavior was noted during transition DAP (digital autopilot) operation other than the manual transition to MM (major mode) 104. This is explained by the THC (translation hand controller) deflection observed prior to the completion of the automatic separation burn. As the separation burn was suspended prior to completion, there should not have been, and was not, automatic transition to MM 104.

The crew reported that during the secondary gimbal check of the left OMS engine, a fail indication was noted in both the pitch and yaw axes. As a result, all the OMS maneuvers were performed using the primary system.

Entry through Landing Guidance Navigation and Control

Essentially, nominal performance was observed throughout the entire flight phase. The only exception being the Mach 9 PTI (programmed test input) which was not performed as expected. The Mach 9 PTI did not occur because a sequencer that locates the correct differential azimuth as a PTI lockout before a bank reversal sequenced directly to the larger value associated with a later PTI. This value was large enough to lockout the earlier maneuver.

The system 2 landing gear isolation valve did not open as programmed during entry. The crew manually opened the valve and all the remaining systems operated normally during entry.

Avionics Detailed Test Objective Accomplishment

DTO (detailed test objective) 0755 which was autoland to 5000 feet was not performed. DTO 402, the primary RCS hot fire test, was successfully performed. DTO 0761, orbiter systems vent model determination, was accomplished. DTO 0765, payload bay g-level measurements, was accomplished. Propellant usage was much higher than predicted. Data analysis and simulation are in work. DTO 0768, improved crew optical alignment sight (ICOS) evaluation was accomplished; DTO 0770, COAS calibration was successfully accomplished. The +X (fwd) calibration STN-5 marks were within 0.03 degree and the -Z (aft) calibration STN-4 marks were within 0.02 degree.

Data Processing System (DPS)

During the countdown a PCMMU (pulse code modulation master unit) 2 bite occurred. Troubleshooting prelaunch did not isolate the problem and no related anomalies were noted during the mission. A GPC (general purpose computer) 2 transient failure-to-synchronize occurred the last night of the mission. Dump analysis indicated probable internal timing problem which was cleared by moding the machine to "HALT". The computer performed normally for the rest of the mission.

Backup Flight System

The BFS (backup flight system) performed nominally during all phases of the STS-6 flight.

Operational Instrumentation

The OI hardware operated as expected with the exception of one pressure and one temperature measurement on the main propulsion system (MPS) for main engine 2. Measurements V41P1260A and V41T1261A were inoperative for 6 minutes during ascent between 94:18:32 G.m.t. and 94:18:38 G.m.t. Seven hydraulic line measurements were miswired or mislocated. The right-hand RCS aft housing thermal switch temperature, read 15° F lower than its redundant measurement.

The flash evaporator water feedline temperature number 3 had an excessive deadband on the controlling thermostat. The B supply flash evaporator system high load water feedline temperature exceeded the fault detection annunciation limit.

Operational tape recorder number 1 (OPS-1) reversed its direction of travel at about 52 percent of tape point instead of at the end of tape as it should have. Use of this recorder was restricted and OPS recorder-2 was used.

Display and Controls

The D and C (displays and controls) system performed well, with the following exceptions:

a. During the first flight day, the onboard TV cameras lens "zoom-out" capability was lost, although the ground retained control. The crew reported that after repeatedly jiggling the switch, they regained the onboard "zoom-out" capability.

b. While conducting the on-orbit OPS-8 FCS (flight control system) checkout, the hundreds digit on the primary miles counter of the right-side HSI (horizontal situation indicator) failed to move to the flag position during the flag test or when power was turned off. The pilot also noted that the thousands digit of the same counter was not reading properly during descent.

c. The crew reported that after getting a caution and warning alarm and punching it off, the Commander used the caution and warning READ switch on panel C3 to see what parameter had caused the alarm on the caution and warning light matrix on panel F7. While he was reading the lighted matrix, one of the mission specialists used the caution and warning READ switch on panel R13 to see the same thing on the LED matrix on that panel. At that time, the light matrix on F7 went blank, but the one on R13 remained lit. The commander toggled the panel C3 switch, but nothing happened.

d. Both rudder pedal transducer assembly outputs at full-right pedal deflection indicated 90 percent during the OPS 8 checkout. The on-orbit lower limit requires an indication greater than 91 percent. Prior to lift-off and after landing, a full right-pedal deflection registered a reading of 96 percent. No determination has been made of why a lower reading was obtained during the zero-g test.

