JSC-17378

STS-1 Orbiter Final Mission Report

August 1981

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

TABLE OF CONTENTS (CONCLUDED)

APPENDICES

1.0 INTRODUCTION

This report presents the summary of an in-depth evaluation of the Orbiter performance on the first Space Shuttle flight (STS-1). The report presents an assessment of subsystem performance and a listing of the anomalies encountered during the flight. Also included are the problem closeout reports for these anomalies and the corrective action for STS-2. The crew's report is presented in section 4. This report, when combined with other element reports, presents an evaluation of the integrated vehicle.

Customary units of measurement are used throughout the report. The International System of Units (SI) will not be used in this report. Unless otherwise specified, all times are presented in Greenwich mean time (G.m.t), with lift-off specified as 102:12:00:03.9 G.m.t (day: hour: minute: second). All weights are referenced to earth gravity.

2.0 ORBITER PERFORMANCE SUMMARY

All Orbiter subsystems performed in an outstanding manner during the STS-1 mission. All major flight test requirements were accomplished, and there were no major hardware failures or anomalies that will affect STS-2.

2.1 PROPULSION SYSTEMS

2.1.1 Orbiter Main Propulsion System

The main propulsion system (MPS) performance during ascent was satisfactory with the exception of several minor discrepancies which are discussed in section 8.0. For detailed assessment of the MPS operation, see the Marshall Space Flight Center STS-1 flight report. The engine start and cutoff commands occurred as planned, and the systems responded flawlessly to all throttling and gimballing commands. The dump of residual propellants and the systems inerting were accomplished successfully.

Prelaunch MPS activities were conducted as planned, with a few minor anomalies that were noted and corrected prior to main engine ignition. The total firing time of each main engine was 8 minutes and 40 seconds, which includes approximately 5.6 seconds of start transient and thrust buildup prior to lift-off.

The liquid hydrogen recirculation pumps performed satisfactorily during the 7-hour STS-1 prelaunch period. The current levels of some of the pumps exceeded specification values, but these occurrences did not affect pump operation (Table 2-I). During steady-state operations, the currents that exceeded the maximum allowable levels did so for only short durations and did not impair the pumps' operation. These high current readings have been noted during tests and the flight readiness firing. The pump rpm and pressure drop were very consistent and indicate steady operation of the pumps. As the pumps ran satisfactorily and the excessive current levels were of such short durations, no plans exist for removing the pumps prior to STS-2.

The pressurization system and helium system performed satisfactorily during loading and the prelaunch operations. The pressurization system maintained the interface temperatures and pressures of the liquid oxygen and hydrogen tanks well within acceptable limits. The helium supply pressures, bottle temperatures, and regulator pressures were also within required limits.

The helium loaded mass was 208.9 lbm compared to the 221.52 lbm normal value, but well above the required minimum mass of 193.22 lbm. The lower-than-normal mass results from the distribution of temperatures between the bottles. The 6 midbody bottles, which contain 78 percent of the volume, were at temperatures of 120° to 130° F. These high temperatures were the result of compressive heating during the loading operation. The 4 aft-body bottles, which contain 22 percent of the volume, were at temperatures of 40° to 60° F. Combining the flow from both sets of bottles resulted in an overall temperature that was higher than the planned 70° F. Since the helium is less dense at elevated temperatures, the loaded mass was less.

The hazardous gas concentration in the aft compartment was monitored closely during STS-1 because data from the flight readiness firing (FRF) and the tanking tests indicated a gaseous hydrogen leak. There was also concern that the leak rate might be increasing. The gaseous hydrogen concentration in the aft fuselage during STS-1 tanking stabilized at a maximum value of around 400 ppm during the high ullage pressure fast-fill period with the recirculation pumps running. The leak rate remained constant, and no evidence of an increasing leak rate was found.

TABLE 2-I.- ORBITER LH_2 RECIRCULATION PUMP CURRENT LEVELS

Event	Current, Amperes							
	Maximum allowable			Maximum recorded during flight readiness firing			Maximum durir	
	Leg 1	Leg 2	Leg 3	Leg 1	Leg 2	Leg 3	Leg 1	L
Pump 1 startup	12.0	12.0	12.0	12.0	12.0	12.0	12.0	1
Pump 1 steady-state	3.5	3.5	3.5	2.5	3.8	2.5	2.5	
Pump 2 startup	12.0	12.0	12.0	12.5	13.8	12.8	12.0	1
Pump 2 steady-state	3.5	3.5	3.5	2.1	2.8	2.0	2.5	
Pump 3 startup	12.0	12.0	12.0	10.0	12.2	12.1	12.0	1
Pump 3 steady-state	3.5	3.5	3.5	2.0	3.6	2.3	2.5	

During the LH_2 tanking for STS-1, a leak appeared at the 8-inch disconnect when the tanking sequence went from topping at approximately 13 psi to the replenish mode at approximately 5 psi. Section 8, flight test problem report 30, contains a discussion of this problem.

The operation of the Orbiter propellant feedlines was satisfactory during ascent. The operating band for feedline temperatures and pressures was within the requirements as shown in figure 2-1. A tabulation of pre-STS-1 predicted conditions and actual STS-1 propellant conditions for engine 1, which is typical of all three engines, is presented in table 2-II.

The maximum surge pressures experienced during engine startup and shutdown were in line with the predicted surges except for liquid oxygen during engine shutdown. A reconstruction of STS-1 data that shows the liquid oxygen level was located at external tank station X_T = 1157 in the external tank feedline at main engine cutoff (MECO). Station 1157 is about 200 in. below the tank outlet. As a result, the liquid oxygen engine inlet pressures were lower than predicted as the surge prediction model was based on the liquid level being in the external tank. The Orbiter feedlines met all pressure and temperature requirements.

The pressurization system performed as expected during ascent. The hydrogen tank ullage pressure was maintained within the control band (33- to 35-psia) throughout engine operation. The oxygen tank ullage pressure was maintained within the control band (20- to 22-psig) except for an overshoot of 0.3 psi at T_0 + 80 seconds and a decay to 0.3 psi below the band at T_0 + 500 seconds. Exceeding the control band did not cause any problems; however, analysis is continuing to determine the cause and corrective action. The engine 2 gaseous hydrogen outlet temperature transducer and pressure transducer failed at T+48 seconds and T+95 seconds, respectively. (See section 8.0, flight test problem report 6.)

As during the flight readiness firing, the engine 1 gaseous oxygen flow control valve only provided partial flow when commanded open (section 8.0, flight test problem report I-3). The engine 1 heat exchanger discharge pressure at maximum flow dropped approximately 200 to 300 psi less than expected when the bypass valve was open. This trend was confirmed by the gaseous oxygen disconnect's pressure rising about 20 psi when the engine 1 flow control valve was open; whereas the pressure rose 70 psi when the engine 2 and 3 flow control valves were opened.

The helium system performed satisfactorily during ascent and the propellant dump. Helium usage was 84.5 lbm compared to 91.5 lbm predicted. A similar decrease in helium usage from that predicted was seen during the flight readiness firing. This decrease is due to less mass flow than predicted for the oxidizer pump intermediate seal purge.

The hydrogen and oxygen systems dumps were successful. Manifold and feedline pressures dropped to near zero by the end of the dumps; however, after the dumps, pressure increases in the hydrogen manifold and feedlines indicated residual hydrogen in the feed system. Temperature and pressure data indicated that the residual hydrogen vapor mass was approximately 1.2 lbm. There were approximately 7.2 lbm of oxygen residuals after the dump. Both propellants were evacuated from the system during the first vacuum inerting.

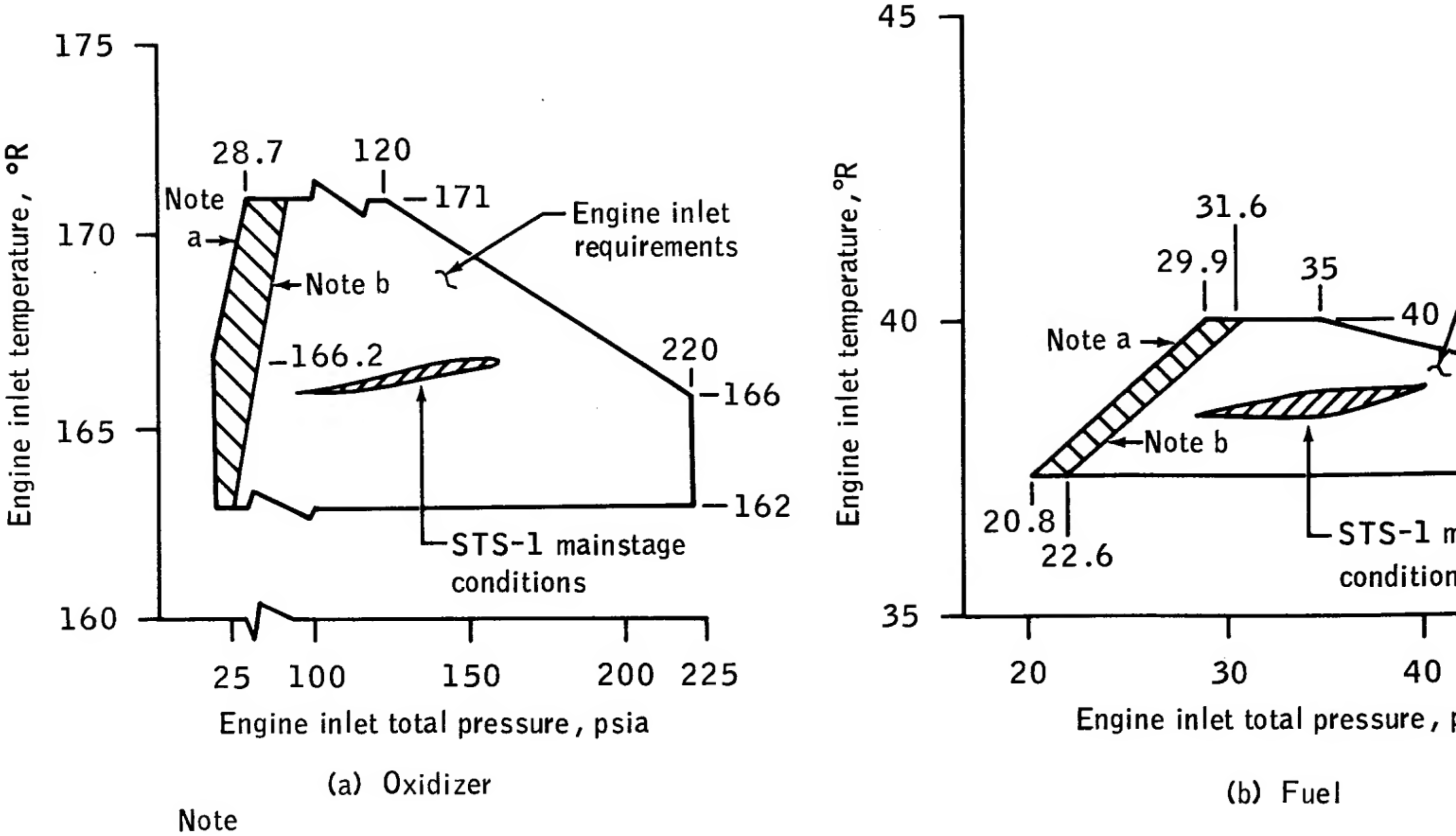
A problem with the replenish valve was detected at the end of the dump. The closing time was excessive (88 seconds compared with the values of 1.1 second and less) when compared with the other closing rates measured during the mission. This anomaly was possibly caused by low temperatures, about 25° R, during the dump; however, the exact cause has not been determined. This problem did not influence the dump and is discussed in section 8.0, flight test problem report 31.

TABLE 2-II.- TYPICAL MAIN ENGINE INLET CONDITIONS

Prelaunch and ascent phase	Liquid oxygen				Liquid hydrogen		
	Pressure, psia		Temperature, ° F		Pressure, psia		Tempe
	Predicted	Actual with bias	Predicted	Actual with bias	Predicted	Actual with bias	Predicte
Prestart[a]	107.0	107.8	167.0	167.5	45.0	45.2	39.0
Max startup conditions[a]	121.0	126.3	165.2	166.0	46.1	46.0	37.2
T_0[b] + 100 seconds	153.0	157.2	165.2	166.0	30.8	34.0	37.3
T_0 + 200 seconds	66.0	67.7	165.2	166.0	27.5	29.2	37.3
T_0 + 300 seconds	84.0	85.8	165.2	166.0	27.4	28.4	37.5
T_0 + 400 seconds	120.0	121.2	165.225	166.1	27.2	28.3	37.7
T_0 + 500 seconds	164.0	160.6	165.25	166.25	29.8	30.8	38.0
Mainstage/shutdown[a]	164.0	130.9	165.3	166.25	30.6	31.6	38.3
Maximum shutdown conditions[a]	221.8	157.7	N/A	175.0	34.6	36.8	N/A

[a] High sample rate data.

[b] T_0 - solid rocket booster ignition.



(a) Oxidizer

(b) Fuel

Note

a 65-percent thrust minimum condition
b 109-percent thrust minmum condition

Figure 2-1.- Engine propellant inlet conditions (mainstage operation).

The predicted hydrogen ice formation in the fill and drain line did not noticeably impair the dump. Also, the fill and drain valve showed no evidence of icing problems, and there was no pressure data evidence that suggested plugging.

Helium system operation was also satisfactory during on-orbit and entry. System leakage losses during the on-orbit phase between special operations were as predicted. There was sufficient mass remaining prior to entry to perform all required repressurization and purging functions. Because of excessive leakage through the engine 2 system, the entry configuration was changed to flow helium through the pneumatic system regulator only rather than through a redundant path that included the engine 2 helium system regulators (Section 8.0, integrated flight test problem report 1-3).

Between special operations during the on-orbit phase, the helium bottles lost 0.3 lbm in 24 hours compared to a predicted 0.25 lbm, indicating that system leakage while isolated was about normal.

The helium mass remaining at entry was 118.1 lbm compared with a required mass of 73.5 lbm. The total mass remaining at Orbiter rollout was 57.6 lb, which was consumed in performing manifold repressurization and space shuttle main engine (SSME) and aft compartment purging.

2.1.2 Orbital Maneuvering System

The orbital maneuvering system (OMS) performance in all modes of operation was satisfactory with the exception of several minor anomalies discussed in section 8.0. The engine and system performance were within operational limits for all firings. Dual and single orbital maneuvering engine operation was demonstrated. The crossfeed hardware was exercised, and the interconnect of the OMS propellant tanks to reaction control system (RCS) engines was accomplished flawlessly.

The first four OMS firings were performed as planned except for OMS-3 ignition, which occurred 1 minute earlier than planned. The OMS-3 and OMS-4 firing times were shorter than planned because of the less-than-expected differential velocity requirements. The deorbit maneuver was longer than expected because of a greater-than-expected differential velocity requirement.

During ascent until SRB separation, the indicated OMS nozzle temperatures were off-scale high. The maximum nozzle temperature was not expected to exceed 2000° F but went off scale high (over 3000° F) just prior to SRB separation. This problem is discussed in section 8.0, flight test problem report 46.

The OMS-to-RCS interconnect operation deviated from the preplanned procedure. All of the RCS test firings were conducted while interconnected to the left OMS; whereas it was planned that only the first RCS test would use left OMS propellant. The OMS fed propellants to the RCS for approximately 22 hours during the 54-hour mission, and during that period, propellant usage was 709 lbm (5.5 percent) from the left pod and 725 lbm (5.6 percent) from the right pod. Pressurization of the propellant tanks was performed manually when required by a low-pressure condition in the propellant tanks or when the OMS and RCS were returned to the normal configuration. An exception to this occurred when the right OMS was returned to normal configuration just prior to the deorbit maneuver. The right pod propellant tanks were not repressurized; therefore, the deorbit maneuver ignition was performed with the right pod propellant pressures approximately 7 psi below regulated pressure. System operation during the interconnect period was normal, with no anomalous interactions between OMS and RCS.

The OMS-1 orbital insertion maneuver differential velocity, maneuver time, and consumables status are listed in table 2-III for this and all other OMS maneuvers. The OMS-1 maneuver was a normal feed, 2-engine firing. Because of the high ullage pressure at lift-off, the first 25 seconds of the maneuver was performed in the tank blowdown mode while the helium regulators were above their lockup pressure. At 12.5 seconds into the maneuver, a 6.5-psi drop in the right pod oxidizer inlet pressure was noted along with corresponding decreases in chamber pressure and fuel injector temperature (see section 8, flight test problem report 24). A comparison between predicted and actual values for the key OMS performance parameters during OMS-1 steady-state operations as well as all other OMS maneuvers is shown in table 2-IV.

The OMS propellant quantity gaging system did not perform to design requirements during STS-1. After a 15-second gaging lockout period at the beginning of OMS-1 maneuver, the OMS fuel gaging quantities were erratic for the rest of the mission (section 8.0, flight test problem report 7). The specific anomaly was that the left and right indicated total fuel quantities were erroneous and behaved in an unpredictable fashion during the mission. Both left and right total fuel quantity outputs did not decrease in the manner observed during ground test and predicted by analysis for the on-orbit accelerations. The fuel outputs would sometimes remain constant for several seconds at the end of the lockout period and then change at a rate higher than predicted as the firing progressed. In the case of the short firings, outputs were erratic. A similar, but to a lesser extent, initial lag response was also noted on the right oxidizer total quantity reading for the deorbit maneuver. The oxidizer gages showed good agreement with the predicted propellant values at the end of each maneuver; however, during the deorbit maneuver, the right pod oxidizer total quantity showed an initial response lag similar to, but smaller than, the fuel side (see section 8, flight test problem report 7). The oxidizer readings did show an oscillation of about ± 0.7 percent. The oscillation frequency of about 1 cycle every 5 seconds could have been slosh induced. The aft probe readouts for both oxidizer and fuel operated properly.

The OMS-2 maneuver was performed in normal feed with 2 engines firing, and the only exception to normal performance noted (other than the quantity gage) was that the right engine primary pitch gimbal actuator response was slow. Section 8.0, flight test problem report 12, discusses this anomaly in detail.

The OMS-3 maneuver was performed in the crossfeed configuration, with the left-pod tankage supplying the right engine. The OMS-4 maneuver was also performed in the crossfeed configuration, but with the right tank supplying the left engine. The OMS flight test objectives (FTO 142-01 and FTO 142-02) were satisfied by these maneuvers. System pressure surges at engine shutdown produced about a 100 psi (measured) peak-to-peak oscillation in feed system pressure, and this correlates with ground test results. The deorbit maneuver, because of the gimbal actuator problem, was accomplished with the secondary gimbal actuator motor (section 8.0, flight test problem report 12).

The pressurization system for both pods performed normally for all OMS maneuvers and during the OMS-to-RCS interconnect period. Although within specification, the propellant tank pressures for both pods were 2 to 3 psi lower during OMS-1 than would have been expected from the preflight checkout data. Data from subsequent OMS firings were in close agreement with preflight data. The propellant acquisition system operation was excellent. Five zero-g starts and both left and right OMS-to-RCS interconnect operations were performed with no gas ingestion by the engines.

The engine performance was as expected, and the engine valve timing and start and shutdown transients were normal. Chamber pressure on both engines was slightly lower than predicted, with the right engine chamber pressure consistently lower than the left. This is reflective of the increase in right OMS oxidizer flow resistance discussed in section 8.0, flight test problem report 24.

TABLE 2-III.- OMS CONSUMABLES FOR STS-1

Event	Time	Differential velocity, ft/sec	Left hand						Right hand		
			Helium, psia	Nitrogen, psia	Oxidizer, percent		Fuel, percent		Helium, psia	Nitrogen, psia	Oxidi perc
					Gage	Cal	Gage	Cal			Gage
Lift-off	102:12:00:04	--	4625	2500	66.4	--	65.2	--	4640	2270	72.6
OMS-1	102:12:10:36	164.5	4093	2340	58.8	53.6	53.0	52.4	4180	2110	59.4
OMS-2	102:12:44:05	137	3631	2180	42.6	42.5	43.6	41.2	3810	2160	47.4
OMS-3	102:18:20:47	25.7	3545	2180	38.4	38.3	39.0	37.2	3710	2100	47.2
OMS-4	102:19:05:36	30.0	3545	2020	38.4	38.3	39.0	37.2	3740	1950	43.6
Deorbit	104:17:21:34	297	2800	1760	9.6	9.5	7.6	7.8	2930	1750	17.0

TABLE 2-IV.- STEADY STATE OMS PERFORMANCE PARAMETERS

Maneuver	Engine chamber pressure, percent		Fuel injector inlet temperature, ° F		Engine inlet pressure, psia		
					Oxidizer		Fu
	Left Pred/Act	Right Pred/Act	Left Pred/Act	Right Pred/Act	Left Pred/Act	Right Pred/Act	Left Pred/Act
OMS-1	104.1/102	102.8/102	223/229	219/225	205/203.5	199/200	219/219.5
OMS-2	105/103	103.7/101	223/231	218/228	207/207.5	201/201	221.6/222.5
OMS-3	---	100.6/99	---	217/220	---	192.5/191	---
OMS-4	102/101	---	221/228	---	198.7/198.5	---	215/216.5
Deorbit	105.2/104	103.8/102	222/223	218/226	207.7/205.5	201.8/200	222/221.5

Table 2-V also shows calculated values of specific impulse (ISP), mixture ratio, and thrust based on observed values of propellant tank and inlet pressures. The low mixture ratio on the right OMS (expected ratio = 1.675) is also reflective of the increase in right OMS oxidizer resistance.

The overall flight test objective for the OMS was to demonstrate satisfactory system operation in the flight environment. This objective was accomplished. Within the accuracy limits of the flight instrumentation, the engine performance and propellant consumption were as predicted. The propellant acquisition system functioned satisfactorily in the normal pod feed mode as well as in the crossfeed and RCS interconnect modes. Two formal flight test objectives, crossfeed to the right OMS engine (FTO 142-01) and crossfeed to the left engine (FTO-02), were demonstrated. The objective of demonstrating satisfactorily the operation of the propellant gaging system in low g was not accomplished. There was an indication of a slight shift in oxidizer flow resistance to the right engine, which would cause a small decrease in mixture ratio.

2.1.3 Reaction Control System

The performance of the reaction control system (RCS) throughout the STS-1 mission was excellent. The only failures detected were a problem with an ac motor valve feedback circuit and a potential thermal open (sensor not physically in contact with the injector) on a leak detector. The system operated in accordance with the design and within the limits expected while performing several planned maneuvers, both in a single axis and in multiple axes.

The system configuration for launch had both pressurization paths open (leg A and leg B) in the forward and two aft modules, with the propellant tanks in the forward module full and in the aft modules "overfilled"; i.e., no gas ullage in the tank. The purpose of the overfill was to prevent gas ingestion prior to and during external tank separation, and flight data confirm that the initial firings of the engines were gas free. Pressure regulation during the initial usage held steady at 250 psia in the forward module and 245 to 248 psia in the aft modules. On orbit, all modules were configured for pressure regulation from leg A and were maintained in that configuration until the deorbit maneuver when both aft pod regulation legs were again opened. The RCS operated normally in all design modes: independent operation of each pod, crossfeed between each aft RCS pod, and interconnected to each orbital maneuvering system (OMS) tank. The system was operated in both primary engine operation and vernier engine operation. Figure 2-2 shows the system configuration throughout the mission. The mission was flown predominantly on verniers to conserve propellants. The vernier mode was also favored by the crew because of the loud noises created by the firings of the forward primary engines (Section 4.0, Crew Report).

Propellant consumption from the RCS was close to preflight predictions, as illustrated by figure 2-3. A tabulation of propellant used from the RCS as a function of mission phase is shown in the following table.

Mission phase	Left RCS, lb	Right RCS, lb	Forward RCS, lb
Ascent	208	180	131
On-orbit	213	229	452
Deorbit to entry interface	53	65	19
Entry interface to landing	459	409	-

TABLE 2-V.- OMS ENGINE PARAMETERS

Maneuver	Specific impulse,[a] sec		Mixture ratio,[a]		Engine thrust,[a] lbf		Chamber pressure,[b] percent		Injector t °
	Left	Right	Left	Right	Left	Right	Left	Right	Left
OMS-1	314.68	313.45	1.662	1.612	5997	5913	102	101	229
OMS-2	314.76	313.53	1.663	1.612	6053	5968	103	101	231
OMS-3	---	312.89	---	1.586	---	5778	---	99	---
OMS-4	314.16	---	1.631	---	5879	---	101	---	228
Deorbit	314.76	313.53	1.662	1.612	6062	5975	104	102	223

[a] Calculated
[b] Actual

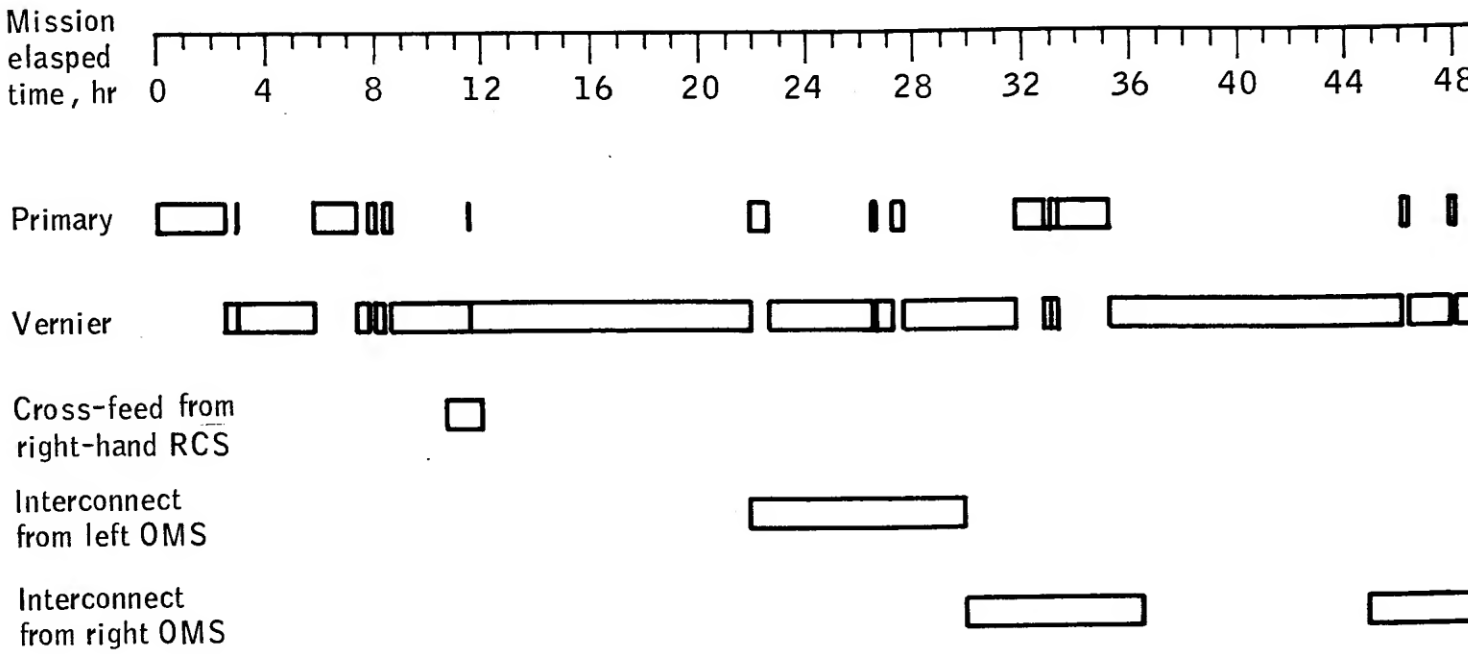


Figure 2-2.- Reaction control system configurations during STS-1.

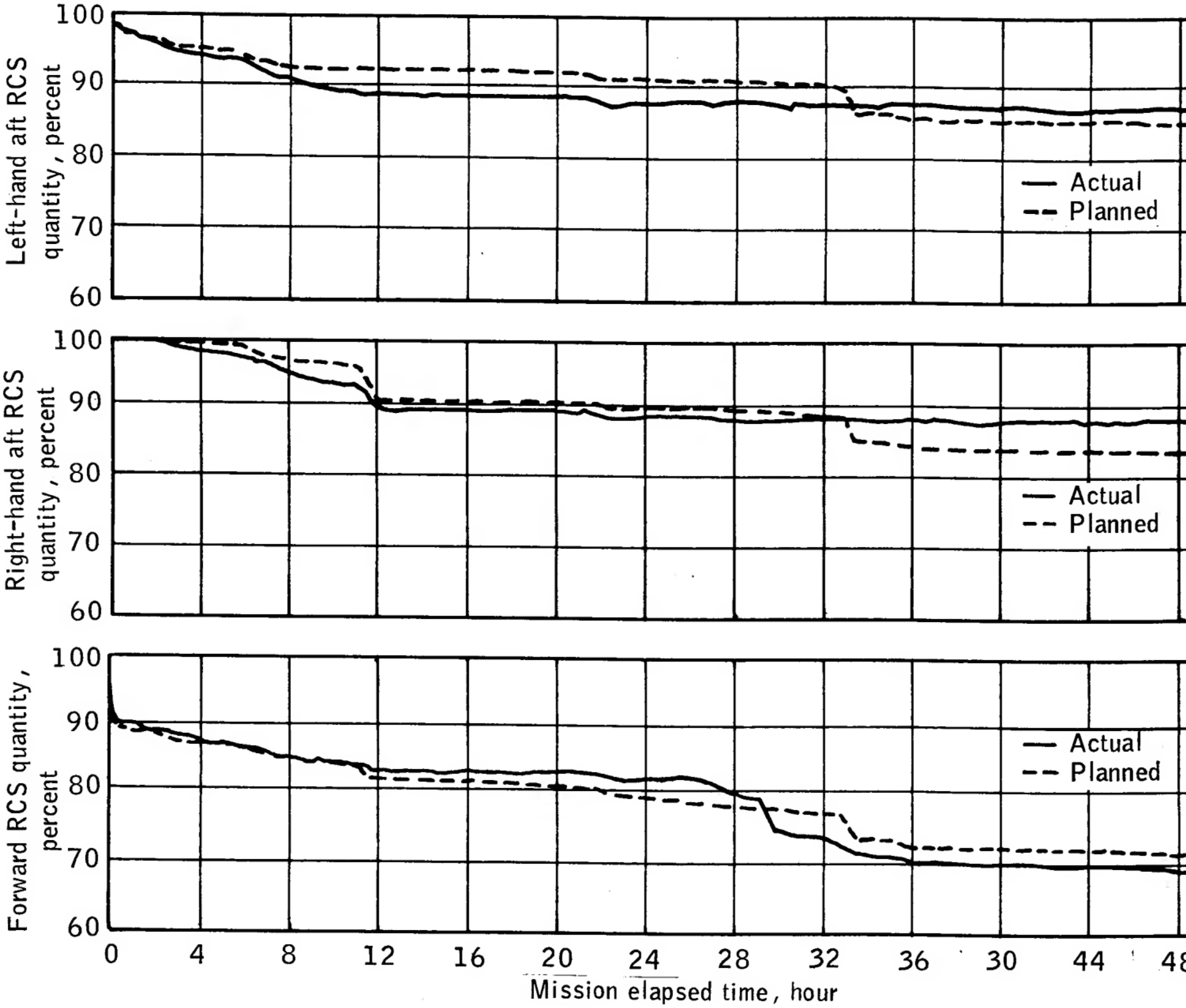


Figure 2-3.- RCS propellant remaining as a function of time during STS-1.

In addition to the propellant used from the RCS tanks, propellant was also consumed from the left and right OMS tanks. In the interconnect mode, the RCS consumed 709 lb of propellant from the left OMS tank and 725 lb from the right OMS tank.

There was no indicated leakage of any engine either during the flight or postflight during ground operations. Engine forward 1 left (F1L) had indicated leakage during preflight operations, but no leak was observed during the flight.

The last thruster usage during entry occurred at an altitude of 56,100 ft. There were 10 firings of the primary RCS thrusters below 70,000 ft, apparently with no "zots" (intra-manifold explosions). The firing of a primary thruster below 70,000 ft has been considered hazardous due to "zots", and special precautions have been observed to avoid them. The desirable condition is to eliminate the RCS usage as high above 70,000 ft as possible, but no sooner than flight control can be implemented using the aerodynamic surfaces.

The thermal environment for STS-1 was benign. The RCS propellant tanks were loaded with 82° F propellant so that 70° F or warmer propellant would be available for entry to avoid "zots" below 70,000 ft. The propellant was maintained at 76° F. All engine heaters cycled within specification limits (66° F to 109° F) except for left 2 up (L2U), which had a bias on its set points and cycled between 105° F and 118° F. The vernier thruster injectors were kept hot most of the time by the thruster activity; therefore, the vernier heaters were seldom used.

A greater than anticipated cooling of the primary RCS thruster fuel leak detector was experienced following firings (see Section 8.0, flight test problem report 17). The greatest detector cooling observed in ground tests was approximately 2° F; whereas flight data indicate 20° F cooling in 22 seconds. This cooling condition poses a potential problem in that the RCS redundancy management (RM) will automatically deselect a thruster if the fuel or oxidizer leak detector temperature falls below 30° F. No thruster was deselected on STS-1, but an analysis of this potential problem is continuing to determine whether a software modification and/or in-flight testing is required for later flights.

The oxidizer leak detector on thruster forward 2 right (F2R) did not track the transient evaporation cooldown that occurred on the fuel leak detector. An apparent thermal open exists between the oxidizer leak detector and the injector tube, and, therefore, a large thermal lag exists between the tube temperature and what the leak detector senses (fig. 2-4). See section 8.0, flight test problem report 50, for a discussion of this anomaly.

Preflight predictions indicated that the engines, particularly the forward down-firing engines, would heat up during entry and after soakout. Temperatures on the engine valve seat were predicted to be approximately 200° to 300° F, with a possibility of valve leakage occurring upon cooling to ambient temperature. The maximum actual temperature observed was 193° F on the F2D engine leak detector. On thruster F1D the leak detector read 181° F, and the valve body was reading 91° F. With the seat being midway between the two locations, the maximum seat temperature observed was approximately 140° F. This temperature did not cause any problems with the valve seat.

The flight demonstrated that the RCS RM operates as designed. The RM monitors the RCS for thrusters failed on, thrusters failed off, and leaks. Evidence of the RM performance for failed-off thrusters was obtained when the crew attempted RCS firing 4 at 103:17:43:45 G.m.t. The firing was being attempted on thrusters R2D and R4D, but the corresponding reaction jet driver power was not on. When the fire command was sent, no chamber pressure response was sensed, and, consequently, a jet fail message appeared. Powering up the reaction jet driver corrected the problem.

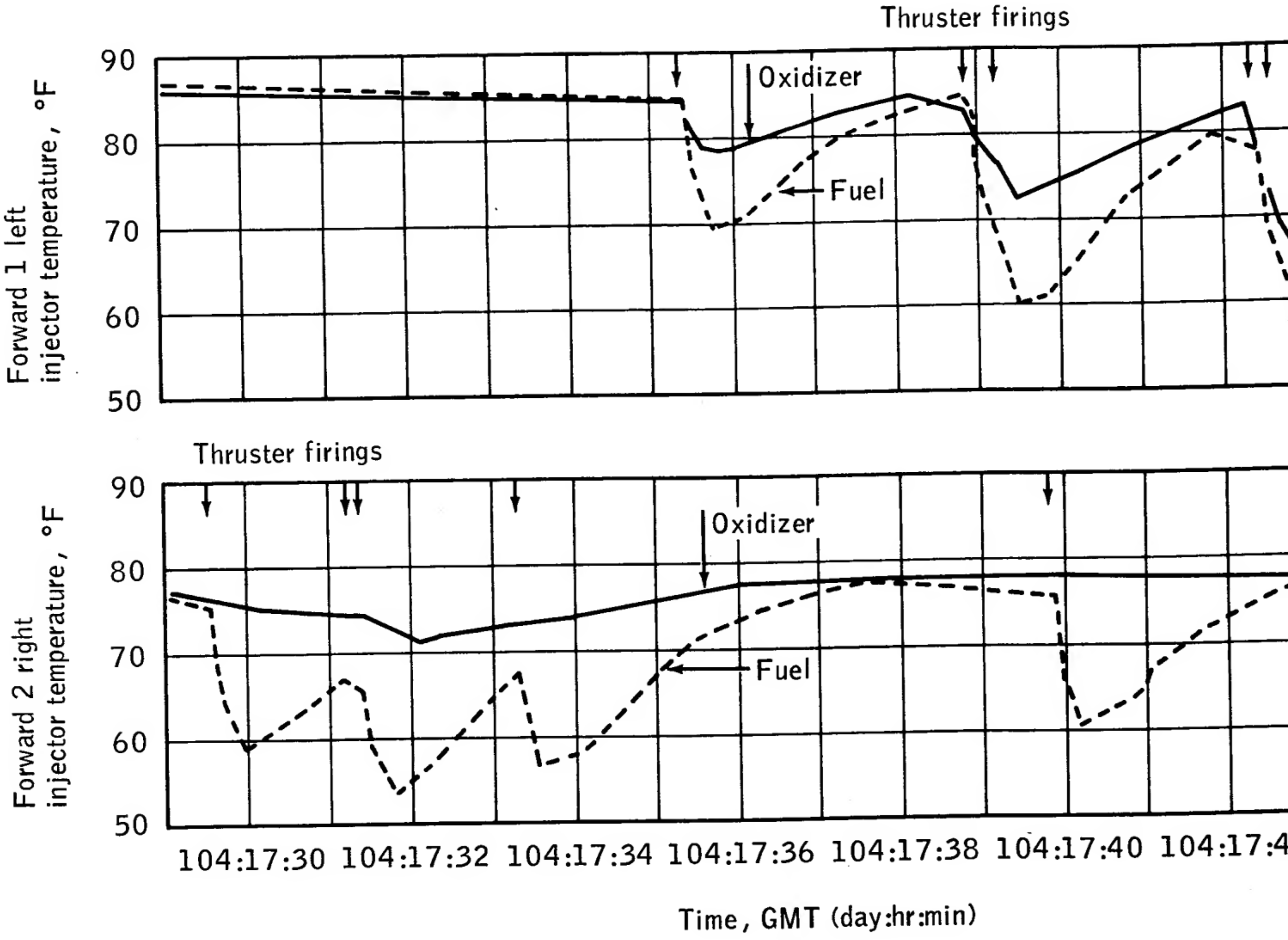


Figure 2-4.- Oxidizer leak detector - injector tube thermal log data.

When the crew switched from OMS interconnect to normal RCS feed at 104:16:29 G.m.t. in preparation for entry, the onboard talkback indicated barber pole (closed) instead of open after the right aft 1 and 2 tank isolation valves were commanded open manually. The telemetry from a redundant microswitch indicated that the valve had opened as commanded. After about 4 minutes, the onboard switch was placed in the general purpose computer (GPC) position by the crew. Feedback from the valve microswitch normally removes power from the valve when the commanded position is reached. When the valve command switch was placed in GPC, power was removed from the valve, and the onboard indication went to open. (See section 8, flight test problem report 21.)

Postflight inspection of the forward RCS module revealed that the oxidizer tank Z strut was buckled. (See section 8.0, flight test problem report 58.) The cause was the high Z loading at solid rocket booster ignition. Boron strips were added to the four replacement struts to double the load-carrying capability.

2.2 POWER SYSTEMS

2.2.1 Auxiliary Power Unit

The auxiliary power units' (APU) performance was normal during STS-1 with the exception of APU 2 gas generator heater failures, low gas generator chamber pressures on APU's 1 and 3, and heater thermostat chatter.

The three APU's were started 5 minutes before launch and were shut down after the main propulsion system dump was completed. The on-orbit checkout was performed with APU 1. For entry, APU's 2 and 3 were started at 3 minutes prior to the deorbit maneuver, and APU 1 was started at entry interface minus 5 minutes. The APU run times during STS-1 are listed in following table.

	APU 1	APU 2	APU 3
Ascent	19 min 10 sec	18 min 59 sec	18 min 49 sec
On-orbit checkout	2 min 54 sec	N/A	N/A
Entry	39 min 27 sec	1 hr 4 min 4 sec	1 hr 3 min 48 sec
Total	1 hr 1 min 31 sec	1 hr 23 min 3 sec	1 hr 22 min 37 sec

Total APU fuel used during the mission was as follows:

	APU 1 fuel, lb		APU 2 fuel, lb		APU 3 fuel, lb	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
Prelaunch	18	18	17	17	16	16
Ascent	44	32	41	33	39	34
On-orbit checkout	7	8				
Entry	64	64	98	116	97	107
Total	133	122	156	166	152	157

The APU 1 and 3 gas generator pressure was low at startup for entry. This pressure should have been approximately 1200 psia but was only about 1000 psia at startup. The pressure trace also showed a dip, which is usually indicative of a bubble in the fuel system. During the course of entry, the pressure level slowly increased so that by the time the APU's were shut down, the chamber pressure had reached its normal level of 1200 psia. (See section 8.0, flight test problem report 42.)

The lubrication oil system was normal, with ascent oil outlet pressures about 60 psia and outlet temperatures about 270° F on APU's 1 and 2. During ascent, the APU 3 lubrication oil temperature went 25° F higher than the measurement for APU's 1 and 2 and then rapidly decreased until it matched the temperatures of APU's 1 and 2. This initially higher temperature of APU 3 was attributed to water's freezing in the water boiler and the lack of water spraying on the lubrication lines because of ice. During entry, the lubrication oil outlet pressures were about 45 psia, with lubrication oil temperatures at 270° F.

The fuel pump/gas generator valve module (GGVM) water cooling system maintained the pump and GGVM of each APU well within maximum temperature limits following the ascent and flight control system checkout of the APU's. The maximum temperatures reached were 195° F on the fuel pump and 120° F on the valve. Unlike ground vacuum tests, the valve was cooled much more than the fuel pump.

The thermal control system heaters for the APU fuel system and the water cooling systems maintained temperatures within allowable limits throughout the on-orbit APU non-operational periods. Four cases of thermostat chattering were noted on the heater circuits of the APU 1 system fuel feed line and the APU 3 system primary and secondary fuel pump/GGVM water cooling lines and on the injector water cooling system (see section 8.0, flight test problem report 1). None of these affected system operation.

Failures occurred in both of the APU 2 gas generator heaters. Both failures occurred late in the mission, as shown in figure 2-5 (see section 8.0, flight test problem report 19). The fuel pump and valve temperatures were 75° to 80° F, and the gas generator temperature was 88° F at APU start. The cool gas generator temperature necessitated a "start override" start of APU 2, and this initiated 209 sec of injector cooling before starting. APU 2 started within 4 sec after the cooling cycle was completed.

The fuel pump seal cavity drain pressures did not exceed 21 psia, indicating that pump shaft seal leakage was not excessive. The measured seal leakage quantities drained from the catch bottles during postflight operations were APU 1 - 25 cc, APU 2 - 60 cc, APU 3 - 11.5 cc, all well within acceptable limits.

2.2.2 Hydraulic Subsystem

The Orbiter hydraulic subsystem performance was satisfactory throughout the STS-1 mission. Preliminary evaluation indicates that no launch commit criteria redlines were exceeded, and with the exception of the anomalies and unexpected conditions discussed in the following paragraphs, system temperatures and pressures were maintained within their allowable bands.

During ascent and entry, adequate hydraulic power was provided for thrust vector control/main engine gimballing, main engine propellant valve control, umbilical retract (after main engine cutoff and external tank jettison), landing gear deployment, and other aerosurface actuator activity.

The auxiliary power unit lubricating oil temperature was controlled within requirements, indicating proper water spray boiler operation, with about 32 lb of water used from each water spray boiler. Most of the water was used to control the auxiliary power unit

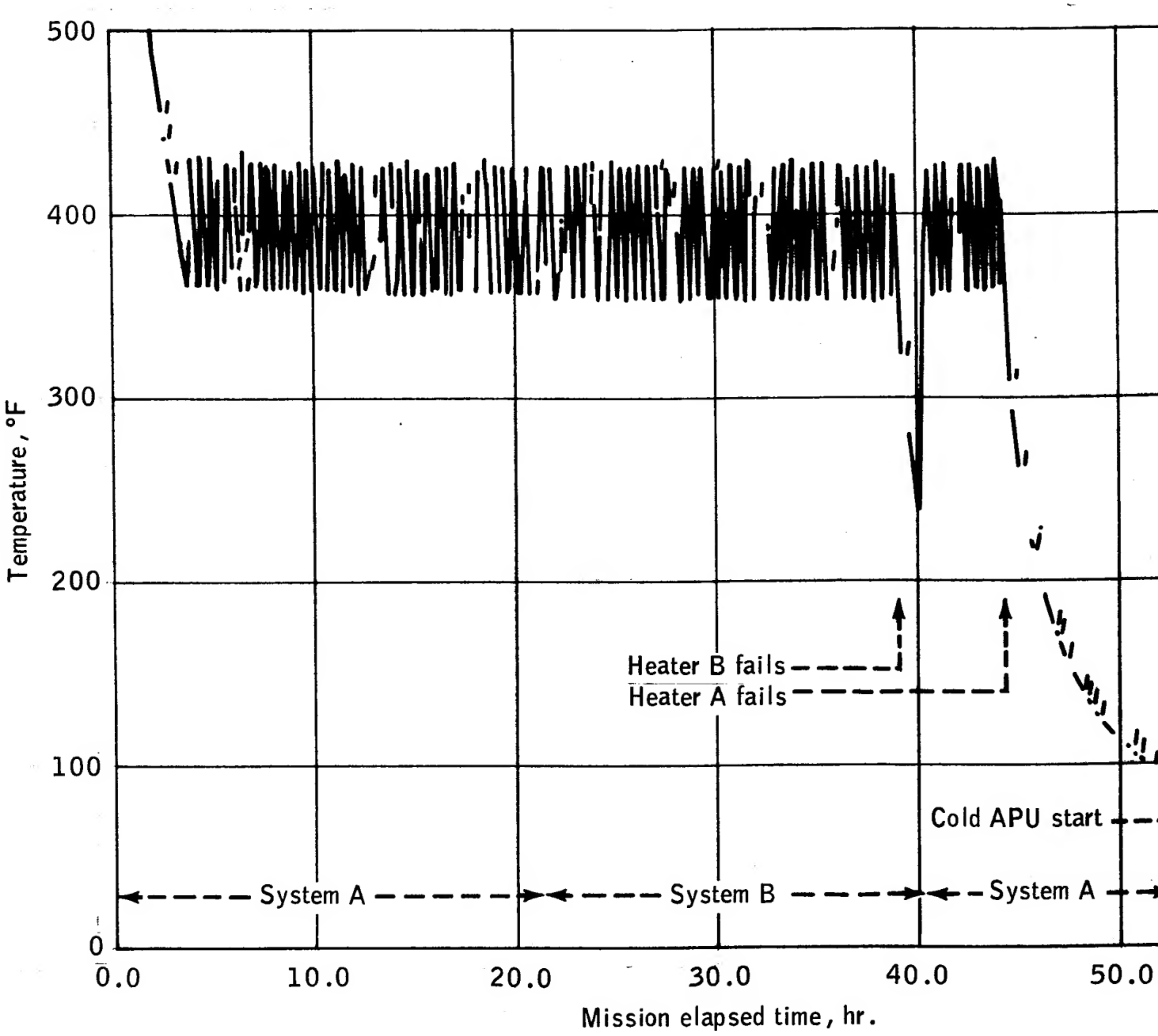


Figure 2-5.- APU gas generator heater failures

lubricating oil temperature because, in most areas of the hydraulic system, system fluid temperatures did not achieve warm enough conditions to boil water.

The only flight test requirement that was accomplished on this flight was data gathering on system accumulator/reservoir performance.

During prelaunch operations, the hydraulic system performance was satisfactory. The circulation pump startup sequence was changed to 3, 2, 1 (instead of 1, 2, 3 for flight readiness firing (FRF) and the STS-1 scrub) to determine the startup characteristics of circulation pump 3 without the other two pumps operating. The results were similar to those experienced previously, with pump 3 requiring approximately 41 seconds to achieve normal operating pressure. The other two pumps started normally in approximately 0.25 to 0.3 second.

Periodic cycling of the system 1 bootstrap pressure during circulation pump operation was similar to that observed during FRF. The suspected cause is a slight internal leak in either the unloader valve or the priority valve.

