

STS 61-B National Space Transportation System Mission Report

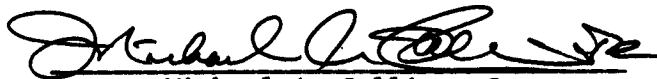
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**National Aeronautics and
Space Administration**

**Lyndon B. Johnson Space Center
Houston, Texas**

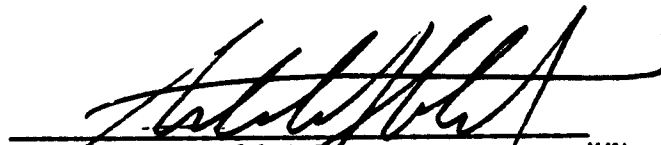
STS 61-B
NATIONAL SPACE TRANSPORTATION SYSTEM
MISSION REPORT



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INTRODUCTION AND MISSION OBJECTIVES

The STS 61-B National Space Transportation System (STS) Mission Report contains a summary of the major activities and accomplishments of the twenty-third Space Shuttle mission and the second flight of the OV-104 vehicle, Atlantis.

The primary objectives of this flight were to successfully deploy the SATCOM KU-1/Payload Assist Module-Delta Class II (PAM-D II), MORELOS-B/Payload Assist Module-Delta Class (PAM-D) and AUSSAT-2/PAM-D satellites, conduct the operations of the Experimental Assembly of Structures with Extravehicular Activity/Assembly Concept for Construction of Erectable Space Structure (EASE/ACCESS), IMAX camera, Continuous Flow Electrophoresis System (CFES) and Diffusion Mixing of Organic Solutions (DMOS) payloads. The sequence of events for this mission is shown in Table I. The Orbiter problem tracking list is presented in Table II.

The crew for the twenty-third mission of the Space Shuttle was Brewster H. Shaw Lt.Col., U. S. Air Force, Commander; Bryan D. O'Conner, Maj., U. S. Marine Corp, Pilot; Mary L. Cleave, Ph.D., Jerry L. Ross, Maj. U. S. Air Force, and Sherwood C. Spring, Lt.Col., U. S. Army, Mission Specialists; and Rodolfo Neri Vela, Ph.D., and Charles Walker, Payload Specialists. Mr. Rodolfo Neri Vela was a representative from the country of Mexico.

MISSION SUMMARY

The 7-day STS 61-B mission was launched at 331:00:29:00 G.m.t. (7:29:00 p.m. e.s.t.) on November 27, 1986, from launch complex 39A at Kennedy Space Center (KSC) on an azimuth of 90 deg. The direct insertion launch phase was normal in all respects with the Orbiter being inserted into the nominal 190-n.mi. circular orbit after the completion of one orbital maneuvering system (OMS) maneuver. The OMS-1 maneuver was not performed because of the direct-ascent trajectory that was flown.

Post-insertion and first-day activities were nominal in all respects. The payload bay doors were opened at the planned time, and the CFES and DMOS experiments being activated on schedule. The remote manipulator system (RMS) was checked out and final preparations for the deployment of the MORELOS satellite, the second in a series of communications satellites for Mexico, were completed. The MORELOS was deployed at the planned time of 331:07:46:50 G.m.t. Fifteen minutes later, a 11 ft/sec OMS separation maneuver was performed, followed by a satisfactory 86-second MORELOS perigee kick motor (PKM) firing 45 minutes after satellite deployment.

The second day's activities were centered around deploying the AUSSAT/PAM-D satellite and performing a checkout of the extravehicular mobility units (EMU's). The AUSSAT satellite was deployed on time at 332:01:20:33 G.m.t. An 11 ft/sec OMS separation maneuver was performed 15 minutes after the AUSSAT was deployed. The PKM firing of the AUSSAT placed the satellite into the planned transfer orbit. The other major day-2 activity involved the checkout of all three EMU's which was successfully completed at 332:04:07 G.m.t., when the batteries were topped off.

The SATCOM satellite was successfully deployed on the third day of the mission at 332:21:57:31 G.m.t. The 119-second PKM firing placed the SATCOM satellite in a satisfactory transfer orbit. With the completion of the deployment of the three satellites, all priority one mission objectives were completed. Other activities of the third day included lowering the cabin pressure to 10.2 psi for prebreathing for the extravehicular activities (EVA's) on the fourth and sixth days. Portions of three detailed test objectives (DTO's) were performed during this third day of flight.