Heads-Up Display Software System

Flight Assessment.- All HUD (heads-up display) symbology behavior was as expected on the flight with the exception that the rollout deceleration command and deceleration actual pointers were saturated at maximum value during the entire rollout.

Electrical Power Distribution and Control

On-orbit, the humidity separator "B" ac motor circuit breakers (all three phases) tripped. Also, the humidity separator single phase ac signal conditioner circuit breaker tripped at approximately the same time. The humidity separator "B" and the signal conditioner were deactivated and the crew used the humidity separator "A" package through the rest of the mission.

T-0 umbilical damage occurred at lift-off when a connector saver on J55 remained on the tail service mast connector. This caused no concern for entry.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM

Active Thermal Control Subsystem

The ATCS (active thermal control subsystem) performance was satisfactory in meeting STS-6 mission objectives. There were no ATCS detailed test objectives on STS-6. The ground half of the GSE freon cooling quick disconnect on the T-0 umbilical was damaged.

Subsystem performance was normal during the prelaunch period, and no launch commit criteria were violated. During ascent, the FES (flash evaporator subsystem) Freon outlet temperatures indicated no unexplained cooling as was evident during STS-1 through STS-5 on OV-102. Performance of the radiators with the new embossed silver-Teflon surface was satisfactory.

The FES system B feedwater line temperature V63T1894A exceeded its 140° F FDA (fault detection and annunciation) upper limit at 2 hours 18 minutes after lift-off. The temperature later rose to within a few degrees of the upper sensor limit of 160° F. The crew switched to system B heater, string 2 and the temperature remained below 160° F.

During the third sleep period, the FES system B feedwater line temperature V63T1877A dropped below its FDA lower limit of 50° F. The crew switched to heater string 1 and the temperature returned to its normal range.

Air Revitalization Subsystem

The performance of the ARS (air revitalization subsystem) was satisfactory during all mission phases and no ARS launch commit criteria were violated during prelaunch operations. An anomalous condition was detected during the flight. It occurred at 94:18:38 G.m.t., shortly after main engine cutoff. At this time the avionic bay 1 fan differential pressure dropped from 3.38 in. of water to 0.30 in. of water. A corresponding current increase to 1.8 A from a nominal indication of 0.9 A was detected in all three phases of the fan B motor. The avionic bay 1, fan B was deactivated and fan A was selected.

Air Revitalization Pressure Control Subsystem

The performance of the ARPCS (air revitalization pressure control subsystem) was normal.

The cabin pressure shell leak rate was less than 1.0 lb/day, well below the specified rate. Four anomalous high-flow rate alarms occurred during the flight. A high oxygen flow rate occurred first on system 1. On system 2, 1 high oxygen flow rate and two high nitrogen flow rates occurred. All of these occurrences were in the automatic mode. The system was managed successfully in the manual mode by using the isolation valves to adjust the partial pressures. The cause of these occurrences is still being investigated by the vendor.

Airlock Support Subsystem

The airlock operated normally. DTO 0611 (EMU/EVA Evaluation) was performed which required a complete airlock depressurization, crew egress, crew ingress and airlock repressurization. The airlock depressurization valve was not closed after depressurization of the airlock for EVA, consequently, during airlock repressurization activities, the airlock would not repressurize until the depressurization valve was closed. Crew procedures will be changed to verify that the airlock depressurization valve is closed prior to initiation of airlock repressurization activity. Airlock support subsystem operations were

normal during pre-EVA and post-EVA activities. The liquid-cooled garment cooling was adequate and the EMU's oxygen and water recharge was normal. The EMU batteries were charged for 4 hours and replaced. The inner hatch "O" ring partially came out of its groove when the hatch was initially opened. The crew pushed the ring back in and there was no indication of a leak during the EVA. Tape has been added to the groove to hold the seal in place.

Water and Waste Management Subsystem

The potable and supply water subsystem performance was normal. Tank quantity management by supply water dumps maintained an adequate amount of water. Postflight, a small water leak was found at the brazed fitting on the tank outlet valve. The crew reported that there was excessive gas in the potable water, causing problems for drinking and food re-constitution. The system was drained postflight and refilled.