During ascent, the hydraulic system met all performance requirements. There was an unexpected phenomenon related to freezing or frost formation in the water spray boilers. During ascent, the water spray boiler temperatures decreased rapidly and were at the lower limit (31° F) on all 3 water spray boilers at main engine cutoff. Water spray boilers 1 and 2 thawed immediately and subsequently provided proper operation. Water spray boiler 3 took 1.5 minutes to thaw, and this resulted in the APU lubrication oil's temperature rising to 282° F (should be controlled at 253° F with redline limit of 290° F). The freezing condition is attributed to the 5 lb of water preloaded in each boiler. During ascent, water spray boiler operation was impaired when the triple point was reached and the water over the spray bars froze.

The water spray boiler steam vent temperature dropped below the low limit approximately 1 minute after lift-off. This is attributed to the water from the boiler collecting in the steam vent duct. Water collecting in this area is not an abnormal occurrence with the 5 lb preload, and elimination of the preload may prevent this condition on future flights.

During normal main engine stowage operations at T+9 minutes, the crew reported perceptible vehicle vibration type motion. Correlated data indicate significant hydraulic pressure transients during this period. This is attributed to the software's commanding the engines to move in 1° steps, which causes high rates and accelerations.

The hydraulic system met all on-orbit performance requirements. During preparations for the on-orbit flight control system checkout on day 2, the water spray boiler heaters were activated as planned, and vent temperatures of all 3 water spray boilers exceeded the 185° F annunciator limit during the heater cycling period. Water spray boiler qualification test data showed overshoots to 230° F to be acceptable. This parameter will be removed as a fault and detection annunciator limit for subsequent flights. All system temperatures remained above 0° F while on orbit; therefore, contingency circulation pump operation was not required.

The bootstrap accumulator pressures decayed as expected. There was a drop of 80 psi in system 2 during the second day of the mission. This was attributed to accumulator seal friction since the accumulator pressure stabilized after the drop. This is considered normal operation.

During deorbit preparations, the water spray boiler vent temperatures remained off-scale high for long periods. The condition is attributed to steam vents facing the sun for long periods as well as very slow cooldown rates and is considered normal. The hydraulic system met all performance requirements during the entry and landing mission phases.

System reservoir quantities were at 60, 53.2, and 63.2 percent for systems 1, 2, and 3, respectively, prior to APU start at entry. Because of the hydraulic fluid void in the thrust vector control actuation system, the quantities on systems 2 and 3 dropped when the main engines were repressurized. System 3 dropped 7 percent and system 2 dropped 4 percent, indicating system 3 filled 4 actuators and system 2 filled the other two actuators. (Hydraulic system 1 was not operating during this time period.) Because of system compliance, there was also a drop of approximately 1 percent when the three systems were pressurized. System 1 dropped an additional 4.5 percent when the landing gear 1 isolation valve was opened. This was due to compliance of the landing gear system circuit and replenishment of any voids created during ascent. System 1 dropped approximately 14 percent at landing gear deployment because of the additional oil required to fill the gross (maximum piston area) side of the three strut actuators.

The three water spray boilers effectively cooled the subsystem hydraulic fluid when the fluid temperature finally increased to 210° F just prior to landing. At that time, the water spray boiler bypass valve switched over to the heat exchanger position. Prior to that time, the water spray boiler only accomplished one of its dual functions; that is, maintaining APU lubrication oil within acceptable temperature limits. The following table provides a listing of the highest hydraulic system temperatures experienced during the mission.

	System 1, °F	System 2, °F	System 3, °F
Reservoir	199	207	204
Return line	204	208	216
Elevon return line	214	216	217
RSB return line	217	220	219
BF return line	181	196	199

Postflight inspection revealed a hydraulic leak near a dynatube fitting near the hydraulic pump suction line on system 1. Also, a crack was observed in the suction line (see section 8, flight test problem report 48).

2.2.3 Power Reactant Storage and Distribution

The performance of the power reactant storage and distribution (PRSD) system was satisfactory. No large pressure drops or other control problems were encountered.

The PRSD purging operations began on April 6, 1981, using the T-0 circuit which provides ground gas to the fuel cells. The tanks were purged and sampled. Both the oxygen and hydrogen samples failed; consequently, the systems were completely repurged. At the conclusion of the second purge operation, the hydrogen samples passed, but the oxygen samples failed. Oxygen sample 1 had 106 ppm inerts and sample 2 had 122 ppm inerts for an average of 114 ppm inerts (specification -110 ppm total). A waiver was processed to accept this out-of-tolerance condition since the sample taken after the liquid oxygen load was acceptable. Procedural changes will be made prior to STS-2.

The cryogenic tank loading began on April 8, 1981, and the oxygen tanks, after pressurization, had quantities of 101.8 percent in tank 1 and 100.9 percent in tank 2. The hydrogen tanks were loaded, and after pressurization the quantities in the hydrogen tanks were 102.8 percent in tank 1 and 102.8 percent in tank 2.

After the April 10 launch was scrubbed, the cryogenic tanks were not reserviced but were placed in a standby mode until the launch. During this 2-day period, the heat leak was higher than experienced during acceptance tests and resulted in 60.9 lb of oxygen and 19.6 lb of hydrogen being lost. The following quantities were in the tanks at launch.

Tank	Quantity, percent
Oxygen 1	97.9
Oxygen 2	97.0
Hydrogen 1	92.6
Hydrogen 2	91.7

As was planned, the tanks were launched with the heaters in the "off" position to lower the launch power levels. The heaters in both of the oxygen and hydrogen tanks were switched to "auto" approximately 6 minutes after lift-off. A typical pressure response from oxygen and hydrogen tank and manifold are shown in figures 2-6 and 2-7. As can be seen in figure 2-6, the oxygen manifold pressure dropped about 100 to 150 psi lower than the tank pressure for a period ending 10 minutes after launch. The problem is discussed in section 8.0, flight test problem report 10. As shown in figure 2-7, the hydrogen manifold pressure began to oscillate when the T-0 valve was closed at T-2:35 and the Orbiter was transferred to internal reactants. These oscillations were possibly caused by the thermal chilldown transient of the manifold lines in combination with the interreaction of the check valves. After the first 8 or 9 minutes, the magnitude of the oscillations decreased to approximately ±1.6 psi. The forces caused by these pressure changes should not affect the check valves as the check valves were qualified for 300,000 cycles with a full reversal of pressure.

The hydrogen and oxygen usage for the mission is shown in figures 2-8 and 2-9. These curves show the redlines and the planned consumption for the mission. In general, the power levels were about 2.0 kW lower than the pre-mission assessment. At landing, the quantities for the PRSD tanks were as follows.

Tank	Quantity, percent
Oxygen 1	61.5
Oxygen 2	56.7
Hydrogen 1	51.5
Hydrogen 2	49.3

2.2.4 Power Generation Subsystem

Fuel cell performance was normal for all ground and flight phases of the STS-1 mission. Preflight performance predictions used to develop flight power profiles and voltage margins as well as to establish launch commit criteria closely approximated the flight performance. The actual electrical loads experienced during the ascent, on-orbit, and entry phases of the flight were slightly lower than predicted, as shown in figure 2-10.

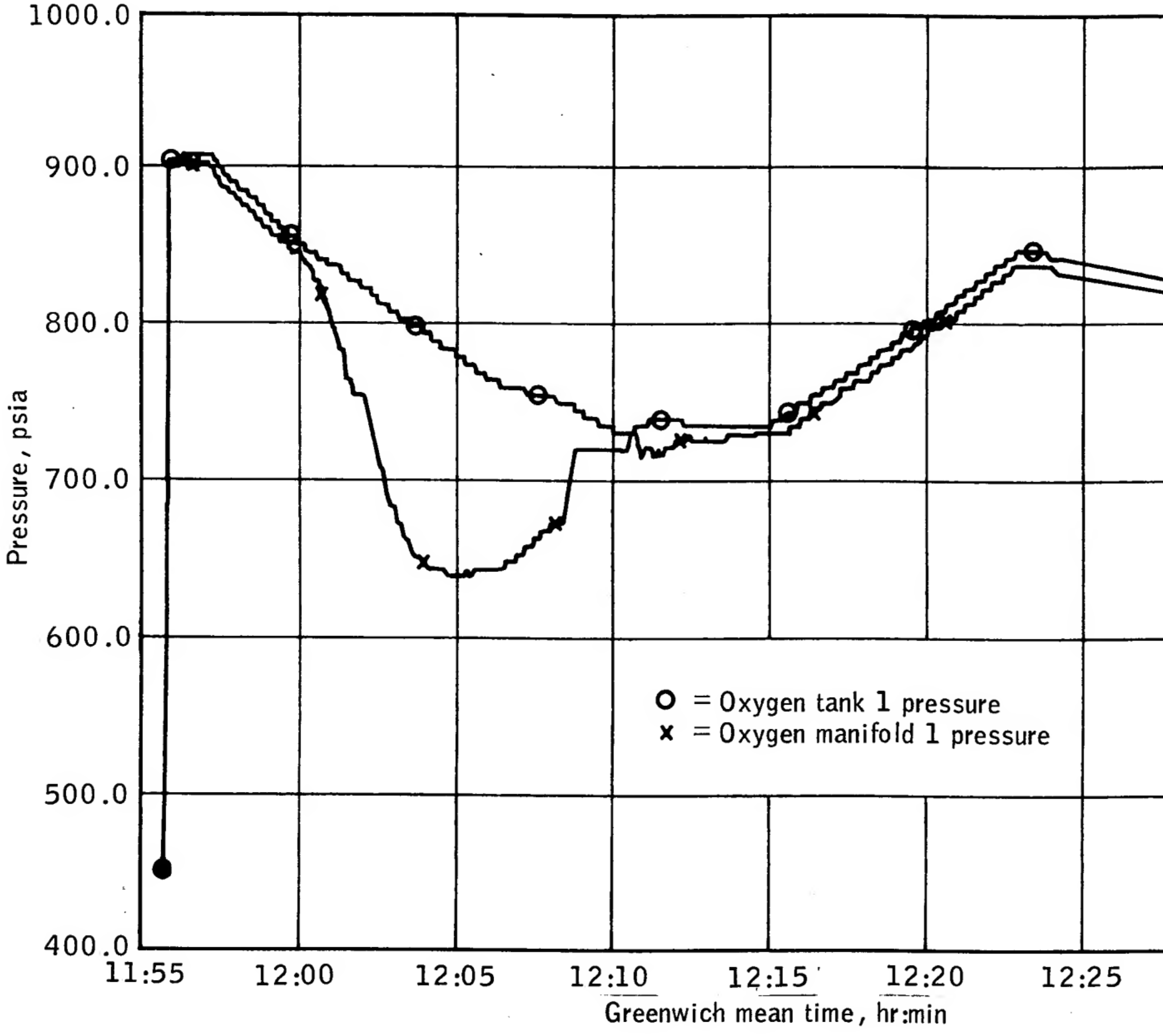


Figure 2-6.- Oxygen tank 1 pressure during launch.

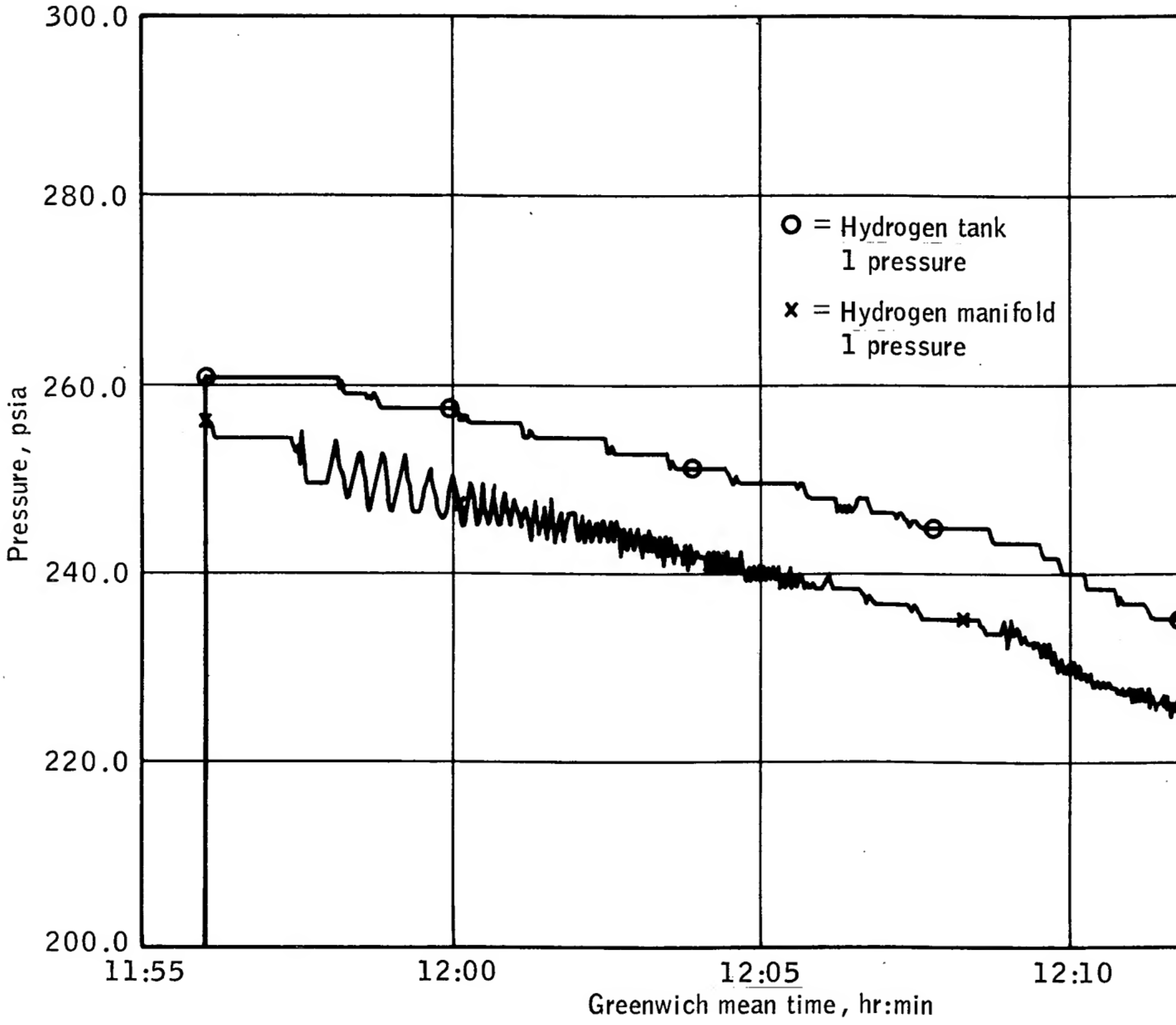
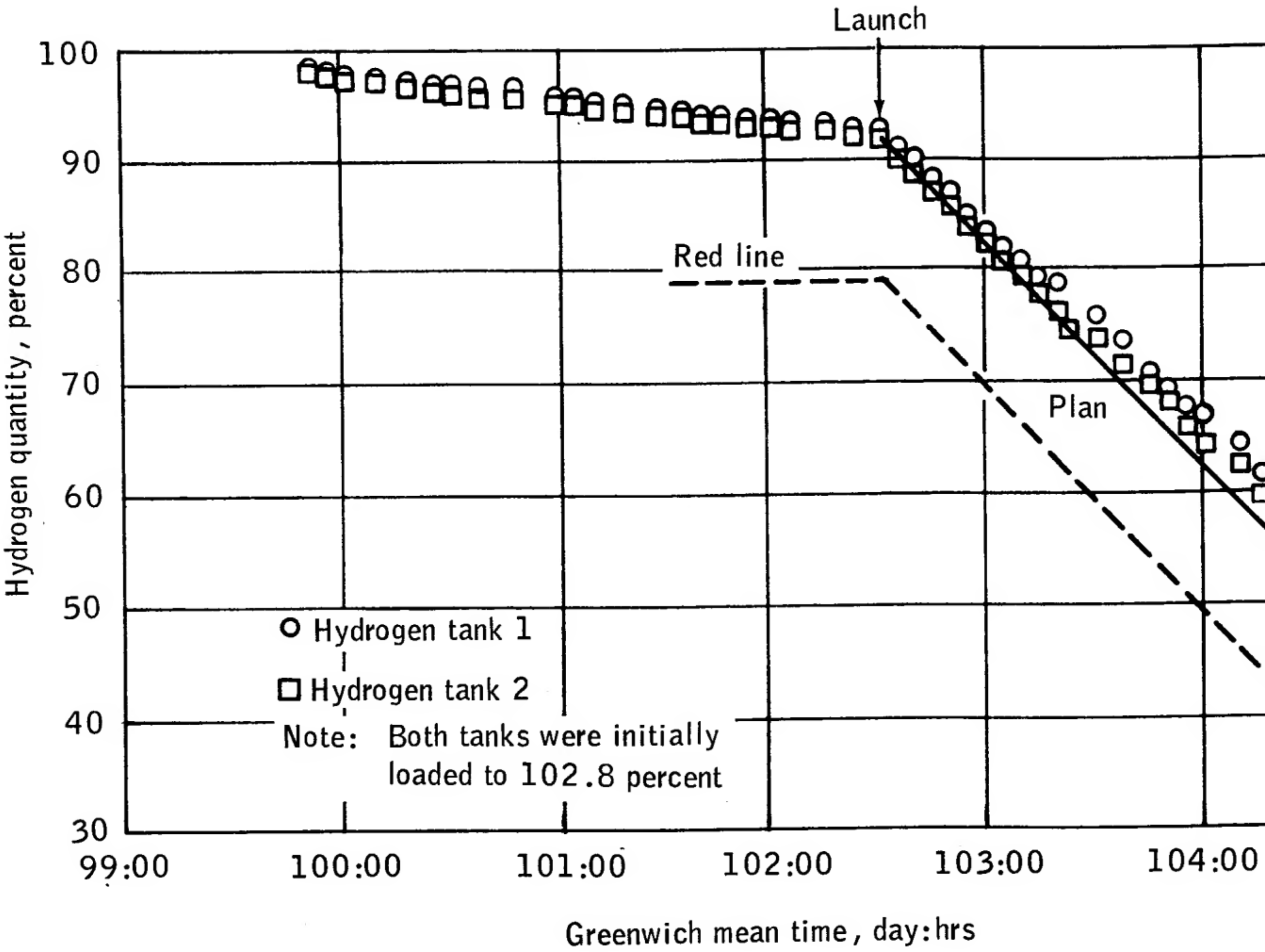


Figure 2-7.- Hydrogen tank 1 pressure during launch



Note: Both tanks were initially loaded to 102.8 percent

Figure 2-8.- Hydrogen quantity during STS-1.

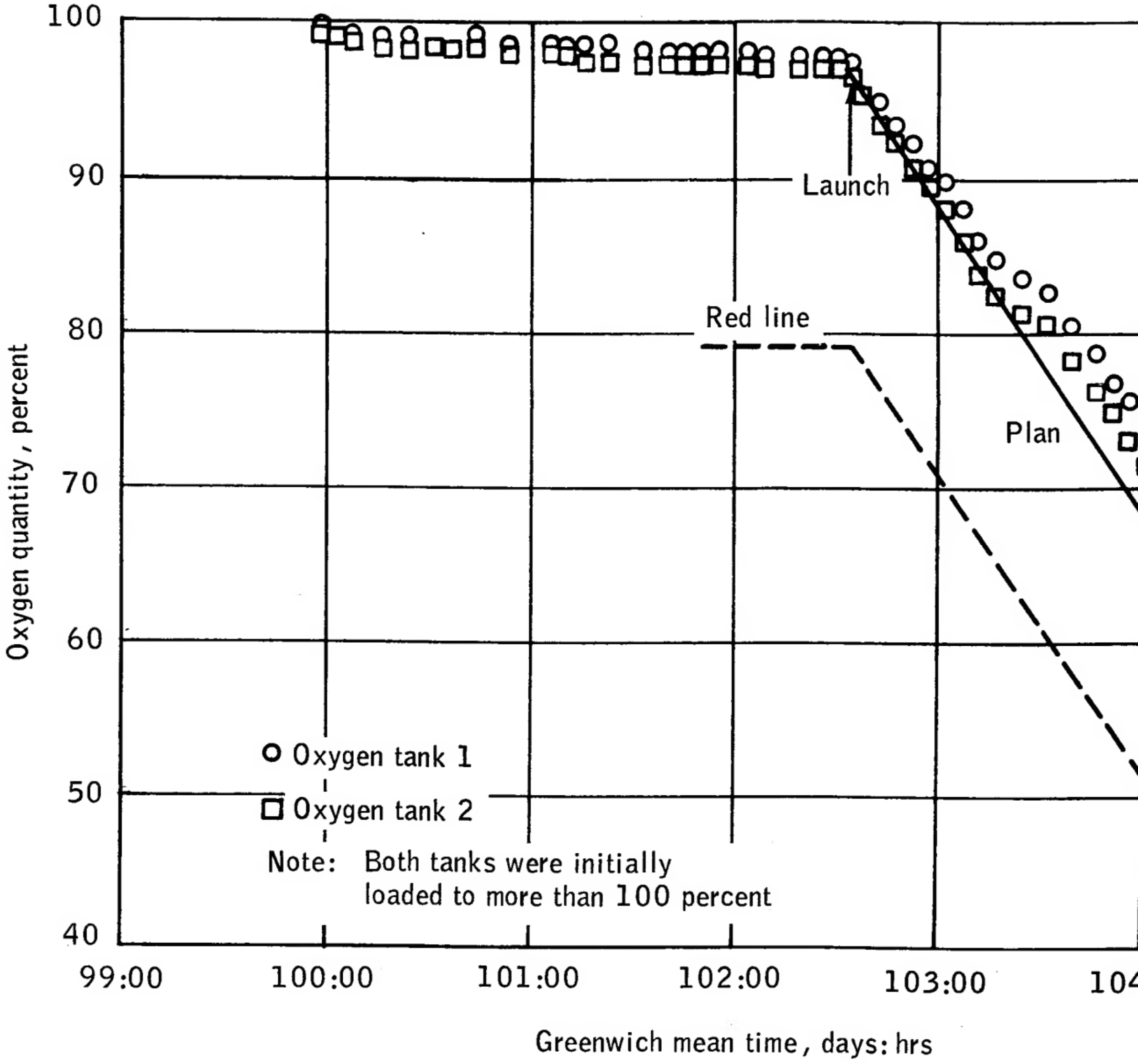


Figure 2-9.- Oxygen quantity during STS-1.

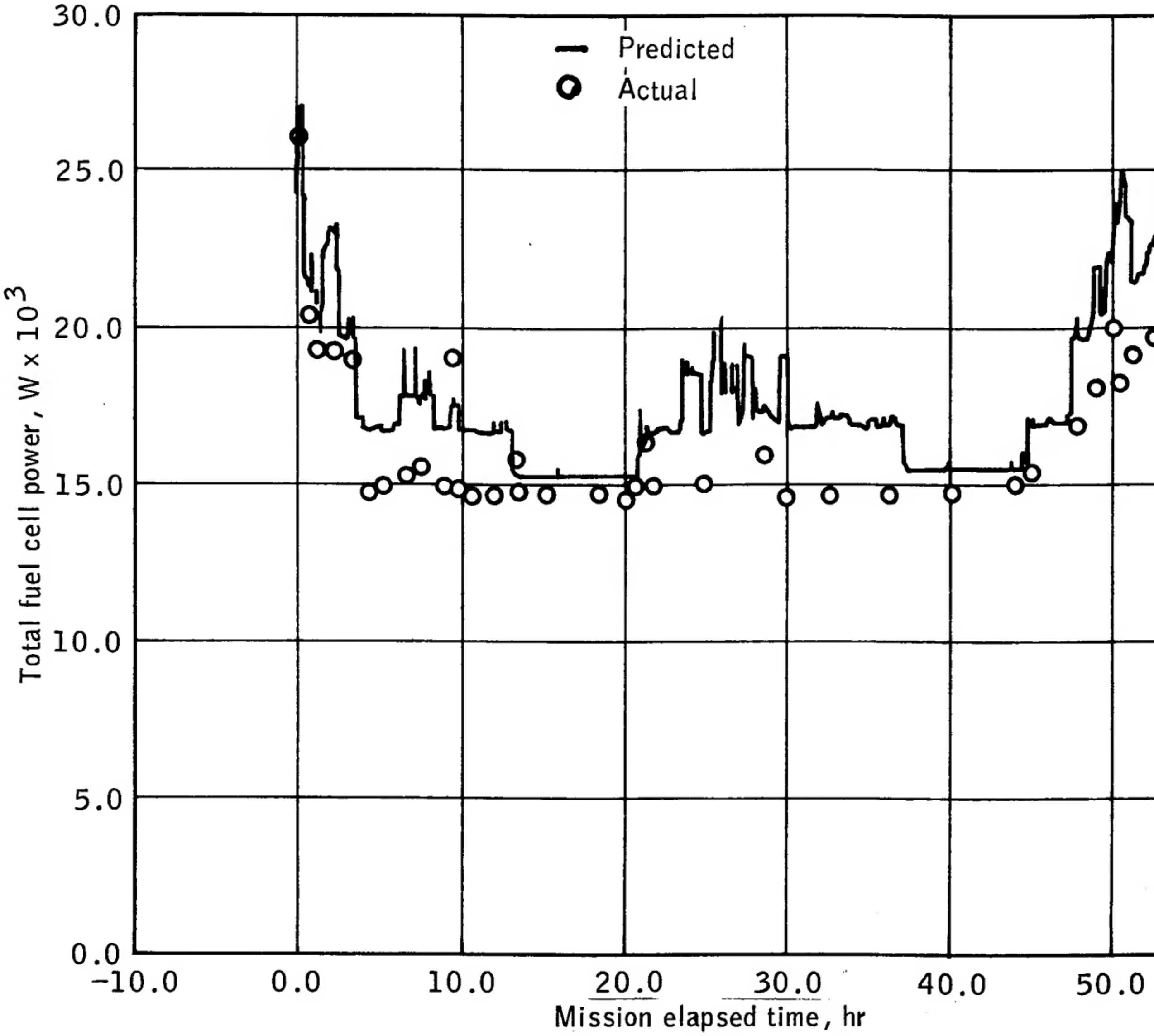


Figure 2-10.- Total fuel cell power during STS-1.

The fuel cell powerplant subsystem performance flight test requirement (FTR V45VV006) was successfully completed during the course of the STS-1 mission.

The fuel cell purging capability (FTR V45VV010) is considered to be 50 percent complete. The manual purge capability was repeatedly demonstrated during the flight; however, the automatic purge software program was not accomplished because of low fuel-cell flowmeter output that is used by the software to schedule the purges. Vendor error in calibration of the flowmeters has been corrected on future units, and changes to the purge valve open/close verification constants are planned to enable automatic purging of the fuel cells for STS-2, regardless of flowmeter readings.

The fuel cell power plant vent port and vent line entry thermal environment (FTR V45VV011) required verification of the adequacy of the hydrogen, oxygen, and water vent line and port thermal isolation design. All reactant vent lines and ports remained within acceptable limits during entry. However, the water relief-nozzle temperatures indicated off-scale high (>450° F) at the end of entry blackout. The water relief nozzle temperature exceeded the upper measurement limit (450° F) during entry (104:17:47 G.m.t.). The water relief port is located at X=631, Y=105, Z-339 on the Orbiter. Thermal analysis has indicated that the temperature would exceed the design limit of 500° F from atmospheric friction on entry. In addition, the nozzle heater was left on during entry because the nozzle heater switch cannot be reached after the crew is fastened in their seats for entry. Leaving the nozzle heater on would result in even higher nozzle temperatures during entry. The areas that might be affected by high entry temperatures are the RTV seal between the relief nozzle flange and the Orbiter's exterior surface and the relief nozzle heater leads. This problem is discussed in section 8.0, flight test problem report 23.

Unexpected momentary fuel cell water relief-valve operation was observed at 102:19:05:43 G.m.t. coincident with the OMS-4 maneuver. Both relief line and nozzle temperature measurement changes indicated water flow overboard. The most likely cause of the water relief valve operation is a slight head pressure in the water line between the water relief panel and the water tank. This pressure momentarily closed the check valve in the line while the fuel cell water discharge valve (which operates intermittently on each fuel cell) was open, thus applying fuel cell internal pressure (approximately 63 psia) to the momentarily incompressible fluid. Under these conditions, the pressure surge could be sufficient to cause the relief valve to crack open. The valve reseated properly since water relief was not observed for the remainder of the mission.

The fuel cells provided 857 kWh of electrical energy to the Orbiter during the flight at an average mission power level of 15.75 kW. The fuel cells operated 91 hours on the ground, including prelaunch holds and postflight operation, plus 54 hours 22 minutes of flight time for a total STS-1 operating time of 145 hours.

2.2.5 Electrical Power Distribution and Control

The performance of the electrical power distribution and control system during STS-1 was exceptional. During prelaunch operations, no launch commit criteria (LCC) redlines were violated.

The ground power supplies were off-loaded smoothly during the T minus 20-minute hold period when all of the Shuttle loads were transferred to the fuel cell power plants. The transition to full internal power was accomplished automatically by the ground launch sequencer at T-3 minutes 30 seconds when the ground-power-connect motor switches on the Orbiter were opened.

All of the Orbiter bus voltages remained well within their design limits for STS-1, and all of the electrical power distribution and control systems worked well. The average total load profile for all mission phases was slightly lower, by 1 to 2 kW, than had been predicted. Table 2-VI compares the actual average total loads versus the predicted average total loads. The differences between the actual loads and the predicted loads are attributed to the lower duty cycle of the heaters and the crew's not using the cabin instrumentation lighting on orbit. The ac system (nine power static inverters) supported all power requirements. The line losses were normal for the bus loads experienced.

The events controller exhibited overall good performance; however, two anomalies occurred during ascent. The Orbiter/external tank left umbilical unlatch system 1B pyrotechnic did not fire; system A completed the operation (see section 8.0, flight test problem report 38). Also, the external tank did not tumble at separation. Neither anomaly, however, was related to deficiencies in the events controller's performance.

Power to main engine controllers (MEC) 1 and 2 was terminated at 102:13:02:59 G.m.t. and 102:13:03:03 G.m.t., respectively. The solid rocket booster (SRB) deadfaced at SRB separation through MEC command of a normally closed relay to preclude shorting and subsequent damage to the Orbiter thrust vector controller 26 vac supply.

At approximately lift-off plus 6 hours 7 minutes 32 seconds, the aft PCA main bus C current measurement went to lower limits (+175 amps) and remained failed throughout the mission. Section 8.0, flight test problem report 11, discusses this anomaly.

Approximately 52-1/2 hours into the flight, during the RCS valve reconfiguration for entry, the aft motor control assembly (MCA) 3 did not remove ac power from right RCS tank 1 and/or 2 oxidizer isolation valve. The crew removed power from the valve manually with a panel switch. Section 8, flight test problem report 21, discusses this anomaly.

Film from the external tank (ET) separation camera indicated that the ET did not tumble. The MEC 1 provides the arm and MEC 2 the fire commands for the ET to tumble. Flight data verify that the arm signal was present. See section 8, integrated problem I-5, for a discussion of this anomaly.

TABLE 2-VI.- STS-1 ACTUAL VERSUS PREDICTED AVERAGE POWER PROFILE[a]

Phase	Actual	Predicted
Ascent	25 kW	24 kW
On-orbit	14 to 17 kW	15 to 20 kW
Descent	20 kW	22 kW

[a] Differences between actual and predicted loads are attributed to the duty cycle of heater loads and lower lighting loads.

2.3 AVIONICS SYSTEMS

2.3.1 Integrated Guidance, Navigation, and Control

2.3.1.1 Operational Modes.- The integrated guidance, navigation, and control system performed satisfactorily in all modes throughout the STS-1 mission.

2.3.1.1.1 Ascent.- There were no significant problems with the inertial measurement unit (IMU) preparations or the attitude direction indicator (ADI) reference quaternion updates during the countdown. The IMU alignments were good and agreed well with one another (as well as with the reasonableness check), but postflight comparison with tracking data indicated an apparent discrepancy in crosstrack velocity at main engine cutoff (MECO of about 20 ft/sec. The inertial velocity magnitude at main-engine zero thrust was only 1.44 ft/sec low, which was most likely caused by incorrect modeling of the main engine thrust tailoff impulse.

The maximum aerodynamic pressure (q) constraint of 620 psf was not violated. Maximum navigated q was 615, but the actual q, including wind effects, is now projected as 606 psf.

Data on thrust vector control actuators, body rates and accelerations, and other indicators show that the vehicle flew as predicted with the exception of an unanticipated pitch attitude error. The pitch attitude error was observed to increase gradually in the negative direction, beginning about 40 seconds after lift-off and peaking at about -5.2° at lift-off +70 seconds, then diminishing gradually thereafter. This error means that the vehicle flew the latter portion of stage 1 with the nose elevated relative to the elevation reference, causing trajectory lofting. The altitude at solid rocket booster separation was about 9221 feet high, with a corresponding lower velocity of about 68.56 ft/sec. Section 8.0, flight test problem report I-1 discusses the lofting problem.

Review of the Orbiter and solid rocket booster actuation subsystem data shows that the thrust vector control and aerosurface actuation subsystems operated normally throughout ascent. The actuator displacements did not exceed 3 deg except as expected during the roll and pitchover maneuver. The aerosurface load relief schedule was normal, and the automatic load relief feature was not required on this flight, signifying that hinge moments were near normal. Also, there was less limit cycle activity than anticipated due to slosh and rigid-body dynamics.

Figure 2-11 presents a comparison of the navigation derived angle of attack for both the primary avionics software system (PASS) and the backup flight system (BFS) for STS-1 along with the preflight prediction. The fact that both PASS and BFS obtained identical solutions for this parameter provides excellent evidence that their navigated states were synchronized, and since the software requirements were implemented independently, this also provides evidence that the navigation subsystem was performing normally. The difference between the preflight predicted and actual flight angle of attack is attributable to the trajectory lofting that occurred during the first stage. The fuel optimal powered explicit guidance (PEG) allowed the altitude rate error to be nulled by gravity, while thrust acceleration was being used more efficiently to accumulate downrange velocity.

Table 2-VII compares the predicted versus flight performance for some of the more significant performance parameters at SRB staging and at main engine zero thrust. The SRB staging conditions indicate the extent of the lofting problem, and the zero thrust conditions show how effective the PEG was in dealing with this dispersed initial condition at guidance initiation in major mode 103.

The flight data show that the ascent guidance, navigation, and control performed in a normal manner. One minor area of concern is the lofting problem (Section 8.0, integrated problem I-1). Another minor area of concern is the fact that the initial attitude error and rate in the pitch axis was not as small at lift-off as expected. The initial attitude error and rate were due to the swaying motion that occurs between main engine ignition and lift-off. A study is in progress to determine if this transient requires any corrective action.

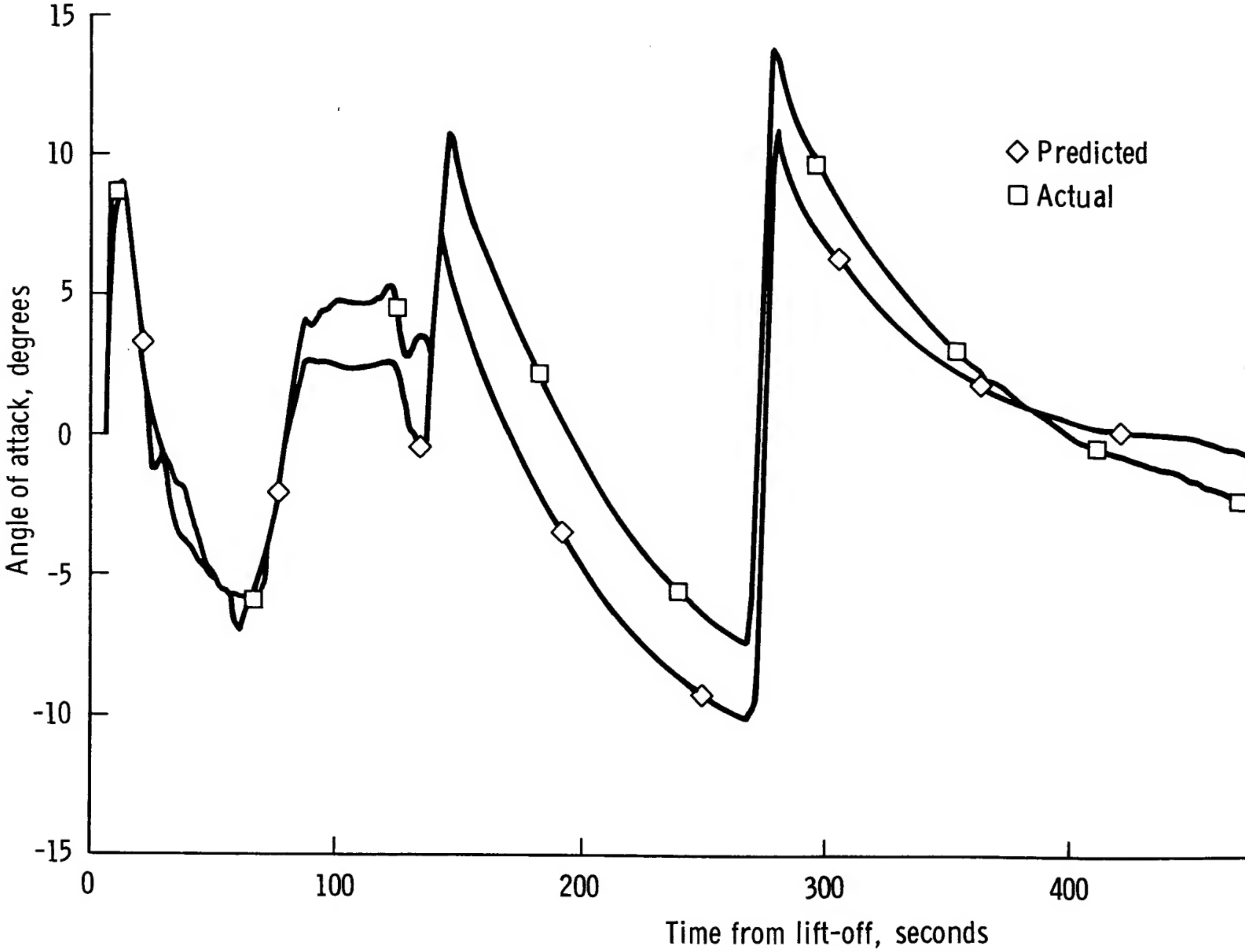


Figure 2-11. - Comparison of predicted and actual angle of attack for STS-1 laun

TABLE 2-VII.- SRB STAGING/ZERO THRUST CONDITIONS
PREFLIGHT PREDICTION VS STS-1

Solid rocket booster staging				Main engine zero thrust			
	Reference	STS-1	Difference		Reference	STS-1	Difference
Time, sec	131.68	130.82	-0.86	Time, sec	520.96	521.4	0.44
Altitude,ft	164736	173957	+9221	Altitude, ft	387593	388092	+499
Reference velocity, ft/sec	4178.56	4110.	-68.56		---	---	---
Inertial velocity, ft/sec	5216.77	5127	-89.8	Inertial velocity, ft/sec	25666.24	25664.8	-1.44
δ_I, deg	26.13	28.73	+2.60	δ_I, deg	.489	.499	+0.001
				Velocity out of plane, ft/sec	0.0	-.54	-0.54*

*Relative to onboard state

STS-1 produced all data required for completion of FTO 101-01 and contributed data attesting to an operational capability for the guidance, navigation, and control systems.

2.3.1.1.2 Transition Digital Autopilot.- A preliminary assessment of postflight data indicates normal transition digital autopilot (DAP) performance for all control modes. However, the data analysis yielded several interesting observations which are discussed in the following paragraphs.

Main Engine Slewing.- The sequence of main engine slewing to the dump position at 102:12:08:45 G.m.t. produced a substantial pitch bending oscillation of about 0.5 deg/sec peak-to-peak at a frequency of 4 hertz. The DAP rate limits were large enough to preclude RCS firings except for one firing that resulted in a 10 lb propellant usage.

Main Propulsion System Dump.- The main propulsion system (MPS) dump at 102:12:10:38 G.m.t. during the OMS-1 maneuver resulted in a larger roll and smaller yaw transient than expected. This probably resulted from the liquid hydrogen expansion via the RTLS abort valve. That is, the expansion produced an impingement on the wing surface which resulted in more of a Z force rather than a Y force. This effect is being further analyzed.

Main Engine Stow.- The main engine slewing from the dump position to the stow position at 102:12:13:20 G.m.t. again caused a substantial pitch bending oscillation (about 4.0 deg/sec peak-to-peak).

OMS Engine Actuator.- The right pitch OMS actuator froze at the null position about midway through OMS-2. During the maneuver, the engines were well trimmed, and the OMS actuator malfunction did not cause a significant transient. The actuator performed sporadically throughout the rest of the mission. This problem is discussed in section 8.0, flight test problem report 12.

2.3.1.1.3 On-orbit.- The analysis of on-orbit data has shown one difference relative to vernier engine control acceleration. During minus pitch or plus-or-minus roll firings, the actual rate change was significantly less than expected. This probably resulted from a reduction in thrust from the two aft down-firing vernier engines caused by plume impingement on the aft end of the Orbiter.

In the area of flight test requirements, detailed test objective (DTO) 174 appears to have been completed as planned.

2.3.1.1.4 Entry Guidance, Navigation and Control. (Major Mode 304 through Rollout).- Entry guidance, navigation, and control operations were normal, with generally better than expected overall performance.

Guidance.- The guidance operations during entry and terminal area energy management (TAEM) were representative of normal preflight test cases. The trajectory profile, in conjunction with guidance steering commands, was near perfect, with no anomalies.

Entry Guidance.- The entry guidance operation was normal. The nominal drag velocity reference was easily captured and maintained, and the entry/TAEM interface conditions were within minimum dispersion values. The subphase transitions were smooth and well-behaved, and no adverse interaction effects from manual takeover at the Mach 5 and 3 reversals were evident. Additionally, the bank reversals occurred in accordance with the predicted STS-1 timeline, and the alpha modulation/bank command cross-coupling was extremely well behaved, even during mixed-mode operations.

Terminal Area Energy Management.- The TAEM guidance operations during automatic and control stick steering operations were normal. All guidance-related trajectory parameters were well within the dispersion envelopes. The approach and landing transition criteria were easily satisfied, and this resulted in moding to the approach and landing mode at the first opportunity (10,000 ft altitude). No discordant guidance interactions have been identified during automatic mode operations. Manual control was employed during the subsonic period in accordance with STS-1 procedures, and hence, guidance interaction effects were not explicitly tested. However, available data indicate that the guidance behavior was stable and without any indication of any major, unexpected transients.

2.3.1.1.5 Navigation.- Overall, the navigation system performance was better than expected. The IMU's performed well, with position errors all less than 1 nmi at the end of blackout (less than 1σ system error). The drag processing worked well. All three TACAN units locked on 30,000 ft higher than predicted, but a longer than expected (>10 sec) series of bearing errors resulted in redundancy management logic's deselecting TACAN 2 (see section 8.0, flight test problem report 22). The TACAN 2 data became good only seconds later and could have been reselected for use by the guidance system. A 1.2° ground station bearing error caused some performance degradation.

The barometric altimeter produced about a 3000-ft error between 86,000 and 82,000 ft altitude, causing a significant navigation state vector error. This situation occurred when the altimeter data were first incorporated. Consideration is being given to delaying navigation use of altitude data until the altitude is $\leq$ 82,000 ft.

The microwave scanning beam landing system performed very well, with stable 3-way lock for all parameters occurring at an altitude of 19,200 ft. The data were very smooth, with fewer unlocks than expected at higher altitudes.

The radar altimeter performed well until the nose wheel landing gear was deployed. At that point, both units indicated a 50-ft step function decrease in altitude (from 80 ft to 30 ft). It is not apparent at what point subsequent to the landing gear deployment that the data again became valid, but the data were dynamic and reasonably accurate at touchdown. This condition was seen during the approach and landing test program, and corrective action was taken to prevent a recurrence. However, the data indicate that a new corrective action for the problem may be required. Section 8.0, flight test problem report 34, discusses this problem.

2.3.1.1.6 Flight Control.- The entry flight control performed well. Most of the entry was flown in the automatic mode, as planned, with the crewman engaging control stick steering at the planned points, Mach = 5 and 3 reversals and just before the heading alignment circle was reached. The modes flown during the entry phase and a brief description of each are shown in Table 2-VIII. All the automatic maneuvers were crisp except for the initial roll, which exhibited a lateral oscillation (see section 8.0, flight test problem report 35). No evidence of a flight control/ bending interaction was observed, although a 5 Hz pitch-rate oscillation (0.3 deg/sec peak-to-peak) was observed starting about Mach 1.1 and continuing through rollout. The aerosurfaces showed no evidence of an oscillation that would indicate the surfaces were either reacting to or forcing the pitch rate oscillation. The lateral and longitudinal trim logic worked well.

Lateral Directional Peformance.- No unexpected transients were seen at the start of major mode 304, and sideslip was maintained within the normal ±0.401 limit cycle, with typical periods of 20 to 40 seconds until the beta (β) loops were opened at a dynamic pressure of 2 psf. Between a dynamic pressure of 2 psf and the first roll maneuver, the control system maintained the roll angle within a few degrees of the command. No large sideslip angles were seen during this region. The first roll maneuver occurred at 12 psf

TABLE 2-VIII.- GUIDANCE, NAVIGATION AND CONTROL MAJOR MODES

No.	Title	Operational software		Description
		PASS	BFS	
				Guidance, Navigation and Control
101	Terminal count	X	X	Contains functions necessary to execute terminal count, ing data, and execute main engine start through 90 perc level.
102	First stage	X	X	Contains functions to monitor, guide, and control vehic rocket booster (SRB) ignition to SRB jettison.
103	Second stage	X	X	Contains functions to monitor, guide, and control the v jettison through termination of external tank (ET) sepa
104	OMS 1 insertion	X	X	Contains functions for vehicle monitoring, and guidance during execution of the first ascent orbital maneuverin maneuver.
105	OMS 2 insertion	X	X	Contains functions to monitor, guide, and control the v executing the second OMS maneuver in the ascent phase.
106	Insertion coast	X	X	Contains functions to monitor, guide, and control the v coasting flight prior to initiation of on-orbit operati
201	Orbit coast	X		Contains functions to monitor and control the vehicle d flight and experiment operations.
301	Predeorbit coast	X	X	Contains functions to monitor, guide, and control the v plish active orbital navigation to prepare for executin maneuver.
302	Deorbit execution	X	X	Contains functions necessary to monitor, guide, and cont while achieving deorbit maneuver attitude and executing maneuver.
303	Pre-entry monitor	X	X	Contains functions to monitor, guide, and control the v completion of the deorbit maneuver until achievement of face.

TABLE 2-VIII.- GUIDANCE, NAVIGATION AND CONTROL MAJOR MODES - CONCLUDED

No.	Title	Operational software		Description
		PASS	BFS	
Guidance, Navigation and Control				
304	Entry	X	X	Contains function necessary to monitor, guide, and cont from achievement of the entry interface to achievement area energy management (TAEM) interface.
305	TAEM/Landing	X	X	Contains functions to monitor, guide, and control the v initiation of the TAEM phase through approach/landing a
601	RTLS second stage	X	X	Contains function necessary to monitor, guide, and cont from return to launch site (RTLS) abort through termina reaction control system (RCS) separation maneuver.
602	Glide RTLS 1	X	X	Contains functions to monitor, guide, and control the v RTLS abort, from completion of automatic RCS ET separat velocity achievement.
Systems Management				
--	Orbit operations	X	--	Mode 201 of systems management major function is OPS 2 general purpose computer and allows onboard access to a significant orbiter subsystems.
--	Payload bay door operations	X	--	Major mode 202 of systems management OPS 2 allows the c and control payload bay door and latches.

and exhibited 3 to 4 cycles of low frequency, lightly damped sideslip oscillations (see section 8.0, flight test problem report 35). Following this roll maneuver, the system tracked the slowly changing roll commands well. The first roll reversal at Mach 18 was performed in automatic and was well damped. The stability roll rate reached the desired 5 deg/sec.

Lateral trim transients were noted prior to and after the roll command step (10°), which occurred at the initiation of the constant drag phase (Mach = 15). The yaw RCS engines and aileron appeared to be reacting to temporary lateral trim requirements. At Mach 11, the aileron trim was about +0.5 deg, and this was slowly reduced to zero by Mach 7 as the vehicle pitched over on the angle-of-attack schedule.

A small (approximately 4°) bank command transient was smoothly flown at the start of the transition phase of entry guidance.

The Mach 10 reversal was flown in automatic and was smooth, precise, and well coordinated. Rotational accelerations matched predicted yaw RCS engine performance. No significant guidance phugoid oscillation was excited.