The fourth day activities centered around the first EVA and the performance of another part of two DTO's. The first EVA was performed very satisfactorily with all tasks being completed either on time or ahead of schedule. Additional repetitions of one assembly process were completed because the extra time was available. The IMAX camera was also operated during the EVA to obtain three different scenes. The EVA was completed in 5 hours 33 minutes. At the end of the first EVA, a target was deployed for stationkeeping tests using the digital autopilot (DAP). After the EVA crewmen reentered the vehicle, the vehicle was maneuvered to within 35 feet of the target with the target centered in the field of view of the payload-bay and end-effector cameras. The Commander and Pilot both maneuvered the vehicle using two different modes of digital autopilot (DAP) control [current DAP and orbital experiment (OEX) DAP] with very good results and good fuel efficiency in the OEX DAP mode.

Activities on the fifth day consisted of servicing the EMU's for the second EVA and performing an OMS orbit-adjustment maneuver.

Day 6 activities consisted mainly of the second EVA and its associated preparations. The second EVA of the mission began approximately 45 minutes ahead of the timeline. Objectives successfully accomplished included ACCESS buildup, simulation of cable installation on the structure, a simulation of a repair to the truss, and manipulation of the truss inside the payload bay. The RMS and manipulator foot restraint (MFR) were used during the EVA. For the EASE portion of the EVA, each crewman built up and manipulated a simulated heat pipe constructed out of two EASE beams. They also manipulated the completed EASE assembly. Total time for EVA-2 was approximately 6 hours 41 minutes.

The crew press conference took place on day 7, as well as final stowage for the return to Earth. The waste-water dump DTO was performed again with about 45 percent being dumped from each tank. The flight control system checkout was also satisfactorily performed using auxiliary power unit (APU) 3.

On the morning of day 8, the DMOS was deactivated and the deorbit preparations were completed. A satisfactory 169-second deorbit maneuver was completed at 337:20:29:34 G.m.t. Entry was normal in every respect. A 170-degree heading alignment circle (HAC) maneuver was performed and the Orbiter landed at 337:21:33:49 G.m.t. on runway 22 at Edwards AFB, CA. Rollout required 10759 feet and was completed 78 seconds after touchdown. The post-landing inspection of the Orbiter showed the thermal protection system (TPS) and brakes to be in good shape.

TABLE I. - STS 61-B SEQUENCE OF EVENTS

<u>Event</u>	<u>Actual time, G.m.t.</u>
APU activation (1)	331:00:24:10
(2)	331:00:24:11
(3)	331:00:24:12
SRB HPU activation command (RH-B)	331:00:28:30.4
MPS start command sequence (engine 3)	331:00:28:53.5
SRB ignition command from GPC (lift-off)	331:00:29:00
MPS throttle down to 65-percent thrust (engine 3)	331:00:29:27.2
Maximum dynamic pressure	331:00:29:50
MPS throttle up to 104-percent thrust (engine 3)	331:00:29:59.2
SRB separation command	331:00:31:04
MPS throttle down for 3g acceleration (engine 3)	331:00:36:34.2
Main engine cutoff (MECO)	331:00:37:31
External tank separation	331:00:37:50
OMS-1 ignition	(Not performed)
APU Deactivation (3)	331:00:42:05
OMS-2 ignition	331:01:09:24
OMS-2 cutoff	331:01:12:25
MORELOS deploy	331:07:46:50
AUSSAT deploy	332:01:20:33
SATCOM deploy	332:21:57:31
FCS (flight control system) checkout - APU 3 activation	336:19:57:30
APU 3 deactivation	336:20:01:14
APU 2 activation	337:20:21:47
Deorbit maneuver ignition	337:20:26:45
Deorbit maneuver cutoff	337:20:29:34
APU 1 activation	337:20:50:21
APU 3 activation	337:20:50:21
Entry interface (400,000 ft)	337:21:03:17
End blackout	337:21:19:22
Terminal Area Energy Management (TAEM)	337:21:27:29
Main landing gear contact (LH)	337:21:33:49
Nose landing gear contact	337:21:34:00
Wheels stop	337:21:35:07
APU deactivation complete	337:21:45:53

VEHICLE ASSESSMENT

SOLID ROCKET BOOSTERS

This flight utilized lightweight solid rocket motor (SRM) cases. SRM propulsion performance was normal and within specification limits, with propellant burn rates for both SRM's slightly above predicted values. Solid rocket booster (SRB) thrust differentials were within specification throughout the flight.

