

STS-5 Space Shuttle Program Mission Report

December 1982



National Aeronautics and
Space Administration

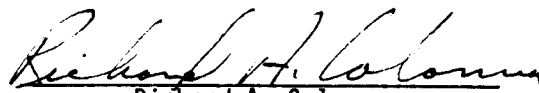
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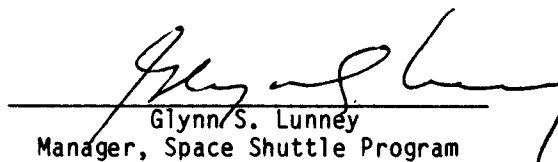
SPACE SHUTTLE PROGRAM

STS-5

MISSION REPORT


Michael A. Collins, Jr.
Chief, Integration Division


Richard A. Colonna
Manager, Program Operations Office


Glynn S. Lunney
Manager, Space Shuttle Program

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

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INTRODUCTION AND MISSION OBJECTIVES

The STS-5 Space Shuttle Program Mission Report provides an overview of the major activities, accomplishments, and findings of the first operational flight based on a preliminary review and analysis of the flight data. With the successful completion of STS-5, the Orbiter (OV-102) will be temporarily removed from the flight program so that modifications may be made in preparation for the first Spacelab mission (STS-9).

The primary mission objective of STS-5, as defined in the Flight Requirements Document (JSC 17462-05), was to successfully deploy the SBS and ANIK-C payloads. To further this objective, a first day deployment was incorporated into the flight design. An additional objective was to perform an extravehicular activity, but problems with the EMU's (extravehicular mobility unit) caused cancellation of this task. The results of the investigation of the EMU anomalies are reported in the STS-5 Mission Anomaly Report of Extravehicular Mobility Unit Anomalies (JSC-18698).

MISSION SUMMARY

The STS-5 mission was launched on November 11, 1982 at 12:18:59.997 G.m.t., and landed November 16, 1982 at Edwards AFB, CA. The sequence of events for this flight is listed in Table 1-1. The crew for this first commercial satellite deployment mission was Vance D. Brand, Commander; Colonel Robert F. Overmyer, Pilot; and William B. Lenoir, Ph.D., and Joseph P. Allen IV, Ph.D., Mission Specialists. All DTO/DSO test objectives of the flight were successfully completed except for the extravehicular activity which was cancelled because of extravehicular mobility unit problems.

The ascent phase was nominal with all systems operating near predicted levels. The main propulsion system and the external tank systems operated properly with no anomalies noted in either system. The solid rocket booster (SRB) performance was slightly below predictions. The solid rocket booster recovery systems operated properly and the SRB's were towed to port. The trajectory parameters at MECO (main engine cutoff) were nominal and the performance of the main propulsion system and main engines was also satisfactory. The resultant orbital parameters after the first and second OMS (orbital maneuvering system) maneuvers were 160.2 by 160.1 nmi., compared with the planned 160 nmi. circular orbit.

The first day of STS-5 was characterized by the successful deployment at 315:20:18:00 G.m.t. of the SBS (Satellite Business System) communications satellite and it was successfully boosted into a geosynchronous orbit on November 13, 1982. An OMS 3 burn was performed to provide a safe separation distance between the PAM-D motor plume and the orbiter. Also, the GAS (getaway special) experiment was activated.

The crew reported one anomaly on the first day. That was the failure of CRT-2 (cathode ray tube). The ground provided a procedure for switching cables on DEU's (display electronic unit) 2 and 4. The cable switching inflight maintenance procedure was successfully performed on the fourth day and this restored normal operation to CRT-2 on the forward deck and disabled CRT-4 on the aft deck which was not required for entry.

On day 2, the Telesat (ANIK-C) satellite (second commercial payload) deployment occurred at 316:20:24:11 G.m.t. This satellite was boosted into a geosynchronous orbit on November 16, 1982. Two OMS (orbital maneuvering system) maneuvers (OMS-4 and -5) were performed in preparation for the second satellite deployment and one maneuver (OMS-6) was made after the deployment to provide a safe separation distance from the PAM-D motor plume on the Telesat satellite.

TABLE I.- STS-5 SEQUENCE OF EVENTS

Event	Planned* G.m.t.	Actual G.m.t.
APU activation (1)	315:12:13:57	315:12:14:06
(2)		315:12:14:07
(3)		315:12:14:08
SRB HPU activation command (4)	315:12:18:32	315:12:18:32.3
MPS start command (Engine 3)	315:12:18:54	315:12:18:53.4
SRB ignition command from GPC (lift-off)	315:12:19:00.0	315:12:19:00*
Main engine throttledown to 65-percent thrust	315:12:19:33.7	315:12:19:35.1
MPS throttleup to 100-percent thrust	315:12:19:53.3	315:12:19:54.5
Maximum dynamic pressure	315:12:20:05.7	315:12:20:11.0
SRB separation command	315:12:21:05	315:12:21:09.0
MPS throttledown for 3g acceleration	315:12:26:36	315:12:26:37.8
3g acceleration	315:12:26:36.6	315:12:26:37.0
Main engine cutoff (MECO) command	315:12:27:35.0	315:12:27:30.7
External tank separation	315:12:27:49.2	315:12:27:48.8
OMS-1 ignition	315:12:29:29.0	315:12:29:31.0
OMS-1 cutoff	315:12:31:54.0	315:12:31:48.8
APU deactivation	315:12:34:00.0	315:12:31:48.8
OMS-2 ignition	315:13:03:39.0	315:13:03:40.8
OMS-2 cutoff	315:13:05:36.0	315:13:05:37.6
Payload bay doors open		315:13:53:28.0
SBS (Satellite Business Systems) release	315:20:32:24	315:20:18:00
OMS-3 ignition	315:20:32:24	315:20:32:35.1
OMS-3 cutoff	315:20:32:33	315:20:32:44.4
OMS-4 ignition	316:13:05:34	316:13:04:00.4
OMS-4 cutoff	316:13:05:36	316:13:04:02.4
OMS-5 ignition		316:13:08:05.4
OMS-5 cutoff		316:13:08:20.9
Telesat (ANIK-C) release	316:20:39:01	316:20:24:11
OMS-6 ignition		316:20:39:11.1
OMS-6 cutoff		316:20:39:20.4
GLOW activation	318:16:29:00	317:16:25:00
GLOW deactivation		317:17:09:00
Close payload bay door		320:10:24:47
APU 3 activation		320:13:31:19
APU 1 and 2 activation		320:13:50:11
Deorbit maneuver ignition (OMS-7)	320:13:28:46	320:13:36:21
Deorbit maneuver cutoff	320:13:31:07	320:13:38:43.4
Entry interface (400,000 ft)	320:13:55:16	320:14:03:11
End blackout	320:14:12:01	320:14:19:47
Terminal area energy management	320:14:14:00	320:14:27:15
Main landing gear contact	320:14:24:00	320:14:33:26
Nose landing gear contact	320:14:24:00	320:14:33:34
Wheels stop	320:14:25:16	320:14:34:29
APU deactivation completion	320:14:27:00	320:14:52:46

*The lift-off time has been rounded from 315:12:18:59.997 G.m.t.