The Mach 5 reversal was initiated in automatic. Two seconds into the maneuver, the system was manually moded to control stick steering (CSS) with the rotational hand controller (RHC) in detent. The remainder of the reversal was flown manually, with the rates following the RHC position. The system remained in CSS until after a small roll (10°) maneuver was performed manually at Mach 4.

When the rudder was activated at Mach 3.5, a very slight transient was noted ($-1° \delta_R$, $+ 0.8° \delta A$). The rudder trim integrator never acquired a significant value. The maximum δ_R trim was about +1° while in the heading alignment phase. There was no evidence of an aileron/rudder force fight.

The last reversal occurred 10 seconds prior to terminal area energy management (TAEM) initiation at Mach 2.5. The maneuver was again initiated in automatic, and after 8 seconds, the system was manually moded to CSS with the RHC in detent. As in the Mach 4 reversal, the roll rate went to zero, and the pilot then reestablished the roll rate and completed the maneuver manually. The reversal was well behaved and normal. No air-data driven problems or transients were evident at Mach 2.5 when the data were incorporated into the guidance and control system.

While the vehicle was slowly commanded from 30° roll to wings level between Mach 2.2 and 1.5, a low frequency (approximately 0.25 Hz) oscillation occurred. This oscillation was poorly damped and may be indicative of the flight control system's responding to non-normal aerodynamic characteristics (see section 8.0, flight test problem report 53).

The vehicle was flown manually from Mach 0.9 through rollout. Incorporation of the microwave scanning beam landing system data produced a small transient that was quickly nulled by the crew. Subsonic lateral performance was normal and uneventful.

A $+6° \delta A$ excursion driven by a roll RHC deflection occurred just after nose wheel touchdown as the RHC was deflected forward for gear load relief.

Longitudinal Performance. - Angle-of-attack command tracking accuracy was good (within ±2.0°) while on the pitch RCS engines. The elevator trim and proportional control loops were activated at dynamic pressures of 0.5 to 2 psf, as planned. After the pitch RCS engines were deactivated, the elevators were able to maintain good alpha control with no indication of any pitch problem.

Pitch rate and elevator activity appeared normal, and in the region between dynamic pressures of 2 and 20 psf, several cycles of a low-frequency oscillation were noted during a 25-second period, as expected.

The switching transient to Nz control at Mach 2.5 was mild, even though a roll reversal was in progress. This interface was flown in CSS as planned.

The pitch channel was flown manually from Mach 0.9 through rollout. Elevator and pitch rate activity was moderate and consistent with the manual control cases seen during verification tests. Touchdown was smooth, with a -5 deg/sec pitch rate at nose gear touchdown.

Speedbrake. - The speedbrake was smoothly deployed to full open at Mach 10, and it remained open until the brake was slowly retracted to 65 percent between Mach 4 and 2.5, as planned. Automatic speedbrake modulation was active between Mach 0.9 and 0.7 when it was manually commanded to 40 percent. Speedbrake retraction at preflare began at 3100 ft and was commanded closed at 2000 ft altitude. The full extension after touchdown was normal.

Body Flap. - The body flap position did not match preflight predictions for the actual c.g. location flown on STS-1. The body flap was at 14 deg versus the 8 to 9 deg prediction above Mach 12 (see section 8.0, flight test problem report 39) and the position saturated in the low supersonic (Mach 1.1 to 1.8) region. The elevator was maintained within 1° of its trim schedule except in the region between Mach 2.3 and 1.6 when the body flap was being driven at the maximum rate the software was capable of commanding.

2.3.1.1.7 Landing. - The vehicle touchdown point was approximately 3000 feet farther down the runway than planned (see section 8.0, flight test problem report 37). The unexpected landing position resulted from a combination of several factors, which include higher than planned lift-to-drag ratio, tailwind, and other error sources.

2.3.1.2 Hardware Performance

2.3.1.2.1 Navigation.- All scheduled IMU alignments were successfully completed. The star trackers acquired and tracked stars to at least +3.1 magnitude. Daylight alignments were successfully performed. Alignment accuracies were better than expected.

The flight test objective (FTO) successfully performed during STS-1 was FTO 173-07. FTO 173-01, -02, -05, and -06 were partially completed and will be restructured and rescheduled for a later mission. FTO 173-07 (Star Tracker Alignment Verification) showed that the IMU torquing angles were reasonable and uncorrelated, indicating no significant navigation base bending or calibration errors. This fact was verified during postflight testing at Kennedy Space Center where a special gyrocompass and optical navigation base azimuth test was performed.

On several occasions during the mission, the -Y star tracker was observed to be closed and latched by the built-in target suppression circuitry. This circuitry senses an excess of light in the star tracker field-of-view and was provided as a backup to the normal bright object sensor (BOS) operation which closes but does not latch the shutter. The BOS functioned properly at least once in the mission, and self-test data show no failures in this area. See section 8.0, flight test problem report 18, for a discussion of this anomaly.

2.3.1.2.2 Controls.- A right OMS pitch gimbal fail flag was issued just after the maneuver gimbal profile test was initiated for the OMS-3 maneuver. This was a failure of the primary drive system (see section 8.0, flight test problem report 12). The profile gimbal test of the secondary (standby) drive system was completed satisfactorily. A retest of the primary drive was repeated twice before the OMS-3 maneuver without a problem (i.e., no fail discretes). However, the data show a reduced drive rate of the right pitch actuator with positive commands. The OMS-3 maneuver (right engine only) was completed on the primary system with no problems. A review of the OMS actuator data during the OMS-3 maneuver shows the gimbal maintained good position with relation to the commands.

All solid rocket booster rate gyro assemblies (RGA's) and Orbiter RGA's and axial accelerometers (AA's) performed well and within their design capabilities. Table 2-IX summarizes accelerometer performance during the STS-1 flight.

Main engine 1 pitch actuator channel 4 exhibited higher than normal differential pressure. The pressure was higher than the flight readiness firing (FRF) data for the same time period during prelaunch countdown. Following engine stowage after cutoff, the secondary differential pressure on engine 1 pitch actuator channel 4 went even higher. The engine 1 yaw actuator exhibited higher drift than it did during the FRF (0.9° vs. 1.5°). However, the drift and the secondary differential pressure did not exceed the specifications.

2.3.2 Data Processing System and Software

All data processing system (DPS) hardware elements functioned normally during the STS-1 mission.

The engine interface unit (EIU) for channel 3 primary port was bypassed shortly after MECO. This bypass has been correlated with powering down the main engine controller. (Section 8.0, flight test problem report 56.)

The primary software performed satisfactorily throughout the STS-1 mission. A discussion of the software problem that caused the scrub of the launch attempt on April 10, 1981 is contained in section 8, flight test problem report 2.

2.3.3 Backup Flight System

The backup flight system (BFS) performed as expected during the prelaunch countdown. The BFS was moded to major mode 101 and tracked the primary avionics software system (PASS) on all four flight-critical strings. Likewise, the BFS prelaunch navigation was well within redlines, and the BFS received and processed uplink commands according to requirements.

During launch and ascent, the BFS performed as expected and sequenced through all major modes correctly. The BFS navigation was very good (less than 1 sigma error throughout ascent). The BFS guidance-calculated MECO as well as OMS maneuver targets and residuals agreed well with the PASS, with the residuals within 1 ft/sec of the PASS values.

The flight crew reported that the BFS did not automatically proceed into major mode 104 and required crew action to proceed. Examination of the postflight BFS memory revealed that the required -4 ft/sec differential velocity (from the ET), that is, the stimulus for automatically proceeding to major mode MM 104, was sensed by the BFS, and both the primary flight system (PFS) and BFS proceeded to major mode 104 within 2 seconds of each other. Thus, the manual proceed action was not necessary.

All flight-critical input/output errors were seen by both the BFS and PASS, and the BFS performed as expected. All BFS systems management fault messages that were annunciated were proper.

TABLE 2-IX.- ACTUAL RATES AND ACCELERATIONS VS. MAXIMUM RANGE

	Maximum amplitudes sensed in flight	Design range capability
Rate gyro assembly roll rate	-4 to +6 deg/sec	±40 deg/sec
Rate gyro assembly pitch rate	-5 to +3 deg/sec	±20 deg/sec
Rate gyro assembly yaw rate	-3.5 to +3.5 deg/sec	±20 deg/sec
Accelerometer assembly, lateral	-0.07 to +0.05g	±1g
Accelerometer assembly, normal	-0.2 to +1.6g	±4g

During on-orbit operations, the BFS performed correctly with the moding of the general purpose computer (GPC) memory loads and the cathode ray tube (CRT) switches. The BFS was placed in OPS 0 standby during most of the on-orbit period.

During deorbit preparations, a two-GPC primary redundant set was established, and BFS was brought up and proceeded from OPS 0 to major mode 301. The BFS tracked the PASS input/output profile correctly. A redundant set of 4 GPC's with normal string assignments was then formed and BFS was downmoded to stand alone, as expected. During the downmoding, the BFS annunciated a redundancy management IMU fail message. An input/output reset was executed by the crew, and BFS tracking of the PASS input/output profile was reestablished.

In all functions associated with preparation for and execution of the deorbit maneuver, the BFS performed as expected. The BFS was used to close the payload bay doors in accordance with normal procedures. During the deorbit maneuver, the BFS guidance solution agreed well with PASS, and the BFS-calculated maneuver residuals were again within 1 ft/sec of the PASS values.

During entry, the BFS moded correctly through all major modes. The BFS navigation used only inertial data and performed well. At 169,000 ft altitude, the navigation error was 200 feet in altitude; at 98,000 ft, it was 1000 ft; and at touchdown, it was 49,000 ft. This is exceptionally good performance for an inertial-only navigation system.

However, after touchdown and rollout, the BFS did not respond to a crew command to proceed from major mode 305 to OPS 0. A real-time procedure was used to cycle the halt/standby/run switch from run to halt to standby. This resulted in the usual downmoding error messages but accomplished the objective of getting the BFS to OPS 0. Subsequent analysis showed that a software routine necessary for accomplishing the moding had never been activated because the BFS navigation state never reached an altitude (above runway) of 2000 ft.

2.3.4 Displays and Controls

The performance of the displays and controls subsystem on STS-1 was good. There were no failures of the approximately 1240 switches, 426 circuit breakers, 240 event indicators, and 240 annuciators. The crew were able to adequately control and monitor the vehicle's rotation, translation, and flight path along with the onboard subsystems.

The caution and warning subsystem operated very well, and there were no crew-reported spurious alarms. One item that is being investigated is the differential pressure/differential temperature ($\Delta p/\Delta t$) caution and warning that did not annunciate when the limit was exceeded (section 8.0, flight test problem report 54). The cabin interior lighting and payload bay lighting were adequate for all mission phases. All meters worked properly, and the crew reported that the meters were readable during all flight phases. The flight displays, except for the horizontal situation indicator (HSI), all worked properly.

There were two failures in the displays and controls system. These were the compass card on the commander's HSI (section 8.0, flight test problem report 15), and one of the payload bay floodlight electronic assemblies (section 8.0, flight test problem report 57). The HSI failure was first reported by the crew during a high-low test on orbit when the card rotated to 300°, and then when it went to the low position, it stuck and would not come out of 25°. The next day the test was rerun, and the compass card worked. During entry, the same card stuck again and was not used any further.

The floodlight electronics assembly failure was found during a postflight review of the midpower control assembly (PCA) current measurements and was confirmed by a verification test at KSC. The electronic assembly was removed, and sent to the vendor for failure analysis and repair.

The crew reported the following problems:

a. On panel R4, "LG RET/CIRC VLV" (switch S21) was inadvertently hit by the crew, and this caused it to move from the "CLOSE" position to the lever-locked "GPC" position. The length of the lever-lock switch handle is slightly longer than the protective wicket when the handle is in the "CLOSE" position. This allowed the pilot to inadvertently hit the switch handle since the switch is close to his right shoulder. Corrective action is being evaluated for STS-2.

b. The glare shield closeout cover partially obscures the top outboard caution and warning annuciator matrix lights. Corrective action is being evaluated for STS-2.

c. The event indicator flags were difficult to read when viewed from an angle. Panel R4 was especially difficult since it is alongside the pilot's shoulder. The mechanical flags are mounted in a case beneath a window, and the indicators are mounted in the panels behind the lighting overlays, thus recessing the flags even further. The current design precludes improvement in their readability.

2.3.5 Communications and Tracking

The overall performance of the communications and tracking system was excellent. Good quality S-band and UHF voice, real-time and playback telemetry, and real-time and playback television were received through the ground network. The crew reported that the S-band and UHF uplink voice quality was good. The command system performance was flawless, and the interim teleprinter operated normally. The S-band ranging system provided good quality ranging data. The RF navigation aids acquisitions were normal, and except for the deselection of TACAN 2 bearing data (section 8.0, flight test problem report 22) and the radar altimeter loss of lock at landing gear deployment (section 8.0, flight test problem report 34), good quality tracking data were obtained from the TACAN, MSBLS (microwave scanning beam landing system), and radar altimeters.

2.3.5.1 S-band Network Equipment: The Orbiter S-band RF equipment operated within its design limits for the entire mission. The S-band PM equipment was in high power for launch and switched to the space ground link system (SGLS) mode for the Indian Ocean station pass. It was then changed to the space flight tracking and data network (STDN) low-power high-frequency mode. This configuration was maintained for the remainder of the mission with the exception of the two station passes used for special communication tests and the remaining passes over the Indian Ocean station. There were no problems during prelaunch or the mission for the S-band PM equipment. The S-band FM equipment launch configuration transmitted main engine data. During the remainder of the mission, the system was used for TV (real-time and playback) and operational instrumentation recorder dumps. There were no problems during prelaunch or mission for the S-band FM equipment.

The S-band antenna switch assembly was under computer control for the entire mission. The appropriate S-band quadrature and hemi antennas were selected as the attitude of the Orbiter changed with respect to the ground station. The configuration of the S-band network equipment was managed by either uplink real-time or stored program commands.

The redundant S-band transponder (no. 1) was not operated during the mission.

2.3.5.2 Orbiter UHF Transceiver.- The UHF transceiver was operated in the high power simplex mode at 296.8 MHz throughout the STS-1 mission. In this mode, the UHF transceiver communicated directly with ground stations during ascent and while on-orbit and with chase aircraft and landing facilities during landing. The performance of the transceiver was normal.

2.3.5.3 Audio Distribution System: The audio distribution system (ADS) and the audio headsets performed satisfactorily during the STS-1 mission with some exceptions. Some squeals were noted during the first part of certain voice transmissions. The first observation of this oscillation was at 102:15:17 G.m.t. during a pass over the Bermuda tracking station. The frequency spectrum of this downlink signal indicates an oscillation at approximately 800 Hz. A second sample, taken during a Guam tracking station pass at 103:14:40 G.m.t., indicates an oscillation at approximately the same frequency. See section 8.0, flight test problem report 20, for a discussion of this anomaly.

2.3.5.4 Interim Teleprinter System: All aspects of the STS-1 teleprinter operation were as expected. Thirty messages containing 1,162 lines of information were transmitted during the mission and were printed onboard without errors. Several items, however, were noted by the flight crew as inconveniences which may merit improvement. These items include the difficulty of threading paper on the paper take-up reel, the noise generated by the printing process, the lack of clearance between the front door paper cutter and the door's inner surface, and the automatic initialization printout preceding the first message of each pass. Another undesirable situation that was found during the mission was that noise in the mission control center voice circuitry occasionally caused one to three lines of extraneous printout at the end of a message, both on a flight-like printer located in building 30 and on the flight printer, resulting in wasted paper. Modifications for all of the discrepant items will be considered.

2.3.5.5 Closed Circuit Television: The closed circuit television (CCTV) equipment was operated from the cabin or via the S-band command link. All of the CCTV hardware was exercised during the STS-1 mission and performance was normal. The crew noted a scratch on the faceplate of one of the monitors, but it did not interfere with operations.

Although the video tape recorder (VTR) operated properly throughout the STS-1 mission, pre-STS-2 checkout showed failure of the VTR either to record or to play back audio. Upon removal of the VTR, structural damage to the VTR housing was found. (See section 8, flight test problem report 60.) Also, there was significant damage to the VTR mounting rails and vibration isolators.

2.3.5.6 GCIL Controller: The ground command interface logic controller (GCIL) performance was normal.

2.3.5.7 Hand-Held Radio: Postlanding attempts by the crew to establish two-way communications with the convoy using the hand-held radio were unsuccessful. The convoy leader copied transmissions from the Orbiter; however, the crew was not able to copy transmissions from the convoy leader. Special tests conducted following the landing demonstrated that the convoy equipment and the hand-held radio were compatible and that good communications between the convoy van and the flight deck were achievable. Thus, the data indicate that the problem was procedural and that the most likely cause was a failure to set the hand-held radio volume control to an adequate level. This failure mode will be circumvented in the future by prepacking the radio with the volume control set to a comfortable listening level.

2.3.5.8 RF Navigation Aids: The three TACAN units locked on earlier than predicted at 104:18:09:15 G.m.t. This was at a range of 311 nmi and an altitude of approximately 158,000 ft. All three TACAN's supplied good data from this point until 104:18:14:12 G.m.t. At this time, TACAN 2 bearing data were deselected by the redundancy management system. The deselection resulted from a series of 40° bearing data errors. The 40° bearing data errors are a known TACAN problem and occur as the bearing receiver acquires and loses lock, as happened at the time the deselection occurred. See section 8.0, flight test problem report 22, for a discussion of this problem.

TACAN's 1 and 3 continued to supply good data for the rest of the mission. After deselection, TACAN 2 again locked on and provided good bearing data and could have been reselected. Range data from all three units were good from lock-on until the end of the mission.

Microwave Scanning Beam Landing System: The three MSBLS units performed normally during the flight. All three had locked on in elevation by 104:18:18:13 G.m.t. At this time, the Orbiter was at an elevation angle of 23.2°. At 104:18:18:37 G.m.t., all three MSBLS units locked on in azimuth and range. The Orbiter position at this time was -13.3° azimuth, 18.5° elevation, and 12.7 nmi range. When the Orbiter heading with respect to the runway reached the acceptable angle of 40°, the MSBLS data were allowed to be incorporated into the navigation system. This occurred at an MSBLS azimuth angle of -3.4°.

Radar Altimeter: Both radar altimeters were locked at a normal altitude of 5090 ft and supplied good data until landing gear deployment at approximately 75 ft. During landing gear deployment, both altimeters broke lock and then reacquired within 4 seconds; however, the data were not valid. Details of this anomaly are discussed in section 8.0, flight test problem report 34.

2.3.6 Instrumentation

2.3.6.1 Operational Instrumentation.- The operational instrumentation subsystem operated satisfactorily during STS-1, with the minor exceptions that are discussed in the following paragraphs. At launch, 2612 of the 2624 operational measurments (1138 analogs plus 1474 discretes) were operational. Twelve measurements (4 analogs and 8 discretes) had been deferred until STS-2.

Three operational measurement transducers failed on STS-1: one pressure (V41P1260A), one temperature (V41T1261A), and one current (V76C3097A). Two of the transducers which failed, the temperature and the pressure, are mounted on the same pipe in the Orbiter interface to main engine 2 (see section 8.0, flight test problem report 6). The pipe carries gaseous hydrogen, and the two failed transducers measure the pressure and temperature of the gas. The temperature measurement transducer failed 47 seconds after engine ignition, and the pressure measurement transducer failed 50 seconds later.

The current measurement sensor that failed (V76C3097A) is a single component current sensor (a 4-inch cube with a hole through which run the wires of the bus) located in the fuel cell area and mounted on the cold plate. The failure occurred at 102:18:07:36 G.m.t. The sensor failure did not affect the flight, and a detailed discussion of the anomaly is presented in section 8.0, flight test problem report 11.

About 10 minutes into the flight (102:12:10:20:1 G.m.t.), the BITE bits for dedicated signal conditioners (DSC) OF1 and OF4 indicated that both began operating from their internal, secondary (redundant) power supplies. A surge of 54 amperes 0.2 second later opened the breaker between main bus B and the two DSC's. Because of the power supply redundancy, the signal conditioner continued to function normally, and no data were lost as result of this failure. A detailed discussion of this failure is presented in section 8.0, flight test problem report 4.

2.3.6.2 Development Flight Instrumentation: The development flight instrumentation (DFI) system performed satisfactorily except that the pulse code modulation (PCM) recorder failed after recording 31 minutes of prelaunch and flight data and did not operate for the remainder of the mission. The failure was due to loss of tape tension, which was caused by a loose shim (section 8.0, flight test problem report 8). In addition, both the PCM and ascent recorders had a transient data recording loss of a third of a second due to the lift-off transient loading (see section 8.0, flight test problem report 47).

Also, approximately 2 percent of the 3500 DFI measurements had discrepant conditions, principally zero shifts (pressures) and signal intermittencies (wideband data). The discrepant DFI measurements will be repaired where practical prior to STS-2 (see section 8.0, flight test problem report 52). The DFI RF downlink transmission operated satisfactorily, and PCM data were recorded at the S-band ground stations during vehicle signal acquisition periods.

The wideband ascent recorder operated during ascent and the OMS-1 and -2 maneuvers. The wideband mission recorder operated during ascent, during all OMS maneuvers, during ACIP tests, and during the deorbit maneuver, entry and landing. The wideband recorder data were successfully dumped from the Orbiter at the landing site. The 31 minutes of ascent data on the DFI PCM recorder were dumped at JSC after the unit was removed from the vehicle and repaired.

In an attempt to retrieve entry thermal data, the crew tried unsuccessfully to replace the PCM recorder with the DFI ascent recorder (in-flight maintenance procedure in Crew System Checklist). However, several panel fasteners on the DFI forward container could not be removed in zero-g with the tools available to the crew.

2.3.7 Systems Management

The systems management performed as desired, with no known "escapes"; i.e., failure to annunciate an out-of-tolerance condition. A total of 92 annunciator messages were logged. Of that total, six were attributed to hardware anomalies, and 83 were ascribed to procedural causes or erroneous limits. Vehicle and ground software idiosyncracies accounted for the remaining three messages. The issue of erroneous limits is under analysis, with 23 specific cases being studied. Many of the procedurally related events will be eliminated for STS-2 because of the new version of software (18) being incorporated.

A port bypass was annunciated for the engine interface unit (EIU) that serves SSME-3 following MECO. The time of the bypass correlates with the powering down of the main engine controller. EIU3 recognized the data interruption and tagged it with an E-bit, which, after repetition, caused a BCE bypass (section 8.0, flight test problem report 5).

2.3.8 Redundancy Management

Redundancy management (RM) performance on STS-1 was excellent, with significant events occurring in the TACAN and RCS RM interfaces. In all other systems, RM successfully provided the best source data to all users while maintaining a comfortable margin of line-replacable unit (LRU) performance evaluation when compared to the RM fault detection thresholds. The bearing data from TACAN 2 were deselected by RM at 104:18:14:12 G.m.t. Postflight analysis substantiated that the faulty condition of the TACAN 2 bearing data was the result of the vehicle's attitude, with a resulting "look angle" problem which produced bearing errors in increments of 40 degrees. These errors persisted for the 10 counts necessary for the RM deselect, which occurred even though subsequently the bearing data of TACAN 2 cleared up and could have been used if TACAN 2 had been reselected manually by the crew (see section 8.0, flight test problem report 22).

RCS RM resulted in two significant events: the actual deselection of several engines and a concern over the potential deselection of multiple other engines due to the temperature response of the engines in vacuum conditions. The engine failures that resulted in actual deselection by RM were logged as off failures but were traced to vehicle configuration. All of the reaction jet driver electronics necessary for the selected digital autopilot (DAP) mode were not powered, and this resulted in the apparently failed-off engines. In this case, RCS RM served the dual purpose of downmoding for the RCS engine tables for the DAP and also provided a clue to the crew about the vehicle misconfiguration.

The RCS RM concern surfaced during on-orbit operations when it was noted on telemetry data that the primary RCS engine temperatures dropped significantly (25°) immediately following a short pulse firing (see section 8.0, flight test problem report 17). This drop was the result of the flash cooling of the dribble volume of unconsumed propellant. The amount of cooling was substantially more than had been observed in ground tests; however, with a specific firing profile, it might be possible to decrease the engine temperature to the RM limit for leak detection (30° F), with a resulting alarm and engine deselect action (see section 8.0, flight test problem report 17).

2.4 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM

2.4.1 Active Thermal Control System

The active thermal control system performed normally and transported thermal energy from the various heat producing components to the heat rejection components. The rejection of waste heat through the ammonia boiler, flash evaporator, or radiators was also satisfactory. The data also indicate that the hardware temperature limits were not exceeded. The available data verify the integrated performance of the active thermal control system, and the data portions of FTR 63VV001 and FTR 63VV003 are satisfied. Further evaluation of system performance will be accomplished as data become available.

During prelaunch operations, the system flowrates were within 15 percent of the expected values, with freon loop 1 flow running slightly lower than loop 2 flow. The total heat load on the active thermal control system was about 15 percent lower than expected; whereas the heat load on the freon-to-water interchanger was about 15 percent higher than expected. About 3 hours prior to the first launch attempt, an apparent heater or thermostat failure was noted in the flash evaporator system feedwater zone 4, starboard 1 system. System 2 was used throughout the mission (see section 8, flight test problem report 1A). From crew ingress to launch, the flash evaporator duct and nozzle temperatures all behaved as expected, with the A and B duct heaters on and the A auto topping nozzle heaters on. In general, the system performance was normal during prelaunch operations, with no launch commit criteria violated and all instrumentation functioning properly.

Following the disconnect of the ground support equipment freon coolant umbilical at T-15 seconds during the final countdown, the flash evaporator outlet temperatures began the expected increase and caused a caution and warning alarm to occur. The primary A flash evaporator controller was turned on as planned 2 minutes, 14 seconds after lift-off. This coincided with an altitude of about 200,000 feet. The controller brought the outlet temperatures back into the control band of 39° ± 1° F at 102:12:03:30 G.m.t. Following main engine cutoff (MECO), a short-duration minimal increase in the flash evaporator outlet temperatures occurred because of the change in pressure of the evaporator water supply resulting from the vehicle's acceleration dropping from 3g to 0g. This increase was expected and posed no problems. At this time, the interchanger load was about 5000 Btu/hr higher than expected, and the combined load of the fuel cell heat exchanger, midbody coldplates, and freon pumps was about 5000 Btu/hr lower than expected. The payload heat exchanger, aft avionics, and total active thermal control system heat loads were at predicted levels.

At 102:13:11 G.m.t. flow through the radiators was initiated. After the flow was initiated, the panel 1 outlet temperatures and the flow control assembly mixed freon outlet temperatures in both loops indicated 70° F, showing normal operation. When radiator flow was initiated, the total flowrate in both loops decreased as expected, and individual loop flows were within 15 percent of the expected flows.

During opening of the payload bay doors at 102:13:43 G.m.t. and radiator panel deployment at 102:13:55 G.m.t., the radiator temperatures behaved as expected. After deployment, the radiators were rejecting heat at their expected rate. The accumulator quantities dropped, as anticipated, from their prelaunch values of about 31 percent and 28 percent for loops 1 and 2, respectively, with a total heat load of about 66,000 Btu/hr, to about 27 percent and 24 percent for loops 1 and 2, respectively, with a total heat load of about 80,000 Btu/hr.

At 102:14:13:53 G.m.t., shortly after the hi-load evaporator was inhibited, a fault detection and annunciation message occurred. The message was triggered when the hi-load duct temperature (measurement V63T1820A) exceeded the fault detection and annunciation limit of 300° F. This temperature limit was exceeded because steam flow through the hi-load duct was terminated after the radiators began providing heat rejection while the hi-load duct heater A was still on. The same message occurred several other times throughout the flight whenever a hi-load duct heater was on with no steam flow through the duct. Raising the upper limit on this temperature from 300° to 350° F will eliminate the situation; however, it did not pose any problems to the system on STS-1 as the crew turned the hi-load duct heater off earlier than expected to prevent any further messages at that time.

Over the next 24 hours, the only changes that occurred were two instances when the primary A flash evaporator controller was turned off for a short period to prevent any steam flow through the evaporator ducts during "free drift" attitude (gravity gradient). The predetermined flight procedures to turn the flash evaporator controller back on were performed at the end of each "free drift" period.

Prior to stowing the radiators and closing the payload bay doors for deorbit rehearsal on the second day, the hi-load evaporator was enabled, and the B hi-load duct heaters were turned on as planned. At 103:15:09 G.m.t., after closing the payload bay doors, radiator flow bypass was initiated. When full bypass was reached with no further flow through the radiators, the radiator flow control assembly outlet temperature increased from 40° to 100° F in a few seconds. When this step change in the freon temperature reached the flash evaporator, the evaporator outlet temperature began to increase and exceeded the caution and warning limit of 60° F. This behavior was expected since the evaporator requires a certain response time to react to such a severe ramp in the inlet temperature, and the evaporator normally would have recovered from this transient in about 2.5 minutes. Believing the evaporator had shut down, however, the crew performed a "restart" of the evaporator controller, and the evaporator started controlling again. A note will be added to future crew procedures to expect a caution and warning when bypassing the radiators.

Following deorbit rehearsal, when freon flow through the radiators was reinitiated, an automatic trip to radiator bypass occurred on loop 2. The trip to bypass was the result of the loop 2 controller's freon outlet temperature dropping below the 33° F limit. The trip to bypass was the same kind of trip observed in preflight ground tests. The payload bay doors were opened before the radiator flow control valves were modulating correctly to the 38° F set point. Depending on radiator temperatures, the control valves may require up to 3 minutes to reach the proper valve position after placing the mode switch to AUTO and the controller switch to either AUTO A or AUTO B. Postflight data indicate that the doors were opened before the control valves reached their stable modulating position. As a result, the radiators began to cool the freon in the panels, and this cold freon reached the control valves just as they were modulating to their stable position (38° F controller outlet). Because of the Orbiter's attitude when the doors were opened, the door opening sequence and controller design, the loop 1 controller outlet temperature dropped to 34° F, and the loop 2 controller outlet temperature dropped to 32° F before their control valves controlled to 38° F. Since the built-in controller limit is 33° F, loop 2 tripped to bypass while loop 1 did not. A subsequent recycle of the control assembly on loop 2 successfully reestablished radiator flow in loop 2. A note in the crew procedures to verify that the radiator flow control assembly outlet temperatures are 38° ± 2° F prior to payload bay door opening should prevent recurrence.

During on-orbit operations, the topping evaporator duct and nozzle heaters were switched to their B heaters and performed normally. At 104:11:55 G.m.t., another "free drift" period occurred. The flash evaporator system primary A controller was turned off, and then on, using the proper procedures. System performance remained normal.

Prior to the deorbit maneuver, the hi-load evaporator was enabled and performed as expected. Insufficient data prevent an evaluation of the STS-1 after payload-bay-door closing, on-orbit portion of FTR 63VV002. Enough data were obtained, however, to determine that FTO 265-01 (STS-2) may be performed safely and that a retest of FTR 163-01 is not necessary.

The amount of water used by the flash evaporator during ascent, rehearsal activities, entry, and normal on-orbit operations was 143.7 lb, 131.8 lb, 279.2 lb and 0 lb, respectively.

During entry, the ammonia boiler system was activated when planned and performed as expected. To provide data for FTR 63VV002, FTR 163-02, full radiator flow was manually initiated shortly after the completion of landing rollout. The prechilled radiators provided colder than anticipated radiator flow control assembly outlet temperatures of 25° and 28° F for freon loops 1 and 2, respectively. This resulted in the ammonia boiler's outlet temperature dropping below the controller's lower limit of 31° F. As would be expected for such a situation, the ammonia boiler controller automatically switched to secondary control and reestablished temperature control. The radiator controller outlet temperatures quickly increased to 40° F after flow was initiated and increased to 65° F over the next 13 minutes of radiator flow. After this 13-minute period, radiator flow was terminated, and ground cooling was established. These radiator temperatures were colder than expected, and, as a result, enough freon cooling was provided by the chilled radiators (9100 Btu) that the ammonia in system B was never used. System A ammonia usage during STS-1 flight was 34 lb.

2.4.2 Air Revitalization System

The air revitalization system performance was normal, and the system operated as expected throughout the STS-1 flight with only two exceptions. The cabin condition was warmer than expected at lift-off and colder than expected during the on-orbit sleep periods. Available operational instrumentation data indicate that the temperature control system operated within the specified limits during all flight phases and that data partially satisfy the requirements of FTR 61VV001.

During the prelaunch phase of the flight on April 10, 1981 (scrubbed attempt), the indicated cabin temperature and pressure at the time of hatch closure were 82° F and 14.88 psia. After the cabin pressure integrity test venting, the vent was closed when cabin temperature and pressure were 83° F and 14.96 psia, respectively. The cabin temperature and pressure had increased to 87° F and 15.04 psia at the time of the scrub decision. Higher than expected cabin temperatures, as indicated by the cabin temperature sensor, were a result of sensor biasing and warmer cabin interface conditions. Because of the sensor's location in proximity to powered avionics, this measurement may be biased high. (See section 8.0, flight test problem report 13.) Prelaunch cabin temperature predictions assumed 70° F gas purge in the cabin plenum area, 70° F bondline temperatures, essentially no window solar load for an 0700-hour launch, and 35° F freon temperature at the cabin interchanger. The actual interface temperature conditions were an 85° F gas purge, approximately 85° F bondline, approximately 2100 Btu/hr solar load through the windows, and a 42° F cabin interchanger freon inlet temperature.

On the STS-1 launch day of April 12, 1981, the cabin temperature and pressure were 80° F and 14.80 psia at hatch closure; 82° F and 14.88 psia at prelaunch vent closure; and 83° F and 15.04 psia at lift-off. Water and air coolant loop temperatures, pressures, and flowrates were normal. Avionics bay water and air outlet temperatures of 93° and 107° F, respectively, were considerably below the specified 130° F limit. The cabin humidity and carbon dioxide partial pressure were within acceptable limits (16 percent and 1.1 mmHg, respectively).

During ascent, transient temperature excursions occurred in the water and air coolant loops, as expected, due to the interruption of vehicle heat rejection. These transients occurred between ground freon cooling disconnect at T-15 seconds and flash evaporator system activation at T+2 minutes 14 seconds (102:12:02:18 G.m.t.). The interchanger inlet freon, cabin heat exchanger inlet water, and cabin heat exchanger outlet air temperatures peaked at 106°, 81° and 79° F, respectively. However, the indicated cabin temperature exhibited no increase due to the launch transient temperatures. The crew reported no sensed increase in escape suit ventilation system temperature during ascent. The water pump outlet (avionics bay supply) water temperature rose from 69° F at lift-off to 84° F. Essentially no increase in avionics bay water and air outlet temperatures was seen due to the thermal capacitance of the avionics bay coldplate-cooled and water-cooled equipment.

All temperatures, pressures, and coolant loop (air and water) flowrates were normal during the on-orbit mission phases with the exception of a cabin air temperature. The cabin heat exchanger bypass valve was physically pinned in the full cool position during prelaunch and was reconnected to the controller when the lithium hydroxide cartridges were installed at 102:18:39 G.m.t. The indicated cabin air temperature remained between 75° and 83° F. However, the crew reported generally cold cabin temperatures during the first sleep period and during the postsleep period until the interchanger flowrate was increased (providing warmer water to the cabin heat exchanger) and the air bypass valve was physically pinned in the full warm position. The crew reported that they were comfortable during the second sleep period. For a more detailed discussion of this anomaly see section 8.0, flight test problem report 13.

The crew reported debris in the cabin and a clinking sound from the fan area. As a result, the cabin air circulation loop flowrate was momentarily turned off and the fan inlet filter cleaned. Cleaning the filter removed the source of the noise.

Changes in the water coolant loop flowrates occurred as a result of planned standby loop (loop 1) operation for thermal conditioning. The first standby loop cycle was manually accomplished at 102:16:42 G.m.t. Subsequent water coolant loop 1 cycling was accomplished every 4 hours under general purpose computer control. During the cycling of loop 1, loop 2 remained active. The dual water loop operation during these cycling times resulted in increases in interchanger water outlet temperature and cabin heat exchanger water inlet and cabin exchanger air outlet temperatures, as expected. The cabin heat exchanger water inlet temperature increased from 42° to 58° F, and there was a corresponding increase in air outlet temperature from 52° to 60° F. Changes in water coolant loop flowrates also occurred as a result of changes in the interchanger bypass position in the primary loop (loop 2). The first change from an indicated valve position of 46 percent to 77 percent decreased the interchanger water flowrate from 1038 lb/hr to 712 lb/hr. As a result, the interchanger water outlet and cabin heat exchanger water inlet temperatures decreased from 41° to 38° F. The reduction in the interchanger and thus cabin heat exchanger water flowrate was accomplished to reduce the cabin heat exchanger effectiveness and, in turn, increase the air outlet temperature.

Indicated cabin humidity remained between 16 and 40 percent during the flight. The maximum value of 40 percent was exhibited at 104:12:28 G.m.t., prior to changing the cabin heat exchanger air bypass valve from the physically pinned full warm position to the pinned full cool position. This higher humidity did not cause any observable condensation.

The cabin carbon dioxide partial pressure readout ranged from 0.4 mmHg to 5.8 mmHg just prior to installation of the lithium hydroxide cartridges. After cartridge change-out, the partial pressure decreased to 0.4 mmHg but increased to 0.6 mmHg before the next cartridge exchange (cartridge A) at 103:05:00 G.m.t. Cartridge B was exchanged at 103:22:50 G.m.t., at which time the partial pressure was 0.9 mmHg. Both cartridges were removed at 104:13:15 G.m.t. in preparation for deorbit and entry, and the partial pressure was then 1.0 mmHg.

During the deorbit preparation, the water and air coolant loops were configured for entry, and the cabin heat exchanger air bypass valve was physically pinned in the full cool position. This change in valve position was indicated by an increase in cabin heat exchanger air outlet temperature from approximately 46° to 49° F. The cabin temperature sensor measurement gave readings from 77° to 80° F from the deorbit maneuver to touchdown. Humidity and carbon dioxide partial pressure measurements at touchdown were 31 percent and 4.8 mmHg, respectively.

During the postlanding phase, the indicated cabin air temperature remained at 80° F from touchdown through hatch opening. The humidity and carbon dioxide partial pressure increased from 31 percent and 4.8 mmHg to 36 percent and 5.9 mmHg from touchdown to hatch opening. At touchdown, the cabin heat exchanger water inlet and air outlet temperatures were 42° and 52° F, respectively. These temperatures increased to approximately 47° and 55° F after the ground support equipment was connected at 104:18:37 G.m.t. At this time, the interchanger freon inlet temperature increased from 38° to 45° F. From the time the ground support equipment was connected until crew egress, the interchanger freon inlet, cabin heat exchanger water outlet, and air outlet temperatures remained at approximately 45°, 47°, and 55° F, respectively.

2.4.3 Air Revitalization Pressure Control System

The performance of the air revitalization pressure control system was normal throughout the flight. Several minor anomalies were noted. These, however, did not affect the ability of the system to provide pressure control and oxygen for crew consumption. Data indicate that the atmospheric pressure control and oxygen partial pressure control flight test requirements for STS-1 were satisfied.

During the launch countdown and scrub on April 10, 1981, the cabin pressure was indicated to be near the launch commit criteria redline and structural limit for crew ejection. Prelaunch calibration verification of the launch processing system readout of the cabin pressure versus the actual ambient pressure indicated a bias of 0.14 psia high. The onboard reading was biased 0.24 to 0.30 psia high. These biases will be accounted for on later flights when accurate and consistent readout of cabin pressure is required for extravehicular activity (9 psia cabin) operations.

The oxygen partial pressure level dropped below the 2.80 psia launch commit criteria redline during prelaunch procedures on the launch day scrub. The low level was detected after the ground nitrogen purge (purge, vent, and drain) was initiated. The ground support equipment air supply flowrate directed to the white room and Orbiter cabin compartment was increased, reducing the nitrogen leakage into the cabin and bringing the oxygen partial pressure up to an acceptable level. The higher ground support equipment supply air flowrate was provided during nitrogen purge procedures on launch day, and no low oxygen partial pressure levels were experienced.

Approximately 25 minutes after crew ingress on April 12, 1981, a minor problem occurred with a quick-disconnect fitting in the ejection seat/oxygen suit flow system. The disconnect was pinned closed rather than open, preventing the flow of oxygen to the crew when they lowered their masks. The quick disconnect was reconfigured to the pinned-open position, permitting oxygen flow to the crew.

The cabin pressure integrity check was started at approximately 102:10:30 G.m.t. The pressure was increased to 16.96 psi and held steady until the cabin vent valves were opened at 102:10:53 G.m.t. At this time, the differential pressure/differential time measurement indicated high, and the caution and warning klaxon alarm sounded, as was expected. The cabin pressure decayed at 14.88 psia, and the cabin vent valves were closed at 102:11:09 G.m.t. to end the test.

Approximately 2 minutes before lift-off, the cabin differential pressure/differential time reading increased from 0.004 to 0.013 psi/min, peaking at a value of 0.17 psi/min. This exceeds the launch commit criteria redline of 0.15 psi/min. Data indicate the pressure increase is due partially to the addition of oxygen to the cabin through the crew ejection escape suit mask flow and partially to a slight increase in the cabin air temperature. The increase in air temperature was probably caused by a temperature spike as the fuel cells were brought to full power. The oxygen partial pressure was noted to increase about 0.06 psia in the 5 minutes before lift-off, indicating the oxygen flow. The differential pressure/differential time reading appears to be a normal occurrence. Adjustments will be made to the launch commit criteria.

The pressure control system was configured for emergency 8-psia operation for launch, with the 8-psia cabin regulators active and the oxygen partial pressure controller in the emergency position. No unexpected incidents occurred during launch with the exception of a high differential pressure/differential time reading at approximately lift-off plus 57 seconds. The differential pressure/differential time reading was observed to go negative for about the first 2 minutes of ascent, peaking at approximately -0.065 psi/min. The differential pressure/differential time variation was probably caused by a slight expansion of the pressure shell as the outside pressure rapidly decreased during ascent. Investigation is currently underway to determine why the caution and warning klaxon alarm, which is set at -0.050 psi/min, was not triggered by the unexpectedly high differential pressure/differential time indication (see section 8.0, flight test problem report 54). Shortly after T+2 minutes, the differential pressure/differential time reading went positive, as expected, because of thermal transients in the cabin air, and peaked at approximately +0.029 psi/min.

Approximately 4.5 hours into the flight, the pressure control system was configured for day 1 on-orbit operation. The cabin pressure was still above the 14.5 cabin regulator set point, and no gas flow occurred. At the time of the pressure control system on-orbit valve configuration, pressures at the system 2 oxygen supply and at the emergency oxygen regulator started a slow decay. The drop in both pressures indicated a small external leakage within the two isolated systems. Also, since the two systems indicated the same pressure even though they were isolated from each other by the system 2 oxygen crossover valve, there was an internal leakage at the system 2 oxygen crossover valve. For further discussion of these two anomalies, see section 8.0, flight test problem reports 14 and 28.

A slow decay in the system 2 cabin regulator pressure indicated an external leakage from either the 8-psia or the 14.5-psia cabin pressure regulators. This leak was noted to be approximately 2 sccm. (Specification leakage is 7 sccm.)

At approximately 103:02:43 G.m.t., the system 1 cabin regulator opened and started a slow oxygen flowrate into the cabin. The cabin pressure leak rate, calculated from the pressure decay until the oxygen flow occurred, was 2.58 lb/day compared with the leak rate of 6.53 lb/day (at a pressure differential of 3.2 psi) determined during ground testing. An analysis of the oxygen partial pressure decay over the same time period indicated the crew metabolic usage to be 1.80 lb/man/day.

At 103:10:23 G.m.t., the pressure control system was configured for day 2 on-orbit operation. At this time, system 1 was deactivated and isolated, and system 2 was activated. Immediately after system 1 was deactivated, the system 1 oxygen regulator pressure climbed from a normal value of 120 psia to 215 psia in 30 minutes. For detailed discussion of this anomaly, see section 8.0, flight test problem report 14. At that point, the system 1 oxygen regulator inlet valve (manual) was closed as it was suspected that the oxygen regulator had failed to seat properly under no-flow conditions, thus allowing the downstream pressure to increase. It was noted that an oxygen/nitrogen control valve and oxygen check valve failure would give the same high pressure indication at the oxygen regulator.

At approximately 103:19:42 G.m.t. during the crew deorbit rehearsal activities, the emergency oxygen system was exercised by the crew's breathing through their suit masks. The emergency oxygen regulator maintained a normal value of 312 psia after indicating a cryogenic supply pressure (800 psia) for the entire flight because of the oxygen crossover valve leakage. After the emergency oxygen use was terminated, the emergency oxygen regulator control pressure again started climbing toward the cryogenic oxygen supply pressure level.

At 104:13:00 G.m.t., the pressure control system was placed in the configuration for entry (same as ascent configuration). The system 1 oxygen regulator pressure dropped from 214 psia to 20 psia, indicating system 1 oxygen regulator inlet valve was still closed from the earlier system reconfiguration. At 104:14:27 G.m.t., about 1.5 hours later, the pressure returned to the normal value of 120 psia. After the inlet valve was opened, the earlier leakage failure did not recur.

After entry interface, the crew elected to lower their visors and seal their face plates, and they remained on the masks until just before touchdown.

Approximately 2 pounds of nitrogen were used during the flight. The nitrogen usage from the tank resulted from pressurizing the water tank bellows during water dumps. Later, as the water tanks were refilled, the nitrogen vented into the cabin. The emergency oxygen usage during flight was essentially zero as the only activation of the system occurred when the crew did the deorbit dress rehearsal.

2.4.4 Airlock Support System

The airlock support system was not used during the STS-1 mission. This system would be used only if a contingency extravehicular activity were required. The airlock-to-payload bay differential pressure sensor did not respond to changes in the payload bay ambient pressure during the flight. For further discussion of this anomaly, see section 8.0, flight test problem report 3.

2.4.5 Water and Waste Management System

The potable and supply water storage system performance was normal throughout the flight. The potable water supply to the drink station was chilled and was acceptable to crew taste. The supply water pressure to the flash evaporator was sufficient for proper evaporator operation. No water management problems occurred in storing fuel-cell-produced water. Two overboard dumps were required to dispose of excess water. The water balance for the flight is shown in table 2-X.

The only anomaly in this system was a momentary decrease from 80 percent to 0 percent on tank B supply water quantity transducer. For futher discussion of this anomaly, see section 8.0, flight test problem report 16.

TABLE 2-X.- POTABLE AND SUPPLY WATER BALANCE

Water Available	
Lift-off weight	864.4 lb
Fuel-cell produced	613.7 lb
Total	1478.1 lb

Water Used		
Flash evaporator use		554.7 lb
Ascent	143.7	
Rehearsal	131.8	
Entry	279.2	
Dump overboard		237.8 lb
Crew use		22.8 lb
Landing weight		662.8 lb
Total		1478.1 lb

The waste water and waste collection system operation was normal for the waste water storage but marginal for the waste collection system. The waste water tank collected 25.4 lb of liquid waste during the flight, of which 12 lb was condensation water from the cabin heat exchanger and 13.4 lb was urine. The waste tank quantity was maintained above 135.3 lb for a contingency water supply for flash evaporator use. Two waste water dumps were performed to manage the supply level, with a total of 24.6 lb dumped overboard. The waste collection system operation was marginal from initial use and degraded to the point that there was no liquid collection at all by the end of the flight. The crew reported that the transportation of liquid and solid waste was not adequate. There was insufficient air flow through the commode to separate solid waste from the user, and the flow rate of the urinal was marginal. On the last day, the crew reported that there was no detectable flowrate at all in the urinal. Further discussion of this anomaly is contained in section 8.0, flight test problem report 33.

The smoke detection and fire suppression system was not used during the STS-1 flight. The smoke detector concentration levels remained at the background noise level throughout the mission. During self-test of the detectors, two of the smoke detectors failed the initial self-test attempt by the crew. Four more attempts were made. The left-hand flight deck detector never passed the self-test, but the cabin detector passed the self-test at least once. This anomaly is discussed in detail in section 8.0, flight test problem report 36.

2.5 CREW STATION AND EQUIPMENT

2.5.1 Cabin Arrangement

The configuration of the crew compartment proved to be an acceptable arrangement; i.e., separating the work stations (flight deck) from the living area (middeck). Dedicated mobility aids and restraints were not used; however, the crew used the ejection seat rails, stowage lockers, and other cabin equipment to aid in body positioning and restraints at the various work stations. Crewman reach and visibility under launch/boost gravity conditions were adequate to accomplish the tasks required during the flight. This corresponded to data obtained in early centrifuge tests and mockup exercises.