The SRB support-post loads data at lift-off showed that footpad compression, tension and bolt loads were within design allowables and were comparable with loads observed on previous flights. The SRB base-moment calculation, based upon mobile launch platform support strain data, indicated a maximum of 89 percent of design during Space Shuttle main engine (SSME) thrust buildup.

The thrust vector control (TVC) prelaunch redlines were not exceeded by ample margins. Analyses verified that the TVC subsystem operated normally.

Evaluation of the electrical and instrumentation system indicates that the ignition and separation pyrotechnics fired as planned. The recovery sequence was performed satisfactorily on both SRB's with pyrotechnics firing and system-reset properly initiated. All SRB operational instrumentation measurements performed properly throughout their required flight periods.

The flight structural temperature measurement response was as expected. The SRB TPS performed as predicted during ascent with little or no TPS acreage ablation.

The performance of the separation subsystems was normal with all booster separation motors expended and bolts severed. Nose-cap ejection, frustum separation, and nozzle jettison occurred normally on each SRB. All drogues and main parachutes were recovered and are reusable.

EXTERNAL TANK

External tank (ET) propellant loading was accomplished satisfactorily. All ET prelaunch thermal requirements were met. There was no excessive ice or frost buildup. TPS acreage performance was as expected for the existing ambient conditions.

Flight performance was excellent. Skin and component temperatures during flight were similar to previous flights. Entry was normal with the impact in the footprint as predicted. Tumbling was verified by tracking from the ground.

SPACE SHUTTLE MAIN ENGINES

All prelaunch purge operations were executed successfully. The ground support equipment provided adequate control capability for launch preparation. All conditions for engine start were achieved at the appropriate times.

All three SSME's started properly. Buildup, mainstage and shutdown performance of all engines was within specification. The SSME controllers provided proper control of the engine throughout powered flight. Engine dynamic data generally compared well with previous test and flight data, and no problems were identified. All on-orbit activities associated with the SSME's were accomplished successfully.

MAIN PROPULSION SYSTEM

All pretanking purges were performed as planned. Liquid oxygen and liquid hydrogen propellant loading, prepressurization and pressurization systems performed satisfactorily. During propellant loading, the facility liquid-oxygen bleed temperature sensor failed off-scale high; however, this did not affect the loading operation.

Main propulsion system (MPS) propulsion and feed system performance was as predicted. The Orbiter liquid hydrogen inlet pressure measurement for engine 1 was erratic during ascent, but this had no effect on vehicle performance. Liquid oxygen and liquid hydrogen propellant conditions were within specified limits during all phases of operation, and net positive suction pressure requirements were met. Trajectory reconstruction indicates that engine specific impulse was near the MPS assessment tag values. At main engine cutoff, liquid oxygen residuals were 1192 lb more than predicted, and liquid hydrogen residuals were 411 lb less than predicted.

ORBITER

Orbiter subsystem operation during STS 61-B was very good with only a few minor anomalies (see Table II). The most significant problem of the flight is discussed in the following paragraphs.

Fuel Cell 2 Performance Degradation

At 334:12:16 G.m.t., it was determined that during a fuel cell 2 cell performance monitor self test, the substack 3 differential voltage measurement (V45V0204A) transitioned from its average operating value of 36 millivolts to its self-test voltage of 48 millivolts. After the 2- to 3-second self-test period, the differential voltage measurement fell to 44 millivolts in lieu of the normal 36 millivolts.

At 336:05:25 G.m.t., the fuel cell 2 performance degradation rates closely paralleled those of fuel cells 1 and 3. However, the overall amount of fuel cell 2 degradation was excessive as compared to fuel cells 1 and 3 because a significant performance increase was achieved by fuel cells 1 and 3 during purges, whereas only a slight increase was seen on fuel cell 2 during purges. Even though fuel cell 2 purge flow rates appeared to be normal, the performance increase that should have occurred did not happen, indicating that the purge system was not operating properly.

Fuel cell 2 performance was degraded by approximately 0.4 volt during the mission. Degradation for this fuel cell over the previous mission (STS 51-J) was 0.25 volt/5 days. Usual observed decay for any fuel cell is on the order of 0.1 volt, or less, for a nominal 7-day mission.

PAYLOADS AND EXPERIMENTS

MORELOS-B SATELLITE

The MORELOS-B satellite was deployed at the scheduled time of 331:07:46:50 G.m.t. Forty-five minutes after deployment, a successful PKM firing of 86 seconds was completed. On day 333 (November 29, 1985), a nominal apogee kick motor (AKM) firing was performed, placing the satellite in the desired geosynchronous orbit.