The crew activated two student experiments and these were:

- a. Growth of Porifera (sponge) in zero g, and
- b. Comparison of solution crystal growth in zero g.

The third day of the mission involved successfully performing the six planned test objectives for that day. Also, during the latter part of day 3, a decision was made to switch day 4 and 5 of the flight plan. This action was taken to improve the crew performance during the extravehicular activity.

The MCC (Mission Control Center) lost one main power buss during the crew sleep period after day 3. The failure caused a loss of data and command capability for a period of 80 minutes; however, the air-to-ground communications capability remained operable. A failure of this type during a critical mission phase would not cause an interruption because redundant system operation exists during those phases.

All planned DTO (development test objectives) and payload operations planned for the fourth day were completed plus one additional DTO that was rescheduled from day 2.

The 46-hour starboard side-to-sun attitude was completed on day 4 and all temperatures were within expected ranges. Likewise, the temperatures appeared to have reached near cyclic steady-state conditions. The nose-to-sun attitude was initiated following completion of the starboard sun attitude and temperatures were essentially within the predictions during this attitude.

The planned extravehicular activity was cancelled because of two problems, one with each suit. The EV-2 (Allen) suit fan would not operate properly even after a significant amount of troubleshooting. The EV-1 (Lenior) suit pressure regulator was regulating to 3.8 psia instead of 4.3 psia. Repositioning of the oxygen actuator a number of times produced no change in the regulated pressure level.

Activities during the final day of the flight included stowing the vehicle, preparing for entry, and returning to earth. The payload bay doors were closed without incident and after a normal deorbit maneuver, the Orbiter was guided to a smooth landing on runway 22 at Edwards AFB, CA. The maximum braking DTO was performed during the rollout after landing. The left main inboard wheel locked up during the last 50 ft. of rollout because of a brake failure. With the wheels stopped at 320:14:34:29 G.m.t., the first operational mission of the Space Transportation System was successfully concluded.

CONSTRAINTS ON STS-6

There are no known constraints to the STS-6 mission that resulted from the STS-5 mission.

PAYLOADS ASSESSMENT

Satellite Deployments

The SBS (Satellite Business Systems) and the Telesat (ANIK-C) payloads were deployed from the Orbiter over the equator on revolution 6 (Nov. 11) and 22 (Nov. 12), respectively. The deployments were in accordance with the nominal flight plan. Both satellites (payloads) used the PAM (payload assist module) -D (Delta class) to reach the planned geosynchronous altitude.

The PAM-D perigee motor was fired by an onboard timer in each satellite 45 minutes after deployment. In each case, this firing was targeted to place the satellite in a transfer orbit that was biased to be slightly above the geosynchronous orbital altitude and at an inclination of 23.5 degrees.

The SBS transfer orbit achieved was 200 miles higher than anticipated and at an inclination of 23.73 degrees, whereas the ANIK-C transfer orbit achieved was 320 miles higher than anticipated and at an inclination of 23.43 degrees. Both transfer orbits reflect the excellent Orbiter state vector knowledge and attitude control as well as a very satisfactory PAM-D perigee motor firing. Two minutes after completion of the perigee motor firing, the PAM-D was separated from the SBS and ANIK-C satellites, and the omni antennas on the satellites were deployed.

The initial signal from the ANIK-C satellite was very weak. A command was sent to change the onboard RF switch after which all operations were normal.

On November 13 and 16, 1982, the SBS and ANIK-C satellites apogee motors were fired, thus placing the satellites in a near geosynchronous equatorial orbit. Subsequently the necessary satellite despinning activities were accomplished, the directional dish antennas were deployed, and the solar drums were extended, placing the two satellites in an operational configuration. The ANIK-C satellite, located at 112 degrees West has been placed in service. The SBS, located at 94 degrees West, will be placed in service next spring (1983).

Investigation of STS Atmospheric Luminosities

The ISAL (investigation of STS atmospheric luminosities) experiment obtained spectral measurements of the optical emission in the vicinity of the orbiter tail section and OMS engine pods.

The postflight review of the still camera film data indicated the optical "glow" was present. Review of the VTR data indicated that none of vehicle glow emissions were recorded.

Getaway Special (G-026) Payload

The GAS (getaway special) payload was apparently activated after solving a labeling problem on the standard switch panel on aft flight deck. However, removal of the G-026 GAS canister from the cargo bay postflight indicated the experiment had failed to operate. A postflight failure assessment shows that the battery provided by the GAS payload had leaked its electrolyte and could not activate the experiment package. A postflight check of the orbiter GAS activation hardware indicated no equipment anomalies had occurred during the mission.

Effects of Interaction of Oxygen With Material Payload

The EIOM (effects of the interaction of oxygen with materials) experiment package which was mounted on the DFI in the cargo bay, was successfully operated during the course of the STS-5 mission.

Postflight observations indicated that a minor failure had occurred to one of the material sample hold down devices, and that oxygen interactions were visually observed on numerous material samples.

STS-5 Student Experiments

Sponge Growth (SE81-2).- The sponge growth experiment was successfully operated in flight. One sponge package was lost during the activation process and was discovered in the orbiter trash during postflight operations. It appears that one of the crewman mistakenly collected the sponge package during clean up operations and deposited it in the trash. The packages are being evaluated for sponge growth in zero gravity.

Crystal Growth (SE81-5).- The crystal growth experiment failed to operate as expected in flight. The seed crystal didn't grow on the string as expected, but it did grow in a different location. The crystal is being analyzed by the student investigator.