2.5.2 Cabin Environment

In general, the cabin seemed to be a acceptable area to work and live in. During the first night, the flight crew did get cold; however, this proved to be a cabin temperature controller problem caused by a poorly located temperature sensor.

Lighting on both the flight and middeck was adequate. The flight deck floodlights provided adequate lighting for the display and control panels; consequently, the panel integral lighting was not used.

2.5.3 Noise Level Survey

An acoustic noise survey was taken during a nominal activity period during the mission. Noise level readings were made at two locations in the flight deck and at two locations in the middeck. An overall A-weighted measurement was taken at each location. In addition, linear measurements were made in the octave bands defined by the center frequencies of 63, 125, 250, 1000, 2000, 4000, and 8000 Hertz.

Acoustic noise data were also obtained from five microphones installed in the Orbiter. The microphones' signals were recorded by the development flight instrumentaion (DFI) recorders. These recorded data are still being analyzed and will provide a better understanding of the noise level within the Orbiter cabin during the flight.

On the flight deck, measurements were made between the commander and the pilot ejection seats at the ear level of the seated crewman. A second measurement was made at the aft crew station between windows W7 and W8. On the main deck, measurements were made in the center of the deck 3 ft. from the center of the M058F locker and at the sleep station.

On the flight deck, at the lower frequency banks, the noise level was well below the NC-55 design requirement standard and the NC-50 standard. In the frequency bands above 500 Hertz, and especially at the 1000 Hertz band, the flight deck noise was greater than the maximum level acceptable to the design standard by as much as 11dB. (For reference purposes, a 10 dB increase in noise is perceived as being twice as loud as the original level.)

The main deck measured levels exceeded the design standard throughout the audio spectrum except for the lowest frequencies. At both the sleep station and the center of the main deck the desired level was exceeded by 12 dB. The peaking of noise energy occurs in the 250 Hz octave band, and this is, unfortunately, in the vicinity of the sleep station.

Similar measurements were taken on the flight deck at KSC in OV-102 during a noise survey. The maximum of 2.5 dB difference can be attributed to not having the instruments located in exactly the same location or in the exact same orientation.

2.5.4 Stowage

The loose equipment stowage for the Orbiter proved to be satisfactory. The locker and tray concept was a good, usable method to organize, install, and gain access to loose equipment. The foam cushions provided both adequate vibration protection and zero-g retention to keep items from floating away when a locker was opened.

A stowage problem that was identified was a lack of adequate volume for trash and dirty clothing. Additional trash volume will be available on operational flights, and ways to provide more volume during the next three flights are being pursued.

The crew found it difficult to lock the doors of lockers MA9L and MF14K during preparations for entry. The door fasteners (two for each door) were misaligned, thus causing the crew to have to physically move the door to the locker frame to engage the locks. Also, the waste management system door was difficult to operate. Section 8.0, flight test problem report 40, contains a discussion of these anomalies.

2.5.5 Flight Crew Equipment

Performance of flight crew equipment, such as food, clothing, tools, communications equipment, photographic equipment, and medical provisions, was satisfactory except for the items discussed in the following paragraphs.

The crew found it difficult to load film in the 35mm camera. The current assessment is that film loading in this camera can be difficult and time consuming if proper sequential loading steps are not followed. Also, the decal-mounted film loading instructions on the camera were not specific. Attempts to duplicate the difficulty showed that if the camera-back lock is not engaged in the open-lock position when attempting to put a film cassette in the camera, it is not possible to load the cassette without forcing. Forcing will result in misalignment of the cassette alignments marks. Once the alignment marks are displaced, the cassette will not load into the camera. Also, once the cassette is loaded into the camera, the camera back lock must be positioned in the closed-lock position or excessive film drag and a possible jam can result. The STS-2 corrective action is to increase emphasis on crew training and improve the instructional decal on the camera.

Discussions on the teleprinter and its operation are contained in section 2.3.5

The crew had difficulty in controlling the umbilical cables through which their headsets were connected to the Orbiter audio system. In zero-g, the cables took a random set and floated randomly. This condition required frequent crew action to move the cables out of the crewman's work area. In addition, the cables frequently snagged as the crewman translated through the vehicle, thereby interfering with activities. The development of a wireless crew communications system to replace the present umbilical cables is underway. The first phase of the project is to develop and fly, as an experiment, a system based on in-house modified commercial wireless headset equipment. This system would be an overlay to the existing communications umbilicals and audio system and would require no Orbiter modifications while retaining the capability of using the cable system should this equipment fail to operate properly. Having this hardware available for STS-2 is the goal.

Some squeals were noted during the first part of certain voice transmissions. The first observation of this oscillation was at 102:15:17 G.m.t. during a pass over the Bermuda tracking station. The frequency spectrum of this downlink signal indicates an oscillation at approximately 800 hertz. A second sample taken during a Guam tracking station pass at 103:14:04 G.m.t. indicates an oscillation at approximately the same frequency. This problem is further discussed in section 8.0, flight test problem report 20.

2.5.6 Flight Test Requirements

Flight test requirement 71VV002 (DTO's 173-01, 02, and 06) was accomplished by demonstrating the use of the crewman optical alignment sight (COAS) as a backup for inertial measurement unit alignment. The on-orbit COAS calibration was performed by sighting through the left forward window on a known star and using aligned inertial measurement units to determine the vector components in navigation-base coordinates. The thermal effects relative to the vehicle during the mission were measured by sightings at the daylight terminator, the middle of the orbital night, and the end of orbital night. The test successfully demonstrated that the COAS was within design limits and that its use was repeatable for aligning an IMU. The thermal effects were minimal.

Flight test requirement 67VV004 (FTO's 162-01 and -02) was conducted by obtaining cabin atmosphere samples for postflight evaluation of trace contaminant buildup. The devices flown on STS-1 were successful in their application for obtaining cabin atmospheric samples. The crew did experience some difficulty in the operation of the sorbent sampling device. Of the trace compounds found in the STS-1 cabin atmosphere, none attained concentrations high enough to be considered toxic hazards.

2.6 STRUCTURES

2.6.1 Flutter/Buffet

Examination of response data from lifting and control surface instrumentation yields no indication of flutter or buzz (FTR 08VV010). Low-level control surface buffet (FTR 08VV012) was detected in the transonic region; however, this was anticipated. Outputs of accelerometers in or near the crew cabin indicate that cabin buffet levels also were moderate. The following maximum accelerations levels were noted and all are within design limits.

Accelerometer location		Approximate zero to peak g's
Right hand wing tip	~ Z axis	5
Right hand inboard elevon	~ Z axis	7
Right hand outboard elevon	~ Z axis	6.7
Body flap	~ Z axis	7 (Clipped during hi-q period)
Vertical-fin tip	~ Y axis	6.7
Payload bay door	~ Normal to surface	5

2.6.2 Loads and Stress Evaluation

No flight-measured design strain excesses have been noted in the evaluation; however, several structural anomalies occurred and require corrective action prior to STS-2. These anomalies are as follows:

Delamination of face sheets in the graphite-expoxy honeycomb skins of both the right and left OMS pods occurred. An area of several square feet at the lower aft outboard corner of both pods suffered damage apparently as a result of severe heating. Also, eight small delaminated areas on the forward area of the pods have been identified, all located beneath points of TPS damage. This anomaly is discussed further in section 8.0, flight test problem report 32.

The right-hand main landing gear door experienced a structural failure during the descent portion of the STS-1 mission. The failure was inelastic buckling of the outer skin of the door. There were two buckles in the skin as a result of local overheating of the structure. The maximum temperature of the 0.065 in. thick aluminum skin was approximately 400° to 500° F as estimated from the discoloration of the green Koropon paint. There were two adjacent buckles, one convex and one concave. The convex buckle was the largest of the two, with an approximate size of 2 in. wide by 10 in. long and 0.250 in. high. The concave buckle had an approximate depth of 0.065 in. and a width of 2 in. An interior stringer, immediately over the smaller buckle, showed signs of decreasing discoloration from the area adjacent to the skin to the top of the stringer. See section 8.0, flight test problem report 49, for a discussion of this anomaly.

The postflight inspection revealed the forward RCS oxidizer tank Z strut was buckled. Review of the flight data indicated that the lift-off dynamic response was aggravated by the SRB ignition overpressure, and this condition was the probably cause of failure. This anomaly is discussed in section 8.0, flight test problem report 58.

Assessment of wideband strain data indicates generally good correlation between flight and ground test measured acoustic induced responses of tank support struts and primary structure.

STS-1 structural temperature data have been reviewed to assess thermal gradients and to correlate these gradients with thermal stresses derived from flight strain data. In general, the maximum thermal gradients occurred after TAEM and varied with time at each location in the vehicle. Thermal stresses were evaluated in detail at several stations of the fuselage. Stresses were predicted analytically on the basis of measured and extrapolated temperatures and compared with thermal stresses which had been backed out of the strain data; reasonable correlation was obtained using a two-dimensional stress analysis. The temperatures were lower than predicted, but the thermal gradients still were significant.

Based on strain measurements taken during entry, midfuselage lower skin factors of safety of 1.4 for maneuver and landing were determined at X station 891. At X station 1055, flight data indicates a factor of safety of approximately 2.0 for both maneuver and landing. The above factors of safety apply at the center of the mid fuselage (Y=0). No strain instrumentation was available on STS-1 at y station 82, which was considered to be the critical region based on preflight analysis. However, based on analysis of flight thermal data, the factors of safety at station y=82 probably are in excess of 1.4 also. Additional instrumentation will be provided on STS-2 to enable a more detailed assessment of the lower midfuselage structure. On the basis of the data review, no STS-2 contraints exist. However, since the thermal gradients are significant, the Orbiter should be thermally preconditioned prior to entry.

Overpressures determined from data taken during the SRB ignition period are significantly larger than predicted. Acoustic measurements on the Orbiter read 2.0 psi at the center of the Orbiter heat shield and on the upper surface of the body flap. This is approximately four times the predicted environment for that structure. Differential pressures across the Orbiter in the Z axis direction are from 0.1 psi to 0.6 psi. These differential pressure values will result in transient forces applied to the vehicle that are four to six times the prelaunch predicted values for overpressure effect. The effect of the pressure loading on vehicle lift-off dynamic behavior is being assessed. (See section 8.0, flight test problem report I-6.)

Significant vehicle response, as indicated by Z axis accelerometer measurements and control surface loading, was also observed at lift-off. Nine low frequency (0-20 hertz) accelerometers, two in the crew module and seven in the payload bay, measured higher than expected Zo accelerations at lift-off. The maximum accelerations measured by these accelerometers are shown in Table 2-XI along with maximums from the preflight verfication loads cycle. As indicated, the Xo and Yo responses are lower than predicted, but the Zo responses are in some cases over twice the predicted value. The differences between measured and predicted responses are possibly caused by the high SRB induced overpressure, with some contribution from the tiedown load characteristics. Shock spectra analysis of the Zo accelerations show significant response at 6 to 7 hertz and in the 18 to 20 hertz range. Other Orbiter accelerometers at various locations from the nose gear wheel well to the ACIP package also showed the high Zo responses.

2.6.3 Midbody Deflection/Door Closing Tests

The evaluation of payload bay door centerline deflection is based on crew visual determinations. The crew reported a position equivalent to a 3-1/2-in. overlap condition versus an analytically predicted condition of 1/2-in. gap to 3/4-in. overlap. Section 8.0, flight test problem report 45, contains a discussion of this anomaly.

2.6.4 Entry Flight Loads

Descent loading conditions were well within the design conditions for the Orbiter and within the flight restrictions established for the STS-1 mission. The maximum Z load factor measured was 1.6g (allowable 2.0g), and maximum dynamic pressure was 300 psf (allowable 375 psf). Both of these maximum values were measured during the flare maneuver just prior to landing.

Flight data for the STS-1 landing were also reviewed to evaluate payload bay loading. The sources of loading data included flight condition measurements such as horizontal velocity, sink rate, speed brake and body flap position, rudder position, and pitch rate as well as the payload bay accelerations.

The main gear impact conditions were well below the payload design requirements. Data indicated that the sink rate at main gear impact was about 1 ft/sec.

The nose gear impact velocity was calculated from the measured body pitch rate to be 5.7 ft/sec as compared with the payload and Orbiter design requirement of 11.0 ft/sec. The payload bay accelerations for nose gear impact are shown in table 2-XII and compared to the preflight verification loads cycle results. Note that they are for different nose gear impact sink rates. As can be seen, the flight values are well below design requirements, as expected. Landing analyses are currently underway to calculate gear loading and corresponding vehicle response for the nose gear impact of 5.7 ft/sec to compare with the flight measurements.

2.6.5 Aerodynamic Pressure Distribution

The aerodynamic pressures measured on the Orbiter during STS-1 ascent and descent are being analyzed in support of FTR 08VV018.

2.6.6 Window Cavity Conditioning System

A desiccant system is provided to preclude contamination of the inner window cavities during flight. The crew indicated that a film deposit was observed on the outer window pane, but the inner panes remained clear throughout the flight, indicating the desiccant system functioned satisfactorily.

2.7 MECHANICAL SYSTEMS

The following mechanical systems functioned during STS-1: ingress/egress hatch, purge and vent door drives, Orbiter/external tank (ET) separation, payload bay doors drive and latch, radiator deploy/stow and latch, star tracker door drives, air data probes deploy/retract, and landing and deceleration. The aerothermal seals subsystem is a passive subsystem used primarily to provide thermal protection for structural elements during ascent and entry. The ejection seats were required to perform the following primary functions: crew support and constraint; vertical positioning; back angle positioning for ascent; suit oxygen and ventilation connections; and communication and biomedical connections. The airlock hatches A and B and seat ejection access door operational subsystems were not operated during STS-1.

2.7.1 Purge and Vent Subsystem

The purge and vent subsystem provided the unpressurized compartments of the Orbiter with an air purge that thermally conditioned system components, prevented hazardous gas accumulation, and equalized compartment pressures during ascent and descent.

All purge and vent system requirements (FTR 38VV001) were satisfactorily accomplished during the STS-1 flight. The prelaunch purge timeline requires a changeover from air to gaseous nitrogen approximately 90 minutes prior to main propulsion system cryogenic loading to insure that the vehicle is inert in the event of a hydrogen leak. The changeover occurred approximately 3 hours prior to launch (102:01:18 G.m.t.).

TABLE 2-XI.- ORBITER ACCELERATIONS AT LIFT-OFF[1]

Axis	Measurement location X_o	Y_o	Z_o	STS-1 measured, g	Preflight, g
Normal Y	511	3	424	-0.19	0.87
Normal Z	511	0	424	3.5	1.43
Normal Z	825	-102	407	2.8	1.85
Normal Z	974	102	407	2.9	1.75
Normal Z	973	-103	407	2.9	1.83
Normal Y	979	-11	302	0.40	-0.45
Normal X	1294	-2	297	-2.10[2]	-2.41
Normal Y	1294	-2	300	0.25	-0.66
Normal Z	1294	-2	289	-1.25	-0.95

[1] The first two measurements are located in the crew module, and the remaining seven measurements are located in the payload bay.

[2] Measurement saturated.

TABLE 2-XII.- PAYLOAD BAY ACCELERATIONS STS-1 LANDING

Axis	Measurement location X_o	Y_o	Z_o	STS-1 measured nose impact (5.7 ft/sec), g	Preflight verification nose impact (11.0 ft/sec), g
Normal Y	511	3	424	0.1	0.21
Normal Z	511	3	424	1.85	4.08
Normal Z	825	-102	407	1.62	2.79
Normal Z	974	102	407	1.41	2.07
Normal Z	973	-102	407	1.40	2.23
Normal Y	979	-11	302	0.1	0.42
Normal X	1294	-2	297	0.58	0.84
Normal Y	1294	-2	300	0.1	0.23
Normal Z	1294	-2	289	1.38	1.92

The Orbiter oxygen concentration, excluding the cabin, was below the one percent (by volume) requirement for inerting within 30 minutes after beginning the gaseous nitrogen purge. The gaseous nitrogen purge flowrate and temperature in the forward fuselage purge circuit were 98 lb/min and 87.4° F, respectively. The gaseous nitrogen flowrate and temperature in the midfuselage circuit were 299 lb/min and 79.6° F except for a planned flowrate reduction at T-11 minutes to 175 lb/min. The gaseous nitrogen flowrate in the aft fuselage purge circuit was 110 lb/min with the purge gas temperature at 75° F prior to cryogenic loading and 98° F from tanking to lift-off. All prelaunch flowrates and temperatures were as expected.

Beginning at T-35 seconds, the vent doors were commanded from their purge configuration to the fully open position for ascent venting. All vents doors operated within the two-motor maximum design time of 5 seconds. The vent doors were commanded on schedule, as shown in the table 2-XIII. The last vent door indicated open during prelaunch operations 6.3 seconds before launch, satisfying the T-4 second all-vent-doors-open criterion for launch.

The vent doors remained open during ascent and during the on-orbit period except for a brief period during the day 2 on-orbit rehearsal activities. At 104:17:42:24 G.m.t., the crew commanded the vent doors closed in preparation for entry. The doors were closed during the high-heating phase of entry to protect the structure around the vents from the effects of entry. The vent doors stayed closed during entry until the ground relative velocity was 2400 ft/sec (104:18:14:28 G.m.t.), at which time the doors were commanded open for Orbiter repressurization. The vent doors remained open through touchdown and rollout. After rollout (104:18:28:44 G.m.t.), the crew commanded the vent doors to a postlanding purge configuration.

Measured internal compartment pressures and bulkhead pressure differentials for ascent and entry were reviewed and are within structural design limits. Higher base heat shield pressures were measured during ascent than were predicted preflight on the basis of wind tunnel test data. This resulted in slightly higher aft fuselage structural pressure differentials, but not in excess of the structural design limits. Data evaluation showed that during entry, the OMS pod pressure did not increase when the helium purge was initiated (see flight test problem report 61).

Postflight inspection of the left-hand and right-hand wing vent ducts revealed cracks in both ducts on the outboard fairing side. The ducts serve to vent and repressurize the wings during ascent and entry. The aluminum ducts appear to have been fatigued. Section 8.0, flight test problem report 51, discusses this problem in detail.

2.7.2 Orbiter/External Tank Separation and Umbilical Devices

The Orbiter/ET separation subsystem (i.e., umbilical separation and retract, Orbiter/ET structural separation and umbilical doors closure) performed normally during STS-1. Postflight inspection of the liquid hydrogen and the liquid oxygen umbilicals indicated that both were properly retracted and in the uplocked position. Damage was noted in two of the six umbilical separation system blast containers. Both damaged blast containers had a single 3/8 to 1/2 in. fracture in the sidewall area. Section 8.0, flight test problem report 43, discusses this problem in detail.

There was no evidence of damage to either of the electrical disconnects or the umbilical closeout curtains.

The Orbiter/ET structural separation subsystem functioned on STS-1 at 102:12:08:55 G.m.t. An inspection of the structural separation hardware was conducted and, in conjunction with analysis, showed that the forward structural attachment had functioned as required.

TABLE 2-XIII.- STS-1 PRELAUNCH VENT OPENING

Vent	Event	Right side, G.m.t.	Operating time, seconds	Left side, G.m.t.	Operating seconds
4 and 7	Closed	102:11:59:26.9		102:11:59:26.7	
	Open	:30.7	3.8	:30.3	3.6
3	Closed	:59:31.9		:59:31.3	
	Open	:35.7	3.8	:35.3	4.0
6	Closed	:59:36.7		:59:36.9	
	Open	:40.3	3.6	:40.7	3.8
5	Closed	:59:41.9		:59:41.7	
	Open	:45.7	3.8	:45.3	3.6
1 and 2	Purge	:59:45.9		:59:45.7	
	Open	:48.9	3.0	:48.3	2.6
8 and 9	Purge	:59:50.7		:59:50.6	
	Open	:53.7	3.0	:53.4	2.8

The separation bolt/monoball assembly was rotated to the flush position by the centering mechanism, and the shear bolt piston was recessed within the outer moldline (0.014-in.). The aerothermal smoothness requirement is ± 0.030-in. maximum at this location. The dry-film lubricant on the monoball had been discolored by the entry heating.

Operation of the aft structural attachments (i.e., socket liners, washers, and retaining hardware) was normal, and all parts were intact and in good condition. The aft attach hole pluggers, which minimize the escape of debris through the bolt holes after separation, had closed off the bolt holes. External tank separation films confirmed a normal separation. It could be seen that the aft attach bolts had retracted into the ET ball fittings as expected.

The ET umbilical doors closure functioned at 102:12:17:31 G.m.t. All functions required for door closure operated within the designed allowable time limits.

2.7.3 Payload Bay Doors and Radiators

The operation and performance of the PLBD and radiators during the STS-1 mission was satisfactory and without anomalies. Tables 2-XIV (FTO 151-02) and 2-XV (FTO 151-03) show the payload bay door and radiator operating sequences.

2.7.4 Star Tracker Doors

The star tracker doors' actuation mechanism performed normally during STS-1 mission. STS-1 operational time to open or close doors was approximately 6 to 8 seconds. The design time for door actuation is 8 seconds for two motors and 15 seconds for one motor.

2.7.5 Air Data Probe

The air data probe deployment mechanism performed noramlly during the STS-1 mission. The port air data probe deployment was initiated at 104:18:13:06 G.m.t. and was fully deployed at 104:18:13:19 G.m.t. The starboard air data probe deployment was initiated at 104:18:13:09 G.m.t. and was fully deployed at 104:18:13:22 G.m.t. Total deployment time for each probe was 13 seconds. The design deployment time is 15 seconds for two motors and 30 seconds for one motor.

2.7.6 Landing Deceleration Subsystem

The landing deceleration system provided acceptable deployment, landing, and rollout performance during STS-1.

2.7.6.1 Landing Gear Deployment: Landing gear deployment was initiated 22 seconds before touchdown, at 104:18:20:35.965 G.m.t., and the last gear was down and locked 16 seconds before landing. This deployment time (6 seconds) was well within the maximum of 10 seconds allowed for deployment. All deployment mechanisms, hydraulics, and pyrotechnic devices performed normally; no backup pyrotechnic systems were required for deployment. During deployment, the hardened outer sleeve around the right main gear uplock roller fell from the Orbiter when the door opened. The broken parts were found 1.54 miles from the touchdown point. Section 8.0, flight test problem report 26, contains a discussion of this anomaly.

2.7.6.2 Landing and Rollout: Touchdown occurred at 104:18:20:57.254 G.m.t. at a sink rate of less than 1 ft/sec. Table 2-XVI provides detailed performance values regarding landing velocities, distances, pitch rates, and times. Figure 2-12 is a plot of ground speed during landing. Rollout was very nearly down the centerline of the runway. Nose wheel steering was not engaged since there was no crosswind and no other steering requirement.

TABLE 2-XIV.- PAYLOAD BAY DOOR OPENING AND CLOSING EXERCISES

Event	Actuator operating time, seconds[a] (two motor operation)					
Centerline latches	First sequence	Second sequence	Third sequence	Fourth sequence	Fifth sequence	Sixth sequence
- 5 through 8 - Unlatch	18	--	18(4)			
- Latch	--	18(3)	--			
- 9 through 12 - Unlatch	16	--	18(4)			
- Latch	--	18(3)	--			
- 1 through 4 - Unlatch	18	--	18(5)			
- Latch	--	15(2)	--			
- 13 through 16- Unlatch	16	--	16(5)			
- Latch	--	15(2)	--			
Bulkhead latches						
- Right forward - Unlatch	25	--	25(6)			
- Latch	--	26(1)	--			
- Right aft - Unlatch	24	--	24(6)			
- Latch	--	25(1)	--			
- Left forward - Unlatch	--	--	--	25(7)	--	25(9)
- Latch	--	--	--	--	25(8)	--
- Left aft - Unlatch	--	--	--	24(7)	--	24(9)
- Latch	--	--	--	--	24(8)	--
Doors						
- Right - Deploy	53	--	52	--	--	--
- Stow	--	94[b]	--	--	--	--
- Left - Deploy	--	--	--	52	--	52
- Stow	--	--	--	--	52	--

[a] Like numbers in parentheses () operated simultaneously.
[b] Includes 39 seconds for crew door-alignment sighting.

TABLE 2-XV.- FIRST RADIATOR UNLATCH/DEPLOYMENT EXERCISE

Event	Actuator operating times,[a] second (two motor operation)
Radiator latches	
-Right 1 through 6 - Unlatch	23(1)
-Right 7 through 12- Unlatch	22(1)
-Left 1 through 6 - Unlatch	23(2)
-Left 7 through 12 - Unlatch	23(2)
Radiator actuation	
Right deployment	37(3)
Left deployment	38(3)

[a] Like numbered parentheses () operated simultaneously.

TABLE 2-XVI.- LANDING DECELERATION SUBSYSTEM PERFORMANCE

	Velocity, knots	
	Estimated air speed	Ground relative velocity
Main gear touchdown[a]	185	192
Nose gear touchdown	146	151
Braking initiated	104	108

Distance from main to nose wheel contact, ft	3099
Distance from nose contact to brake initiation, ft	2853
Braked roll, ft	3041
Braked duration, seconds	34
Pitch rate at nose wheel contact, deg/sec	4.8
Sink rate at main gear touchdonw, ft/sec	<1
Total rollout, ft[b]	8993
Rollout duration, seconds	61
Touchdown points from threshold	
Left main, ft	6053
Right main, ft	6073

Note:

[a] Touchdown straddled centerline within 8 inches

[b] Drifted 14 ft to left of centerline - gradual from touchdown to stop

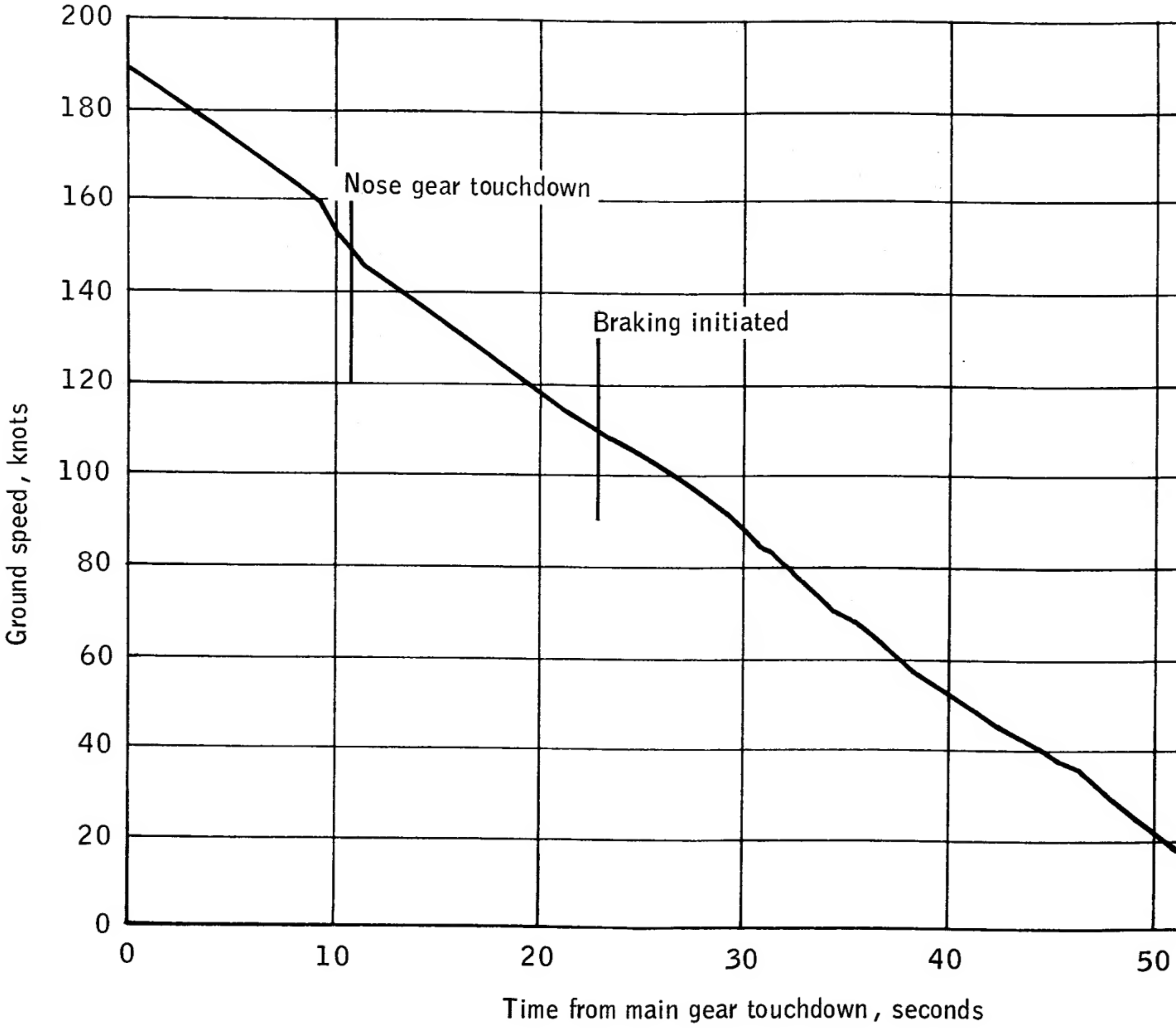


Figure 2-12.- Ground speed during landing and rollout.

The left-hand outboard tire had a cut through five of 17 plys (34 ply rated) of carcass fabric. This cut was located 2 in. from the centerline of the tire and measured 1-1/4 in. long x 3/8 in. wide by 11/32 in. deep. Section 8.0, flight test problem report 25, contains a discussion of this condition.

Postflight data revealed that the right-hand inboard brake received higher than expected pressure on one of its two pressure channels. This apparently was compensated for by the Commander, who balanced the total braking to each side of the Orbiter, thus producing a straight course down the runway. The crew did detect a slight pull to the right just before stopping. Section 8.0, flight test problem report 27, contains a discussion of this anomaly.

2.7.7 Aerothermal Seals

The control surface aerothermal seals satisfactorily performed their primary function of restricting gas flow entry to the hinge cavity areas. An inspection of the right-hand elevon seal has revealed a cracked seal housing in the wing tip assembly. Gouge marks found on the adjacent seal indicate binding. After the removal of the high-temperature reusable surface insulation (HRSI) carrier panels at the elevon cove, the flexible reusable surface insulation (FRSI) bonded to the lower cove seal panels was found to have thermal damage to the coated surfaces at the outboard areas. This damage was apparently caused by spanwise flow in the cove. Volatile deposits were carried into the wing/elevon cavity, and there is evidence of leakage into these cavities. These deposits were found in the vicinity of hinge seals, polymide radial seals, and the honeycomb lower cove panels. The deposits are a white to rust-brown color and were determined, by analysis, to be tile residue by-products. There is no apparent thermal damage as a result of the leakage.

The perimeter seal on the rudder/speed brake trailing edges was damaged on entry. The bottom 5 in. of the flange were torn away, as was a smaller piece at the top. These damaged parts will be removed and replaced. All other control surface aerothermal seals (body flap and vertical tail conical seals) were in good condition when inspected during postflight operations.

The DFI temperature measurements were not obtained for a portion of the STS-1 entry; therefore, a complete assessment of the performance of the subsystem compared with the predicted temperatures is not possible.

The door thermal barriers and pressure seals satisfactorily accomplished their function of restricting gas flow, on entry, from entering at these penetration areas and overheating the airframe structure, except for the right main landing gear door (section 8.0, flight test problem report 49). Some evidence of flow past the tile flow barriers around all lower surface doors was evident from volatile deposits on the thermal barriers and their supports.

A small amount of fraying of the AB312 cloth was evident on some thermal barriers. The forward nose gear door thermal barrier was torn loose just before landing when the nose gear door was opened. This was observed on films of the landing, and the thermal barrier was found on the lakebed approximately 1-1/2 miles before the touchdown point. Discussion of this anomaly is contained in section 8.0, flight test problem report 44.

2.7.8 Crew Escape System

The crew escape system ejection seats properly provided the crew with support and constraint, vertical positioning, back angle positioning for ascent, oxygen and ventilation connections for suited operations, and communications and biomedical connections.

Once on orbit, the crew reported difficulty with installing the scramble handle safety clip and the D-ring safety pin (see section 8.0, flight test problem report 41). One crewmember experienced difficulty installing the D-ring safety pin following landing. The crew were able to push the scramble handle down and install the safety clips. Both were able to install the D-ring safety pin.

2.7.9 Pyrotechnics

All pyrotechnic functions on the Orbiter were successfully completed. The forward attachment shear bolt and two aft frangible nuts along with six frangible nuts on the umbilical-plates separated the Orbiter from the external tank after ascent. The nose landing gear extension thruster assisted in deploying the nose gear and doors just prior to landing. All backup or emergency devices were unfired.

One NASA standard detonator at the outboard position on the liquid hydrogen umbilical plate was unfired. Postflight inspection revealed that the wiring and associated detonator connector were destroyed by shrapnel from the successful operation of the companion (redundant) detonator in the frangible nut. This condition may be expected when a sufficient time skew exists between firing circuits A and B to allow detonation products from the first detonator to impact the second detonator or wiring. The normal detonator function time is 100 microseconds, with an anticipated skew of 1.5 to 2 milliseconds. A discussion of this conditions is contained in section 8.0, flight test problem report 38.

2.8 THERMAL

2.8.1 Thermal Control

2.8.1.1 Prelaunch and Ascent: The main propulsion system cryogenic childown induced significant air temperature gradients in the aft fuselage compartment. Generally, 70° F air temperature was recorded in the proximity of the X_0 1307 bulkhead, but bulk temperatures as low as 32° F were recorded in the proximity of the base heat shield.

With the exception of the aft fuselage structure, overall structural temperatures were responsive to ambient conditions. Generally, the aft structure was cold biased due to the cryogenic childown effects, with the base heat shield area reading the coldest at 34° F.

During the launch attempt on April 10, 1981, an anomalous heater thermostat was observed in the flash evaporator system secondary feedwater zone 4 circuit, and this condition required switching from heater system 1 to system 2. The corrective action was required to preclude a potential freezing situation, and average temperatures were raised 30° F by the switchover. Overall, thermal control of other critical subsystem components/ lines requiring heater operation was maintained. Several OMS crossfeed heater zones operated at high duty cycles because of the cold bulk gas near the base heat shield; whereas heater systems near the warm bulkhead did not operate at all. Section 8.0, flight test problem report 1c, contains a discussion of this anomaly.

The integrated main engine/Orbiter hydraulic system performed within the required specification temperature limits. During prelaunch, the engine inlet oil temperatures were maintained at approximately 102° F, well within the required 60° F to 150° F range. During ascent, the engine inlet temperature increased to a maximum of 165° F at auxiliary power unit shutdown, a temperature that is considerably less than the 250° F maximum allowable. A typical oil inlet temperature profile during prelaunch and ascent for one of the main engines is shown in figure 2-13.

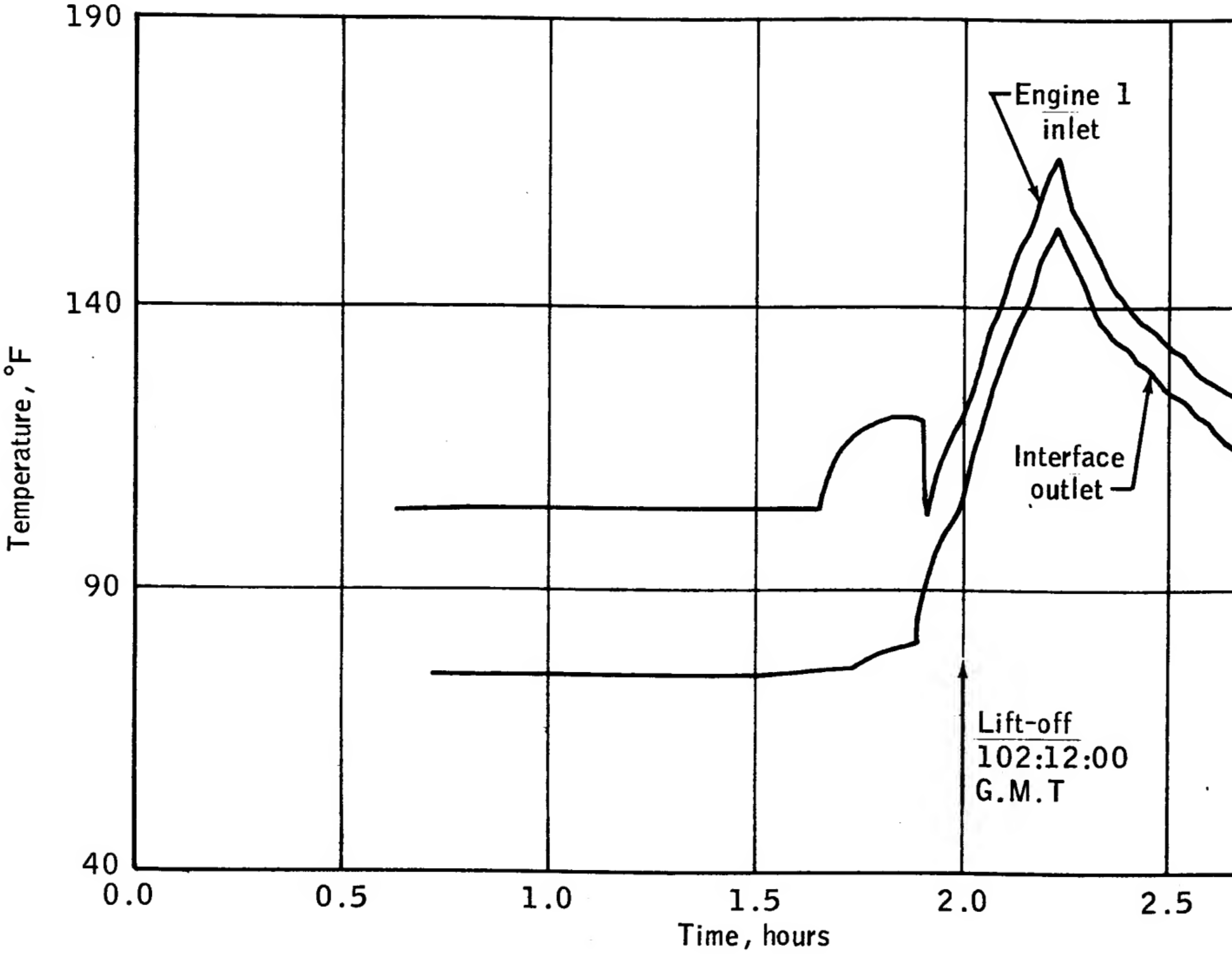


Figure 2-13.- Main engine/orbiter hydraulic oil temperature.

Compartment and insulation venting adequacy has not been evaluated at this time because of the unavailability of on-orbit data. However, a concern exists over the differential pressure observed during ascent between the forward lower equipment bay and the payload bay volume.

Differential pressure gage V07P9083 exceeded 0.10 psid at approximately 102:12:00:30 G.m.t. and reached a peak of 0.312 psid at approximately 102:12:01:23 G.m.t. The concern is that the liner and liner level insulation blankets are designed for a limit pressure differential of 0.10 psi. There is no evidence at this time that any damage occurred to the insulation. However, the liner was not installed for this flight, and since the liner would seal vent paths through the insulation, a higher differential pressure would be realized on flights where the liner is installed. Gage calibration is planned to determine the validity of the data.

2.8.1.2 On-Orbit: During on-orbit operations, the primary structure of the Orbiter showed a trend toward warmer temperatures than predicted with virgin external thermal protection system (TPS) coating properties. The bottom structural areas beneath the black high temperature reusable surface installation (HRSI) TPS were approximately 5° to 20° F warmer than predictions during the extended Z axis local-vertical hold periods. However, the structure below the white low-temperature reusable surface insulation/felt reusable surface insulation (LRSI/FRSI) TPS areas ran 20° to 35° F warmer than virgin predictions (figs. 2-14 and 2-15). This trend indicates a definite increase in virgin TPS solar absorptance in the LRSI/FRSI regions in particular. Initial on-orbit structural cooldown rates were also generally slower than predicted, and temperature responses to attitude and environment changes were slower than anticipated, indicating larger mass effects in the Orbiter. These conditions imply longer times to reach limits, but also longer recovery times.

Pre-entry bondline temperatures were within acceptable entry interface requirements as the result of the pre-entry cooldown attitudes, with most areas considerably below the entry start temperatures required for STS-1. The more critical bottom bondline regions ranged from 3° to 37° F at entry interface compared with the normal entry requirements of 60° F. Conditioning attitudes for payload bay door closure and lower midbody wing glove thermal stress at entry interface achieved expected temperature levels. Temperatures of the longeron, 582 frame, and bottom midfuselage skin on entry day resulted in maximum predicted door overlap due to structural thermal gradients of 0.6 in. at X_0 756 with the port door latched at the bulkheads and starboard door free. These temperatures gave slightly more benign structural gradients than predicted for the STS-1 conditioning attitudes. The crew's readout of the payload bay door deflections showed a 3-1/2 inch overlap (see paragraph 2.7).

The combination of the top-sun solar inertial pre-entry conditioning attitudes with the black-top wing glove TPS coating achieved the expected warming of the top and bottom wing glove structure areas. Entry interface temperatures on the bottom fuselage (10° F) and wing glove areas (21° to 24° F) were within 10° F of predicted temperatures. Structural temperature levels in the terminal area energy management time period (approximately 104:15:30 G.m.t.) were at lower levels than predicted for the normal STS-1 entry, but temperature gradients were comparable to predictions.

The forward RCS bulk propellant temperatures decreased from an initial on-orbit temperature of approximately 82° F to a low of approximately 73° F, well above the minimum limit of 60° F to prevent thruster valve seat leakage. The RCS and OMS bulk propellant temperatures decreased from an initial on-orbit temperature of 80.5° to 74° F for the port RCS oxidizer and 79.5° to 73.5° F for the port OMS oxidizer during the on-orbit phase. Ample margin existed above the 70° F minimum limit to prevent RCS primary engine "zots" during entry.

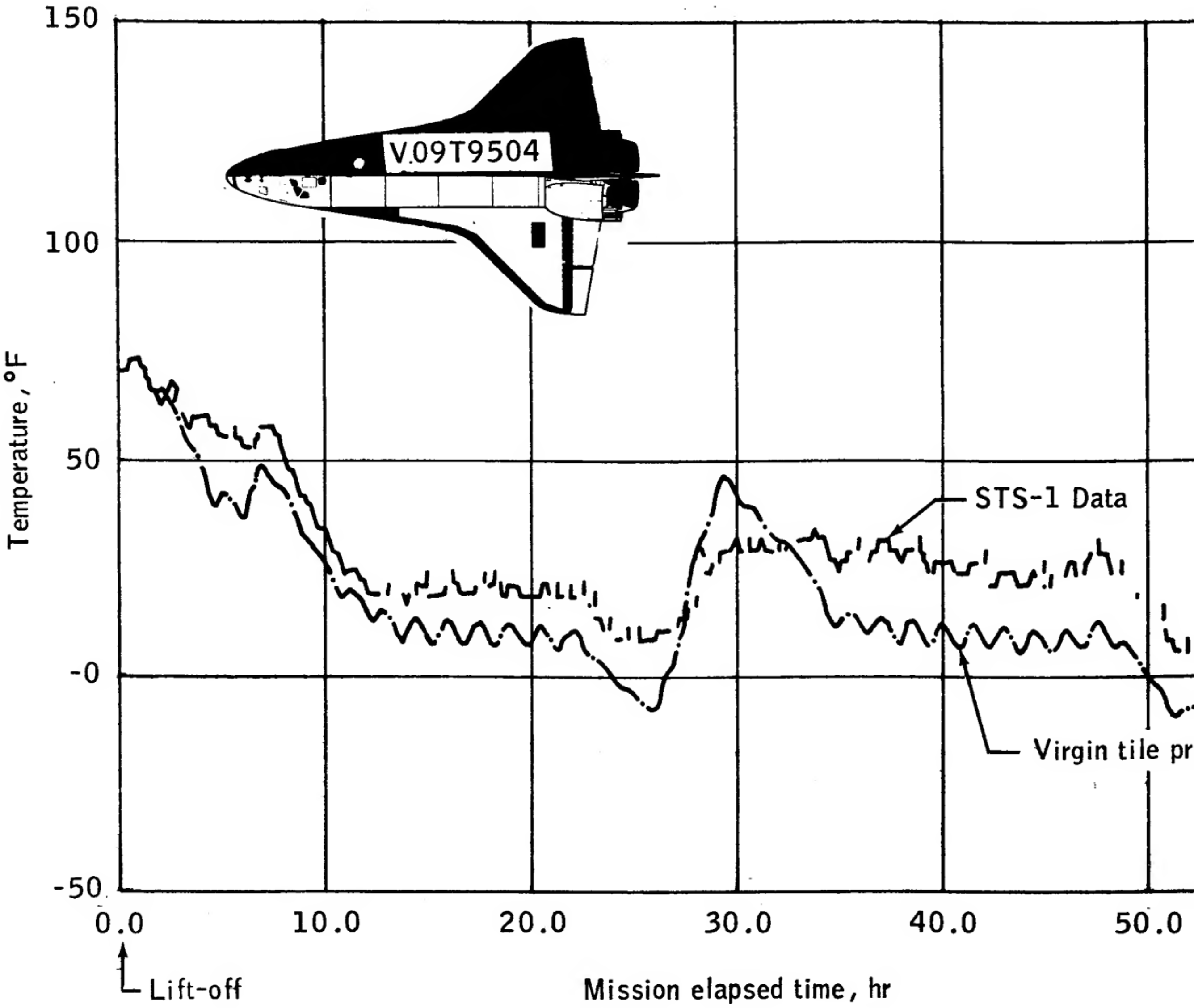


Figure 2-14.- Structural temperature response on bottom fuselage.

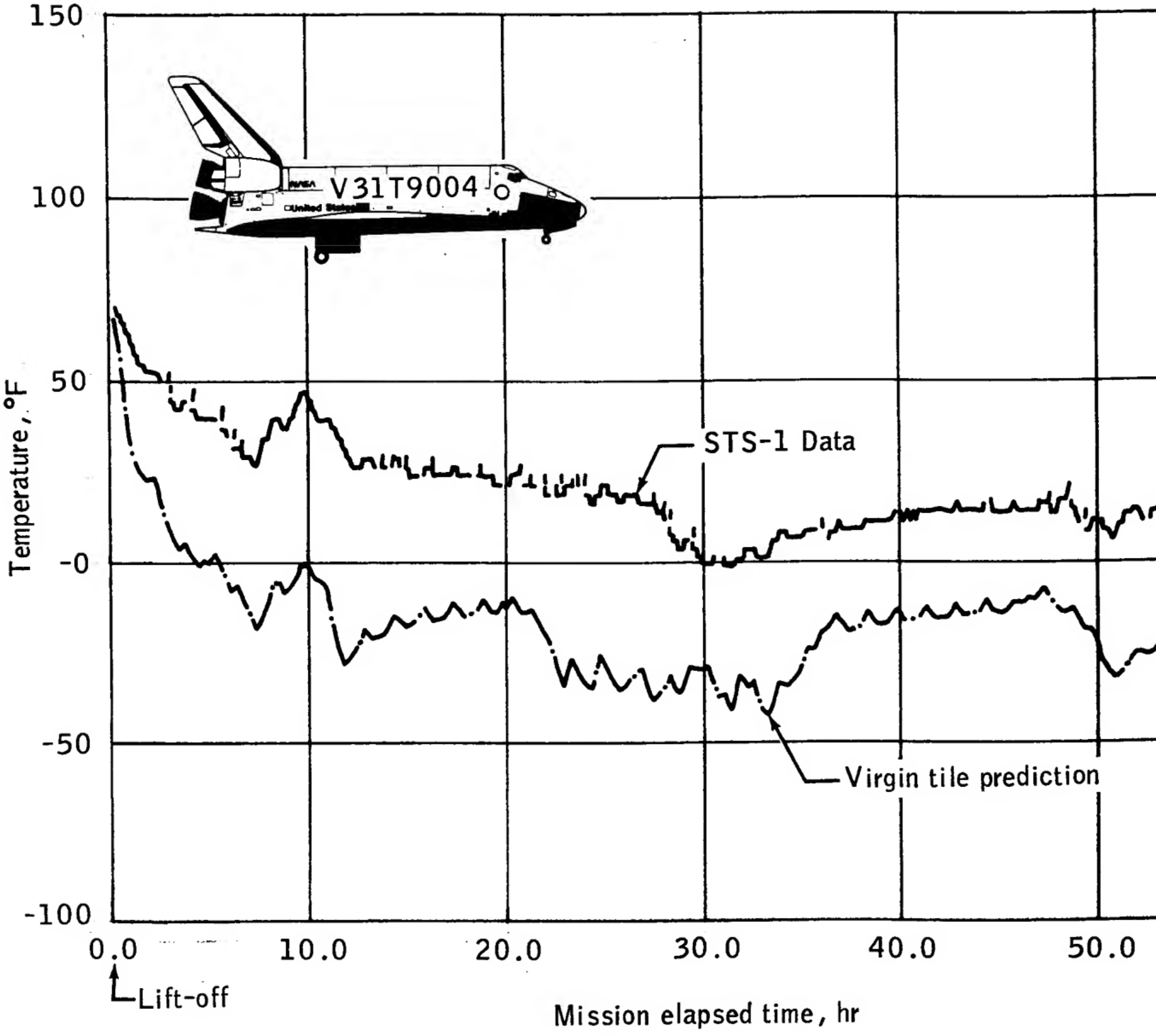


Figure 2-15.- Structural temperature response on forward side fuselage.