AUSSAT-2 SATELLITE

The AUSSAT-2 satellite was deployed at the scheduled time of 332:01:20:33 G.m.t. Forty-five minutes after deployment, a successful PKM firing was completed. On day 333 (November 29, 1985), a nominal AKM firing placed the satellite in the desired geosynchronous orbit.

SATCOM KU-2 SATELLITE

The SATCOM KU-2 satellite was deployed on schedule at 332:21:57:31 G.m.t. on revolution 31. The nominal PKM firing was initiated 45 minutes later, and the satellite was placed in the planned transfer orbit. The AKM firing was performed 1 day ahead of schedule and the satellite was successfully placed in the desired geosynchronous orbit.

DIFFUSION MIXING OF ORGANIC SOLUTIONS

All six cells of the DMOS experiment were processed during STS 61-B. A slight temperature problem was noted in the processing of these six cells; however, the cell temperature elevation was not expected to adversely affect the experiment results. The cells were returned to the experimenters for analysis.

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM

The CFES was flown to test the concept of mass production of hormone material. Approximately 1 liter of hormone material was successfully processed during the flight.

G-479 GETAWAY SPECIAL EXPERIMENT

The G-479 Getaway Special (GAS) experiment was activated at 02:06:32:20 mission elapsed time. The crew reported that about 12.5 minutes of free drift time was available during the GAS experiment operation. The canister has been returned to the experimenter (Telesat Canada) for evaluation.

IMAX CAMERA

The IMAX camera was successfully used to document payload bay activities during opening of the payload bay doors, numerous EVA operations, and a final photograph of Earth's features over the United States and Texas. Over 400 seconds of photographs were taken during the nine scenes that were documented.

EXTRAVEHICULAR ACTIVITIES

SUMMARY

The crew of mission STS 61-B successfully demonstrated the first construction of large structures in space. Two structures, EASE and ACCESS, were assembled during two EVA's. Crew members used small components to form large structures, just as they might do to build a Space Station.

During the first EVA, baseline techniques for assembly were used to examine the human factors aspects of construction in space. During the second EVA, the experiments were expanded, and crew members assembled the structures while being moved on a work station attached to the RMS; they also demonstrated repair and maintenance techniques. All tasks planned for the two EVAs were completed, and investigators were able to take advantage of extra time to complete bonus tasks during the first EVA.

Preflight, the crewmembers completed several simulations constructing the structures underwater in neutral buoyancy facilities. One of the mission objectives was to compare the inflight assemblies with similar constructions underwater. During inflight experiments, the crew members said that their training in the underwater environment was very valuable.

EXTRAVEHICULAR ACTIVITY 1

ACCESS Basic Experiment

The first EVA proceeded at a brisk pace as both crewmen completed all tasks ahead of schedule. Upon entering the payload bay, the crew members inspected the EASE/ACCESS equipment and reported that it was in the proper configuration.

The first EVA task was to assemble a 45-foot high ACCESS truss tower. The crew unfolded the assembly fixture, the structure to which the other ACCESS components are attached, and opened the three canisters that contained 93 struts and 33 nodes. They then connected the struts and nodes on the assembly fixture, completing 10 ACCESS bays. Each bay was completed in an average time of 2 1/4 minutes, and the entire 10 bays were constructed in 26 minutes. Each bay was then disassembled in an average time of 1 3/4 minutes with the entire disassembly completed in 20 minutes. The astronauts finished the entire task in about 56 minutes; a 1-hour and 45-minute period was allocated for the task in the timeline. This construction used an "assembly line in space" technique with both crew members working in fixed work stations mounted on the equipment support structure.

EASE Basic Experiment

As the crew began the EASE assemblies, they were 45 minutes ahead of the premission timeline. During these assemblies, the crewmen were encouraged to modify the construction method as the EVA progressed. Six assembly/disassembly cycles were planned, but the crews' fast pace enabled them to complete two bonus assembly cycles. The first four assembly/disassembly cycles were completed with one crewman working at the bottom of the equipment support structure, and the other crewman operating at the top of the structure. The crew completed the first four cycles in 1 hour and 4 minutes; this task was allocated 2 hours in the timeline. Assembly times improved with each construction. During the first four cycles, assembly times ranged from 9 to 12 minutes and disassembly times ranged from 5 1/2 to 8 minutes. Four more assemblies were completed with the crewmen's positions reversed. The last four cycles were completed slightly slower; investigators said this was expected to happen as the crew neared the end of their work. A total time for completion of the last four cycles was not calculated.