Convection in Zero Gravity (SE81-9).- Preliminary information from the crew indicates that the convection experiment may not have operated properly in flight. The crewman indicated the fluid (krytox oil) in the syringes did not get down onto the collector pan, and that there was not sufficient experiment time to develop an injection technique to successfully operate the experiment. The film taken of the experiment is being reviewed to determine if parts of the experiment were successful.

INTEGRATED SYSTEMS ASSESSMENT

The terminal countdown for the fifth launch of the Space Transportation System (STS-5) was concluded on November 11, 1982. Timing of all critical elements of the launch proceeded essentially as planned.

Initial data indicate that a maximum positive pitch-attitude error of 3.3 degrees existed during first-stage ascent as compared to the preflight predicted value of 2.3 degrees. For this flight, the ascent trajectory and booster trim angles were shaped to flight-derived aerodynamic results from the previous missions. It is anticipated that upon completion of the analyses accounting for known dispersions, the attitude error attributable to aerodynamics will more closely resemble the predicted value. The vehicle equivalent I_{sp} during second stage was 2.2 seconds lower than the main engine test value.

A film review showed far fewer impacts on the Orbiter during lift-off than on previous flights, although a substantial quantity of debris was again observed moving away from the Orbiter at SRB ignition. Ice/frost observed falling from the umbilicals and ET lines at lift-off was similar in quantity to previous flights, but far fewer impacts on the Orbiter were observed. The ET nose and ogive appeared to be completely free of ice/frost.

GROUND OPERATIONS ASSESSMENT

The ET arrived at KSC (Kennedy Space Center) on June 1, 1982. Checkout was accomplished and the ET was ready for mating with the SRB's on August 17.

The SRB components began arriving at KSC on June 2, 1982. The units were built-up with stacking on MLP (main launch platform) -1 completed and ready-for-mate on August 19. Subsequently, the ET was moved from high bay -4 and mated to the SRB's on August 20, after which the stack was made ready to accept the Orbiter on September 9.

Orbiter 102 completed STS-4 activity on July 16, 1982, when it arrived in the OPF (Orbiter Processing Facility). Rollout to the VAB occurred on September 9 and the Orbiter was mated to the stack on September 13.

The integrated stack was transferred to the pad on September 21.

The cargo was installed in the Payload Checkout Room on October 12, 1982. The cargo was installed in the Orbiter on October 19 utilizing the payload ground handling mechanism (PGHM). This operation was the first vertical installation of a payload, and more significantly, it was a two-component payload. Cargo-to-Shuttle interfaces were validated and the payload bay area was closed out on November 4, with all countdown preparations completed.

Landing and Ferry Operations

Subsequent to the completion of the mission at Dryden on November 16, the Orbiter was safed, made ready for the ferry flight and mated to the SCA by November 20. Ferry was initiated November 21 and completed November 22 with a stop-over at Kelly AFB, TX. Demate and tow to the OPF on November 23 completed the mission.

Launch Facility Damage

Subsequent to launch, the launch facility was inspected and the damage identified. There were four items requiring engineering. Three items were minor. The fourth item, a 25 ft crack in the 0-level blast shield, caused concern. It was concluded that the crack resulted from stresses placed into the blast shield during installation. This stress was relieved when corrosion developed at a weld defect and the resulting crack propagated across the plate. All evidence shows that the launch platform main structure is sound and no significant degradation due to the five launches is indicated. The repair will consist of removing and replacing the plate (2 ft by 20 ft by 1 in.) and welding several other small cracks.

SRB ASSESSMENT

The STS-5 solid rocket motors (SRM) performed at near to predicted levels. Quick-look evaluation shows that head pressures between 5 and 20 seconds were lower than predicted by approximately 2.0 percent for the right-hand motor and 1.2 percent for the left-hand motor. The action burn time was long by approximately 2 seconds for the right-hand motor and 1.3 seconds for the left-hand motor resulting in a later than predicted separation by approximately 1.8 seconds. The thrust time history for the SRM's was well within the specification limits.

Operation of both SRB (solid rocket booster) TVC (thrust vector control) systems was normal. The accumulators functioned properly in providing the expected improved system stability. The SRB actuators performed in a normal fashion. The maximum deflection observed was -2.8 degrees on the right-hand tilt actuator occurring at 10 seconds. Maximum rate was 4.5 deg/sec on the right-hand tilt actuator at 21.2 seconds.

Review of data shows that the SRB E&I (electronics and instrumentation) pyrotechnic and DFI systems functioned nominally.

A problem with one radar tracking system resulted in both radars tracking the same SRB. The decelerator subsystems on both SRB's performed nominally. The splashdown vertical velocity of the SRB tracked by radar was approximately 90 ft/sec. Both frustums and the SRB's were found floating in the buoy mode and the parachutes were still attached to the SRB's from where they were recovered indicating that the fix for the parachutes was successful. All BSM (booster separation motors) covers were intact.

Inspection of the SRB's upon return to KSC revealed no significant debris issues. All separation motor covers were recovered with the frustums, although several were severely damaged as on previous flights. Several pieces of shoe liner material were still attached to the SRB hold-down post feet sidewalls.

EXTERNAL TANK ASSESSMENT

Available data indicated that all ET systems performed well during the prelaunch and ascent operations. The LH₂ ullage temperature measurement appeared to fail off-scale high during ascent.

During ascent, the ET nose cap and intertank compartment venting stayed within limits and agreed very closely with the predicted normal values.

Preliminary data from the ET/Orbiter struts, LH₂ tank (Sta 1554), ET crossbeam and the LO₂ feedline supports show all loads and strains mostly below predicted levels. No design loads or stresses were exceeded and all the lift-off and maximum dynamic pressure loads were as expected. The LO₂ aft dome strain gauge measurements indicated an oscillatory pressure load of approximately ± 6 psi, and this is comparable to STS-4.

The prelaunch thermal environment was nominal. TPS (thermal protection system) acreage experienced only minor ice/frost buildup in waived areas. 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.

Radar data from Antigua confirmed the ET tumbled. The preliminary estimate of the ET impact point was approximately 90 nmi. downrange of the predicted nominal, but well within the predicted footprint.

MAIN PROPULSION SYSTEM ASSESSMENT

The liquid oxygen and liquid hydrogen loading was completed very smoothly with no problems reported. Based on the loads assessment at T-1 hour, actual loads appeared close to those predicted. One instrument failure was experienced and it did not affect launch.