No hydraulic system component heaters were activated, and the warm STS-1 environment maintained all hydraulic system return line temperatures above the 0° F circulation pump turn-on temperature.

The main and nose landing gear strut actuators and landing gear dump valves were significantly above their minimum full performance temperatures of -35° and -20° F, respectively These components uniformly cooled from their lift-off temperature of 75° to 55° F for the nose landing gear strut actuators and 25° F for the left main landing gear dump valve and strut actuators.

Overall heater performance was adequate to maintain temperatures within required ranges. At this time, the loss of on-orbit recorded DFI data limits the understanding of actual mission environments and the effect of this environment on heater systems performance. Generally, the internal compartment environments were warmer than predicted. Therefore, for those systems which exhibited a higher duty cycle than expected, further evaluation is required to determine that acceptable performance will occur on the colder STS-3 and STS-4 missions. Of the 145 thermal control system heater thermostat locations which were enabled, 115 (80 percent) of the heaters cycled during the mission.

Of particular interest is the performance of the forward RCS compartment heaters. The port heater came on for the first time at 35:20:00 mission elapsed time (MET) as compared with an expected time of 16 hours MET, and this would indicate that the loss from the compartment was much less than expected (see section 8.0, flight test problem report 1e). However, the heater remained on (100-percent duty cycle) until it was disabled, as planned, for entry. A typical temperature response of the port panel heaters is shown in figure 2-16. The expected duty cycle was approximately 25 percent. In addition, the temperatures of the heater panels ranged from 115° to 130° F maximum as compared with an expected range of 132° to 153° F (see section 8.0, flight test problem report 1f). This would indicate either a larger than expected compartment or a heat leak or lower than expected voltage. Evaluation is underway to identify potential causes. No problems are anticipated for STS-2 since the planned major attitude, payload bay to earth, is the same as that of STS-1.

The forward and aft RCS engine heater duty cycles were, in general, two to three times higher than predicted. Further evaluation is required to determine the potential impact for colder missions. Of the eight port OMS pod heater systems, five heaters cycled as expected. In addition, the outboard Y-web heater was predicted to come on but did not. Except for the oxidizer drain/inboard Y-web heater, all first-on times were later than predicted, and duty cycles were less than predicted. Of the eight starboard OMS pod heater systems, only the keel web heater came on; whereas six heaters were expected to operate, similar to the port pod. The lower duty cycles and later first-on times were probably due to the warmer environments experienced during flight.

The flash evaporator feedlines in the midbody, except for the forward starboard zone that did not come on, showed significantly higher duty cycles (30 percent as compared with 10 to 15 percent predicted) than expected with shorter on periods. This is of some concern for colder missions since the actual flight environment was warmer than expected. The aft fuselage flash evaporator line-heater duty cycles compared very well with predictions; however, the actual environment is suspected to have been slightly warmer.

Four APU fuel feed system and water cooling system thermostats exhibited anomalous performance (section 8.0, flight test problem report 1). In general, the APU fuel feed and service line and water cooling heater systems compared well with preflight predictions. Duty cycles were near or below predictions.

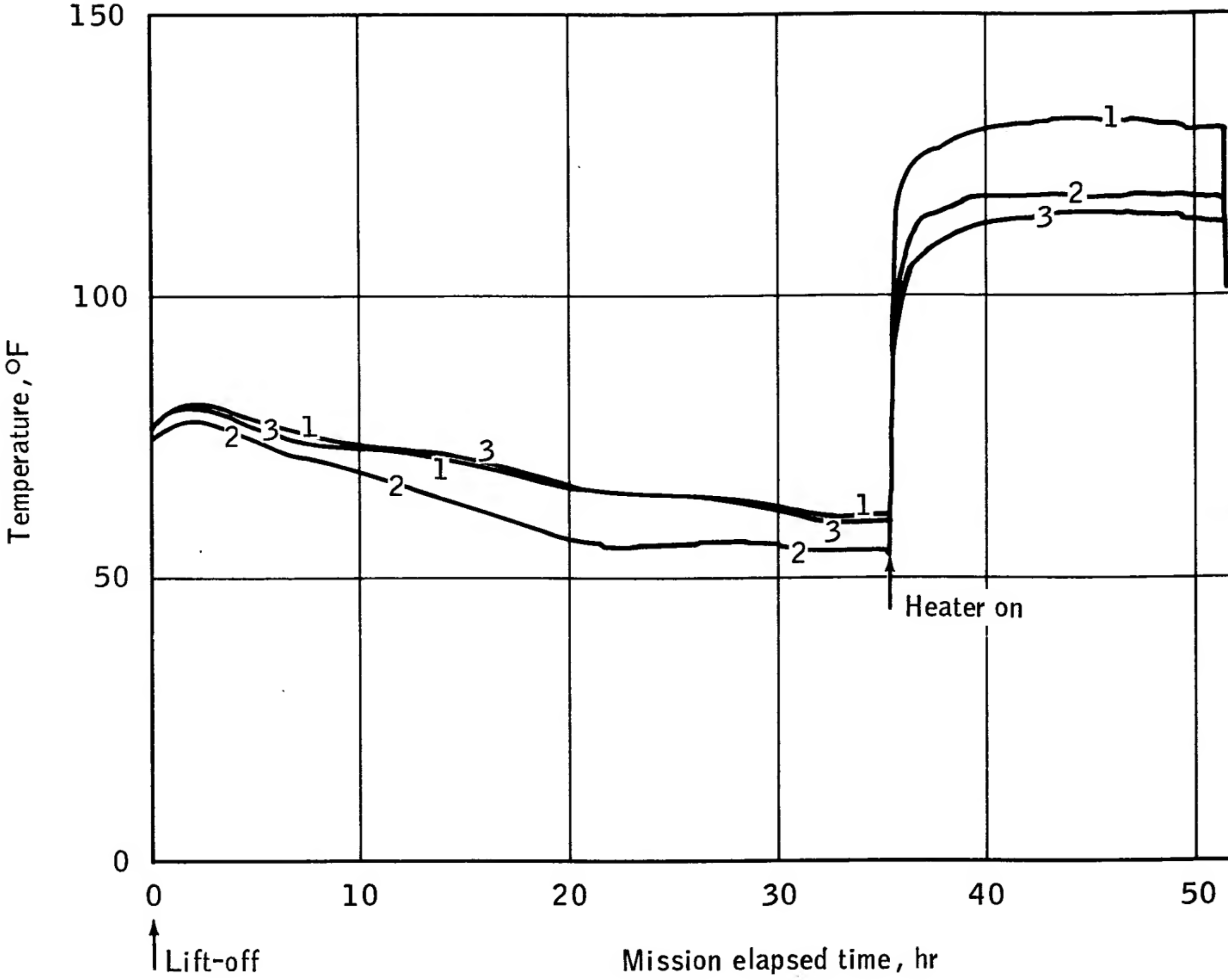


Figure 2-16.- Typical temperature response in RCS forward compartment.

Anomalous performance of two OMS crossfeed bleedline heater thermostats and, potentially, one temperature transducer was observed (section 8.0, flight test problem report 1). Crossfeed line heater performance compared well with predicted values; however, the high point bleed zone 13 and low point drain zone 14 duty cycles were one-half to twice as great as predicted. Further evaluation is planned to determine if there is any impact on colder missions.

In addition to the prelaunch FES feedline and the forward RCS compartment heater problems discussed previously, ten other anomalous thermal conditions associated with heater thermostats and monitoring temperature transducers were identified in the FES water feed system auxiliary power unit (APU) fuel, APU water cooling, environmental control life support system (ECLSS) potable water dump line, and OMS crossfeed systems. Section 8.0, flight test problem report 1, discusses these anomalies in detail.

At 103:09:30 G.m.t., the FES feed water line heaters on the port side were switched from system A heaters to system B heaters, the switch resulting in a temperature amplitude change (figure 2-17). Mislocation of the temperature transducer is suspected.

A heater switch reconfiguration on APU fuel 1 from system B to system A was made after 102:16:00:00 G.m.t. to preclude the possibility of hydrazine freezing (35° F) because of unacceptable thermostat performance (thermostat creep). A similar thermostat creep response was observed on the APU 3 injector cool-water line with heater system B enabled. After the preplanned heater switch reconfiguration at approximately 103:08:00:00 G.m.t., acceptable thermostat performance was observed on heater system A. Furthermore, after this APU switch reconfiguration from system B to system A, additional thermostat creep anomalies were identified on the APU 3 secondary water cooling line and APU 3 primary water cooling line. However, no temperature limit violations occurred as a result of the anomalous operation.

A potential control thermostat "on" condition on the OMS low-point drain line zone 15, system A, was observed at the start of the on-orbit mission. It appears that the over-temperature thermostat (normal settings - 70° to 90° F) on system A was the controlling thermostat whenever system A was enabled. However, when system B was enabled, only the control thermostat (normal settings - 55° to 75° F) resumed control. It is suspected that the problem is because of the installed location of the temperature transducer.

2.8.1.3 Entry and Postlanding: The maximum bondline temperatures observed during entry (real-time measurements) were 233° F on the starboard OMS pod and 222° F on the port OMS pod. Initial entry interface temperatures were 19° and 6° F for the starboard and port pods, respectively.

The maximum bottom fuselage real-time measurement bondline temperature observed was 214° F at X_0 1215 centerline. Entry interface temperature was 21° F at this location.

The hydraulic system was maintained above the minimum full performance entry temperature during entry and postlanding. The delayed start of hydraulic system 1 did not prevent the system from achieving the required minimum full performance temperature at touchdown minus 10 minutes (approximately 104:18:20:58 G.m.t.). Prior to entry, the minimum line temperatures were 54° F for the elevon actuators, 45° F for the rudder speedbrake, and 28° F for the body flap. At landing minus 10 minutes, their respective temperatures were 180°, 154°, and 210° F, all of which are considerably above the minimum requirements of 75°, 35°, and 45° F, respectively.

Entry and postlanding thermal soakback evaluation is incomplete at this time. The largest responses observed at this time occurred on forward RCS propellant lines, where responses increased from approximately 60° to 88° F. Forward RCS propellant tanks increased approximately 5° F.

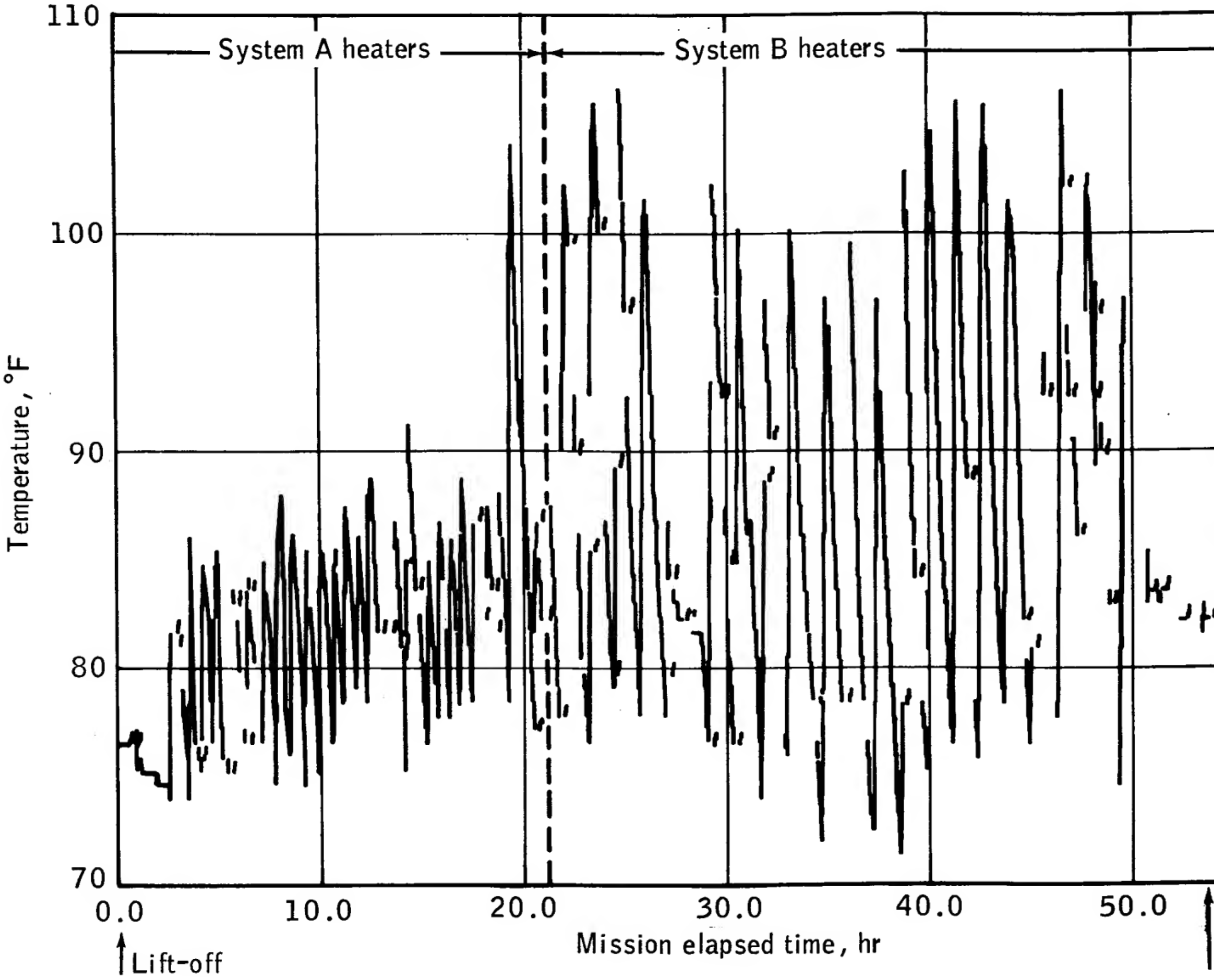


Figure 2-17.- Flash evaporator feed line temperature amplitude change.

2.8.2 Thermal Protection

2.8.2.1 Leading Edge Structural Subsystem: Visual inspection of the nose cap and wing leading edge panels indicated that the leading edge structural subsystem (LESS) elements were in good shape. However, 11 wing panels (nine right-hand and two left-hand) had discoloration areas of unknown origin. Initial investigation indicates that these discolorations are typical of coating repair after heating.

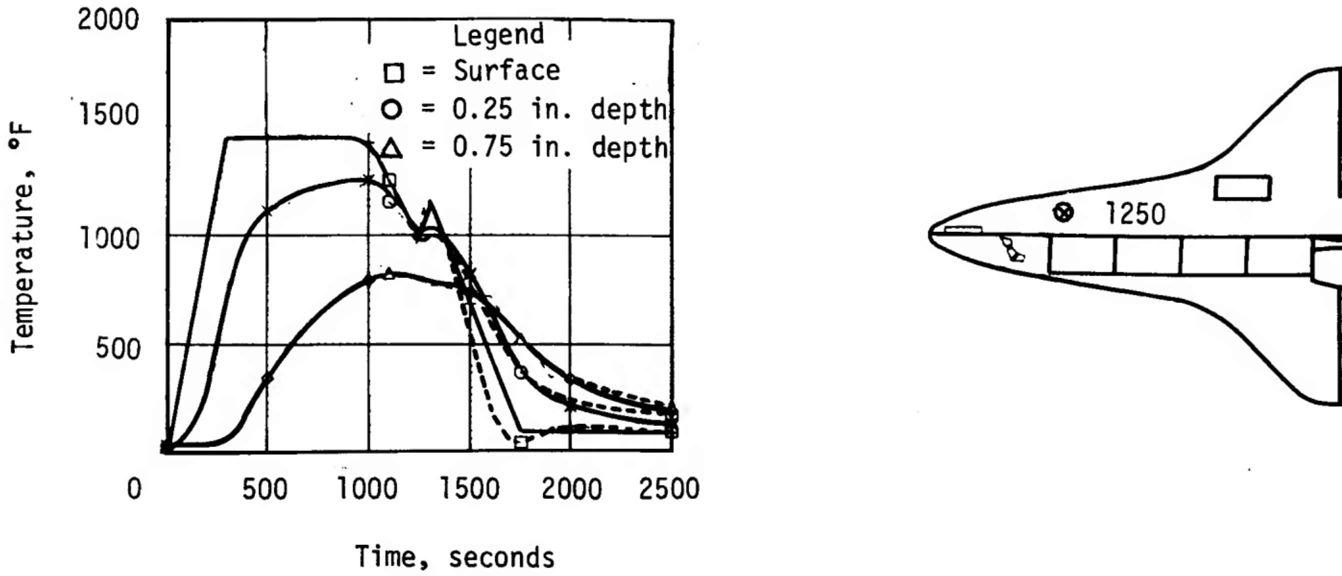
2.8.2.2 Thermal Protection Reusable Surface Insulation Subsystem: The objective of the Orbiter thermal protection system (TPS) verification flight test requirement (FTR) 09VV001 is to verify the thermal performance, structural integrity and reusability of the TPS for the operational entry conditions. This verification will be completed during the remainder of the OFT program because entry flight data were lost above a velocity of 15,300 ft/sec and the STS-1 flight objectives could not be completely satisfied. However, sufficient data were obtained to indicate that the thermal performance of the TPS supports an entry with turbulent transition on-set as predicted using the 30 mil roughness heating analysis. Using the preflight 30 mil roughness heating predictions as inputs to the analysis models show reasonable agreement with the in-depth tile and structural temperature measurements noted after data acquisition on STS-1. Some structural temperature measurements, however, show a drastic slope change at approximately Mach 1.0. The preliminary assessment indicates that a potential internal convective cooling effect occurs below Mach 1.0. Figures 2-18, 2-19, and 2-20, compare the flight data with the 30 mil heating prediction temperatures at three locations on the lower fuselage. Figure 2-19 shows the cooling effect starting 1700 seconds into entry.

The detailed postflight inspection showed that extensive minor surface damage occurred to the surface of the TPS tiles. The inspection showed 303 surface dings and gouges and 98 tile coating chips. Approximately 80 percent of the dings and gouges occurred during ascent as evidenced by entry heating effects on the damaged tiles (section 8.0, integrated flight test problem report 8). The remainder probably occurred during landing. Preliminary estimates are that the TPS surface damage was caused by ice, frost and/or spray-on-foam insulation (SOFI) coming off of the external tank. Fortunately, the lower entry surface temperatures (nominal versus RSS worst case combination of uncertainties) resulted in much less sensitivity to damage than the preflight testing at the RSS-indicated temperature levels. Significant damage was found on the right nose gear door (8 in. x 2 in. x 1 in. deep gouge), (fig. 2-21), the right inboard elevon lower surface (coating loss of about 25 in^2) (fig. 2-22), and the left lower forward region of the body flap (about 2 in. diameter coating impact damage) (fig. 2-23). The body flap damage propogated into a significant melting of approximately one-half of the tile. (See section 8.0, flight test problem report 56.)

Also, the inspection showed that extensive surface contamination to the TPS outer surfaces occurred. Room temperature vulcanizing 577, used as gap filler, was deposited as a combination of calcium and zinc oxide on the surface of the downstream tiles. Acoustic sensors on the lower forward fuselage depositied iron oxide, chrome, and nickel on the surfaces of downstream tiles. Aluminim oxide from the solid rocket boosters was deposited on the surfaces of the aft region tiles. The aluminum oxide on the lower surface of the body flap (fig. 2-23), subsequently fused with the coating during the heat of entry. Considerable calcium and zinc oxide from the RTV in the elevon cove region was deposited on the lower surfaces of the elevons. An unknown contaminant reacted with the low-temperature reusable surface insulation (LRSI) coating on the sides of the mid-fuselage (fig. 2-24).

Excessive tile-to-tile gap heating was noted in a number of locations. The leading edge of the left nose gear door had breaching of the thermal barrier and localized shrinkage of the sidewalls of four adjacent tiles (fig. 2-25). No structural or pressure seal

High temperature reusable surface insulation tile comparison



Tile strain isolation pad comparison

Bondline comparis

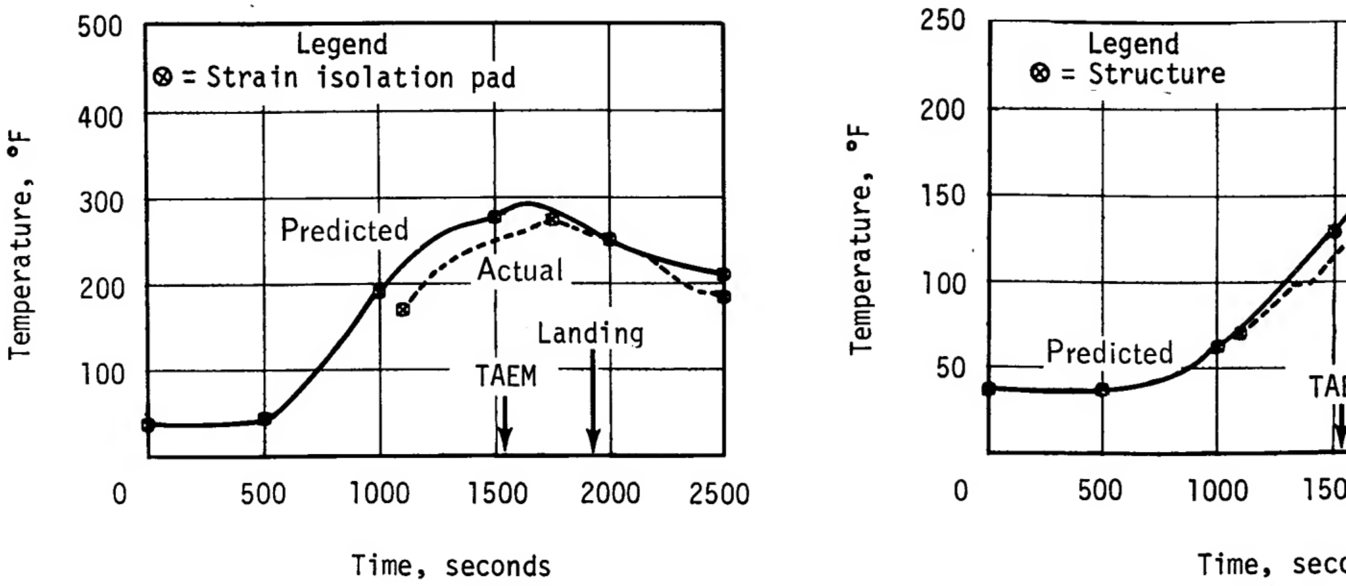


Figure 2-18.- Temperature comparisons at body point 1250 on lower fuselage

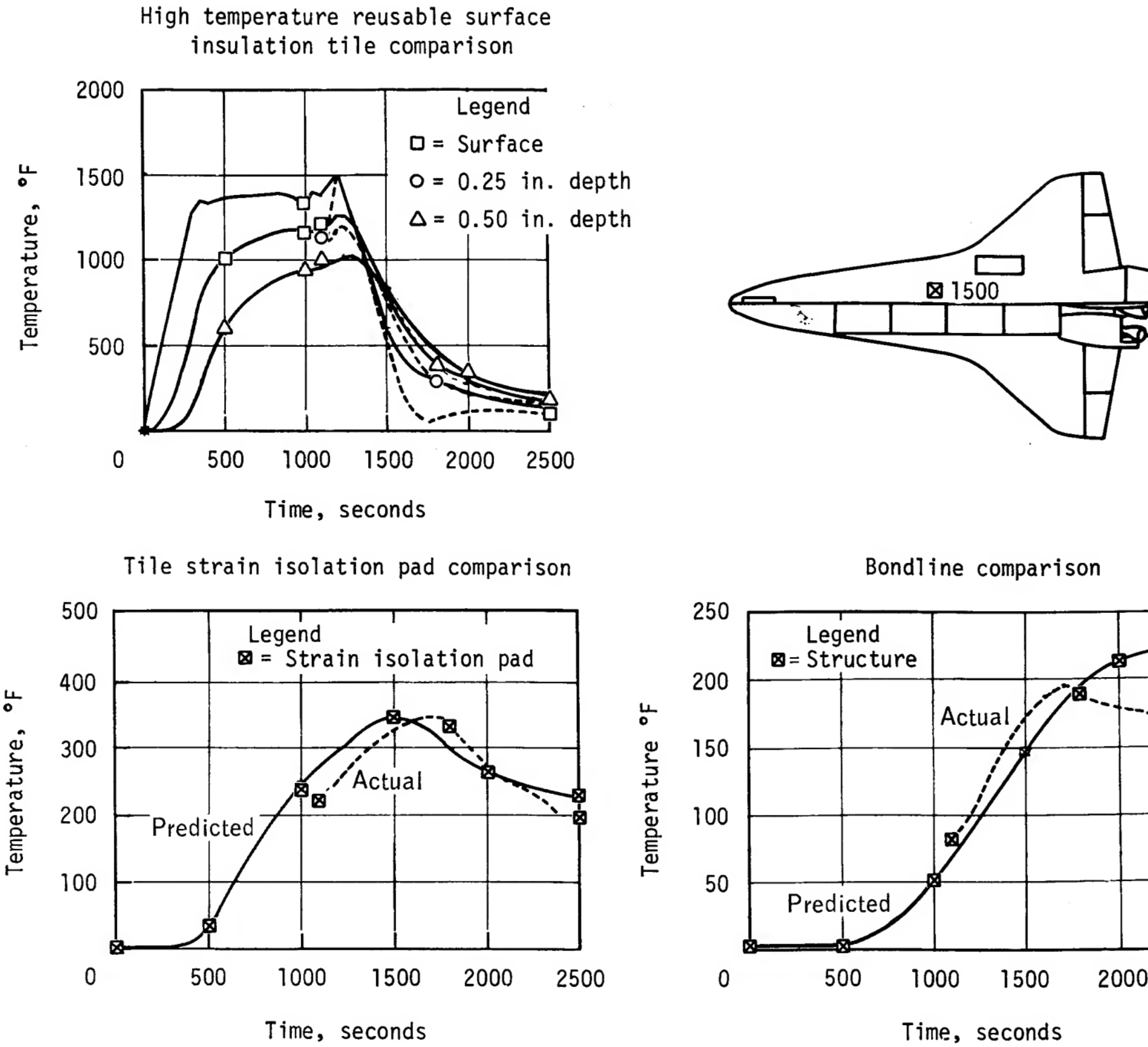


Figure 2-19.- Temperature comparisons at body point 1500 on lower fuselage

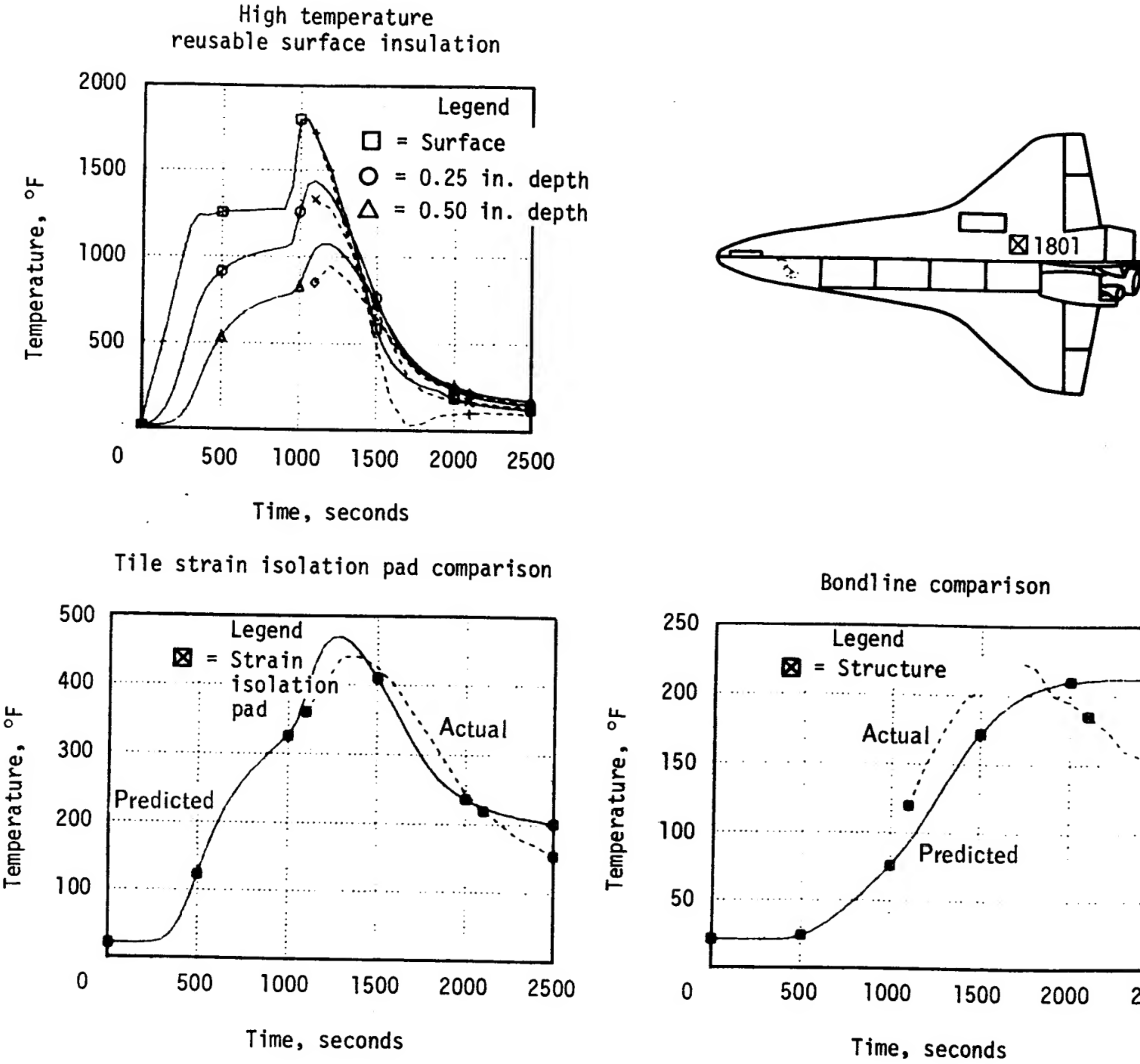


Figure 2-20.- Temperature comparisons at body point 1801 on lower fuselage

Figure 2-21.- Thermal damage to right nose landing gear door.

Figure 2-22.- Coating loss on lower surface of right inboard elevon.

Figure 2-23.- Impact damage to left lower forward region of body flap.

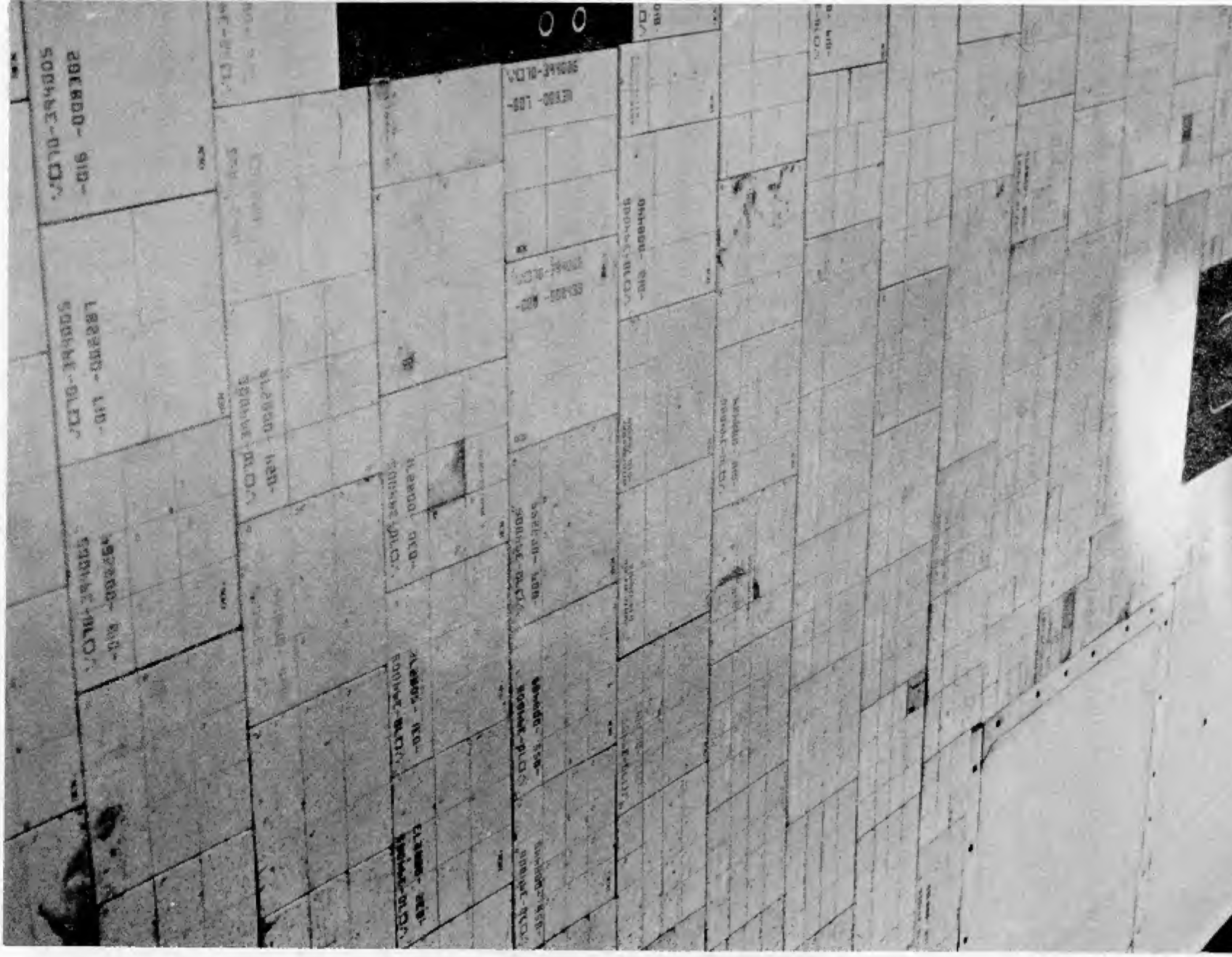


Figure 2-24.- Coating loss caused by unknown contaminant.

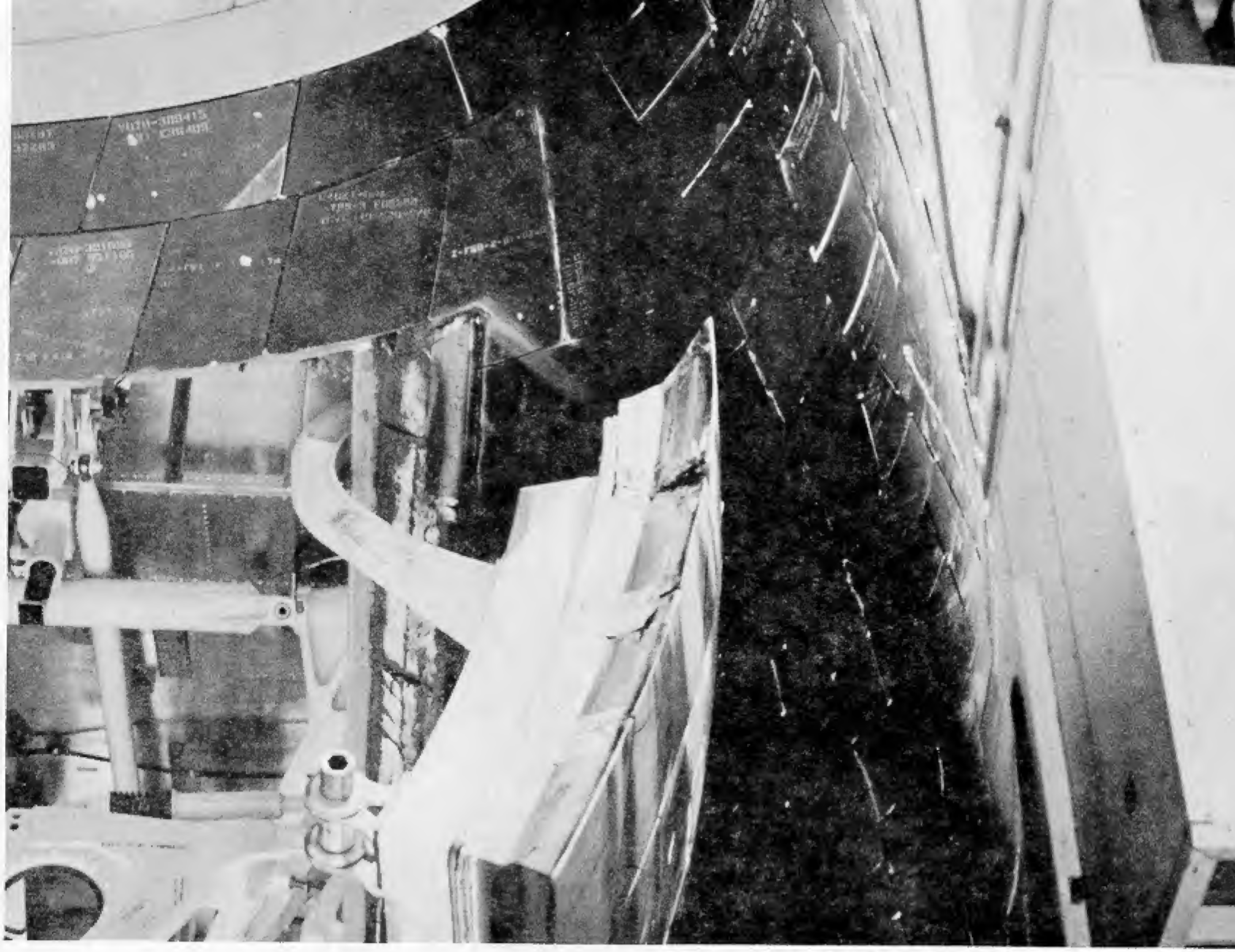


Figure 2-25.- Breaching of thermal barrier on leading edge of left nose gear door.

damage occurred. Excessive gap heating occurred in a local area of the right main landing gear door. Tile sidewall shrinkage, filler bar charring and a buckle in the local aluminum structure occurred (Section 8.0, flight test problem report 49). Approximately 250 other locations had discolored and/or charred filler bar. Parameters affecting this excessive gap heating are forward facing tile-to-tile steps, tile-to-tile gaps, local pressure gradients, tile-to-filler bar gaps and soft strain isolation pad (SIP).

The forward latch fitting on the right external tank door protruded from the outer mold line and showed evidence of some discoloration/distortion from the STS-1 entry. A better fit check and installation procedure will be used in the future to preclude this problem from recurring. This problem is discussed in detail in Section 8.0, flight test problem report 29.

The maximum allowable temperature of 1200° F was exceeded during entry on payload bay door hinge 7. The DFI temperature sensor on hinge 7 peaked at 1530° F. The hinge and components will be inspected and refurbished, if required, prior to STS-2. (Section 8.0, flight test problem report 55.) A black high emittance coating will be applied to all the bare hinges to reduce the maximum entry temperature on subsequent flights.

The elevon cove experienced higher than expected heating. Flow leakage under the wing trailing edge tile carrier plates was found. Also, spanwize flow in the cove was noted. The result of this higher heating was severe degradation of the RTV and felt reusable surface insulation (FRSI) in the cove region. However, no damage to the cove structure or seals was identified.

The orbital maneuvering system (OMS) pods experienced several significant problems during entry. The forward regions of the pods, covered with diced LRSI tiles, lost 16 pieces and/or tiles during ascent (fig. 2-26) (Section 8.0, flight test problem report 9). Entry heating with this missing TPS insulation caused 13 local delaminations of the OMS pod graphite-epoxy honeycomb structure (Section 8.0, flight test problem report 32).

The FRSI located on the forward area of the pods experienced higher than expected surface heating and this resulted in scorching of the white FRSI coating (fig. 2-27). The lower trailing-edge sides of the OMS pods experienced much higher heating than expected. Severe degradation of the FRSI occurred and delamination of the OMS pod structure occurred (fig. 2-28) (Section 8.0, flight test problem report 32).

Although a number of anomalies occurred during STS-1, the overall performance of the reusable surface insulation was outstanding. Minimal modifications will repair the majority of anomalies for multiple mission usage. The total estimated tile replacement prior to STS-2 is about 300, significantly below preflight estimates.

2.8.3 Aerothermodynamics

The objective of the Orbiter entry heating verification flight test requirement (FTR) 07VV024 was to verify that the thermal environment of the Orbiter during a normal entry follows predictions. The verification was to be demonstrated by comparisons of flight data from 24,600 ft/sec to 10,000 ft/sec relative velocity to wind tunnel data. Because flight data were not obtained above a velocity of approximately 15,300 ft/sec during STS-1 (recorder malfunction), the objective of the FTR was not completely satisfied. However, sufficient data were obtained to meet several objectives.

One objective was to determine the thermal protection system (TPS) roughness effects. A preliminary analysis indicates that boundary-layer transition on the forward 50 percent of the lower fuselage agrees with the smooth body of not more than 0.05-inch roughness

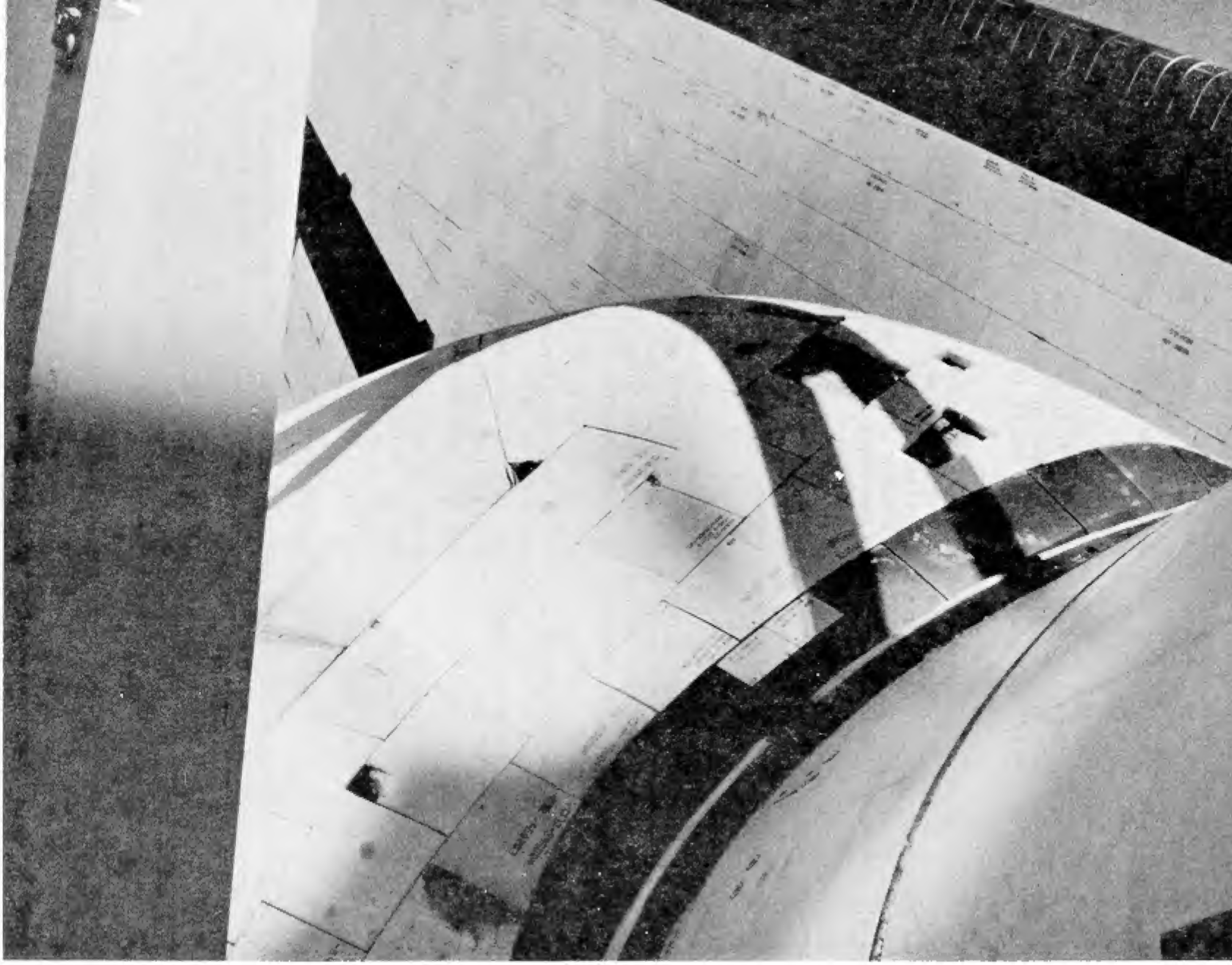


Figure 2-26.- Areas of lost tile on right OMS pod.

Figure 2-27.- Scorching of tile on forward edge of OMS pod.

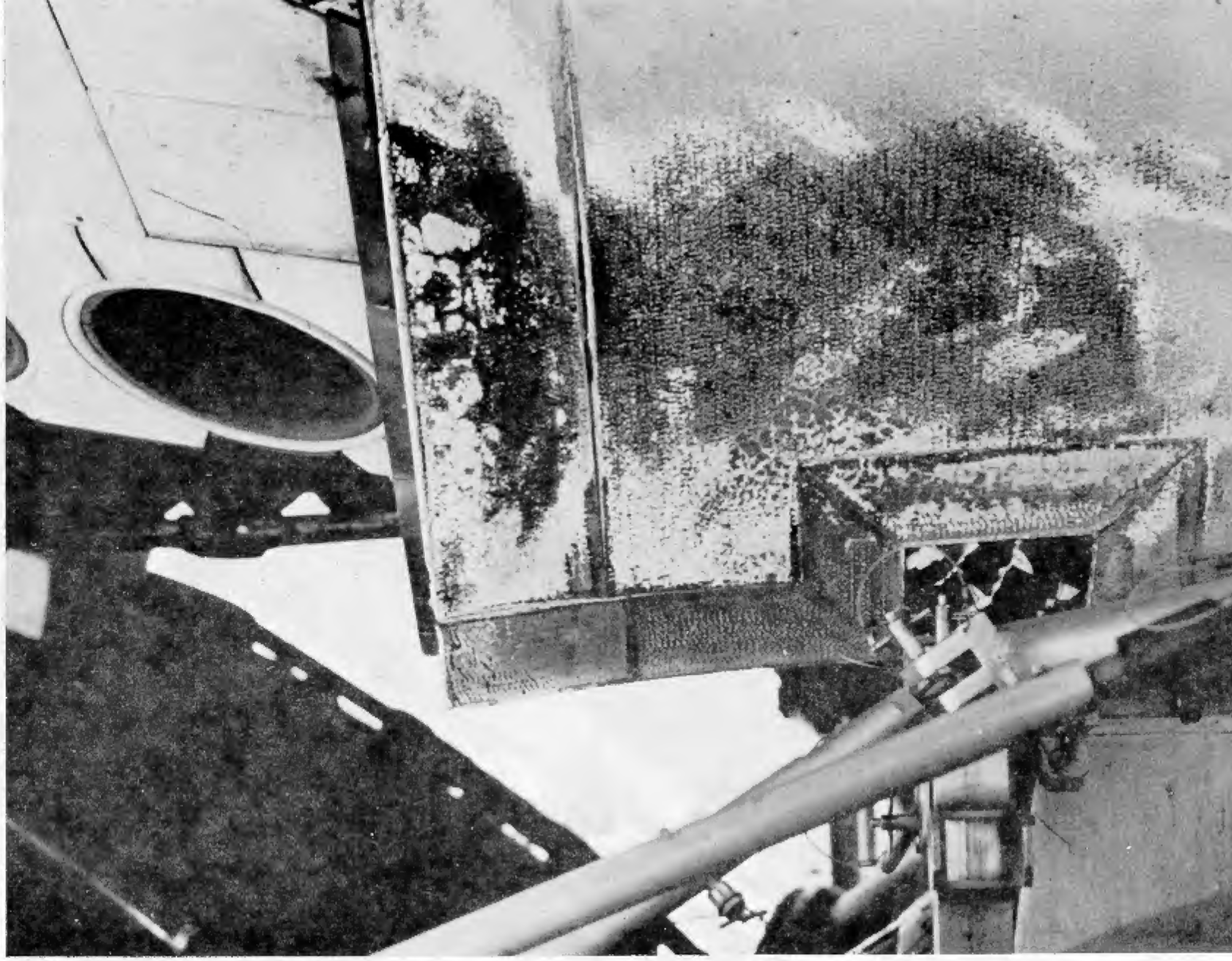


Figure 2-28.- Delamination of OMS pod structure.