Waste water management and waste collection was satisfactory. After the flight, the crew reported that the speed of the fan separator 1 of the waste collection system increased and decreased for no apparent reason. The fan separator has been removed.

Smoke Detection and Fire Suppression Subsystem

Performance of the SDFSS (smoke detection and fire suppression subsystem) was normal. Smoke detector readings remained within the background level, and there were no problems with the smoke detector self-testing. The detectors are of a new design and their output levels were comparable to that of the OV-102 detectors.

The fire suppression subsystem was not used.

MECHANICAL SUBSYSTEMS

Mechanical Actuation Subsystems

All motors for the vent doors, ET umbilical closeout doors, the payload bay doors, star-tracker doors, and air data probe deployment mechanism functioned nominally. The initial payload bay door rigging alignment verification (DTO 0507) was performed, but the data were not sufficient to verify non-interference contact between the door and the aft bulkhead during closure.

Airlock Hatches

No problems were reported on operating airlock hatch A or hatch B. However, during a pre-EVA checkout, the crew noticed that the pressure seal on hatch A had come loose from its dovetail groove when the hatch was opened. The crew was instructed to press the seal back in. No further problems were reported on the seals for hatch A or hatch B.

Landing Gear Deployment

The landing gear deployment, touchdown, rollout, and braking parameters were within nominal requirements and objectives. Table II shows the landing and deceleration subsystem performance parameters for STS-6. Postflight disassembly of the brakes revealed that three stators on the right-hand inboard brake were cracked in several locations. The saddle modification to the brakes for this flight successfully prevented brake damage which has been previously caused by axle, wheel, and brake flexibility. The crosswind DTO was not accomplished.

TABLE II.- STS-6 LANDING/DECELERATION SUBSYSTEMS PERFORMANCE

Parameter	Velocity, knots	
	Equivalent air speed	Ground relative
Main gear touchdown	194.5	180
Nose gear touchdown		147
Braking initiated		137
Nose wheel steering	none	none

Touchdown points from threshold¹:

Left main, ft	2026
Right main, ft	2075
Distance from main to nose wheel contact, ft	2946
Distance from nose contact to brake initiation, ft	709
Braked roll, ft	3591
Braked duration, sec	35
Pitch rate at nose wheel contact, deg/sec	Note 2
Sink rate at main gear touchdown, ft/sec	1 to 2
Total roll out, ft	7180
Roll out duration, sec	38

Notes:¹Touchdown occurred 12 feet left of runway centerline and the Orbiter was stopped on the centerline.

²Those data are not available.

PLBD EVA Backup Tools

The EVA backup tools used during the simulated IUS contingency operations and winch operations appeared to have functioned normally with the exception of the aft winch hook release from the IUS mechanism. The crew had difficulty in releasing the winch load for removal of the hook after completing the simulated IUS contingency operation.

THERMAL CONTROL AND THERMAL PROTECTION SUBSYSTEMS

The thermal response of OV-099 was similar to that of OV-102 for the same β angle and orbiter orientation. All subsystem temperatures were maintained within design limits. The zone 4 starboard FES heater system 2 failed off at 97:07:33 G.m.t. Heater system 2 was activated and the FES temperatures were maintained satisfactorily. Two additional heater systems had unexpected performance characteristics an these are:

- a. Zone 2 port FES heater system showed a 30 to 35° F deadband (set points are 71.4 to 81.5° F) and a duty cycle of 15 percent with 30 percent expected.
- b. Zone 4 FES port heater had a cuty cycle of 4 percent with 20 to 30 percent expected.

The TPS (thermal protection subsystem) and structural temperatures remained within satisfactory limits both on-orbit and during entry. The maximum entry temperatures observed were 217° F on the port OMS pod and 164° F the mid-fuselage bottom.

The AFRSI (advanced flexible reusable surface insulation) on the OMS pods experienced severe damage on the forward portion and minor damage at other locations. In addition, two FRSI (flexible reusable surface insulation) closeout strips on the right OMS pod and captive gap fillers around the window closeout panel protruded or came loose during ascent. Also, several tiles just aft of the nose cap experienced slight sidewall slumping.

Several hydraulic system temperature measurements appear to be improperly installed and one aft RCS measurement appears to be improperly calibrated.