EXTRAVEHICULAR ACTIVITY 2

ACCESS Expanded Experiments

The purpose of the expanded ACCESS experiments was to demonstrate construction with one crew member positioned in the MFR attached to the RMS, and to demonstrate possible Space Station repair and maintenance scenarios. The RMS was used to move the EVA crewmen to specific locations in the payload bay.

The second EVA began on a positive note with the crew starting 40 minutes earlier than planned. They completed nine of the ten ACCESS bays using the baseline techniques with both crew members working in fixed-foot restraints attached to the MPSS (Mission Peculiar Equipment Support Structure). The tenth bay of the 45-foot truss tower was completed while the EVA crewman was positioned in the RMS work station. He then installed a flexible cable along the frame of the tower; similar cables may be used to route power to different parts of the Space Station.

Next, a crewman removed the entire 190-pound ACCESS from the equipment support structure and rotated and translated it into various positions. The task was important in demonstrating that large structures can be handled in a controlled manner. The other crewman then worked from the MFR, disassembling and reassembling Bay 10, practicing a repair of a segment of the structure, and repeating the removal and manipulation of the entire framework. Finally, both crew members moved to positions in fixed-foot restraints and disassembled the structure.

The preliminary data seems to indicate that times for in-orbit assembly were comparable to average assembly times during underwater training. As expected, tasks took slightly longer to perform while using the MFR.

EASE Expanded Experiments

Upon stowage of the ACCESS hardware, the crew immediately began the expanded EASE experiments. The crew was slightly behind the timeline, but were able to complete all planned EASE experiments with no difficulty. The goal of these experiments was to demonstrate the handling of various masses in space. Throughout the EVA, the crew members handled masses ranging from two 130-pound connected EASE beams to the entire 450-pound EASE structure.

One crewman was positioned in the MFR, and began the EASE activities by connecting two EASE beams to form one 25-foot beam that might resemble heat pipes used in a Space Station. He then maneuvered the cylindrical structure into various positions. Next, the crewman assembled EASE while moving throughout the six-beam structure. A minor problem developed when the base cluster could not be reattached to the equipment support structure because of a pin that would not fit. A spare EASE node was used to replace the base cluster. No operations were cancelled, and the other crewman successfully manipulated the entire structure with the spare node serving as a connector. To end the EVA, the other crewman disassembled the EASE, and repeated the heat pipe manipulation task. At the end of the EVA the crew carried the base cluster inside for stowage during landing.

DETAILED TEST OBJECTIVES

All Shuttle DTO's assigned to this flight were accomplished as planned with the exception of DTO 0318, Direct Insertion ET tracking. The following DTO's required special test conditions or crew activity.

Upper Stage Plume Damage Model Verification (DTO 0316) - The witness plate on the RMS was deployed in an orientation to capture combustion products from the PAM-D2 during the SATCOM satellite PKM firing.

Crew Compartment Structure Deflection Investigation (DTO 0321) - Locker distortion measurements were made on flight days 5 and 7.

Waste and Supply Water Dumps (DTO 0325) - Thirteen water dumps were performed (10 supply, 2 waste and 1 simultaneous). All were accomplished without incident. The RMS television was used to observe five dumps: the first use of the reconfigured waste nozzle, the first supply and waste dumps at 10.2-psia cabin pressure, the simultaneous dump (the first simultaneous dump with the redesigned nozzles), and a supply dump with the radiator in high-set point to force flash evaporator system (FES) operation. All dumps were useful in the evaluation of the new nozzles, but only the supply dump with the FES activated actually cleared a test condition of the DTO.

Radiator Performance (DTO 0624) - One test condition was performed from this DTO's set of required tests. This was an evaluation of radiator performance in a -ZLV attitude with the radiators stowed followed by evaluation of the performance with the radiators deployed.

Orbiter Attitude Control Translational Thrusting (DTO 0779) - Night passes in -ZLV with nose forward and tail forward will be analyzed in the investigation of possible Orbiter-caused orbital energy growth. Quick-look analysis indicates a net forward translation.

EASE/ACCESS Space Station Assembly (DTO 0817) - This DTO was performed on the second EVA as planned, and was considered to be very successful.

Orbital Experiments (OEX) DAP Performance (DTO 0909) - This DTO was performed as planned. This was the last planned flight for this DTO. The only notable unaccomplished test was closed-loop stationkeeping using radar with a real target. The target was flown and deployed on this flight, but the Ku-Band radar was not installed.