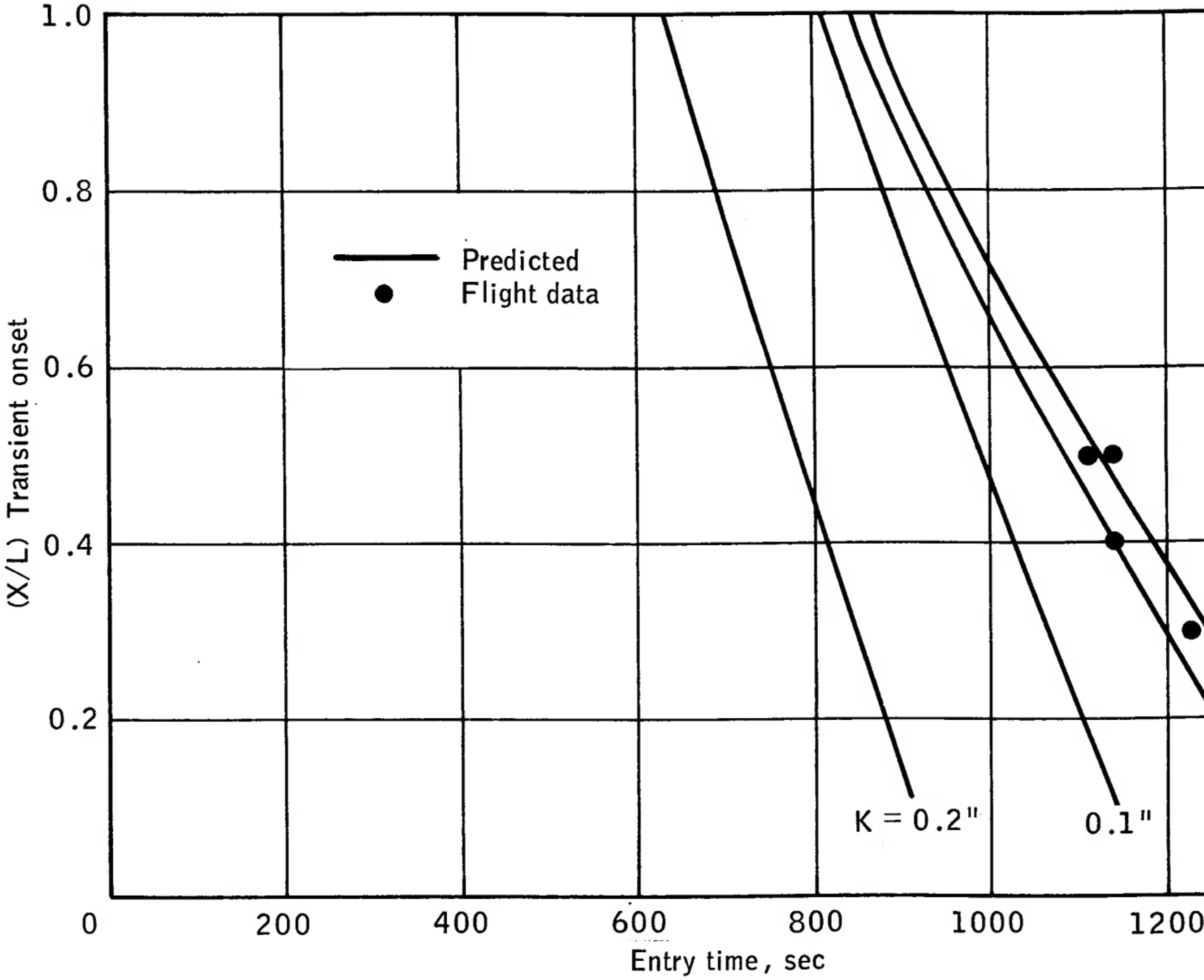


Figure 2-29.- TPS roughness effect on STS-1 boundary layer transition time

criterion predictions (figure 2-29). The higher velocity data are required to evaluate the aft fuselage boundary-layer environment. These data will allow a larger roughness criterion to be imposed on the installation of the Orbiter TPS. The data agreed with the turbulent predictions and with the laminar predictions lowered by 20 percent.

Another objective was to assess the applicability of wind tunnel data in predicting the OMS pod environment during entry. A cursory examination of the flight data indicates that the direct use of wind tunnel data in predicting OMS pod heating is very good.

The heating to the upper wing, vertical stabilizer, and upper and side fuselages was predicted with direct application of wind tunnel data. Preliminary assessment of the flight data shows both over and under predictions of heating to these regions.

The cause of the high temperature experienced by the lower portion of the aft OMS pod is not known. Tests are being conducted to resolve the phenomenon. Sensors will be relocated for STS-2 to determine the cause.

2.9 AERODYNAMICS

2.9.1 Ascent

Ascent aerodynamic coefficients have been extracted using OI telemetered data, strain gage data, preliminary propulsion data, preliminary ascent air data system data, and predicted mass properties. Also, telemetered base pressure data from the Orbiter and SRB were used to determine the vehicle power-on base effects.

The preliminary Orbiter-extracted aerodynamic coefficients are within variation bands of the predicted coefficients. The only exception is the axial force coefficient, which was expected to have extraction accuracy problems. The preliminary Orbiter base force data show that the Orbiter power-on base effects were significantly less than the predicted levels. These preliminary estimates were determined from flight base pressure measurements on the Orbiter. The cause of the lower-than-predicted base effects is attributed to exhaust gas afterburning, which results in larger plume boundaries than were obtained in the cold flow plumes during wind tunnel test.

2.9.2 Entry

2.9.2.1 Performance and Trim. - Comparisons of the predicted lift-to-drag (L/D) ratio and the predicted ± uncertainties data with the calculated STS-1 L/D ratio are shown in figure 2-30. There was no discernable difference between the predicted and actual calculated values down the last 100 ft before touchdown. At that point, ground effects occurred which caused the L/D to be higher than predicted. This difference was traced to the axial force coefficient that was lower than predicted (fig. 2-31).

The body flap functioned as predicted except at the higher Mach numbers (28 to 8) where the body flap was down 7 degrees further than predicted. Between Mach 21 and 12, the pitching moment coefficient flight values fall outside the predicted and uncertainties bank (fig. 2-32) (Section 8.0, flight test problem report 39). Below Mach 8, the pitching moment coefficient followed the predicted value.

2.9.2.2 Bank Reversals. - The initial bank reversal was performed at a dynamic pressure of 14 lb/ft. This reversal created several cycles of lightly damped motion that resulted in peak beta values of 4 degrees (fig. 2-33). Analysis and motion matching studies have shown that this discrepancy resulted from the rolling moment from the yaw thrusters. The predictions had this roll moment included, but at a higher level (fig. 2-34).

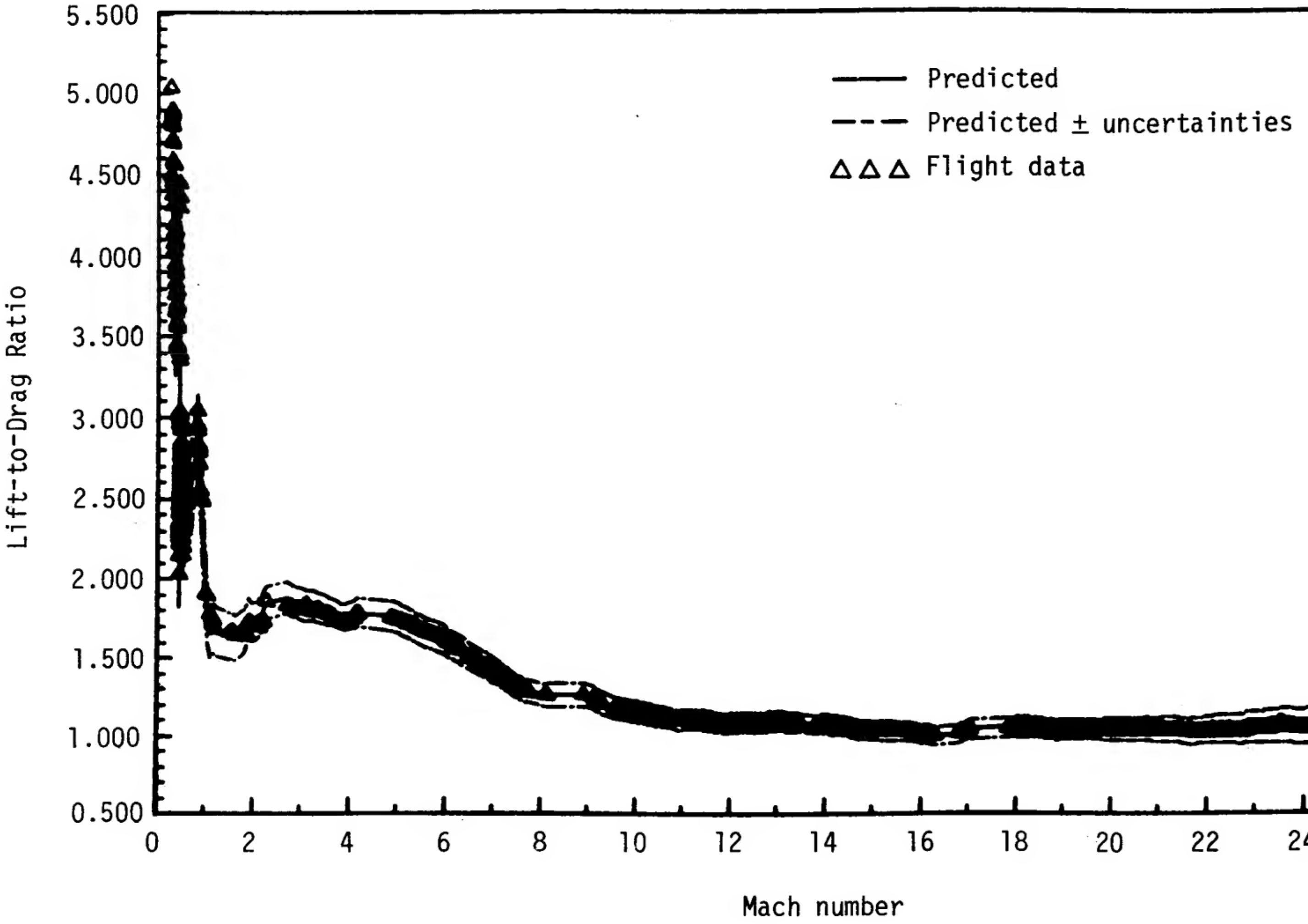


Figure 2-30.- Lift-to-drag ratio.

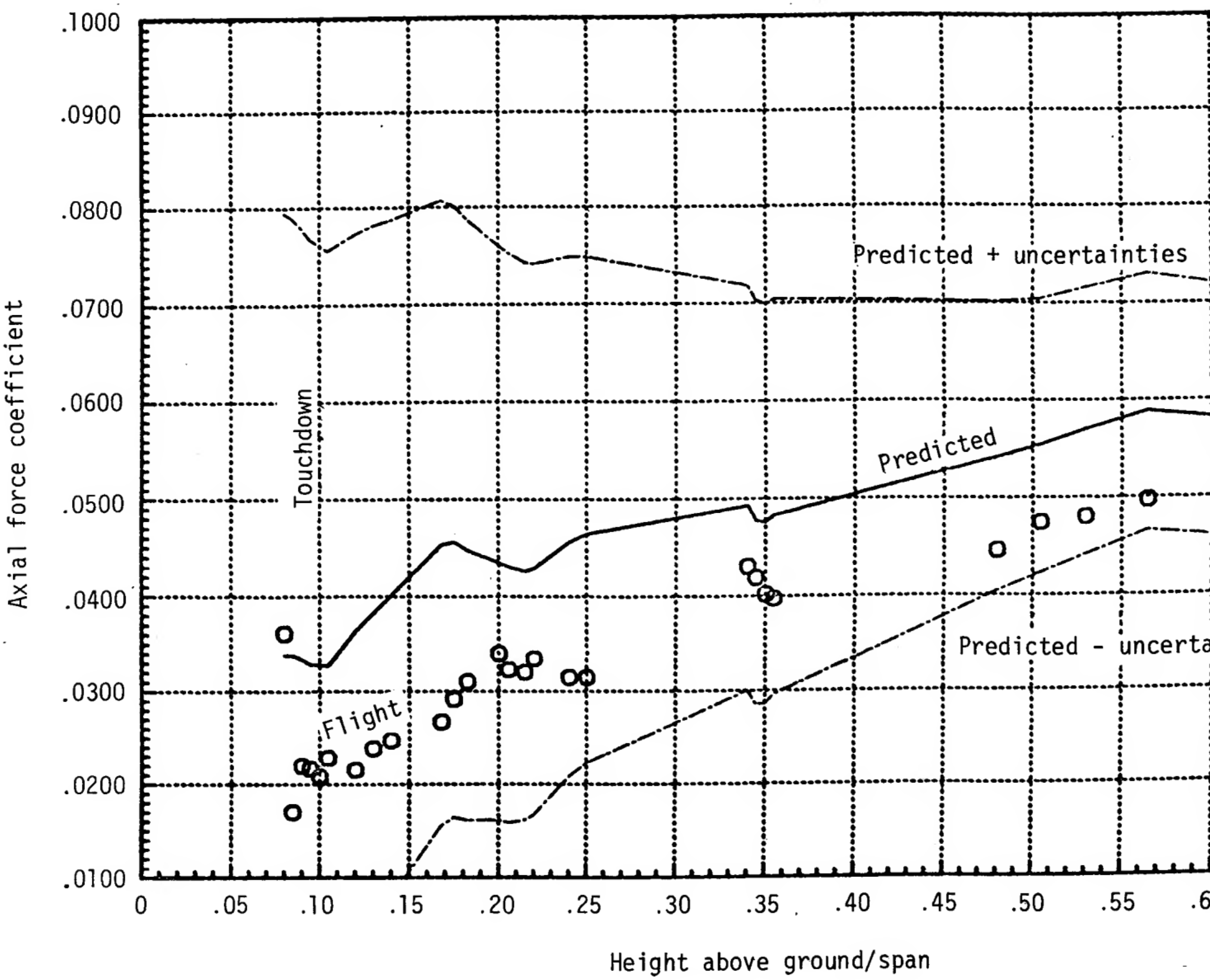


Figure 2-31.- Lower than predicted axial force coefficient during landing.

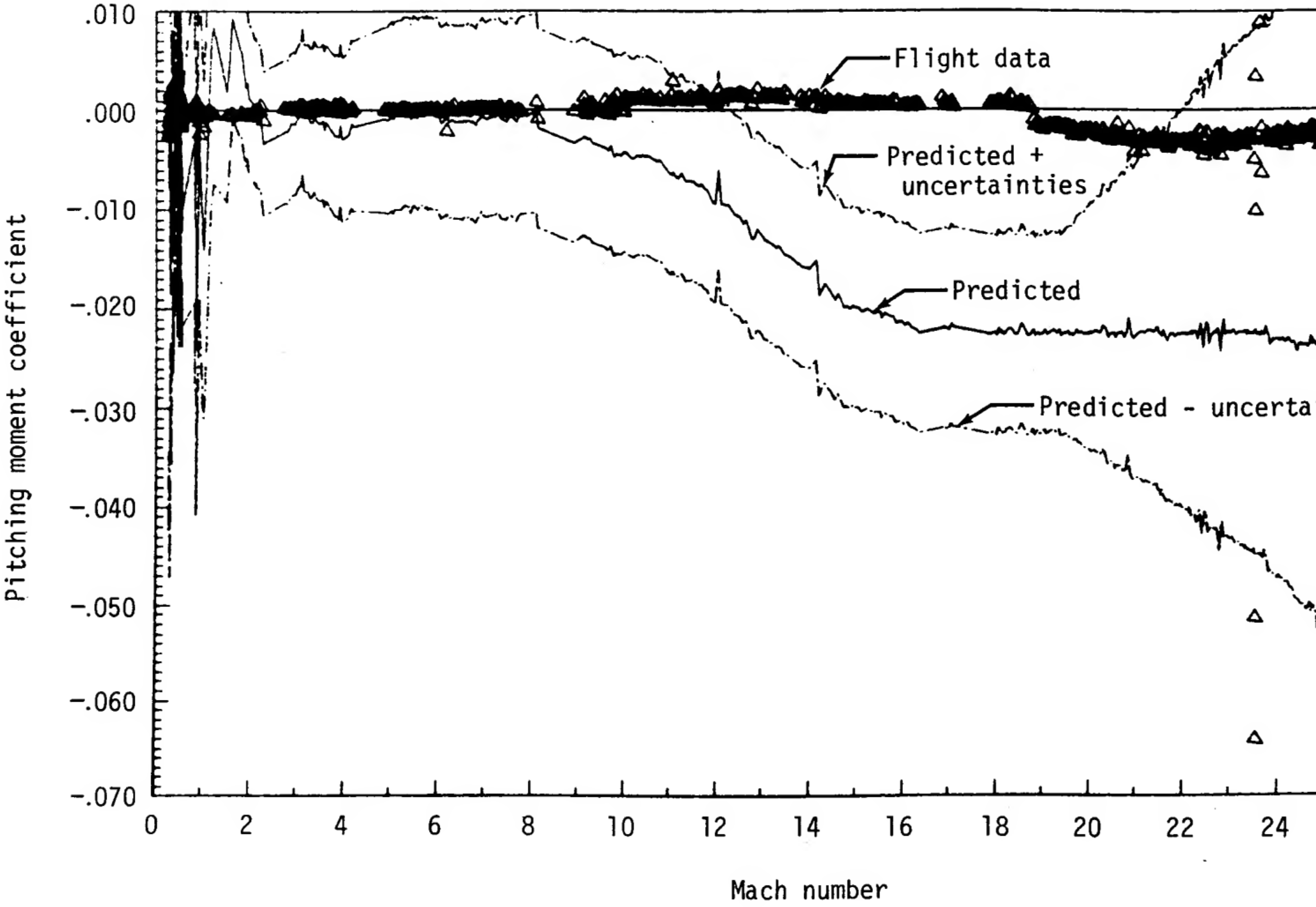


Figure 2-32.- Pitching moment coefficient during entry phase.

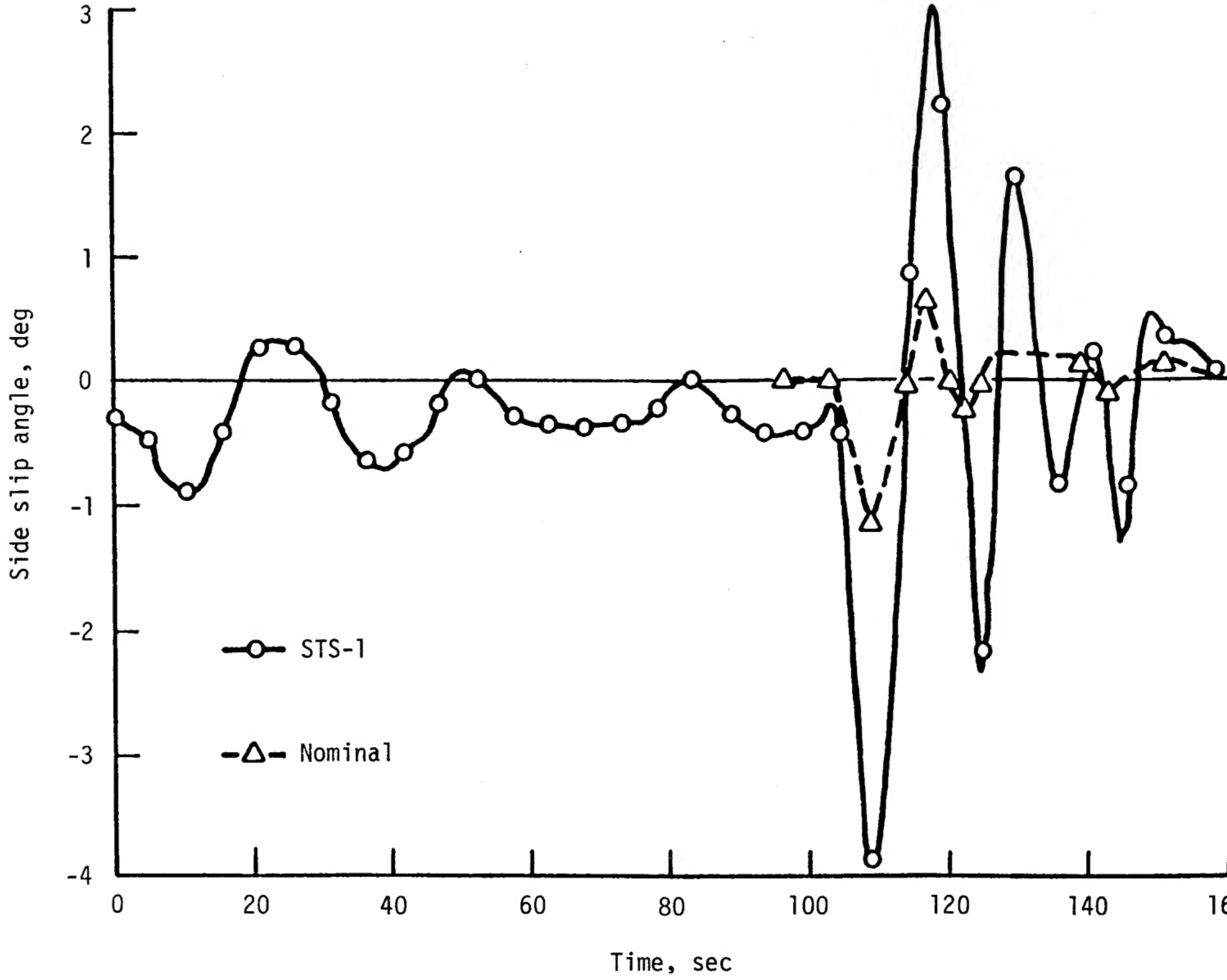


Figure 2-33.- Oscillations from first bank reversal.

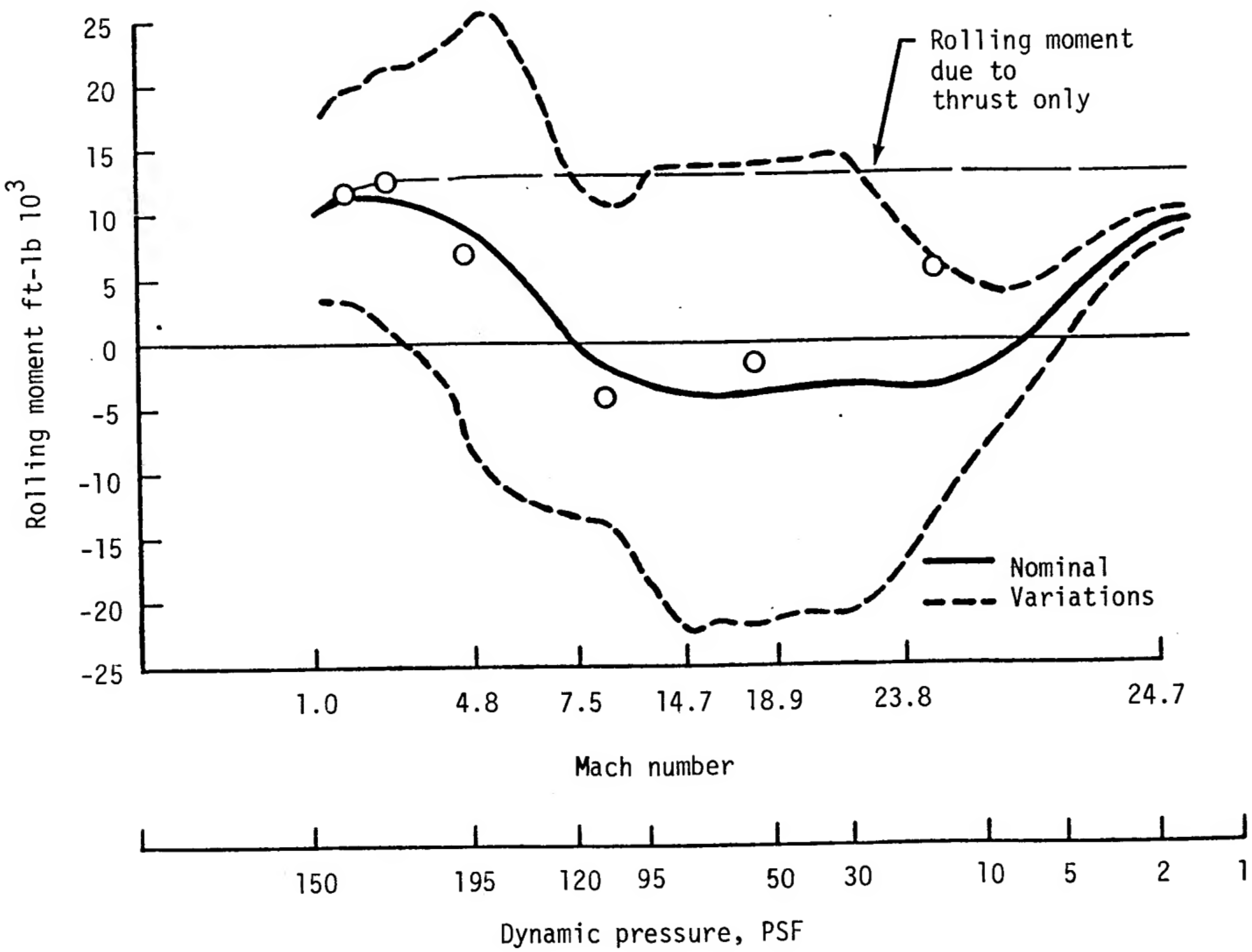


Figure 2-34.- Rolling moment due to yaw jets.

The aerodynamic stability and control coefficients were extracted for each bank reversal and evaluated using motion matching programs. Of the nine derivatives (three for each beta, aileron, and rudder) five were in accordance with predictions contained in the Aerodynamic Data Book, SD72-SH-0060-1. The four that showed variations greater than those contained in the Data Book were the rolling and yawing moment coefficients with respect to beta, the side force coefficient with respect to aileron and the rolling moment coefficient with respect to aileron. The beta derivatives for the rolling moment are shown in figure 2-35 and the aileron derivatives for the rolling moment are shown in figure 2-36.

2.9.2.3 Transonic Oscillation. - Figure 2-37 shows an undamped low frequency oscillation that was apparent during the Mach 2 to Mach 1 region. Motion matching studies using optimization programs were attempted, but repeatable stability and control derivatives could not be obtained. Consequently, specially designed maneuvers will be conducted and STS-2 to more clearly identify the coefficients.

2.9.2.4 Approach and Landing. - An evaluation of the aerodynamics during the approach and landing phase showed differences from the preflight predictions in both the drag force coefficient (fig. 2-38) and the speedbrake drag (fig. 2-39). The difference along with the increased L/D discussed previously, contributed approximately 1000 ft of the 3200 ft landing point overshoot.

2.9.2.5 Air Data Probe Calibrations: The air data probe system used wind-tunnel determined calibrations to provide onboard air data parameters for use by guidance, navigation, flight control, and crew displays for Mach numbers less than 2.5.

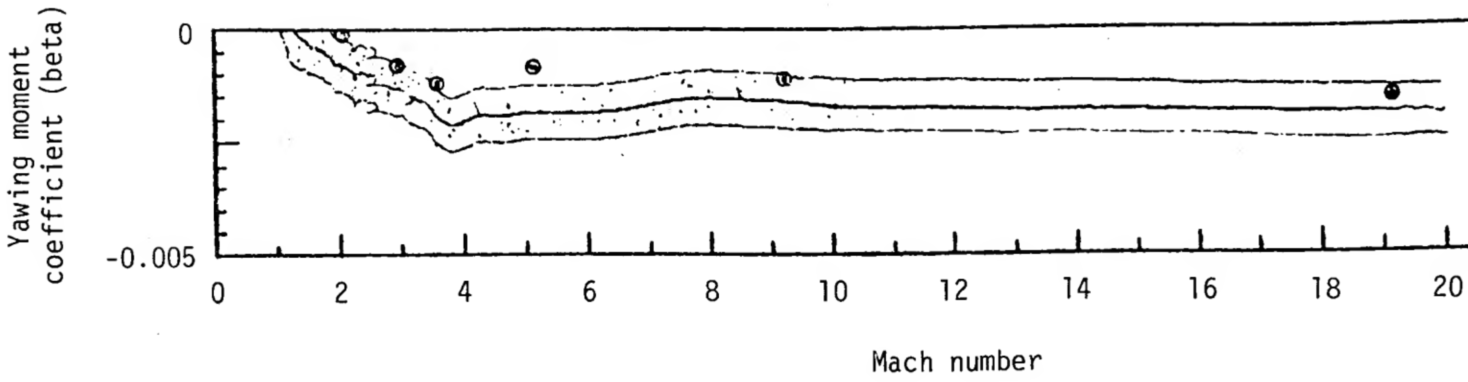
A preliminary analysis to determine whether the calibrations provided air data that satisfied operational accuracy requirements has been performed. This analysis used onboard velocities and landing site touchdown +5 hour atmospheric data to develop reference air data which are then compared to the side probe data. The difference is the compared to operational accuracy requirements. The results of this analysis are presented in figures 2-40 through 2-43, where comparisons for Mach number, angle-of-attack, n dynamic pressure, and velocity are made. On the basis of these comparisons, the conclusion is that the air data probe wind tunnel calibrations provided air data parameters within operational accuracy requirements.

2.9.3 Aerodynamic Coefficient Identification Package

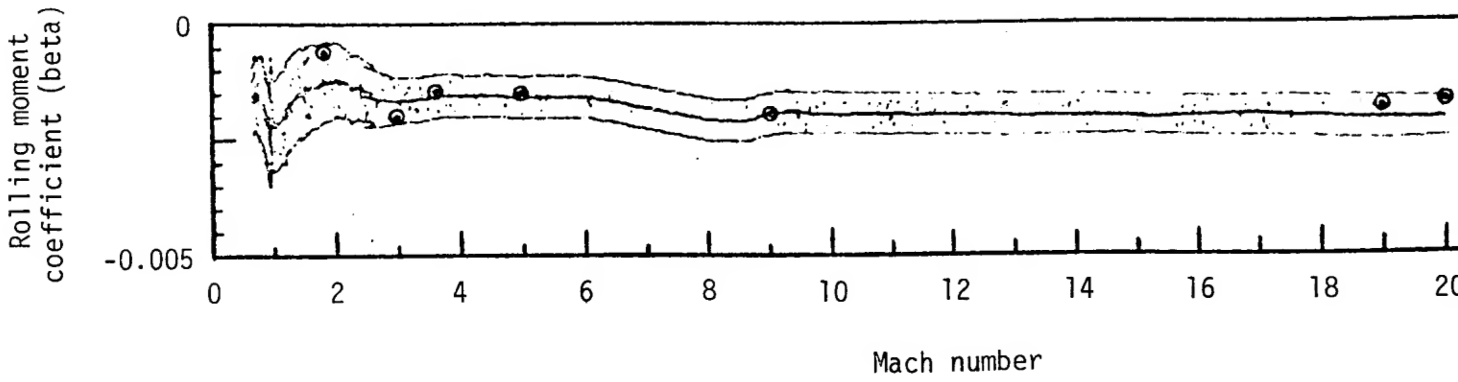
The aerodynamic coefficient identification package (ACIP) provided data at sample rates and sensor accuracies that permitted the identification of aerodynamic coefficients to support the rational removal of flight placards.

The ACIP was activated and deactivated during the ascent, on-orbit, and entry flight phases as planned. Table 2-XVII summarizes the commanded stop and start times for the data takes. Approximately 4 hours of data were collected during the mission.

Preliminary evaluation of the data shows that all three rate gyros functioned and all three linear accelerometers functioned, but no data were received on the X-axis high-sensitivity channel. This condition was known long before launch but was flown "as is" due to low priority of this channel on STS-1. Also, all angular accelerometers functioned, and all housekeeping data were received and were within expected limits except for the Y-axis angular accelerometer temperature, which was known to be inoperative prior to launch. The preliminary evaluation indicates good data on all functioning channels.



(a) Yawing moment coefficient derivative



(b) Rolling moment coefficient derivative

Figure 2-35.- Rolling and yawing coefficient derivatives with respect to bet

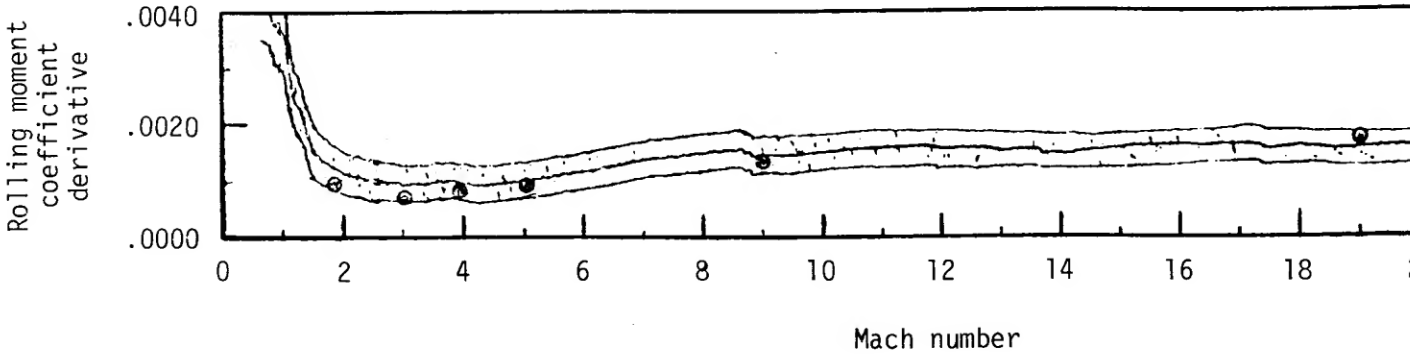


Figure 2-36.- Rolling moment coefficient derivative with respect to ailero

TABLE 2-XVII.- STS-1 AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE COMMANDED DATA TAKE TIMES

Data take period	Start, G.m.t.	Stop, G.m.t.	Time diffe min:s
Prelaunch			
Warmup	102:10:31:40	102:10:34:38	2:58 (o
Test cycle	102:10:34:38	102:10:38:02	3:34 (t
Launch data take	102:11:54:34	102:12:41:37	57:03 (o
On-orbit test cycle	102:12:41:37	102:12:42:39	1:02 (t
Flight control system check out			
Warmup and data take	102:19:23:59	102:19:47:11	23:22 (o
Test cycle	102:19:47:11	102:19:50:41	3:30 (t
IMU calibration			
Warmup and data take	102:21:19:31	102:21:38:23	19:52 (o
Test cycle	102:21:38:23	102:21:42:00	3:37 (t
COAS verification (RCS data)			
Warmup and data take	102:23:05:05	102:23:58:00	52:55 (o
Test cycle	102:23:58:00	102:00:01:00	3:00 (t
Manual rotation disc. rate/accel. (RCS rest)			
Warmup and data take	103:20:35:10	103:21:17:36	42:26 (o
Test cycle	103:21:17:36	103:21:20:40	3:04 (t
Entry			
Warmup	104:17:38:06	104:17:41:06	3:00 (o
Test cycle	104:17:41:06	104:17:44:06	3:00 (t
Data take	104:17:44:06	104:18:22:08	38:02 (o
Test cycle	104:18:22:08	104:18:22:48	0:40 (t

[a] Total operating time was 3 hours 59 minutes and 38 seconds.
[b] Total test time was 21 minutes 27 seconds.

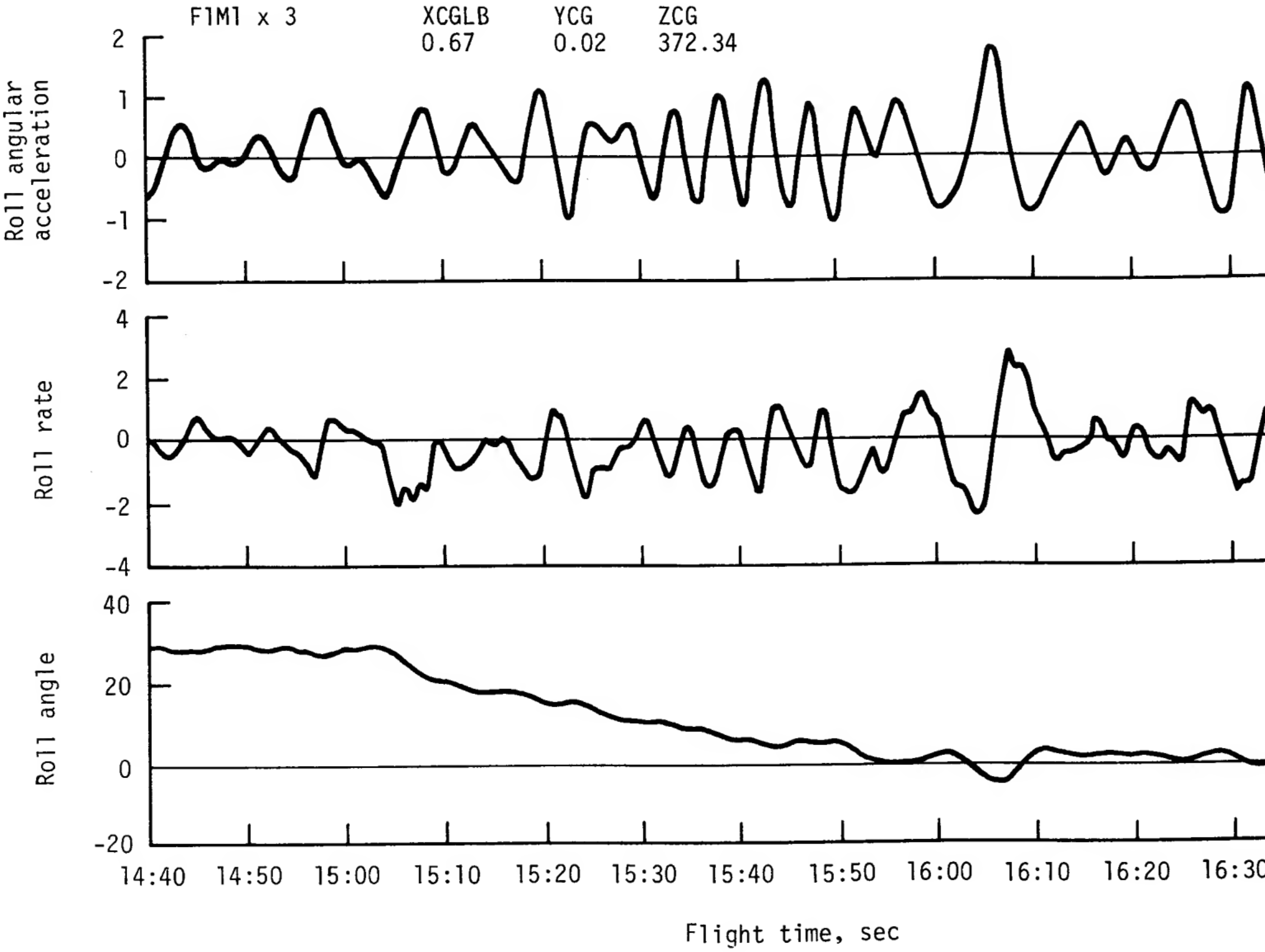


Figure 2-37.- Transonic undamped low frequency oscillations.

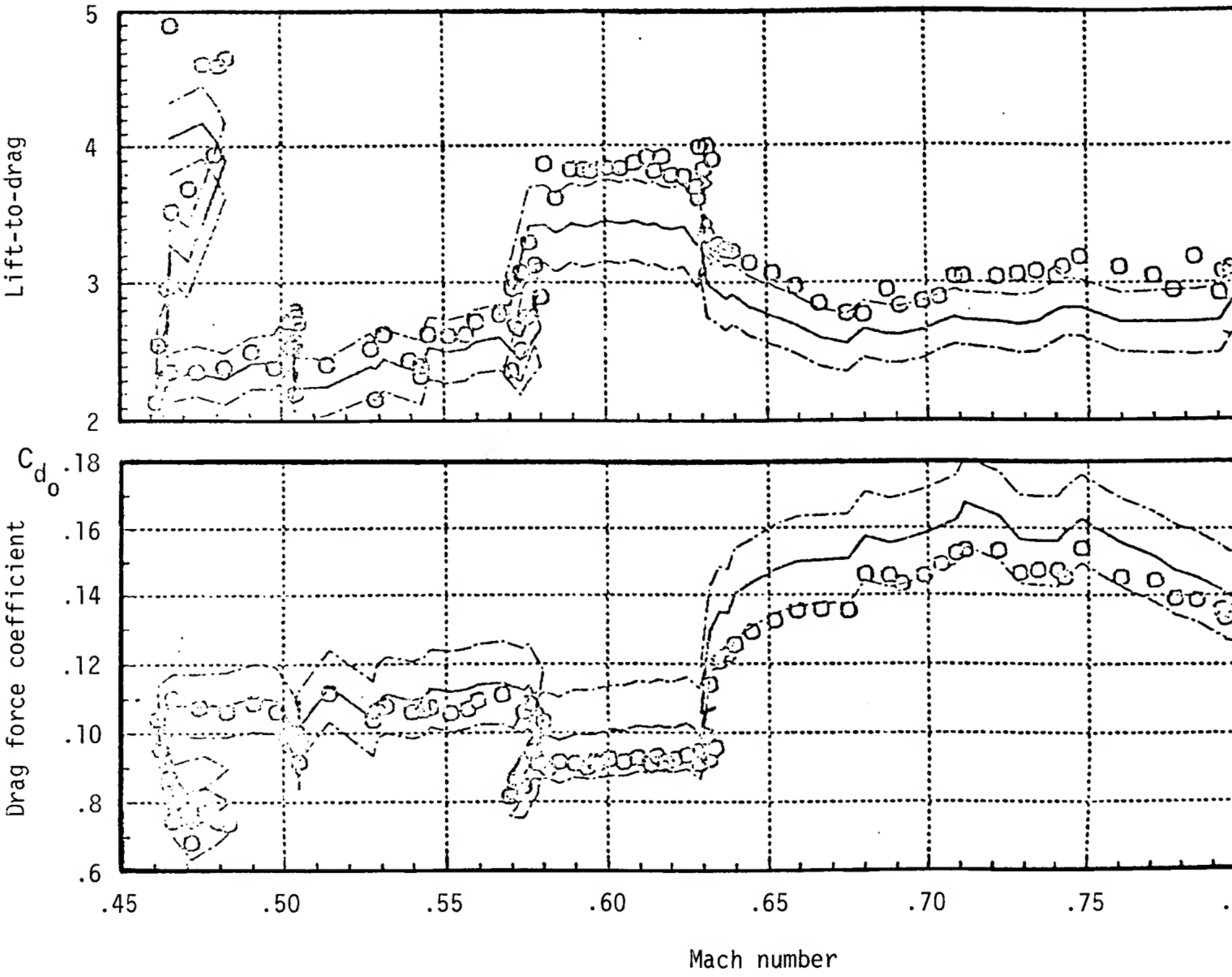


Figure 2-38.- Drag force coefficient and lift-to-drag ratio.

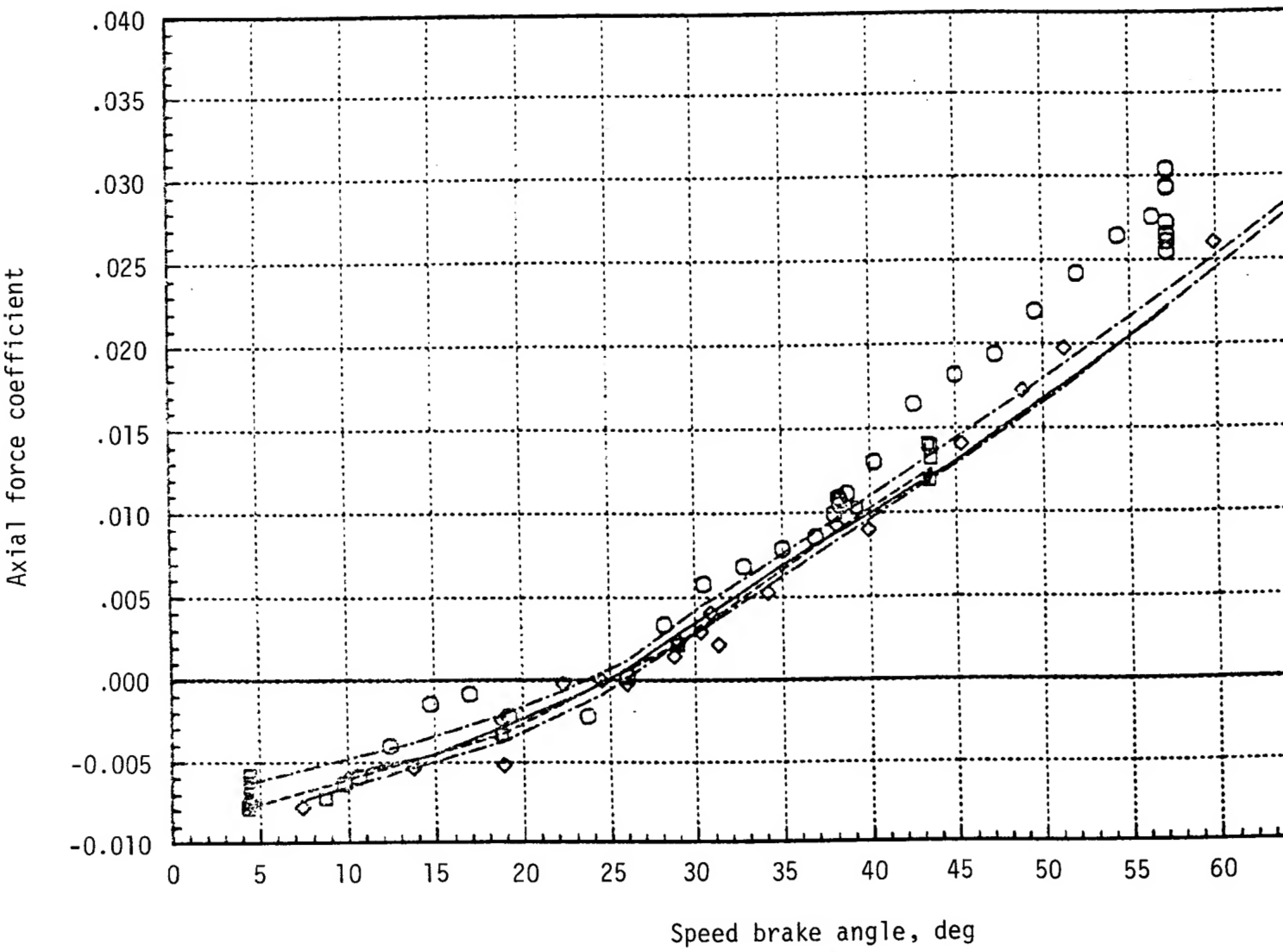


Figure 2-39.- Speed brake efficiency.