V42T3304	Starboard aft RCS drain panel
V58T0157	Left inboard elevon return line, system 1
V58T0159	Right inboard elevon return line, system 1
V58T0184	Body flap return line, system 2
V58T0257	Left inboard elevon return line, system 2
V58T0933	Right inboard elevon return line, system 2
V58T0833	Left inboard elevon return line, system 3
V58T0359	Right inboard elevon return line, system 3

STRUCTURAL SUBSYSTEM

All structural subsystems performed their functions as designed except for the clevis bracket for the CCTV monitor failed where it was bonded to the crew cabin sidewall. This failure occurred about 60 seconds in the ascent portion of the flight. The clevis was mislocated approximately 1/2 inch too far forward and 1/2 inch too far outboard.

Also, the crew reported that the waste collection system and avionics bay 38 doors could not be closed on-orbit. The crew taped the doors closed for entry. The crew noted that the doors could be closed after entry. This same problem occurred during the first flight (STS-1) of OV-102.

Further the crew reported that most of the stowage locker doors could not be locked on orbit, but could be locked after landing.

EXTRAVEHICULAR MOBILITY UNIT AND EXTRAVEHICULAR ACTIVITY

On the first day of flight, the third EMU (extravehicular mobility unit) was tested in accordance with the Spare EMU OPS flight procedures. At that time, a locker-stowed CCC (contaminant control cartridge) and battery were installed in the unit. The secondary oxygen pressure regulation and preliminary oxygen pressure regulation checks verified nominal performance. Proper EMU fan operation was also verified, EMU leakage checks were successfully performed, and communication checks showed nominal operation. Both EMU 1 and EMU 3 water tanks were topped off.

On the second flight day [the day before EVA (extravehicular activity)] flight procedures were successfully completed. Procedures included primary and secondary pressure regulation checks, fan operation verification, communications checks and EMU leakage checks. Each unit's primary oxygen supply was topped off and the batteries were fully charged.

During EVA preparations on the second day of flight, four of the twelve EMU light batteries failed to power the lights. As there were 8 other batteries available, the failure had no impact on the EVA or flight.

The day of EVA, the EVA equipment was donned, the communications, leakage and biomedical checks were completed, and the 3.5-hour de-nitrogenization (prebreathe) procedure was completed.

Airlock depressurization was begun at 97:21:05:00 G.m.t. The hatch was opened at 97:21:21 G.m.t. and EVA began. The crewmen successfully followed their EVA timeline tasks which consisted of translation to the aft bulkhead using handrails, inspection of the payload bay, an EVA mobility evaluation, a tool accessibility test, slide wire operation, translation with a massive object, winch operations to simulate closing of payload bay doors, IUS ASE (airborne support equipment) operations and ingress of the portable foot restraints.

During EVA, the following observations were made:

- a) The EMU's performed flawlessly throughout the 4-hour activity. Status reports read by the crewmen showed all systems were operating correctly at all times. The suit fit was such that the crewmen reported no pressure points, and suit mobility allowed successful performance of all assigned tasks.
- b) On-board tapes verified that during a high metabolic period, EV2 (extravehicular crewman 2) received a "high O₂ usage" warning. The message cleared immediately and did not recur. Overall oxygen usage for the mission was normal. An analysis has been made that shows that the message could occur under realistic circumstances involving high work rates and suit flexure. Postflight testing shows all systems are normal.
- c) The payload bay lighting conditions when illuminated from direct and indirect solar radiation showed that it was difficult, but did not prohibit the crewmen from reading the DCM's LED displays.

Airlock repressurization took place at 98:01:15:00 G.m.t. The suits were doffed and the EMU's were recharged with water and oxygen. Batteries were recharged, then replaced. All three EMU's were restowed for entry at that time.

DETAILED TEST OBJECTIVE/DETAILED SUPPLEMENTARY OBJECTIVE

Over 97 percent of the scheduled DTO's and DSO's were accomplished during the STS-6 flight. Twenty-nine DTO's and eleven DSO's were assigned to this flight. Three of the DTO's were not scheduled, but were carried as shopping list items and were not selected by the crew or mission planners during the flight to be performed. Two DTO's were scheduled, but not accomplished, and these were DTO 0755 (autoland to 5000 feet) and DTO 0805 (crosswind landing performance). DTO 0805 could not be accomplished as no crosswinds existed at the landing site.