The prelaunch MPS (main propulsion system) operations were nominal, except for the LO₂ overboard bleed valve test. Switch "B" on the valve required 41 seconds to indicate closed, while switch "A" was within acceptable limits.

This was the first ET flown without an antigeyser line. The procedures developed to load propellants without an antigeyser line that were verified on MPTA and STS-5 PLAST worked well for the launch. There were no stop flows or unscheduled holds during loading, all requirements were met, and propellant conditions throughout loading were basically as predicted.

Purge requirements prior to and during loading were met. Hazardous gas concentrations were well within limits; however, a helium concentration (greater than 16000 ppm) was detected by the intertank sense line due to a helium purge leak at the ground umbilical carrier plate into the sense line. Propellant preconditioning was satisfactory; all interface pressures and temperatures were met and all SSME prestart requirements were satisfied.

During ascent, the engine start, throttling and MECO were nominal. Engine operation and performance during mainstage operations appeared satisfactory. During steady-state performance, ET/Orbiter pressures and temperatures, and Orbiter/SSME pressures and temperatures satisfied interface requirements. Quick-look mixture ratio and thrust values from the flight indicate repeatable engine performance. Power-level throttling operation appeared normal. Engine shutdown was satisfactory. The LO₂ engine cutoff sensors went dry near MECO, but the timer had not expired when cutoff was issued by the guidance system.

Post-ascent MPS operations were nominal. It was reported by the crew and later verified by data review that the LO₂ prevalves had been slammed. New actuators, to reduce slamming damage, are scheduled to be added to this vehicle before the STS-9 mission.

Prestart operation was excellent on all engines. All purges occurred at the proper times and within pressure limits. Engine ready occurred at the proper time for all engines. Hydraulics, propellant conditions and the POGO precharge for all engines during the prestart phase were at proper times and all parameters were within required limits.

Thrust buildups on all three engines were within limits. Pump breakaway, turbine temperatures, valve positions, POGO charge and chamber pressure buildup were satisfactory for all engines. Photographic data revealed small flight nozzle tube ruptures on two of the SSME's [one on ME (main engine) -1 and two on ME-2 during start]. These ruptures had no significant impact on the flight other than a slight reduction (0.2 sec) in vehicle ISP.

Mainstage operation of all engines was excellent. All chamber pressures, turbine temperatures and pressurization gas temperatures were normal. Shutdown of all engines was satisfactory with shutdown transients tracking each other closely and very close to nominal values.

Engine controller performance was very satisfactory during prelaunch and launch phases. There were no hardware failures experienced during either phase.

Close-loop operation of all three engines was as expected. No unexpected oscillations occurred during state operation, and no unexpected overshoots occurred during throttling. The aft compartment thermal environment, hydraulic warmant flow temperatures and pressures, and actuator valve temperatures were nominal and well within requirements during the prelaunch phase.

ORBITER ASSESSMENT

Orbital Maneuvering Subsystem

The OMS (orbital maneuvering subsystem) performance was normal. The left pod was used for 7 maneuvers for a total firing time of 435 seconds and the right pod was used for 5 maneuvers for a total firing time of 417 seconds. Propellant supplied by the OMS to the RCS is estimated at 489 lb from the left pod and 887 lb from the right pod.

During ferry preparations at DFRF (Dryden Flight Research Facility), an inspection of the nozzle showed three cracks on the interior of the nozzle. The cracks were estimated to be 18 to 30 in. from the nozzle exit and in the 8 to 9 o'clock position (toward the main engines).

Reaction Control Subsystem

The RCS (reaction control subsystem) performed normally during ascent and entry, but some problems were noted during on-orbit operations. During prelaunch helium loading operations, the in-series stages of regulation of the "B" path of the fuel helium circuit in the right pod were leaking a significant amount. After a leak check, a decision was made to fly the regulator "as is" and manage the leak in real time. The helium circuit was isolated until T-15 minutes when it was opened for lift-off. The circuit remained open through external tank separation and no leakage was noted. The circuit was again reopened at mid-mission and remained open through entry and no leakage was observed.

About 16 hours into the mission, the leak detector temperature on primary thruster R4D had dropped below the minimum heater set point of 66° F, indicating a possibly failed-off heater. Further data substantiated this, and to keep the thruster from being deselected at the 30° F leak detector threshold, an occasional firing of the thruster was made to maintain the temperature above the leak detector threshold. This was done for about half the mission after which the heater apparently began functioning again and stuck-on. The remainder of the mission was spent with a heater in a failed-on status and the thruster temperatures achieved thermal equilibrium above the heater cut-off point. The equilibrium temperature was not hot enough to cause any problems.

A fault message was received on primary thruster F4D at 04:21:27:14 MET (mission elapsed time). The RCS RM (redundancy management) deselected the thruster because of a failed-off indication; i.e., there was no indicated chamber pressure for three consecutive pulses (240 msec continuous). A sharp drop was observed in both fuel and oxidizer leak detector temperatures after each firing. However, there were three pulses during a 30-minute period around 04:21:27:14 MET where a sharp drop of the fuel detector was seen with no sharp drop on the oxidizer detector. Preliminary conclusions drawn from this condition are that the oxidizer valve never opened when commanded.

Hydraulic Subsystem

The Orbiter hydraulic subsystem performed as expected during the ascent, on-orbit, entry, landing, and post-landing phases of the mission. The ascent performance of WSB (water spray boiler) 3 with the reduced steam vent orifice was as expected, and no signs of freezing in the heat exchanger section were observed.

The WSB 1 regulator pressure indication dropped rapidly from 29.1 to 0.0 psia approximately 9 minutes after lift-off and no mission impact resulted.

Electrical Power Distribution and Control Subsystem

During payload bay door closure, the ac-1 phase B inverter disconnected from the ac-1 bus. A data review showed no overload conditions to cause the disconnect. The ac-1 phase B inverter was connected for entry and the automatic disconnect was inhibited. Although the overload indicator caused a caution and warning, all ac-1 loads continued to be normal and within limits.