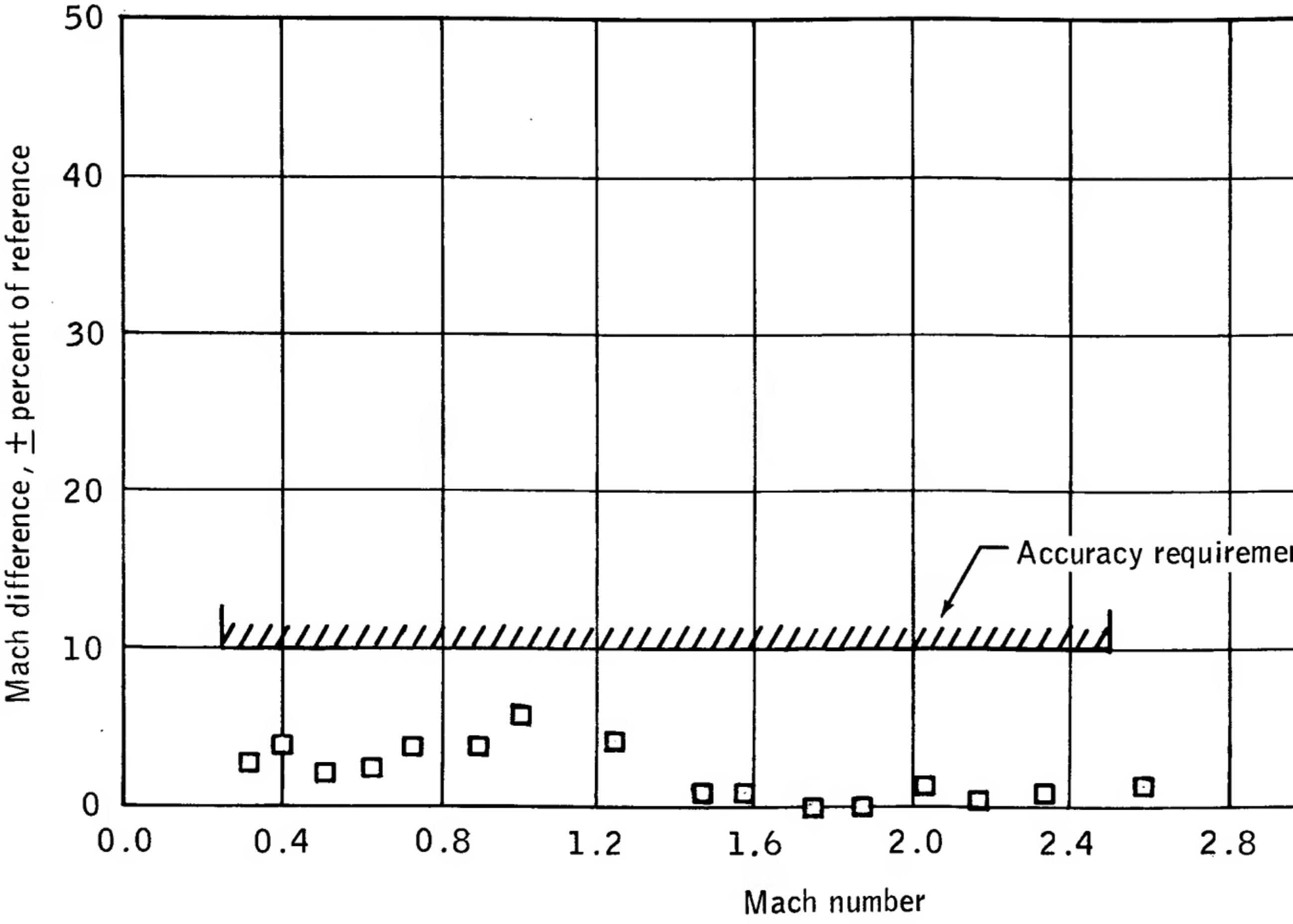


Figure 2-40.- Quick-look analysis of air data system accuracy for mach nu

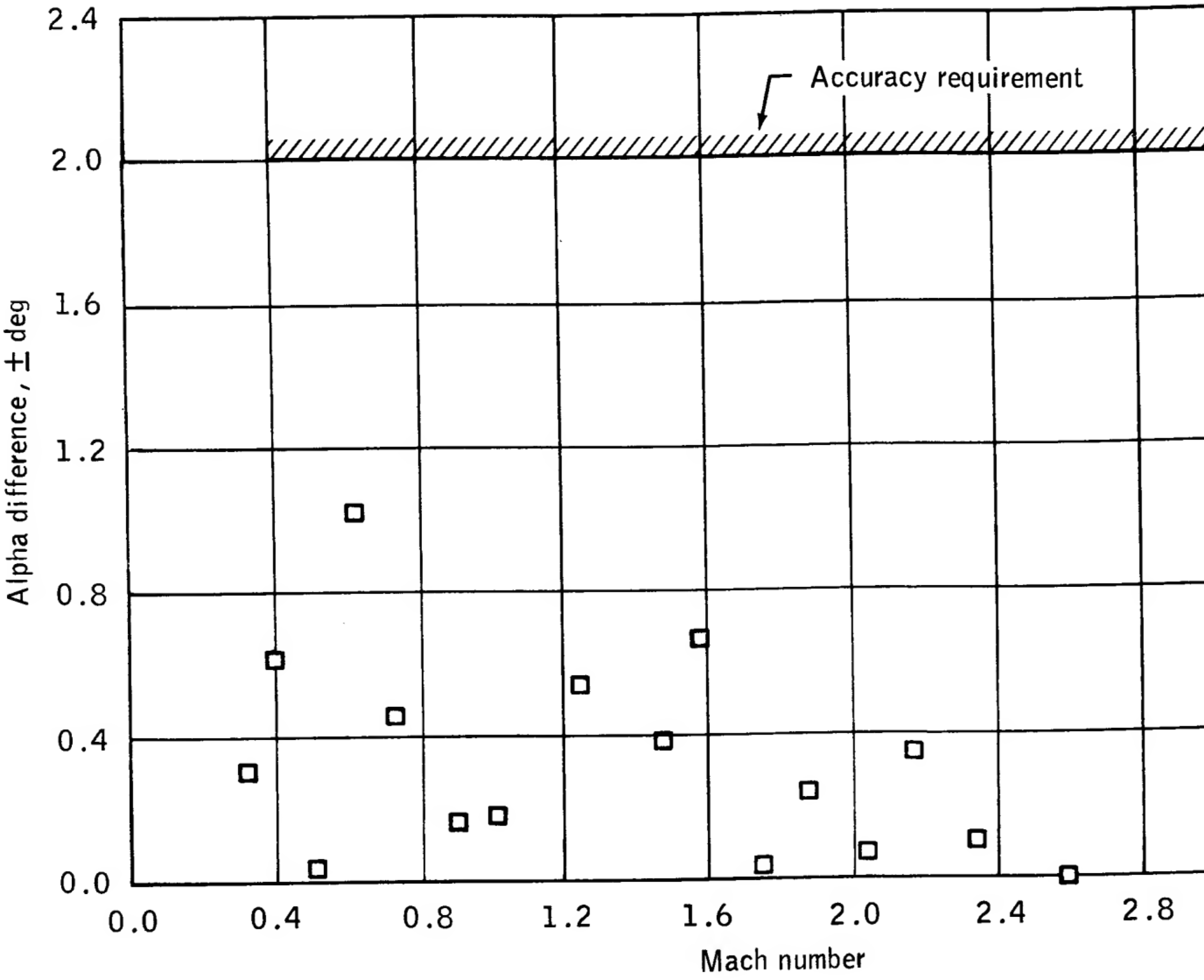


Figure 2-41.- Quick look analysis air data system accuracy for alph

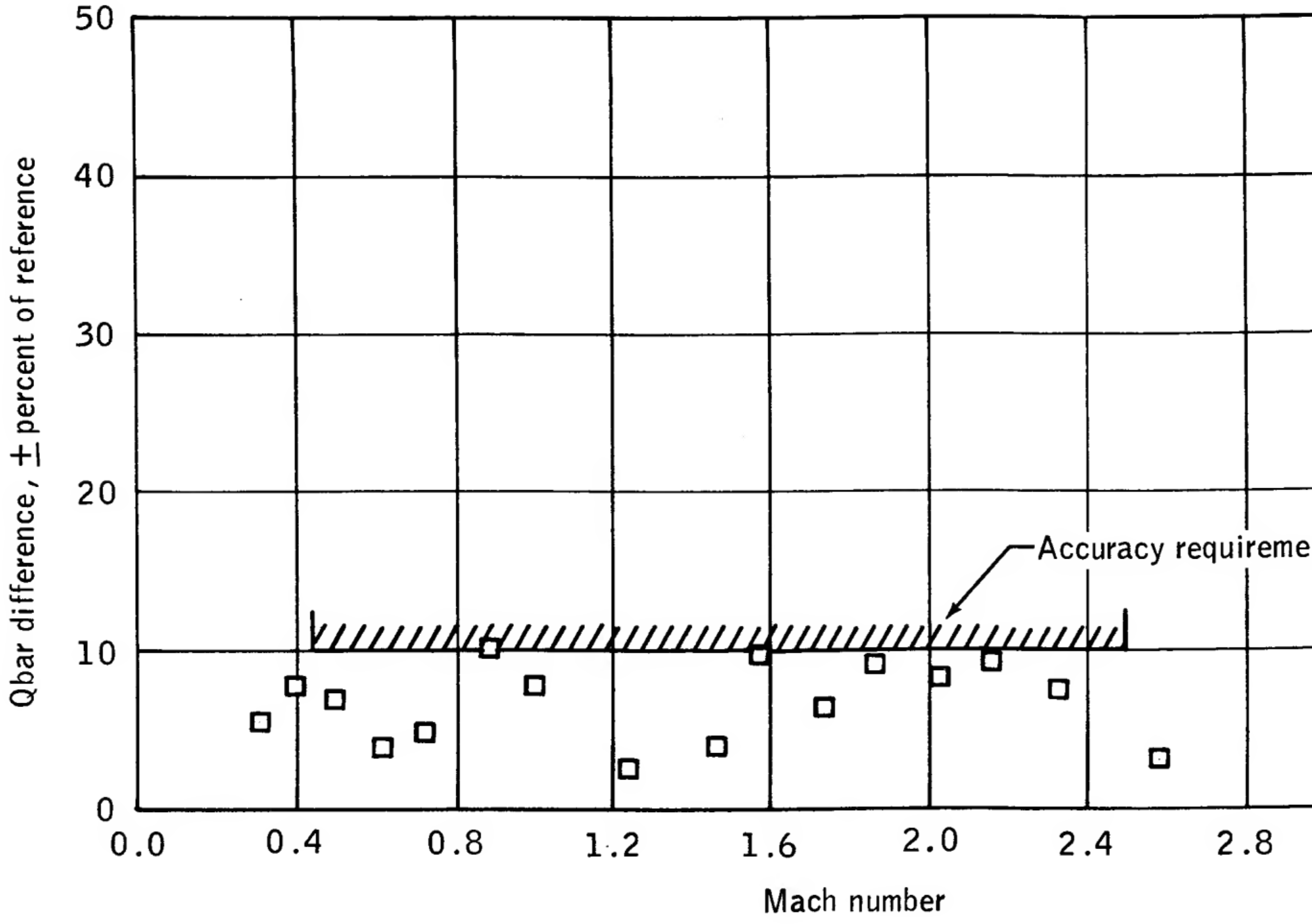


Figure 2-42.- Quick look analysis of air data system accuracy for Q b

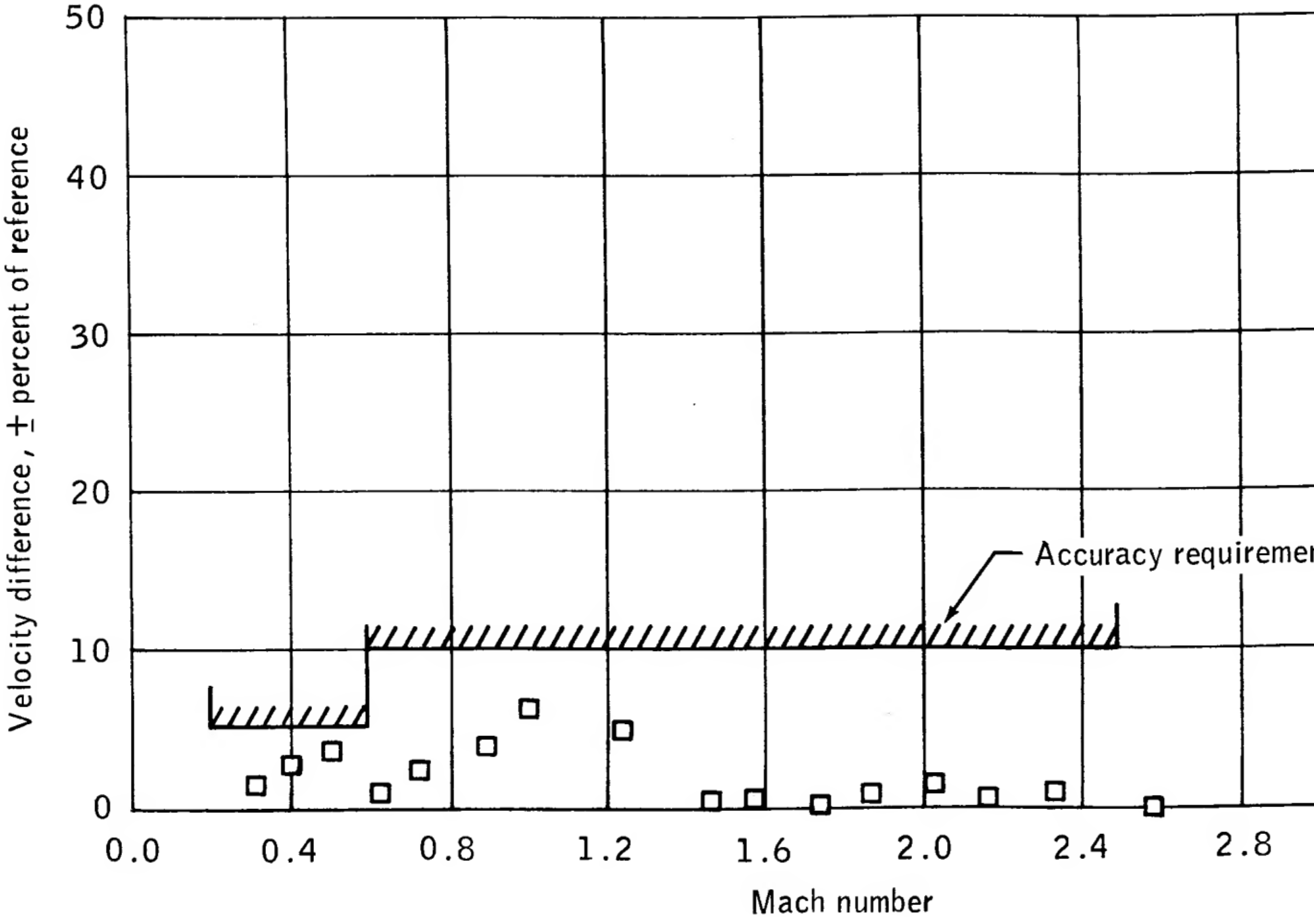


Figure 2-43.- Quick look analysis of air data system accuracy for veloci

3.0 ENVIRONMENTS ANALYSIS

3.1 ACOUSTICS EVALUATION

Acoustical data measured on the Orbiter active transducers were reviewed for compliance with the design specification criteria. Data were reviewed for the time period from main engine start through the supersonic phase of ascent and for the entry phase of maximum dynamic pressure. The measured data were within specification with the exception of two areas; i.e., the top of the body flap and the tip of the vertical tail. These two areas were also above specification during the flight readiness firing. Figures 3-1 and 3-2 show a comparison of the noise levels measured for these two areas during STS-1 lift-off and during the flight readiness firing. After the firing and prior to STS-1, a detailed evaluation of the structure and the thermal protection system (TPS) loading in these areas showed no constraints for STS-1, and since the STS-1 and flight readiness firing levels are about the same, no constraints apply to STS-2.

Comparisons of the internal payload bay data were made with the specification, and the results are discussed in section 3.5. As expected, the maximum internal noise levels occurred during lift-off. At the upper frequencies, the levels roll off much faster than anticipated. The levels at the lower-frequency noise levels are closer to the specified criteria. Acoustic levels measured during STS-1 main engine startup show good agreement with the data taken during the flight readiness firing (FRF) main engine startup. The firing of the solid rocket boosters during STS-1, which occurred after main engine ignition, was at a time when the main engine noise had stabilized at levels lower than at ignition.

In the transonic and supersonic flight time, the noise levels increased in certain areas of the Orbiter as was predicted; however, none of the levels exceeded the design specifications.

3.2 VIBRATION EVALUATION

Only a limited amount of vibration data have been reviewed for selected areas of concern. In these areas, there were no indications of the specification levels being exceeded. The maximum random vibration levels in the crew module were less than 0.01 g^2/Hz for the 10 different locations reviewed. A continuing review of all vibration spectra is being made as data become available.

3.3 THERMAL ANALYSIS

The STS-1 flight by design was exposed to a benign thermal environment. Preliminary evaluation of the thermal data substantiated that benign thermal environment.

STS-1 thermal data in itself can not be used to verify the thermal design requirements for the Orbiter as specified in the environmental requirements and test criteria for the Orbiter vehicle document. Additional thermal data from STS-2 through STS-4 are required before the thermal design requirements for the Orbiter can be verified.

The thermal design requirements for the forward lower midbody inner mold line (x=693 to 919) has a temperature range of -120° F to +165° F on orbit.

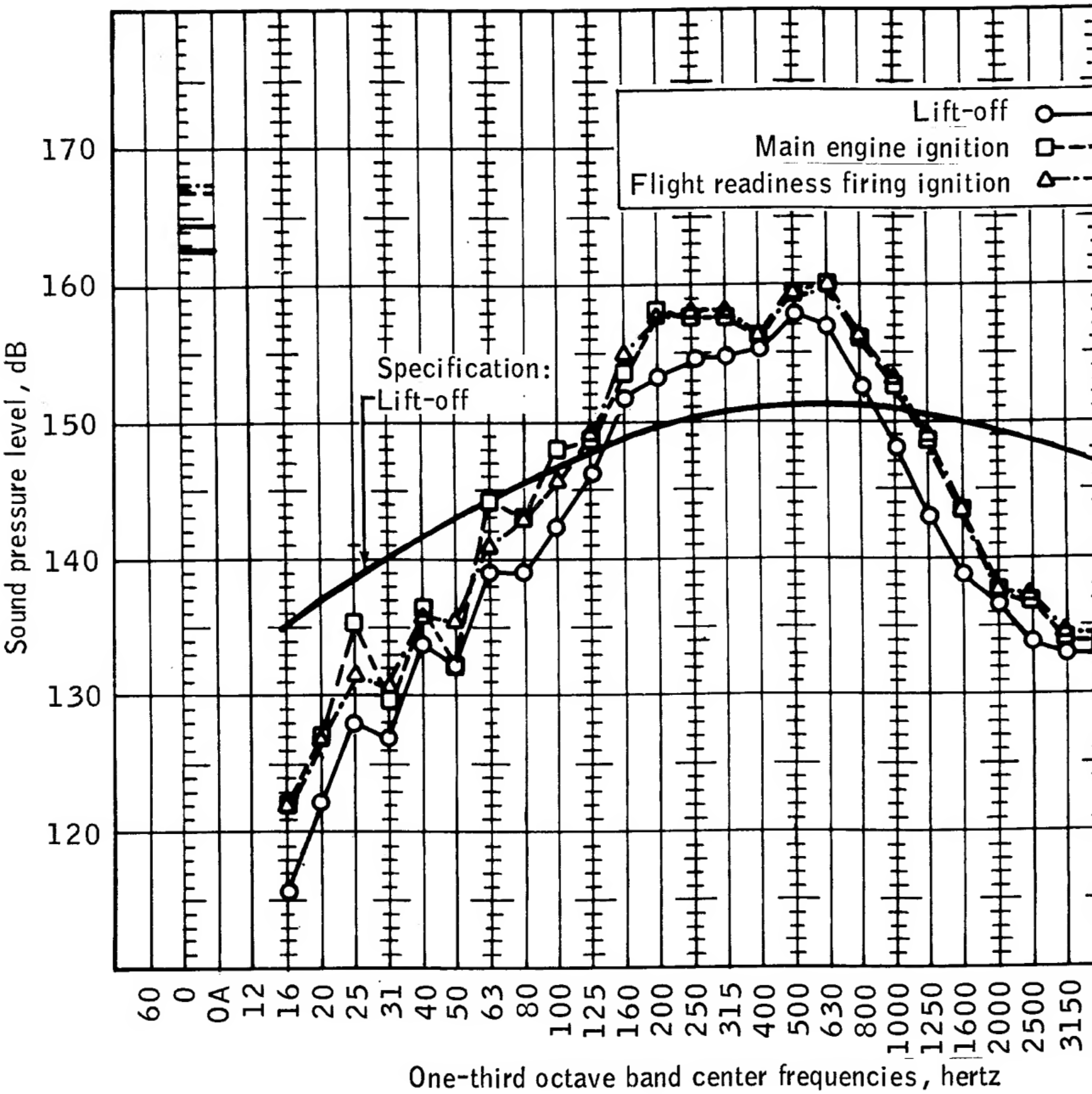


Figure 3-1.- Comparison of launch phase. Noise level at the tip of the vertica

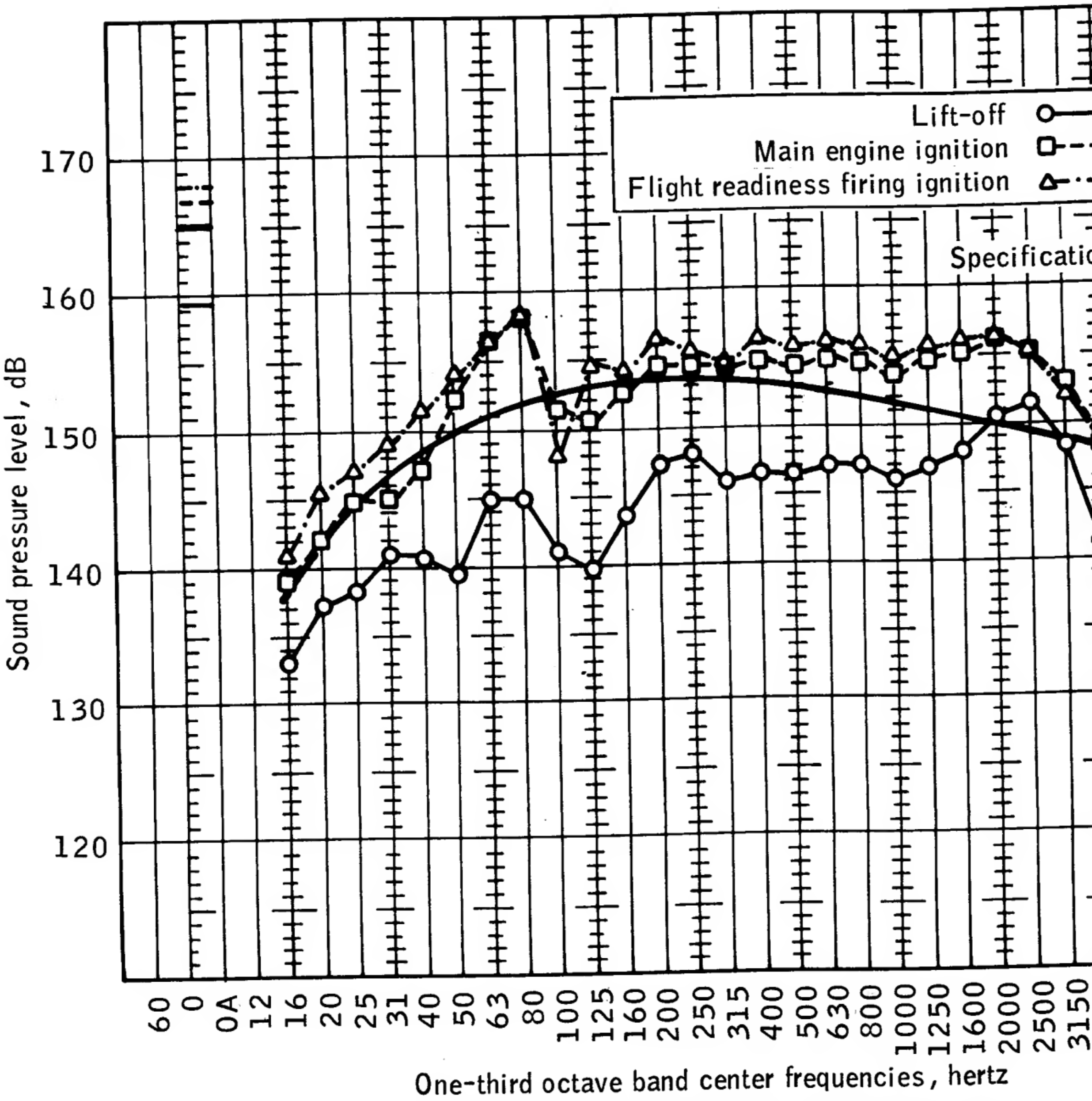


Figure 3-2.- Comparison of launch phase noise level at top of body flap

3.4 CONTAMINATION

A minimum amount of film contaminants was found in the payload bay. Additionally, some particulate contamination was found, but this may have resulted from the initial ground base contamination that was not completely removed prior to flight. However, the particles and film contamination had no ascertainable affect on system performance or the flight.

The initial contamination assessments have been obtained from crew comments, video tape observations, post-mission visual inspection of the OV-102 surfaces, and a preliminary evaluation of the passive optical sample array (POSA).

The crew comments and video tape analysis gave some insight, primarily, into large particle contamination. The crew did not see any evidence of contamination, either transient or permanent, when the upward-firing reaction control subsystem (RCS) thrusters were fired, nor was there any noticeable aerosol around the vehicle or payload bay found in the video tape.

Numerous large particles were identified from the video tape of the payload bay and these were:

(a) Pieces of thin foil or tape, a few inches across.

(b) Round flat parts, appearing to be washers.

(c) Parts looking like pencils.

While the payload bay doors were closed, occasional particles appearing as thin pieces of foil or tape were observed floating at low velocities inside the payload bay near the radiators. Sometimes these particles were deflected by the radiators back into the bay without sticking or damage to the radiators. The flotation direction was ramdom. After the payload bay doors were opened for the first time, an increased number of large particles were observed leaving the bay. These particles appeared to be travelling at a higher velocity than before the doors opened (on the order of 1 ft/sec). The origins of the particles have not yet been defined. The crew noticed particles coming from all over the bay. During the early period of the observation, particles were detected at a rate of several per minute, and the rate appeared to decrease with time. The particles were driven from the bay by gases that were present in the bay before door opening, as well as by gases desorbed from the bay surfaces.

A visual inspection was made of the Orbiter surfaces, primarily in the payload bay, and samples were taken of localized areas of contamination. In general, the surfaces were free of condensable films, but had localized areas of particulate deposits.

Particulate matter was found in relatively high concentrations in three areas, which were the aft bulkhead, the blanket under the forward part of the radiators on the payload bay doors and the insulation blankets in the OMS pod. The particulates on the aft bulkhead appeared to be general debris, pieces of metal and other material, and were located on the peripheral edge of the bulkhead. Samples were removed and are being analyzed.

Inspection of the forward radiators and insulation blankets below the radiators revealed evidence of particulate matter. Samples were taken by cotton swab (black deposit on swab) and will be analyzed.

A light, dust-looking deposit was evident on the TG-15000 Kapton blankets located on the aft fuselage under the OMS pod. The deposit was very uniform. Samples were removed using tape and are being analyzed.

The left-hand forward television camera had a deposit on the front surface of the insulation and lens. The deposit was unique in that it was very tenacious. A cotton swab wipe of the blanket with isopropanol only removed about 50 percent of deposit in a 1 in^2 area. It was not possible to identify the deposit as particulate or film by visual observation. Samples were removed for analyses. Other camera surfaces and lens appeared in generally good condition. The aft windows showed no evidence of film deposits.

None of the large particles seen on video tape were found in the bay during the postflight inspection.

Passive Optical Sample Array: A passive optical sample array (POSA) containing six different types of surfaces including MgF2/Al, Gold, CaF2 and Teflon was exposed in the payload bay on top of the developmental flight instrumentation (DFI) pallet during flight. This sample array along with a control array that had been installed in the lower bay at Dryden Flight Research Center after flight were removed for analysis. The flight sample had a grease smear of unknown origin on one of the witness plates. None of the plates contained any visible film deposits. Particulates could be seen on all surfaces of both the flight sample and the ferry flight control.

Optical property measurements have been performed on the flight array samples in the wavelength region from 1200 A to 2.5 microns. No degradation in reflectance was observed for the MgF2/Al and gold flight array samples in the wavelength region from 0.20 and 2.5 microns. Data from other flight array samples are being analyzed. Reflectance measurements of the ferry flight samples have not yet been completed. Further analysis to be performed includes X-ray micro-probe analysis, particle distribution measurements, and scanning electron microscope photography.

3.5 PAYLOAD BAY ENVIRONMENT ANALYSIS

3.5.1 Lift-Off Accelerations

Flight data from STS-1 have been reviewed to evaluate payload bay loading environments. The primary sources of data which have been reviewed include launch pad tiedown loads, SRB and SSME thrust buildup, payload bay accelerations, and other fuselage accelerations.

The timing of the SRB and SSME buildup and tiedown bolt release is within tolerances used for loads analyses. However, some dynamic response in the tiedown loads is indicated from tiedown post strain measurements. This dynamic response is not modeled in the existing forcing functions. This is a possible source of increased vehicle excitation. The SRB thrust buildup data are very similar to the SRB qualification test and are well within the buildup characteristics used for payload loads analyses.

The payload bay accelerometers measured higher than expected Z_0 accelerations on STS-1 lift-off. The maximum accelerations of the nine low-frequency accelerometers are shown in Table 3-I along with maximums from the preflight verification loads cycle results.

As can be seen, the X_0 and Y_0 responses are lower than predicted, but the Z_0 responses are, in some cases, over twice the worst-case predicted value. The differences between measured and predicted values were caused by higher SRB-induced over-pressure, with some contribution from the tiedown load characteristics. Shock spectra analyses of the Z_0 accelerations show significant response at 6 to 7 Hertz and in the 18 to 20 Hertz range. Other Orbiter accelerometers from the nose gear wheel well to the ACIP package also showed the high Z_0 responses. Design changes are in process to reduce Z_0 accelerations for STS-2 (see section 8.0, integrated flight test problem report I-6).

TABLE 3-I.- LIFT-OFF ACCELERATIONS

Measurement		Measured acceleration	Preflight prediction	Core ICD
	X_0			
1. NY	511	-.19	.87	±1.4
2. NZ	511	3.5*	1.43	±2.5
3. NZ	825	2.8*	1.85	±2.5
4. NZ	974	2.9*	1.75	±2.5
5. NZ	974	2.9*	1.83	±2.5
6. NY	973	.40**	-.45	±1.4
7. NX	1294	-2.10	-2.41	-3.20
8. NY	1294	.25	-.66	±1.4
9. NZ	1294	-1.25*	-.95	±2.5

*Exceeded preflight predictions
**Measurement saturated

3.5.2 Landing Accelerations

Flight data for STS-1 landing was also reviewed to evaluate payload bay loading. The sources of landing data included flight condition measurements, such as horizontal velocity, sink rate, speed brake and body flap position, rudder position, and pitch rate, as well as the payload bay accelerations.

The main gear impact conditions were well below the payload design requirements. Navigation data indicated the sink rate at main gear impact was on the order of 1 ft/sec. No preflight analyses were done because of the low sink rate, but future analyses are planned to analyze such a case.

The nose gear impact velocity was calculated from the measured body pitch rate to be 5.7 ft/sec as compared to the payload and Orbiter design requirement of 11.0 ft/sec. The payload bay accelerations for nose gear impact are shown in Table 3-II and compared to the preflight verification loads cycle results. Note that they are for different nose gear impact sink rates. As can be seen, the flight values are well below the design requirements, as expected.

Landing analyses are currently underway to calculate gear loading and corresponding vehicle response for the nose gear impact to compare with the flight measurements.

3.5.3 Quasi-Static Accelerations

Flight accelerations were also examined for ascent and descent to compare with load factors used as payload design requirements for quasi-static conditions, such as max q, max g, pitch maneuver, and so forth. The flight levels were all below the payload requirements and are shown in Table 3-III.

3.5.4 Acoustic

Analysis of the acoustic environment for the payload bay has been completed. Data for the analysis were taken during SSME start transient, SRB ignition/lift-off, and transonic flight regimes. The analysis of the acoustic levels for the payload bay is based on six microphones: four located internal to the bay and two located fore and aft on the payload bay door exteriors. Reduction of the microphone-measured data was performed in two separate data reduction facilities, and the results were repeatable.

The plots in figures 3-3, 3-4, and 3-5 are one-third octave bands representing the frequencies of 12.5 to 2000 Hz for analyzing averaging time of 1.0 second. In the frequency range from 12.5 to 80 Hz, the measured noise level is in agreement with the specification curve. From the 80 Hz to 2000 Hz the attenuation of the noise level was greater than predicted. The variance from the specification is around 5-8 dB at the midfrequency and reaches as much as 15-19 dB at the extreme upper frequency. The overall dB level for the four internal microphones ranged from 130 to 133.5 as compared to the 145 dB for the specification criteria overall. Figure 3-6 is a space average plot of the four internal microphones for the SSME ignition and SRB ignition/lift-off event times. The space averaging takes into consideration the influence of any microphone that may be reading high or low relative to the other microphones. The overall dB levels of 133 and 130 for each time event are still below the specification criteria.

The measured noise level for SSME ignition on FRF was repeatable on STS-1.

TABLE 3-II. - LANDING ACCELERATIONS

Measurement	X_O	Main gear impact	Nose gear impact STS-1 5.7 ft/sec	Nose gear impact Verification Loads 11.0 ft/sec
1. NY	511	.15	.10	.21
2. NZ	511	1.30	1.85	4.08
3. NZ	825	1.38	1.62	2.79
4. NZ	974	1.40	1.41	2.07
5. NZ	974	1.37	1.40	2.23
6. NY	973	.21	.10	.43
7. NX	1294	.24	.58	.84
8. NY	1294	.20	.10	.23
9. NZ	1294	1.45	1.38	1.92

TABLE 3-III.- QUASI-STATIC LOAD FACTORS

	Measured	Payload design
Ascent		
NX	-2.92	-3.17
NY	±.10	±.40
NZ	~0.0/-.63	.25/-.80
Descent		
NX	.4/~0	1.01/-.15
NY	.15/-.15	±0.85
NZ	1.65/~0	2.5/-1.0

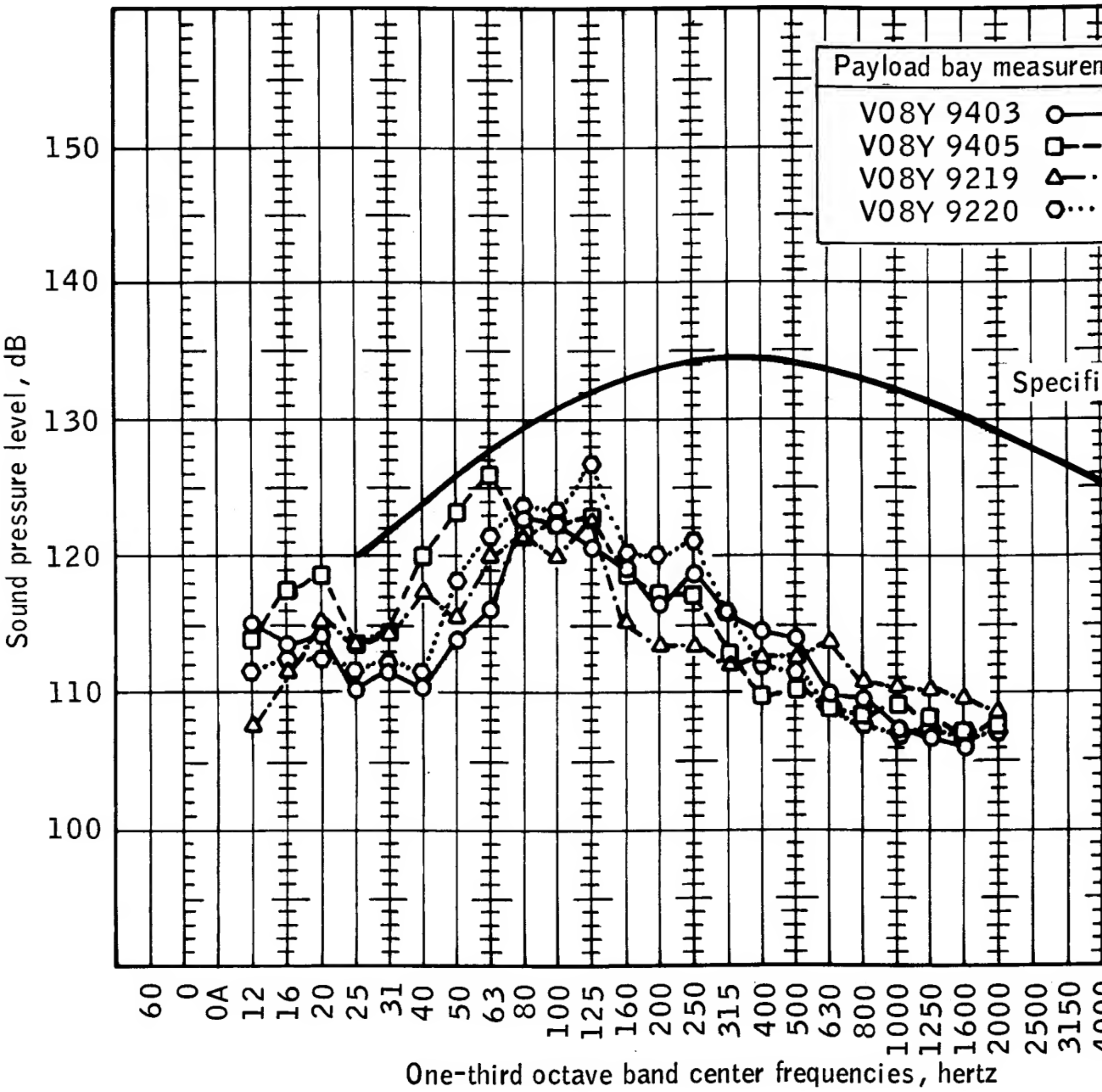


Figure 3-3.- Internal acoustic measurements from payload bay at main engine s

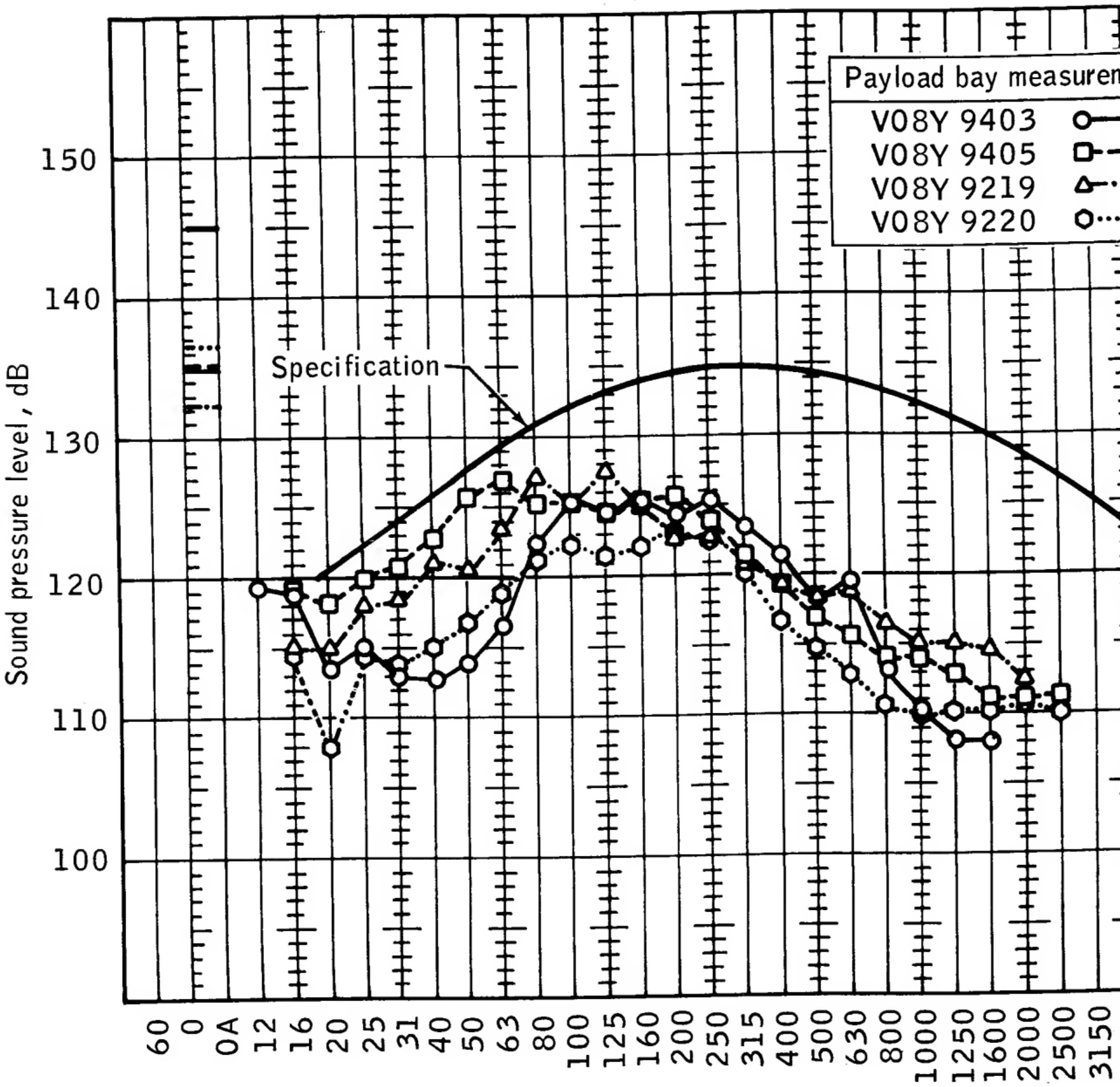


Figure 3-4.- Internal acoustic measurements from payload bay at lift-of

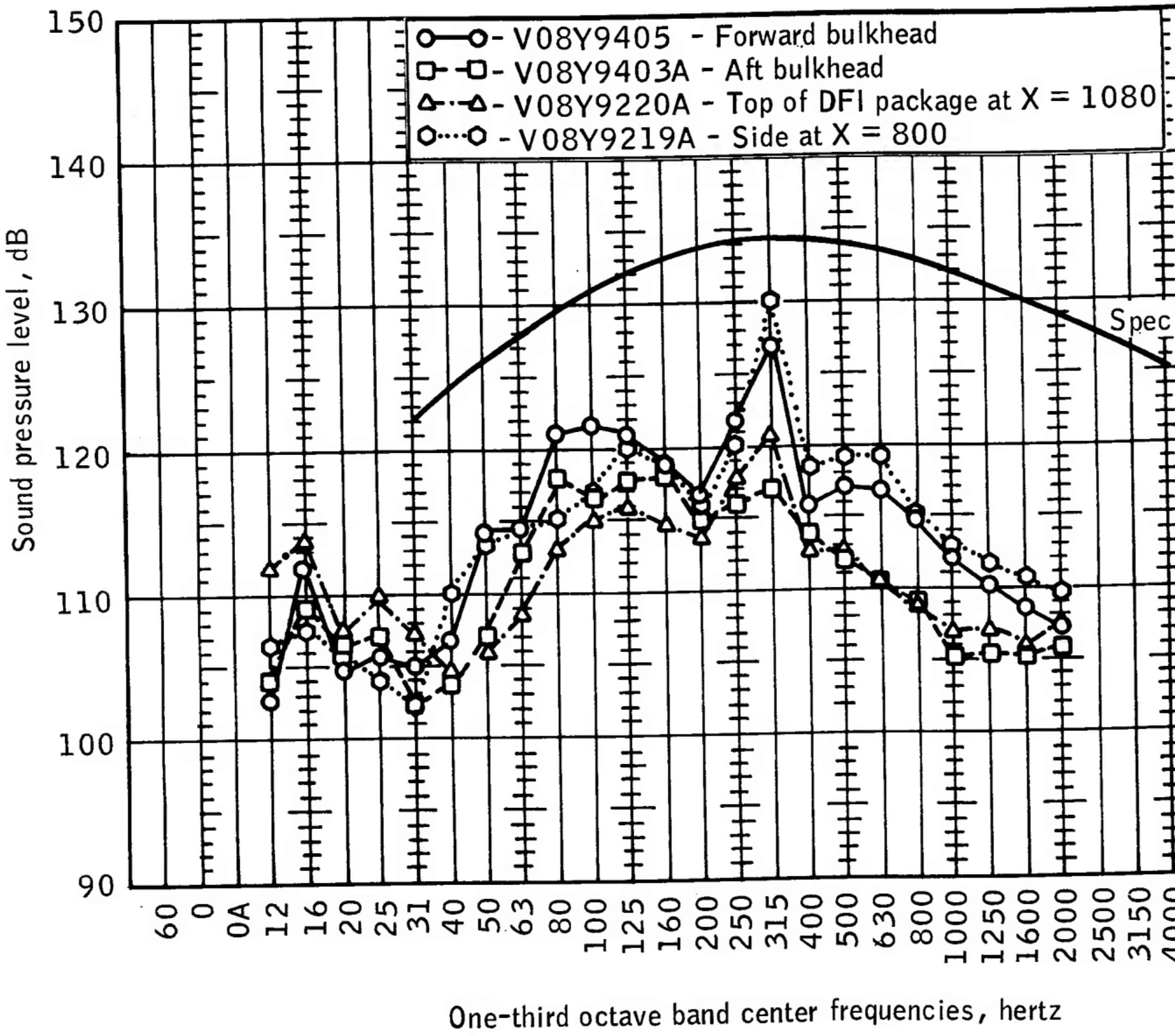


Figure 3-5.- Payload bay acoustic data during transonic region.

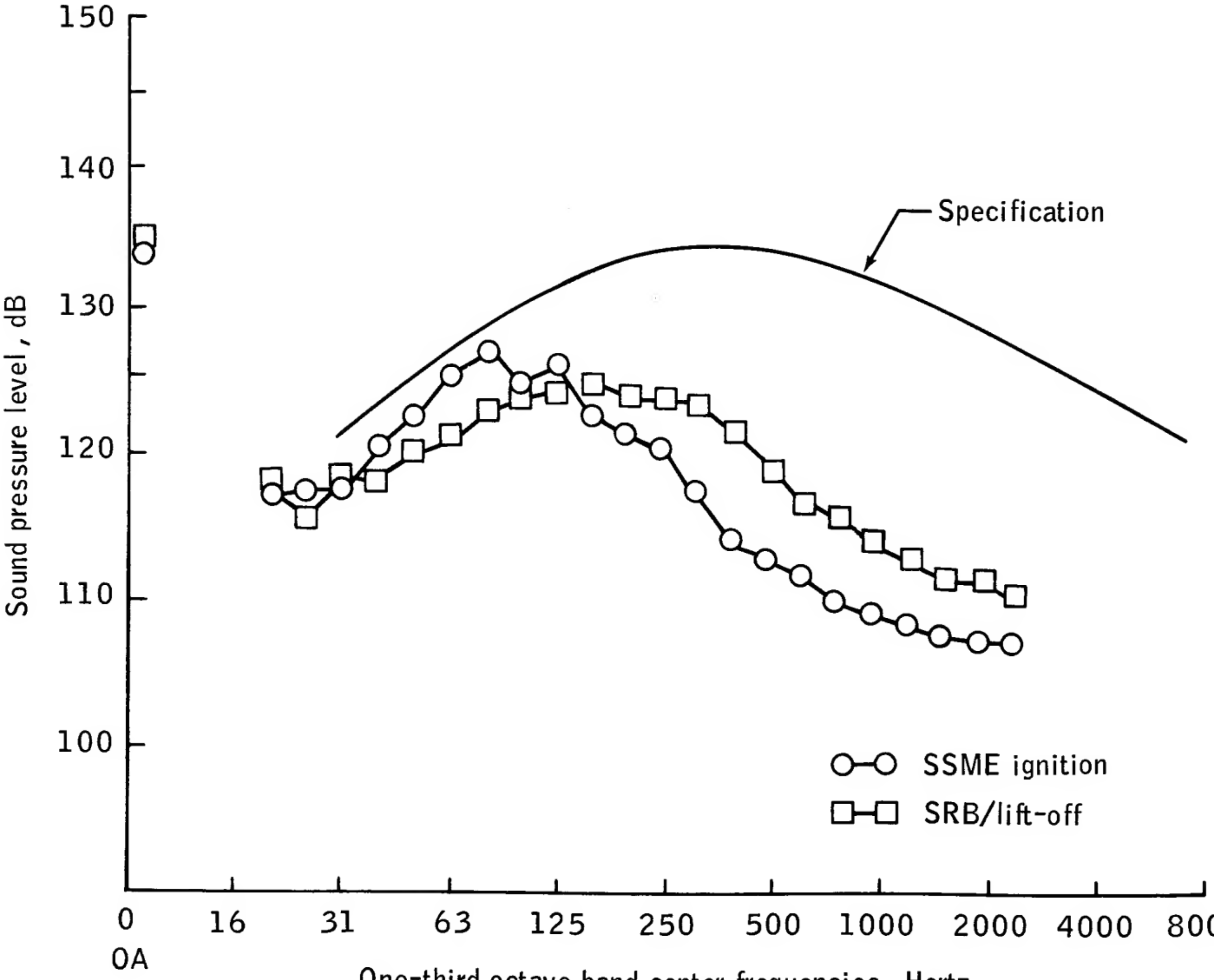


Figure 3-6. - Space average internal payload bay acoustic data.