Avionics Subsystems

During prelaunch while the data processing system error log was being reset, GPC-2 incurred a fail-to-sync with the other three GPC's in the redundant computer set. Overall GPC-2 operation was normal and standard procedures were performed to re-establish full redundant set operation. Analysis of computer memory dumps indicated a phasing condition within the software which caused different processing in GPC-2. This condition was isolated to four displays and certain keyboard item entries on these displays. The condition was accepted for flight based on the fact that dynamic flight phases do not require use of these displays.

Overall the DPS and BFS subsystems performance was satisfactory; however a failure occurred in DEU (display electronic's unit) 2 about 30 minutes after lift-off. An inflight maintenance procedure was developed and the crew were successful in restoring operations to display 2 (CRT-2), but with loss of display 4 at the aft station. Since the aft station was not required for entry, this workaround was successful during the entry operations.

Displays and controls performance was also satisfactory with two minor exceptions- the loss of two floodlights in the payload bay, and loss of the aft mission and event timers.

Entry avionics systems performance was satisfactory, however, two of the programmed test inputs were not performed because of RCS redlines.

All of the telemetry tape recorders operated properly and only four measurements within the OI (operational instrumentation) failed during the flight. An external tank measurement (LH₂ ullage temperature) failed off-scale high; water spray boiler 1 regulated outlet pressure failed off-scale low; an APU-3 exhaust gas temperature was erroneous; and the OMS low-level sensor tripped at an improper value. None of these measurements caused any concern for the successful accomplishment of the STS-5 mission.

Communications and Tracking Subsystem

Five minor problems were encountered during the flight and these are discussed in the following paragraphs.

The left audio circuit breaker on panel R15 popped open three times during the mission. This breaker controls power for the Commander's ATU (audio terminal unit). When the circuit breaker was reset the second time, there were no active elements drawing power. The circuit breaker was found open after landing.

WCCU (wireless crew communications unit) A and B were reported failed by the flight crew. The crew reported a "popping" sound from unit A and immediately replaced it with unit E. When unit B became inoperative, the crew changed out the batteries, but the unit still did not function properly. Unit B was stowed, and the pilot used a headset cable for the rest of the mission.

The EVA UHF transmitter VOX (voice-operated relay) was not tripped by the ground-originated voice during the EVA preparations. A postflight test at Edwards confirmed that the UHF transceiver was not being keyed by uplink S-band audio.

Radar altimeter 1 provided a false altitude reading of 8 feet from when it was turned on until approximately 43 feet from the runway where it began providing good data. Unit 1 was installed during the launch countdown.

The crew reported during postflight debriefings that the TV monitor was out of synchronization with the video tape recorder during playback operations.

Environmental Control and Life Support Subsystem

Data indicated the FCL (freon coolant loop) 1 Freon leak increased from the prelaunch value of 1.1 percent/day to an end-of-mission value of 1.5 percent/day, while the FCL 2 Freon leak remained at about 0.3 percent/day. This increase in FCL 1 leakage had no effect on ATCS performance or planned operating conditions during the mission.

During the mission, the crew reported free water on the middeck floor area around the LiOH cartridge stowage area. A subsequent inspection revealed a buildup of condensate on the cabin heat exchanger outlet duct around the uninsulated duct connections and clamps. An inspection for free water inside the duct at the GSE access port revealed a small quantity of water (approximately 2 to 3 ounces). Water separator B was operating during this period. Separator A was then turned on (both separators operating) and an increase

in the rate of waste water collection resulted during the sleep period suggesting possible degradation in separator B performance. Separator B was later deactivated and separator A was utilized for the remainder of the mission. The rate of waste-water collection began to decrease near the end of the mission, indicating possible degradation in performance of separator A.

Because of the 4-man crew, there were substantially more oxygen-to-nitrogen and nitrogen-to-oxygen flow switchovers than had been observed on previous flights. On several nitrogen-to-oxygen switchovers on system 1, the oxygen flowrate increased above 5 lb/hr, momentarily resulting in a master alarm and FDA (fault detection annunciator). After the first alarm, the caution and warning for high N₂/O₂ flow was inhibited on system 1. The first alarm resulted from an off-scale high flowrate for approximately 1 second. Each of three other switchovers resulted in high oxygen flowrates of about 25 seconds duration.

Mechanical Subsystems

The left-hand main landing gear inboard wheel brake failed during the last 50 feet of Orbiter rollout as evidenced by the skid marks made by the inboard tire for that distance. A postflight inspection showed the following brake damage. The inside diameter of the no. 3 stator was completely sheared out and contained 3 radial cracks. The no. 3 and 4 rotors were damaged on their inside diameters and the 2 stator lugs (at the inside diameter) were distorted. This type of brake failure is apparently caused by axle flexing which forces the wheel to scrape against the 2 and 3 stators which in turn forces the no. 3 and 4 rotors to scrape against the torque tube.

Structures

Significant excitation of the Orbiter also occurred during the brake malfunction which occurred shortly before wheel stop. This excitation was primarily in the 18 to 20 hertz range which corresponds to landing gear characteristic frequencies. Oscillations in the Z direction as high as 1g about the steady-state condition occurred during the brake problem. These levels did not exceed airframe design capability.

A cursory review of wing structure ascent flight data shows that the 1365 spar web experienced a shear load of approximately 102.8 percent of the design limit. This load occurred at the A-8 load indicator location during the maximum dynamic pressure period of ascent.

Leading Edge Structural Subsystem

Two RCC/HRSI (high-temperature reusable surface insulation) interface tiles had a 3-inch long by 1/4-inch gap between the tiles as a result of excessive heating. The gap filler and tile sidewall surfaces were melted from the OML (outer moldline) to the IML (inner moldline) of the 416 aluminum carrier panel. Postflight inspection showed that the left-hand end of the lower centerline 416 panel had local surface melting and a small melt hole at the forward corner next to the RCC expansion seal. The aluminum-coated fiberglass flow stopper and S-glass/Dynaflex insulation blanket were locally melted, but the RCC inconel 718 attachment hardware did not appear to be overtemperated as a result of this localized overheating condition.

The left-hand elevon/elevon tiles look good. The inboard tiles appear in an as-installed condition with no evidence of overheating. The outboard tiles along the miter joint corner had some slumping, shrinking, and glazed coating. The gap filler located at tile corners were breached and brittle.

ENTRY AERODYNAMICS

One POPU (pushover pullup) maneuver and eight PTI (programmed test input) maneuvers were planned for aerodynamic identification. The POPU was executed as planned and recorded data were obtained. The second and third PTIs were deleted due to the RCS fuel being below redlines. The other six maneuvers were executed properly and data were collected.

The L/D, longitudinal trim and ground effects aero appeared nominal. The air data system operated within specification. Just after rudder activation, a small aileron/rudder force fight occurred. Data evaluation is continuing.

TRAJECTORY

The STS-5 descent trajectory was completely nominal. For the first time since STS-1, the initial bank maneuver was performed in the auto mode. The effect of the flight control modification implemented to alleviate the severe rate oscillations seen on STS-1 was satisfactory.

Just prior to the first roll maneuver, the first automated test input was made. Following the maneuver, the programmed test input RCS propellant redline (37 percent at this point in the entry) was violated and the crew inhibited the next two maneuvers. The pushover-pullup maneuver, 40-35-45-40 angle of attack sweep at Mach 18, was performed in the CSS (control stick steering) mode. The maneuver was very clean in the pitch axis, however, a small drift in the roll axis (5 deg off command) produced an 80 ft/sec loft from the reference altitude rate profile that was quickly corrected when the auto system was reengaged.

STS-5 was the first flight utilizing the new OTT (optional TAEM targeting) TAEM (terminal area energy management) guidance. TAEM performance was nominal with no unexpected events. Interface occurred at Mach 2.5 and 82900 ft. The Q was 15 psf below the reference value during the approach to the HAC (heading alignment circle) due to tailwinds at this altitude. The commander engaged CSS at Mach 0.88 and followed the HAC (heading alignment circle) to perfection.

The transition to approach and landing guidance occurred at 10,000 ft. The vehicle pitch and roll/yaw axes were in CSS through landing, with the speedbrake channel in auto. Touchdown occurred at 198 knots EAS with the left gear touchdown at 1637 feet past the threshold and right gear at 1778 feet. A braking test was initiated at 140 knots with a peak deceleration of 13 ft/sec². The Orbiter rolled 9553 ft. with a stopping point 11190 ft past the threshold.

CREW EQUIPMENT ASSESSMENT

The major anomaly of the STS-5 flight involved the EMU (extravehicular mobility unit) that were to be worn during the extravehicular activity. The first failure was found in the EV-2 (Allen) suit when faulty fan operation was noted. The fan produced a motor-boating noise and then stopped running. Inflight troubleshooting was unsuccessful in restoring proper fan operation.

Shortly thereafter, the EV-1 (Lenoir) suit encountered pressure regulation problems. The suit would only pressurize to 3.8 psi instead of the normal 4.3 psia. Here again, normal operation of the suit pressure regulator could not be restored after troubleshooting.

The results of the analysis and investigation into the extravehicular mobility unit failures will be reported in JSC-18698.

The crew reported that the port-side EMU lights (helmet-mounted) did not operate properly, whereas the starboard lights operated satisfactorily.

GFE Evaluation

The WCS (waste collection subsystem) operated satisfactorily. As a result of the modifications made for this flight, the crew believed that no additional restraints are required to use the WCS. Likewise, the new-type urine filter was much easier to change.

MISSION CONTROL CENTER LOSS OF POWER

At 8:50 p.m. on November 13, 1982, the A-1 bus cable failed at or near a splice in one cable of a three-cable phase system. The failure manifested itself by heat and a short-to-ground in the area of the failure. Also damaged as a result of the heat and high amperage in the remaining phase cables were cables and splices between building 48 (emergency power building for the Mission Control Center) and the controlled-mode RF filters. The A-2 bus cable received no apparent damage from this occurrence.

The A-1 bus cable failure took down most data systems which were in use at that time. The capability to perform command functions, receive and process telemetry data or generate display information was lost. Within 1 hour and 15 minutes, the primary capability to perform the previous functions had been restored with power being supplied by the A-2 bus and the B bus system. During the subsequent 15-hour period, all equipment on the A-2 bus was either powered down or transferred to the B bus. This action was necessary to permit inspection of the A-2 bus cable. After determining that no damage was present, selected equipment power loads were transferred back to the A-2 bus to decrease the load on the B bus. Shortly after midnight on the morning of November 15, all equipment power transfers were completed and the MCC operational posture of primary and redundant data systems was restored.

Inspection of the aluminum A-1 and A-2 bus cables, which were installed during the original facility construction, has shown that the cables require replacement. New cables are being procured and will be installed prior to STS-6.

DTO/DSO ASSESSMENT

Over 96 percent of the assigned DTO's and DSO's (detailed supplementary objectives) were accomplished during the STS-5 mission. Fifty-five DTO/ DSO's were assigned and 53 were completed based on available data. The two objectives not accomplished were DTO 0611 (EVA/EMU Evaluation) and medical DSO 0405 (Acceleration Threshold). Four DTO's (0401, 0771, 0772, and 0805 - titles shown in following table) were assigned to STS-5, but because of their low priority or improper test conditions were not scheduled. These four DTO's were assigned as targets of opportunity (shopping list) items, and consequently are not being counted in the evaluation of mission success. The following table lists all DTO/DSO's assigned to STS-5 and completion status.

PROBLEM LISTS

The problem lists for the two elements that had anomalies are included as table III and IV.

TABLE II.- STS-5 DTO/DSO ACCOMPLISHMENTS

DTO/DSO	TITLE	COMPLETION STATUS	DTO/DSO	TITLE	COMPLETION STATUS
0001	Ascent Performance	Yes	0613	Radiator Performance	Yes
0003	Entry, Approach, and Landing Verification	Yes	0615	Waste Collection System Modifications	Yes
0102	Thermal Control System Test	Yes	0705	Performance	
0109	Aft RCS 3 Engine Soakback Test	Yes	0706	SLSS Communications	Yes
0110	Aft RCS 1 Engine Soakback Test	Yes	0713	Antenna Test	Yes
0111	Vernier RCS Single Engine Soakback Firing	Yes	0720	Orbiter/Detached Payload Communications	Yes
0201	Entry Aerodynamic Test (PTI's)	Yes	0750	Lightweight Head Set Evaluation	Yes
0213	Aerothermodynamic Test (Push-over Pull-up Maneuver)	Yes	0757	Air Data Performance	Yes
0217	Ascent Aerodynamics Verification	Yes	0770	Local Vertical-Local Horizontal Digital Autopilot Performance	Yes
0218	Ascent Plume Heating	Yes	0771	Aft COAS Calibration	Yes
0219	ET and SRB Heating	Yes	0772	On Orbit TACAN Navigation	No
0301	Ascent Structural Capability	Yes	0774	Visual Star IMU Alignment	No
0303	Thermal Protection System Entry Heating	Yes	0805	Star Tracker Threshold Level	Yes
0305	Ascent Compartment Venting	Yes	0904	Crosswind Landing	No
0306	Descent Compartment Venting	Yes	0905	OEX Tile Gap Heating	Yes
0307	Entry Structural Capability	Yes	0906	OEX Catalytic Surface	Yes
0308	Vibration and Acoustic Evaluation	Yes	0907	OEX D.A.T.E.	Yes
0309	Ascent Flutter	Yes	S0301	OEX A.C.I.P.	
0312	ET Thermal Protection System Performance	Yes	S0401	Oxygen Interaction Test	Yes
0313	SRB Recovery	Yes	S0401	Motion Sickness Countermeasures Assessment	Yes
0314	Flight Debris	Yes	S0402	Cardiovascular Deconditioning Countermeasures	Yes
0317	Airframe Distortion Theodolite Measurement	Yes	S0404	On-Orbit EOG	Yes
0401	PRSD Stratification Maneuver (85 Percent)	Yes	S0405	Acceleration Threshold	No
0401	PRSD Stratification Maneuver (50 Percent)	No	S0406	Kinescopic Repeatability	Yes
0404	Cold OMS Engine Restart	Yes	S0407	Body Fluid Shift	Yes
0406	Hydraulic Interaction Test	Yes	S0408	Near Vision Acuity	Yes
0506	PLBD Centerline Latch Performance	Yes	S0616	Cabin Atmosphere Sampling	Yes
0508	Braking Test	Yes	S0901	Documentary Television	Yes
0611	EVA/EMU Evaluation	No	S0902	Documentary Motion Picture Photography	Yes
			S0903	Documentary Still Photography	Yes
			S0904	GLOW Experiment	Yes

TABLE III.- MSFC STS-5 ANOMALY LIST

STS-5 ANOMALY LIST		Date:	Page:
No.	Title	G.M.T. D: H: M	1
1.	SSME Flight Nozzle Tube Ruptures Prior to Lift-off		Project Contact R. Piedsof/ FF21
			December 15, 1982
			Comments
			Pre-ferry flight nozzle visual inspections and leak checks were performed at Dryden Flight Research Center. The following anomalies were noted: ME-1 (2007) - Tube 1003 had a 3/8-inch long rupture about 20.5 inches aft of MCC nozzle joint C-15. ME-2 (2006) - Tube Z06 had a rupture 20.5 inches aft of C-15. Tube Z26 had a rupture 11 inches aft of MCC nozzle joint C-15. Most likely cause of ruptures is contamination. The nozzles will be checked at Rocketyne, Canoga Park, for contamination. A materials and process analysis of the rupture area will be performed to confirm the cause of the ruptures. They are PPL configuration. Assessment will be completed approximately January 15, 1983.

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5		Date:	Page:
No.	Title	G.M.T. D: H: M	Project Contact
1.	Aft Right RCS Fuel He "B" LFC Regulators Leaking.	Prelaunch 7:20 P.M. 11/07/82	D. Blevins CLOSED For STS-6 12/15/82
2.	MDM FF1 Exhibited Transient BITE-Detected Internal Error.	Prelaunch 314:09:21	B. Hood CLOSURE IN PROCESS
3.	GPC 2 Failed to Sync Prelaunch.	Prelaunch 314:22:50	B. Hood CLOSURE IN PROCESS
4.			

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5		Date:	Page:
No.	Title	G.M.T. D: H: M	Project Contact
4.	CRT 2 Flickered and Failed.	315:13:13	P. Sollock CLOSURE IN PROCESS
5.	Operational Instrumentation Failures:		CLOSED 12/15/82
	a. WSB #1 Reg Out Pressure (V58P0104A) Failed.	315:12:28:16	C. Haines
	b. ET LH2 Ullage Temp (V41T1205A) Failed.	Ascent	P. Cota
	c. APU 3 Turbine Exhaust Temp 2 (V46T0340A) Transducer Failed.	Descent	R. Lance
	d. OMS OX Low Level C&W (V43) Erroneous (V43Q5232J)	320:13:38:32	C. Humphries
			Upper right quarter of screen was displayed in lower left quarter. BITE indicated a DU power supply error. Display went blank. Crew swapped cables with DEU 4. CRT 2 O.K. at 318:14:45. Removed DEU2. Replace. SAR K2416. Potentiometer failed on Y deflection board. Defective solder connection on memory parity board.
			Failed off scale low after MECO. MDR 645. IPR OV0022. Isolated to WSB controller. Replace controller.
			Failed high during ascent. Troubleshoot at KSC. IPR OV0040.
			Measurement failed about 10 minutes before landing. Troubleshoot at KSC. MDR 646. IPR 29.
			Triggered at 7.8% OX quantity instead of 5%. Totalizer modified for OV-103 and subs.

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5			Date: December 21, 1982	Page: 3
No.	Title	G.M.T. D: H: M	Comments	Project Contact
6.	Gas Encoder Cable connector Plugged Into Inboard Standard Switch Panel (SSP) L11 and Gas Could Not Be Activated	315:22:14	Plugged connector into outboard SSP L12 and gas was activated at 315:22:57. SSP L11 improperly labeled "GAS". All procedures correct and verified by quality. JSC simulator also wired and labeled on wrong panel.	M. Lusk CLOSED 12/15/82
7.	RCS R4D Jet Heater Not Operating	316:05:19	R4D injector temps dropped below 76° set point at 2.5 deg/hr indicated heater failed. Periodic firing of R4D kept temperature above minimum 30° operating temp. At 317:21 the heater cycled on and remained on. Injector temperature stabilized at 155°F with starboard sun attitude. Dropped to about 130°F with nose to sun and remained within thermal limits. Remove and replace. Troubleshoot in HMF. IPR SV0015.	D. Blevins T. Taylor CLOSED For STS-6 12/15/82
8.	MPS 3 GOX Flow Control Valve Did Not Open Properly for First 40 Sec.	LIFT-OFF 315:12:1	Valve only partially open for first 40 seconds. Valve cycled properly for rest of ascent. Probable cause pneumatic unbalance. Remove and replace.	P. Cota CLOSURE IN PROCESS
9.	ESS 1 BC Audio CB4 Panel R15 Found Open.	316:12:32	Reset CB4. At 317:10:35, CDR lost Comm using WCC bulkhead unit A. CB4 found open again on-orbit. CB4 opened during entry without comm. connected. Remove ATU panel. SAR K2423.	C. Schmidt CLOSURE IN PROCESS

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5		Date:	Page: 4
No.	Title	G.M.T. D: H: M	Project Contact
10.	Free H ₂ O Observed Migrating Through Middeck Floor.	315:12:28:16	N. Prince CLOSED for STS-6 12/15/82
11.	Crew Reported VCCU A and B Failed.	318:18:41:46 318:18:21:53	C. Schmidt CLOSURE IN PROCESS
12.	Crew Reported Faulty Operation of Fan in FV-2 Suit.	318:00:35	J. McMann CLOSURE IN PROCESS
13.	EVA UHF Comm Not Keying on Uplink Audio.	318:10:57	C. Schmidt CLOSED 12/15/82

Comments

Inspection in ECLSS bay revealed H₂O on cold duct surfaces and in other isolated areas. WMS H₂O production rate less than predicted when operating on SEP B or SEP A. Simultaneous operation of SEP A and SEP B resulted in significant increase in waste H₂O production. Postflight air flow check low on A or B, only 23 lb/hr versus 51 preflight. Flow improved after cleaning. Remove and replace separators. Separators on OV-099 tested above 52 lb/hr.

CDR heard a pop when WCCU A failed. Short on transceiver board in WCCU A. No problem found in WCCU B.

Fan was motorboating and then stopping. Onboard troubleshooting reproduced and did not clear the problem. DFRC troubleshooting repeated problem. Suit and power supply removed and at JSC. Moisture in speed sensor caused erratic fan motor operation.

During EVA comm prep ground audio uplink did not key orbiter UHF transmitter. Orbiter crewman can key ground audio through to EVA. Remove and replace. Chits 682 and 683. Delta modulators were set below the voice level from S-band.

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5			Date:	Page: 5
No.	Title	G.M.T. D: H: M	Comments	Project Contact
14.	EV-1 O ₂ Regulated Pressure 0.5 Psi Below Required Level.	319:11:30	EV-1 Suit Pressurized to 3.8 psid (gauge) instead of the 4.3 psid required. Troubleshooting in air lock at 9 psia did not clear the problem. DFRC troubleshooting repeated problem. Suit removed and at JSC. Vendor found 2 KEL-F locking inserts missing.	J. McMann CLOSURE IN PROCESS
15.	Aft mission and Event Timers Inoperative.	Reported 319:08:15	Possible problem with lighting circuit. Both timers on same transducer and fuse. SAR K2425. IPR 9V0026. Short in mission timer blew fuse.	A. Farkas CLOSED for STS-6 12/15/82
16.	Potable H ₂ O Dispenser Failed.	320:06:31	Dispenser failed to disperse water in the auto mode and in the bypass mode. Needle plugged with core from food package. Redesign for STS-6.	R. Sauer CLOSURE IN PROCESS
17.	Fwd Port and Stbd P/L Bay Lights Inoperative.	Reported 320:08:08	Both lights did not operate on either FD 5 or 6. Two old design vibration sensitive lights. SAR K2424. IPR 9V0025. Port light failed. Starboard light ok. Pull FEA for fwd stbd light.	B. Hood CLOSED for STS-6 12/15/82
18.	RCS F4D Failed Off.	Reported 320:09:47	Thruster deselected. Troubleshooting at KSC. SAR K2421. Check resistance. IPR 9V0014. Continue tests in HMF.	D. Blevins CLOSED for STS-6 12/15/82

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5		Date:	Page: 6
No.	Title	G.M.T. D: H: M	Project Contact
19.	AC-1 Phase B Inverter Disconnected	320:10:32 320:14:24	J. McMann CLOSURE IN PROCESS
20.	High O ₂ Flow During PCS Switchover From N ₂ to O ₂	316:12:55	A. Farkas CLOSED for STS-6 12/15/82
21.	Radar Altimeter #1 Failed	On Orbit	R. Sauer CLOSURE IN PROCESS
22.	Left Main Gear Inboard Wheel Locked Up During Landing	Landing	B. Hood CLOSED for STS-6 12/15/82

December 21, 1982

Comments

Buss volts and current were normal at time of disconnect. Suspect nuisance trip. AC-1 sensor in monitor mode for entry. AC-1 overload false indication during entry. SAR K2422. IPR 9V0024. Remove and replace inverter and IDCA.

C&W and FDA occurred several times. Remove, repair and reinstall motor control panel. Probably PCS 1 regulator sensitive to inlet pressure transients.

Failed prior to deorbit burn. Troubleshooting at KSC. SAR K2418. IPR 9V0020. Improper analog output adjust prelaunch.

Pressure at 1600 psi. Cord showing on tire. 35 feet of skid marks on runway. Tire leaked. Went flat during towing. Brake stator broken. Blew a thermal plug and melted 2 others. Saddle installed for STS-6. MCR. Pulled brakes. Found beryllium carbide build up on heat sinks indicating hot spots on the brakes.

TABLE IV.- STS-5 ORBITER PROBLEM TRACKING LIST (Continued)

JSC OV-102 PROBLEM TRACKING LIST FOR STS-5			Date:	Page: 7
No.	Title	G.M.T. D: H: M	Comments	Project Contact
23.	Right OMS Nozzle Coating Damaged.	Postflight Inspection	5 scratches on the inner surface, the longest 3 inches long. Remove and replace nozzle.	C. Humphries CLOSED for STS-6 12/15/82
24.	Monitor Display Out of Sync With VTR Playback.	Postflight Crew Comments	Picture flickered and jumped during playback. Remove and replace. Problem in VTR housing.	O. Schmidt CLOSURE IN PROCESS
25.	FM Light Batteries Degraded.	Postflight Crew Comments	4 batteries were totally discharged after return to JSC. Conditioner discharged batteries.	J. Barnett CLOSURE IN PROCESS
			Prepared by : /s/RLB Robert L. Blount	02/02/83
			Prepared by : /s/JEM Joseph E. Mechelay	02/02/83