3.5.5 Vibration

Vibration data analyzed from the STS-1 mission were obtained from 12 high-frequency transducers located on the main longeron, keel, and trunnion areas. The vibration was analyzed in the frequency band of 20 to 2500 Hz at an analysis bandwidth of 2 Hz and 10 Hz. Acceleration spectral density plots were made for the same event times as the acoustics. Figure 3-7 is an envelope of the 12 measurements. The envelope represents the highest peaks of the measured level for the transducers for all the event times.

At certain frequencies (150, 350, 800, and 1900) there are predominant spikes which go as high as .035 g^2/Hz. The levels shown in the plot are for an unloaded condition, and the weight factor must be considered when using the data for a specific payload. The vibration levels experienced by the payload bay are within the specification criteria.

3.5.6 Thermal

The STS-1 flight timeline was a conservative thermal environment. The thermal environment was as benign as possible, with each additional flight of increasing thermal intensity.

The data obtained from the thermal sensors located in the payload bay were of good quality.

Table 3-IV summarizes the temperatures as measured for the different flight environments. The predicted environments are shown for comparison purposes. The only thermal environment concern was during the orbital phase, when the sun was shining in the payload bay, the temperatures on the forward bulkhead exceeded the flight prediction. Although the temperatures were within design limits, further studies will be performed.

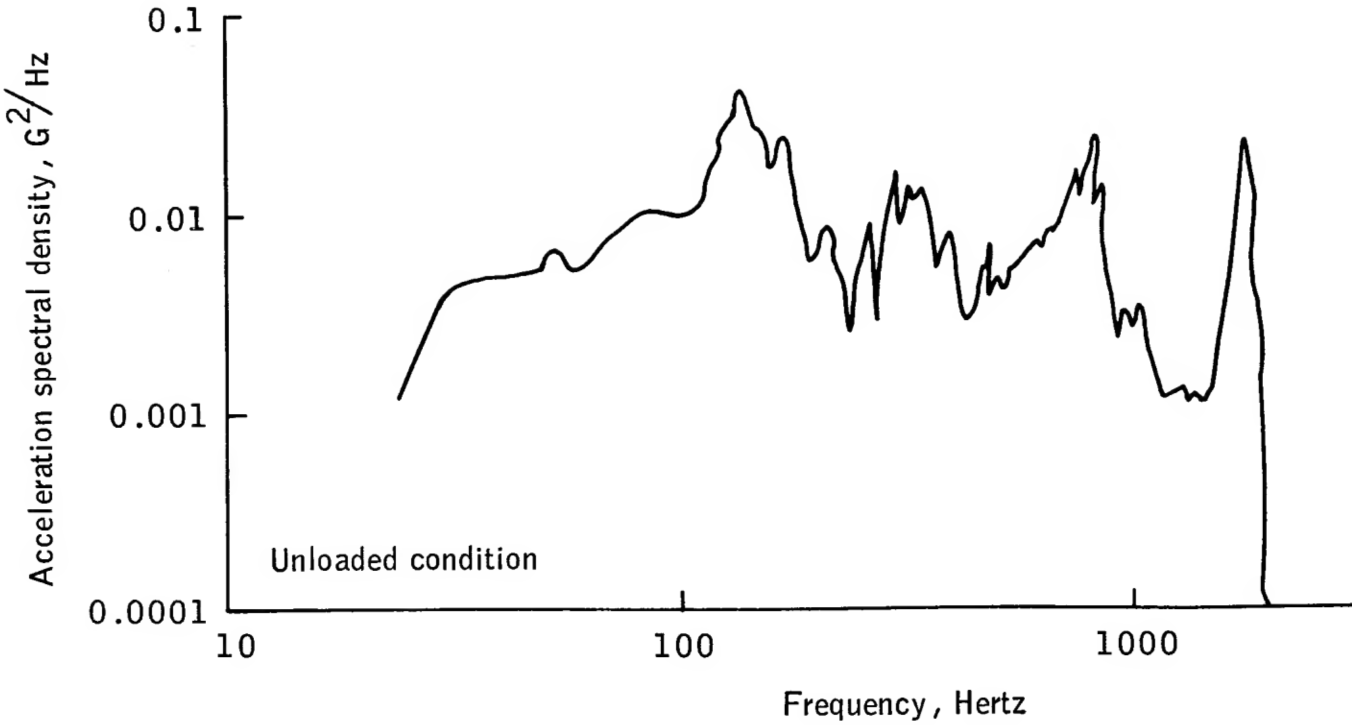


Figure 3-7. - Payload bay random vibration data for envelope of 12 measuremen

Table 3-IV. - STS-1 DATA COMPARISON

Component	Mission phase							
	Prelaunch, °F		Ascent, °F (Lift-off/minimum/ maximum)		On Orbit (+ZLV), °F (Minimum/maximum)		Entry, °F (Entry interfa touchdown/maxi	
	Prediction	STS-1	Prediction	STS-1	Prediction	STS-1	Prediction	ST
Liner	90	80	80/36/97	80/62/84	0/65	5/80	20/48/96	20/4
Sill	70	75	70	75	18/30	15/20	3/25/70	3/2
Radiator	75	75	75/65/70	75/65/70	30/90	20/80	10/35/100	10/3
Forward bulkhead	80	80	80/30/70	80/60/70	-20/100	-5/120	16/39/70	16/4
Aft bulkhead	80	80	80/30/70	80/50/70	-32/130	-15/120	24/42/87	24/4
Payload bay	80	80		80/60/70			-/50/80	-/4

Note 1: No postlanding predictions with flight environments available.

4.0 CREW REPORT

4.1 TRAINING

The training of both the prime and the backup crews for the first launch was augmented by engineering simulations, engineering development activities, and spacecraft (Columbia) testing. Engineering simulations were performed in the Orbiter at the vehicle contractor's Flight Software Laboratory, at Ames Research Center in the visual motion simulator, at Edwards AFB with the Air Force Flight Test Center downmoding studies, and at the Johnson Space Center in the Shuttle engineering simulator and the Phase 1 Shuttle procedures simulator. Development activities included the definition of techniques and procedures in flight techniques meetings and mission rules development meetings. During the initial flight-data-file development period, studies were made of the feasibility of the crew's performing the procedures and completing the flight test objectives within the alloted times.

Crew systems procedures, such as those involving crew escape suit donning and doffing, and cabin operating procedures were developed in early crew station reviews. The crews also participated in developing the techniques for the contingency extravehicular activity door closure and/or latch replacement operations. Both crews also participated from the start in developing and reviewing in-flight maintenance procedures.

Each of the prime and backup crewmen spent about 150 hours in the Columbia during spacecraft testing at Palmdale, California, and at the Kennedy Space Center in the Orbiter Processing Facility and the Vertical Assembly Building and at Pad 39A.

Both crews participated extensively in basic training on T-38 lift-to-drag (L/D) approaches. With this trainer, significant experience was gained in such factors as winds, turbulence and shears, sunlight and visibility effects, and temperature/density effects. The advantage of this basic T-38 trainer was that the L/D ratio could be made the same as the Orbiter, and the aircraft was less expensive to operate than the Shuttle training aircraft.

Formal training was conducted in classrooms, the single system trainers, and the Shuttle mission simulators in stand-alone crew training and with the Mission Control Center (MCC) in integrated ascent, orbit and entry phase training, the 1g high-fidelity stowage mockup, zero-g water facilities, and the Shuttle training aircraft. The prime crew completed four and the backup crew two full-duration integrated simulations with MCC of the 54½-hour mission in the Shuttle mission simulator. Escape suit operations and the long hours in 1g devoted to completing flight plan objectives and handling multiple simulated problems made these simulations considerably more fatiguing than the actual flight.

Feedback from the flight will enhance the crew training in the Shuttle mission simulator by more accurately simulating the aural, visual, and motion cues.

Early in the Shuttle training aircraft program, significant down time was experienced because of range unavailability, unsatisfactory weather, and aircraft and computer malfunctions. For example, the Commander in his first 50 flights experienced nine air aborts and in the last 50 only three. Shuttle training aircraft/Orbiter handling qualities were also improved to be more like those of the Orbiter. However, limitations existed because the Shuttle training aircraft with its high aspect ratio wing could not fly turbulence like the real Orbiter. A realistic turbulence model should be incorporated and flown for training in the Shuttle training aircraft even if this turbulence model can only be used on calm days. (Editor's note: Evaluation of turbulence model modifications is being pursued.) On the actual flight in calm air, the Orbiter displayed a much tighter control loop, almost like attitude-hold, in both pitch and roll/yaw, than the Shuttle training aircraft had modeled. This subtle flight control system performance difference is being investigated. Incorporating the flight control handling qualities of the Orbiter into the Shuttle training aircraft should be considered.

The 3 years of engineering, development and support activities, and formal crew training resulted in both crews being trained and "ready to fly." However, only in the 2-1/2 months prior to the mission was the final software release properly incorporated and available for training; only then were the crews trained in proper downmoding techniques and procedures, end-to-end contingency aborts, and the trans-Atlantic abort to Spain.

4.2 STS-1 PRELAUNCH AND ASCENT

4.2.1 Prelaunch Activity to Crew Ingress

During the final 10 days before the flight, the crew flew the Shuttle training aircraft at Edwards AFB on April 2 and at KSC on April 9 and again following the first launch scrub on April 11. Performing these flights close in to the actual launch provided essential training and maintained high crew readiness. The crew also spent several stand-alone periods in the Shuttle mission simulator performing ascents and entries to gain additional practice on the latest techniques and procedures. This type of simulator activity in the last week before flight was also essential to maintaining a high state of crew readiness.

At KSC crew operations consisted of several mission, systems, and weather briefings with flight control personnel in Houston and with the launch personnel at KSC. In addition, reviews of the flight data file were performed. During the week before flight, the prime crew reoriented their day to the wake-up time on launch day, about 2:15 a.m. Our STS-1 experience indicates the wake-up time on launch day should be adjusted to the in-orbit wake-up time.

4.2.2 The First Launch Attempt - April 10

The count progressed smoothly until the DPS PASS/BFS timing problem was encountered and eventually resulted in the launch's being scrubbed. The crew was strapped in the spaceship and ready to launch for about 6-1/2 hours. Based on the fatigue and general discomfort associated with ejection seat/crew interface, launch holds should be limited to 6 hours when the crewmen are wearing pressure suits.

4.2.3 Prelaunch Activity - April 12

For the April 12 launch, crew ingress, strap-in and prelaunch count activity proceeded even more orderly than during the launch attempt on April 10. However, during the oxygen flow check in the escape suit helmet with the visor closed, neither crewman could breathe. The oxygen system quick-disconnect fitting under the center panel was found to be mispositioned. (Editor's note: Ground procedures are being revised to assure proper mating. Connector location does not enable good access; however, the connector is not used during flight operations.)

The remainder of the count proceeded exceptionally well. Two events surprised the crew. The first was the unexpectedly slow retraction of the gaseous oxygen pressurization "coolie hat" at T-9 minutes. The second was the very jerky start and stop motion of the cabin white room access arm that was retracted at T-7 minutes. Its retraction was very slow, appearing to take more than 2 minutes. Subsequent events in the count were on time and normal in all respects.

4.2.4 Ascent Phase

Ignition of the Space Shuttle main engines was characterized by a sharp noise increase in the cabin. The vehicle rocked forward and back. The longitudinal vibration levels were very low. Solid rocket motor ignition was identified by a sudden noise that occurred simultaneously with vehicle lift-off at the vertical position of vehicle rock back. The lift-off acceleration was obvious. The lift-off acceleration onset was not as sharp as had been predicted. Vibration frequencies were estimated subjectively at 10 hertz or more. Initially, the flight instruments were blurred by the vibration, but they were interpretable. Cabin vibration amplitudes damped significantly before the launch tower was cleared. Instrument readability was unmarred by vibration during the remainder of the launch phase. The northward translation of the Shuttle vehicle and tower clearance with respect to the launch tower lightning rod was readily apparent from the cabin side window. The roll, pitch, yaw program to heads down was very smooth. The accelerations that started and stopped the roll phase were so gradual that the position of the crew above the vehicle c.g. produced no discernible lateral g forces. While accelerating to maximum dynamic pressure, the engines' noise as well as vehicle vibration amplitude increased slightly. Vibration amplitudes seemed to increase and decrease in a random manner during the solid rocket booster phase of ascent; however, the levels never had any effect on the crew's ability to read the instruments. The primary and backup evaporator outlet temperature high caution and warning alarms occurred very close to preflight predictions.

Attitude errors in roll and yaw on the flight attitude director indicator were insignificant. The pitch error needle saturated full scale high (5° full scale) around the time that maximum dynamic pressure was reached. This indicated that the stacked vehicle was lofting significantly (see section 8.0, Integrated problem I-1).

The cabin noise levels were considerably less than those predicted before the flight, and the levels did not affect intercommunications or air-to-ground communications at any time. At some time before staging, the booster noise that was heard had decreased to essentially zero.

Solid rocket motor tailoff was a symmetrical decrease in acceleration. Solid rocket motor separation was characterized by a bright tenuous yellow-orange flash that appeared to stream up forward of the nose and then back above the front cabin windows. There were no noise, acceleration, motion cues, or attitude error changes on the flight direction attitude indicator that were associated with solid rocket motor separation.

In the less than 1g environment following solid rocket staging, switch operations such as activating the flash evaporator primary system A and the topping and high load duct heaters were easily accomplished. The vibrations after staging were estimated subjectively to feel like a grinding in the background that was similar to that experienced on the Saturn IV-B. The T-fail pitchover maneuver was performed accurately. The maneuver placed the horizon in the window for the first time, and it was an absorbing view. The crew noted that white material was coming over the nose of the vehicle and was streaking past the front and forward side quarter cabin windows. The particles were subjectively estimated to range from 1/4-inch diameter to fist size.

The Orbiter external-tank-only launch phase was characterized by a steadily and smoothly increasing acceleration until 3g were achieved. At that point (about Mach 19), the engines began throttling down to maintain 3g. Main engine throttling had no discernible g transients above or below the steady-state 3g point. The negative g that the crew received during the boost phase was barely noticeable and in no way affected crew performance. Comparison of predicted vehicle performance parameters with the onboard readouts showed that, except for lofting, the trajectory was normal.

The engine shutdown from the 3g condition was soft and without transients. After shutdown no oscillatory tank unloading was experienced as on the Saturn II stage. Also after shutdown, moderate amounts of debris (washers, bolts, screws, filings, and wire) were seen floating in the cabin. The mated Orbiter and external tank coast phase was characterized by a unanticipated 5° or less vehicle pitch-up (nose toward the horizon) just prior to external tank separation. (Editors note: The pitchup was caused by positioning of the main engines to the propellant dump position.) No noise or acceleration cues were noted as a result of the external tank separation.

The only available cue for the external tank separation was the extinguishing of the three main-engine red lights on the instrument panel. The -Z axis translation acceleration away from the external tank was a very obvious "seat of the pants" translation. The mode change from OPS 103 (trajectory display) to OPS 104 (maneuver display) followed the translation, faithfully cueing the lateral translation. The lateral +Y axis translation was also obvious, but the associated motion was not. This resulted from the way the two Y thrusters (one forward and one aft) fire because of the unbalanced moment that causes the nose Y thruster to frequently stop firing to maintain attitude. Therefore, the vehicle felt like it was "walking sideways," in a lateral deadband oscillation, during the Y translation.

Upon completion of the translation, pulse mode was selected and a manually controlled maneuver was initiated to the OMS-1 maneuver attitude. The pulse mode firing the primary RCS thrusters was easily controllable and very positive. The firing of the nose primary RCS thrusters sounded like the dull thud of a muffled Howitzer cannon just outside the front cabin windows. The entire crew compartment also shook noticeably at the first impulse from these thrusters.

The first translation maneuver (OMS-1) was executed on time. The acceleration from the engine thrust in the +X direction was easily sensed. During this time, the main propulsion system feedline's dump of approximately 5000 pounds of propellant was also accomplished. Both the pitch and yaw attitude error needles on the attitude director indicator remained well centered. There were no discernible pitch or yaw errors resulting from the main engine propulsion feedline dump as had been predicted. No particles or gasses from the dump were visible in the forward windows. The velocity of the translation maneuver was about 165 ft/sec, and the velocity residuals at cutoff of the engines were negligible. Around this event time, several unexpected jolts were felt in the vehicle. The reaction control system thrusters fired to counteract the attitude transients caused by these jolts. The crew believes these transient events were caused by the main engines being rather abruptly stowed for entry following completion of the dump. Auxiliary power unit shutdown was completed on time. The main propulsion system power down and vacuum inerting were also completed. The manual closure of the Orbiter external tank umbilical doors indicated that both door closure motors were operating.

The Commander had difficulty safing the scramble handle of his ejection seat. In zero-g, the scramble handle had mechanically raised and required compression with both hands so that the scramble handle clip could be installed between the handle and the pin.

The maneuver to the orbital maneuvering system 2 translation attitude was performed in the manually controlled pulse mode. In the undamped pulse mode, the vehicle was rolling and yawing to the left. The roll-to-yaw ratio of the attitude motion appeared to be about 2 to 1. This perturbation may have been caused by thrust from the high load flash evaporator. The primary RCS pulse mode thruster firings tended to overcorrect for this attitude perturbation. However, the automatic transition digital autopilot maintained the vehicle very well inside the attitude deadbands without any unusual thruster firings. Long before the allotted time for the vacuum inerting of the main propulsion feed system to be complete, no pressure could be detected in the feedline manifolds.

Engine ignition for OMS-2 was on time, and the residual velocity at engine shutdown was insignificant.

4.3 GENERAL ON-ORBIT OPERATIONS

4.3.1 Crew Timelines

No problems were experienced with operating within the timelines specified in the post-insertion or pre-deorbit procedures checklists. The complete crew activity plan was accomplished on time. The notable exception was the timeline revision of the day 2 afternoon activity, which included considerable camera activity and added the in-flight maintenance of the DFI recorder.

4.3.2 Zero Gravity Operations in Columbia

Operating in zero g in Columbia was delightful. The cabin environment surroundings were comfortable because of the extensive training activities on the Shuttle mission simulator flight deck and the 1g trainer middeck compartment. Initial seat egress was accomplished by simply pushing backwards over the center console. The rear cabin A-16 and A-17 stowage compartments were accessible and easy to reach, as were circuit breakers on panel R-15. These had been hard to reach in the simulator. The flight deck in sunlight was adequately lighted. In zero g, all the switches on the overhead panels from 0-13 to 0-17 were readily accessible for multiple and frequent configuration changes and checks. Initially, when operating in the seat, the lap belts were used for optical sightings and translation maneuvers. However, even the lap belt restraint proved unnecessary. Operating the television and the payload bay doors and radiators on the aft flight deck also required no restraint systems. On the basis of STS-1 experience, we believe rendezvous and remote manipulator system operations should be comfortable using only natural in-place positioning. No activity on the flight deck or the middeck required any type of restraint system. Zero-g translation between the upper and lower flight deck was both rapid and efficient through either hatch.

4.3.3 Vehicle Surface Observations

The crew carefully observed the visible surfaces of the vehicle, including the tiles, flexible reusable surface insulation (FRSI) areas, and the carbon-carbon leading edge of the wings. When the payload bay doors were initially opened, the missing and damaged diced tiles on the front of the OMS pods were readily apparent. Through binoculars, the raised edge of the RTV around each of the missing diced tiles could be seen easily. The missing triangular tiles on the outboard sides of each pod were also readily apparent. Careful visual examination of the vertical fin (through both windows) and the outboard wings after payload bay door opening, but prior to radiator deployment, showed that there were no tiles missing from the vertical fin and no tiles or FRSI missing from the wings. The carbon-carbon wing leading edges were also intact. Also inspected were the nose and the forward cabin window frames. Through the front windows we could see the tile up to the upfiring primary RCS thrusters and as far forward as the Z star tracker identation in the quarter windows. No nose tiles appeared to be damaged or missing; however, when the window frames were inspected, both the left and right quarter window aft frames had portions of one tile on each window frame gouged out and missing. This condition was documented with 70mm photography.

4.4 ON-ORBIT GUIDANCE, NAVIGATION AND CONTROL SYSTEM PERFORMANCE

4.4.1 Attitude and Translation Maneuvers

4.4.1.1 Automatic Maneuvers. - Over 30 automatic maneuvers to attitudes for inertial measurement unit (IMU) alignment, coasting local vertical position, passive thermal control, gravity gradient testing, and translation maneuvers were made without incident.

The maneuvers were usually performed at 0.2 deg/sec rate and 1.0 deg deadband, using vernier thrusters. Several variations of digital autopilot attitude deadbands and rates were also evaluated. The firings of these vernier 25 lb thrusters resulted in no cabin noise or vibration and only a faintly reflected light at night. As previously reported, the primary engines in the nose made considerable noise, shook the cabin, and were readily visible at night. The primary thruster noise will provide an excellent cue should procedural errors be made in selecting engines for firing. Inadvertent attitude and translation thruster firings also occurred when the flight control power was turned on or off, even though pulse and vernier thrusters had been selected. With flight control power on, inadvertent bumping of the attitude control will select manual control and can even maneuver the spaceship. It is necessary on the other hand to have flight control power on to perform manual maneuvers of translations and also for backup of automatic translations. (Editors note: Software changes are being made to the thrust hand controller logic to preclude simultaneous engine firings in OPS 1, 2, and 3 and to the rotational hand controller logic to raise the out-of-detent firing level for OPS-2 to preclude inadvertent firings when the controller power is turned off.)

4.4.1.2 Control Stick Steering Maneuvers. - Over 25 manual maneuvers were performed in the pulse mode, using the ascent, orbit, and entry phase software. These maneuvers were to attitudes required to perform translations, for star tracker star acquisitions for platform alignments and optical sighting marks on stars, and for attitude trimming before translations. The ascent and entry transitional autopilot pulse control mode always used the primary thrusters. In those cases, vehicle motion was crisp and positive. Attitude hand controller movement always resulted in a thruster firing. After completion of a manual pulse maneuver, automatic attitude hold was re-selected to counteract the effect of the flash evaporator thrust (left roll/yaw) rates or the auxiliary power units thrust (pitchup) when those systems were operating.

4.4.1.3 Orbital Maneuvering System Translations (OMS-3 and OMS-4). - No noise or visible light was associated with the OMS-3 and -4 maneuvers. The acceleration thrust from the two single engine firings was easily sensed. During the gimbal check for the first on-orbit translation, the right engine primary pitch gimbal displayed a down arrow. Repeated gimbal checks failed to reproduce this failure. (See section 8.0, flight test problem report 12.) Single engine control in the automatic mode using only the left engine was precise. The manual thrust-vector-controlled OMS-4 maneuver was performed on the right engine and required pitching and yawing the attitude controller to the pitch and yaw hardstops and then using manual thrust-vector control to hold the pitch and yaw attitude error needles in the center for the remainder of the translation. This proved to be an easy task even though the right engine primary gimbal was significantly degraded in rate. Velocity residuals from both maneuvers were negligible.

4.4.1.4 RCS Translations. - Three manual RCS translations were performed for nulling residuals to less than 0.2 ft/sec in all axes. In those translations where the vehicle had a +Z velocity component together with a +X velocity component, the vehicle thruster-to-body axis cant aided reduction of the +Z component when thrusting in the +X direction. Translations in the X and Z directions were smooth. Translations in the Y direction exhibited the previously mentioned "walking" deadbanding motion. A fourth manual flight control system (FCS) translation was made in the DPS on-orbit mode of OPS-2 using the thrust monitor display. Since the thrust monitor system has known velocity measuring limitations, the crew has no idea of the precise translation velocity applied. Subjectively, the crew believes that the thrust monitor displayed only about one-half of the translation velocities input. Initially, the OPS-2 translation thrusters were out of configuration for these firings. A failed-off thruster redundancy message resulted, and the configuration was corrected.

During the second day, the orbital maneuvering system propellant tanks were interconnected to the reaction control system to save the propellant for the reaction control system tasks for entry. The crossfeeding procedures prevent thrusters from firing to preclude isolating the propellant manifolds from the propulsion tanks and thus prevent evacuation of a propellant manifold. These procedures are subject to error. In one instance, the pitch discrete rate autopilot mode was inadvertently left selected, but fortunately an engine firing did not occur.

4.4.1.5 RCS Flight Test Objective Test Maneuvers.- Four manually performed reaction control system maneuver tests were accomplished. The discrete rate vernier and primary thruster tests were completed using normal amounts of propellant. Nulling rates in the acceleration mode test using primary thrusters was impossible without overshooting or undershooting the zero rate. Manual attitude rate acceleration command control modes in the Space Shuttle appear to have no practical utility and probably could be eliminated without decreasing vehicle operational capability. Different tests of various reaction control system attitude deadbands using both the primary and vernier thrusters exhibited, subjectively, no abnormal propellant usage. The use of vernier thrusters was superior from the standpoint of propellant consumption and crew comfort. Crews would not be able to sleep when using the forward primary thrusters for attitude control because of the noise and vibration produced by those thruster firings.

4.4.1.6 Gravity Gradient Free Drift Operations. - Gravity gradient mode B was established using vernier thrusters. This mode has the nose vertical to the center of earth with the wings rolled 120 deg to the left of the Orbiter velocity vectory. The Orbiter held this attitude exceptionally well, without consuming propellant, for over 3 hours. The maximum error of about 30 deg was in roll.

4.4.2 Data Processing System (DPS) Operations

Twenty-three OPS transitions, including the initial orbital configuration (GNC 2, SM 2), three flight control system checkouts (GNC 8), six OMS and RCS maneuver configurations (GNC 3), the final entry configuration (GNC 3) for deorbit and the postflight configuration (GNC 9), were made. All these OPS transitions used the mass memory and were accomplished with no anomalies.

During the initial dump of the freeze-dried GPC, a procedural error was made. The programmable format was not selected, and the dump was lost. On day 2, this dump was accomplished successfully.

The backup flight system (BFS) computer failed to automatically mode to OPS 104 after external tank separation. The mode change was then accomplished manually. The system also failed to mode to OPS 0 after completion of rollout. The computer was then moded to halt and back to run to obtain OPS 0. (Editor's Note: Manual moding to OPS 104 was accomplished before the automatic switching function should have been performed. A software change has been made for STS-2 to change the velocity cue timing for the BFS monitoring or external separation. During rollout, the BFS calculations showed the Orbiter to be at 5000-ft altitude because the air data inputs to the BFS had been inhibited in the software. Since the BFS thought it was at 5000 ft and not on the ground, moding to OPS 0 after rollout did not occur.)

4.4.3 Flight Control System (FCS) Checkout

The OPS 8 control mode was used on all 3 days. On day 1, the FCS checkout part 1, involving aerosurface drive and secondary actuator checks using APU system 1, was performed. For each of the four channel bypasses of the secondary actuator check, a noticeable jolt was felt in the crew compartment.

On the day 2 and 3 FCS checkout part 2, the avionics with self test and dedicated display checkout was accomplished. The only problem encountered was on the CDR's horizontal situation indicator (HSI) compass card. (See section 8.0, flight test problem report 15.)

4.4.4 Star Tracker, Inertial Measurement Unit, and Optical Alignment Sight Operations

The star trackers were used for 10 platform alignments or platform alignment verifications during the mission. Both star trackers passed their self tests. Pre-mission the crew had been briefed to expect up to 3 minutes for star selection when the star acquisition and tracking mode on either star tracker was selected. However, during the flight, stars were tracked and entered into the star table in 15 seconds or less. The maximum error recorded between the two stars tracked was 0.02°. The star tracker operation was evaluated both at night and during daylight. With the Orbiter's large windows, it was very easy to see from the constellations at night that the correct stars were being tracked. A -Y star tracker software bit kept closing the star tracker shutter override software display entry. On several occasions, the -Z star tracker shutter was closed by the earth's occulting disk, which is 20° above the real earth's horizon in the software. A reduction of the disk size could probably be made to less than 10° to allow significantly more stars of opportunity to be tracked. Such stars of opportunity might enable the deletion of specific maneuvers for platform alignments.

The performance of the three inertial platforms was exceptional. At 2 hours 37 minutes after orbital insertion, the maximum torquing angle of the worst aligned platform was 0.1° (allowable was 0.12°). After periods of about 8 hours without alignments, the maximum torquing angle observed on any platform axis was 0.28°. The platforms were still accurate enough to have performed an entry without the necessity of a time-consuming platform alignment. Based on two star tracker platform verification checks, the total star tracker platform torqueing system uncertainty appeared to be, at worst, 0.05° for any given platform axis.

The re-skew of the platforms for entry, which aligned the two other (IMU's) to reference IMU 3, required about 6 minutes. The new reference IMU 3 was then selected for a second alignment; the necessity for this second alignment is questionable. The crewman's optical alignment sight was calibrated by manually maneuvering to center the star in the sight and marking the star. Vernier thrusters with a rate of 0.01 deg in pulse control mode with vernier compensation were used. Unlike the Shuttle mission simulator, stars were very easily seen at night even when using cabin instrument lighting. On the first optical calibration, the bright red star, Arcturus, was seen before sunset because the shadow cast by the Orbiter allowed the Commander to become dark adapted. The initial calibration value was 0.23°, and subsequent calibration values were 0.1° or less. Calibrations were very repeatable, even though the alignment sight was frequently bumped and could easily be vibrated by the hand in zero gravity. The alignment sight was used to make a test platform alignment shortly after the platforms had been aligned by the star trackers. The star angle error between the two stars was 0.01°, and the maximum torquing angle on any of the platform axis was 0.05°. This confirms that the optical alignment sight can perform platform alignment for an entry and, therefore, can be used as a backup to the star trackers.

4.5 SYSTEMS OPERATIONS

4.5.1 Electrical Power System

4.5.1.1 Load. - The electrical power system functioned normally throughout the flight at a lower than anticipated load (approximately 25 kW for ascent, 15 kW for orbit and 19kW for entry).

4.5.1.2 Fuel Cell Purge. - An automatic purge of the fuel cells was attempted at 102:15:04:10 G.m.t. This resulted in failure messages due to the oxygen purge heater temperature's being high and high cryogenic gas flows in all three fuel cells. (Editor's Note: This was the result of the fuel cell flow meter measurements that cue the automatic purges being out of calibration.) Thereafter, all purges were accomplished manually. This proved to be no problem. Purge heater temperatures were such that no wait was required after heater activation prior to commencing the purge.

4.5.2 Water Dumps

Supply and waste water dumps were accomplished with no problems. The dump line heaters provided an adequate temperature for dump initiation in less than a minute after activation. The SM (systems management) low-level quantity alert value was changed for the appropriate tanks to provide a cue for dump termination, and this change also worked well. When the lighting conditions were right, a large ice shower could be observed coming from the port side of the vehicle during water dumps.

4.5.3 Communications Operations

The communication equipment functioned well throughout the flight. A slight barrel effect had been noted preflight as well as in flight when using the S-band and UHF channels simultaneously, but this was not considered a serious problem.

The UHF communications link proved to be operationally invaluable to fill in S-band keyholds and add coverage extension through UHF sites only. UHF quality onboard was excellent; however, there were numerous cases where the Mission Control Center could not receive UHF due to vehicle antenna orientation. Consideration should be given to placing a UHF antenna on top of the vehicle or in the payload bay to eliminate this problem. (Editor's note: An additional UHF antenna is being considered for later flights.) The star headsets with molded earplugs were used when not in the emergency escape suits. There was some difficulty in attaching the headset to the eyeglasses with the plastic clip. This resulted in the headset's continually coming off and the crewman's having to hold the mike boom. A better interface between the eyeglasses and the headset needs to be found. Every time the star mike was used anywhere in the vehicle while the middeck speaker unit was on an irritating feedback squeak was also generated. This made the speaker unit unusable. The flight deck speaker unit was never turned on.

The wires associated with connecting the headset interface units to the vehicle system provided a difficult management problem with two people and would be intolerable with larger crews. (Editor's note: A wireless headset is planned for STS-2.)

The teleprinter functioned well, but several operational problems were noted. Insulation on the inside of the door prevented placing the paper between the door and the cutter bar. Each transmission generated an initialization message that resulted in the crew's scanning unneccessary messages. The slots on the takeup reel were narrow, and this made the re-threading operation very tedious. The teleprinter was noisy to the point of disturbing someone sleeping lightly. Trash management was a necessary evil with the teleprinter. A snap pattern with a permanent trash bag should be mounted in the vicinity of the teleprinter. (Editor's note: Corrective action is in process.)

4.5.4 Auxiliary Power Unit (APU)/Hydraulic System Operation

The APU/hydraulic system performed well throughout the flight with the exception of a dual heater failure on system 2. APU start could be felt on the pad and on orbit. It was characterized by a high frequency but very low amplitude buzz. No discernable difference was noted in this buzz between single or multiple APU's. There was no apparent difference between a zero-g and a 1g start. APU 1 was used to perform the flight control system checkout on day 1. When the secondary actuator bypass check was performed, a thump was felt in the cockpit for each of the four bypasses. No anomalies were noted during this check.

During the sleep period on day 2, the crew was awakened by an APU gas-generator-bed temperature being out of limits low. This was verified as a heater problem by cross-checking with the injector temperature, which was also low. The heater switched on;

however, a few hours later, the alternate heater also failed to control the temperature. Because of this heater failure, an alternate start procedure, using start/override, had to be used on system 2. All other operations of the system were normal.

4.5.5 Mechanical Systems Operation

The external tank umbilical door operation was normal, and the operation times indicated dual-motor operation. The Mission Control Center made a real-time switch position change to put the mode switch back to computer control to prevent switch failures from inadvertently driving latches or doors after they were closed. This was a desirable change and has been included for STS-2.

Payload bay door operation was accomplished with no anomalies. Both the port and starboard doors had several hesitations in their motion between the closed and 90-degree positions during opening and closing. This had been observed preflight and was attributed to the strongback zero-g fixture operation. During the starboard closure and stop for the centerline overlap check, the door oscillated an estimated ±8 in. (maximum) for for approximately five cycles.

On the initial overlap check, the starboard door appeared very straight, and all latch rollers appeared to be passing just to the left of position A. On days 2 and 3, the forward position of the door appeared as it had on day 1 (just to the left of "A"); however, the aft 1/4 of the door was shifted slightly toward the port door. It appeared that latch 12 would hit about 1.5 in. below position "C". Judging this position on the aft latches is very difficult and should only be considered an approximation. No change was noted between days 2 and 3. (Section 8.0, flight test problem report 45.) All door-closed indications were obtained using the door drive only; i.e., the bulkhead latches were not required to get this indication.

4.5.6 Fire/Smoke Detection System Checks

During the two checks of the fire and smoke detection system, the sensor A cabin light came on intermittently. Even with repeated cycling of the sensor A circuit breaker, the flight deck left sensor A light would not operate; however, the lamp test was satisfactory. (Section 8.0, flight test problem report 36.)

4.5.7 Environmental and Thermal Control Systems Performance Operations

The flash evaporator performed normally during the mission. Primary flash evaporator system A was manually activated during the launch phase. Also, it was restarted after each accelerometer calibration and the gravity gradient free drift test.

Neither flash evaporator primary system B nor the secondary flash evaporator controller system were operated. Future flights should require activating these systems since the space environment is required to get a proper end-to-end test of these critical systems. Shortly after the high load evaporator was deactivated, the high evaporator duct temperature caused a caution and warning illuminated at 302° F, a normal condition. The duct heater was shut off. The duct temperature caution and warning should be raised to a value which is consistent with design limits and still will activate the caution and warning.

4.5.8 Radiator Operations

The radiator performance was normal except for the second activation following payload bay door opening on the second day. The radiators were placed in automatic and the initial check at 90 seconds showed both freon loops in "radiator flow" on the talkbacks. Some time later, freon loop 2 was in "bypass". The display checks showed that temperatures in loop 2 were cooler than those in loop 1. Manual was selected, the radiator placed in flow, and after a suitable wait, the raditor was put back to the automatic position. This time the loop stayed in "radiator flow." Based on frequent comparisons of the evaporator outlet temperatures against the radiator outlet temperatures, the radiators handled the entire heat load of the vehicle while they were flowing.

4.5.9 Cabin/Avionics Bay/Water Loop Operations

The first night the cabin temperature on the flight deck was in the low 60's. The cabin temperature control knob was turned full up, and both crewmen donned extra clothes. A check of the cabin temperature control valve on the equipment deck showed the valve to be fully open. Some time later the mechanical temperature control valve was discovered to be in the full cold position while the temperature control knob was set at full hot. The machanical valve was then pinned in the full-hot position until just prior to entry, at which time it was pinned to full cold.

The second evening, water loop flow was also increased, and the cabin temperature was confortable during the second sleep perior. Manual control of the water loops was straightforward except for switch nomenclature on the water loop bypass manual switches. Cold cabin temperatures for pressure suited operations are very desirable and should be planned for that period.

(Editors Note: The cabin temperature instrument that controls the automatic system is located between two electronics boxes that hot bias the cabin temperature control. The temperature sensor is to be relocated on the basis of STS-2 temperature data.) (Section 8.0, flight test problem report 13.)

4.5.10 Pressure Control System Reconfiguration Operations

The secondary pressure control system was selected on the second day. At this time, the primary system oxygen regulator was leaking. The pressure increased on the oxygen side of the regulator until it was equal to that of the nitrogen regulator, about 212 psi. Closing the oxygen valves in the first system did not stop the leak; the ground notified us that the system, even with the leak, was operational in all respects. Normal configuration with both 14.5 psi regulator valves off was selected for entry. The location and orientation of the pressure control system mechanical/electrical valves on the overhead panel of the waste management system lends itself to frequent crew procedural errors both during simulations and in flight. Extreme care is required when operating these valves and switches.

4.6 CREW/ORBITER COMPATIBILITY TESTS

4.6.1 Television Camera Operation

Both the payload-mounted and crew compartment television cameras and equipment performed well. All associated flight test requirements were performed except the daylight portion of TV04, and only a single camera was used for the lithium hydroxide canister changeout in TV09. Both of the camera activity deletions were due to time constraints.

Once deployed, the cabin cameras were left out for the remainder of the flight. The small attachable monitors were not used; instead the flight deck monitors were used. It was noted during the fourth television transmission that no data were displayed on monitor 2, and this is believed to be the result of a switch misconfiguration. Monitor 2 also had a large scratch on the glass surface as noted during crew ingress prior to lift-off.

4.6.2 Crew-Operated Cameras

4.6.2.1 General Operations. - The camera systems provided for STS-1 usage were from previous programs; consequently, the 16mm interior camera did not have an automatic exposure control system or a zoom lens, and the film magazines had limited film capacity (140 ft). The 35mm interior camera was extremely difficult to load, requiring specialized knowledge that could be gained only through extensive training. Also, in the event of a failure, a high probability exists that repair would not be possible.

There are camera developments available that would enhance onboard photographic operations and reduce training requirements. The 70mm camera is an excellent, easy-to-use camera for exterior (out-the-window) operations; however, there was no capability available for annotating time on the film, such as is common on engineering cameras. Film backs with this feature are available. The crew-operated cameras should be reviewed from the standpoint of performance upgrading and potential cost reductions.

4.6.2.2 35mm Camera Operation. - The 35mm camera was used for crew compartment photography, with most such photography being spontaneous rather than controlled by the flight plan. The flash attachment required a warmup time, and this condition was not compatible with photographs of opportunity. It is desirable to have a flash that is ready whenever required. Preflight training had shown that leaving the flash enabled quickly ran the batteries down.

A significant problem was encountered in getting the film securely attached to the takeup reel when changing the film canister. The film felt as though it was hanging up in the film canister. A second canister proved to be easier to thread, but is was still a very time-consuming and frustrating activity.

4.6.2.3 70mm Camera Operations. - The 70mm camera was used with the interior film to photograph the payload bay latches. Only two pictures were produced from all that were exposed. The reason for the loss of these photographs is a total mystery. Exterior film was used to photograph targets of opportunity as briefed informally by several geologists and oceanographers. Using the 250mm lens, stereo pairs of interesting features were made in areas such as the Himalayas, Vesuvius near Naples, Mt. Etna in Sicily, and the Edwards lakebed complex in California. About 450 frames were taken. The overhead windows proved to be the most useful for photography when flying backwards and upside down along the velocity vector. The crew were not aware that the filters from the rear payload-bay-facing windows should have been removed during filming. As a result, some photographs taken at F11 and 1/250 sec were underexposed.

4.6.2.4 16mm Camera Operations. - No significant problems were encountered with the 16mm cameras. There were several instances where exterior film inadvertently was used for interior shots. On two occasions, the 16mm camera was hand-held for interior photography instead of being positioned as recommended. Hand-held 16mm camera operations allowed the crewman to better frame the subject and direct the camera to the objects of interest. Also, within limits, the cameraman can follow the other crewman around the cabin while holding the camera. Although the positioning capability with suction cups was also used satisfactorily to aim the 16mm camera, the cups were used mostly with the TV cameras. The cups would remain attached at most about 1/2 hour.

4.6.3 Food Operations

Meal preparations required a minimal amount of time. The large number of meals that were prepared for the long duration integrated simulations had more than trained the crew for this task. Zero g meal preparation was very similar to 1g, except food handling is easier in zero g. No food packaging failures were encountered.

The food warmer performed exceptionally well. Hot meals made a significant difference in food palatability and improved the comfort of the crew. The food warmer was strapped to a locker door during activation and remained there until deactivation. Food and beverages were acceptably warm after 15 minutes. They could also be left in the warmer well over an hour with no noted degradation.

Meals were consumed on the flight deck. The Commander allowed his tray to float above panel C3 while the pilot ate in the aft flight deck with the tray strapped to his leg. It would be desirable to have several patches of hook Velcro on the back of the food tray. This would permit attaching the tray to available panels for more security.

After-meal cleanups were no problem. Food waste was, in general, stowed in the food overwraps and placed in the wet trash container on the waste management compartment door. Utensils and trays were cleaned with wet wipes and tissues.

4.6.4 Window Operations

The forward windows all had some particles on them. Windows W1 and W6 had a coating that appeared like a fine powder. It ran almost the full length of the leading edges of these windows and extended aft approximately 1 inch.

There were streaks on the forward windows that had been made by particles flying off forward of the vehicle and impacting the windows. There was also a minor amount of contamination on windows W8 and W10. All other windows, including the hatch window, were clean. All contamination was very minor and did not impair the use of the windows in any manner. After landing rollout, all the forward windows were still clean.

4.6.5 Cabin Noise

Cabin noise measurements were taken forward and aft on the flight deck as well as the center of the middeck and forward on the middeck. With the noise curtains installed, the noise measurements were:

Flight deck,	forward	62 dB
	aft	65 dB
Middeck	center	67 dB
	forward	67 dB

With the curtains stowed for entry, the level was 70 dB. From a subjective standpoint, the cabin noise environment was acceptable and the noise curtains did little to enhance that environment.

4.6.6 In-flight Maintenance

The in-flight maintenance activities associated with the cabin fan filter cleaning went very well. The in-flight maintenance on the DFI recorder did not go well. Both crewmen working together were unable to remove the coverplate screws. As a result, the recorder replacement had to be abandoned. Should in-flight maintenance of other equipment be added as an option, the fasteners, fittings, and hardware should be evaluated to make sure that they are both readily accessible and easily changed out within the limitations of the zero-g environment.

4.6.7 Pressure Suit Doffing and Donning Operations

Zero-gravity was an outstanding aid in suit doffing and donning. The suits were self-doffed and donned twice. To doff the pressure garment, it was only necessary to pull the head down and wiggle the garments. Suit mass shook it free. No disorientation inside the suit on the middeck was evident. To maintain communications with Mission

Control, the suits were doffed and donned serially. In addition to maintaining communication, the other crewman had, of course, to be ready to copy instructions or to work problems in real time. The only way to don suits serially to stay on the timeline, was to unstow all the equipment associated with suit donning to have it handy on the middeck and ready to don. In addition, the in-flight clothes were pre-stowed and the transferable equipment was placed in the pressure garment. On future missions the crews should continue to exercise suit donning practice in zero-gravity, and when required, serial suit donning should be continued.

4.6.8 Gas Sampling and Solid Solvent Sampling

Gas sampling and solid solvent sampling tests were conducted. The only difficulty was that when the solid solvent sampler was vented to vacuum, a pair of pliers was required to break the lid seal to move from day 1 to day 2 and back to off. The stowage drawer of the sampler devices, MA9L, was badly misaligned and extremely difficult to lock. (Section 8.0, flight test problem report 40.)

4.6.9 Waste Management System Operations

The waste management system was first activated during suit doffing about 3 hours into the mission. Use of the urine collection hose was straight forward and accomplished without restraints. Initially, although the suction was low, the urine system collected all the urine, and the cone was free of any urine droplet residuals. On the second day, however, the urine system began to degrade significantly. About 5 hours prior to the deorbit maneuver, the system would not accept urine. The urine completely backed up, filling the cone cup. A towel was stuffed in the cone. Following that, both crewmen used their pressure-suit urine collection devices.

The fecal system apparently operated normally, but the system from first use did not have sufficient suction to separate the feces from the buttocks and this resulted in extra cleanup time being required for the defecation task. The fecal system suction continued to degrade during the mission. (Section 8.0, flight test problem report 33.) When the waste management system was operated, it made a loud whirring noise like a washing machine spinning up. This will interfere with the crew's sleep when this system is used during the sleep period.

The timelines did not allot time for use of this waste management system. This is another reason for keeping the post-insertion and predeorbit procedures uncluttered. Also, the checklist had the crew securing the waste management system for entry prior to suit donning. This activity should be scheduled post-suit donning along with the PCS reconfiguration when the waste management door is closed. There seems little reason to fly the heavy waste management system door, as it was left open the entire flight after it was discovered necessary to use a pair of vice grips to operate the latching handle. There is, however, a requirement for a platform to the side hatch for rapid unaided crew egress after the white room closeout crew has departed.

4.6.10 Stowage

The crew experienced difficulty stowing equipment for entry in the single entry trash stowage locker. As has been noted on past programs, equipment that is packed with the aid of 1g cannot be compressed to the same dimensions for stowage in zero g. Difficulty was encountered in the zero-g stowage of the in-flight garments, the flight data file, and the used food wrappers. An extra trash stowage locker would have minimized the trash stowage difficulties on STS-1. Provisions that are adjusted for mission duration should be made for additional empty stowage lockers for equipment and/or trash. A trash compactor should be considered for use on long duration missions.

4.7 ENTRY PHASE

4.7.1 Deorbit Maneuver

The OMS two-engine deorbit translation maneuver had a velocity of about 297 ft/sec. The maneuver to the deorbit attitude from the top sun attitude was performed about 19 minutes prior to the deorbit maneuver in the pulse transition digital autopilot mode. This maneuver was a pure body axis roll. However, the attitude perturbation due to the high load flash evaporator thrust resulted in the use of the automatic attitude control mode after roll completion to maintain the proper attitude. The OMS primary and secondary gimbal checks were performed on the primary gimbal system first due to the previously mentioned slow operation of the right engine primary thrust vector control pitch gimbal. No drive problems were apparent on either gimbal system during the drive test. The maneuver was performed on the secondary TVC systems of both engines. The attitude for the propellant wasting angle was about 20° out of plane on the local horizontal local vertical attitude director indicator reference.

Auxiliary power unit (APU) 2, the one with the failed primary gas bed generator heaters, was started at the deorbit maneuver minus 6 minutes and 30 seconds in the start override mode. The APU came on normally 3 minutes before the maneuver. APU 3 was started normally 3 minutes before the maneuver. Both APU's were operated in the depress mode except when repositioning the engines to the entry position. When the repositioning occurred, the small vehicle transients indicated that little movement of the main engine bell had occurred since the engines were originally stowed after the main propulsion system propellant dump.

The deorbit maneuver targets had been loaded and checked and a final trim in pulse mode to the deorbit attitude was completed 1 minute before the maneuver. The OMS engines ignited normally, with the chamber pressure on both engines reading slightly in excess of 100 percent. Attitude errors were tightly controlled by the autopilot, and the maneuver was completed on time. The velocity residual was 0.1 ft/sec.

4.7.2 Post-Firing Maneuver to the Entry Attitude

Following the deorbit maneuver and after performing entry switch position checks, a pitch-up maneuver to the entry interface inertial attitude was initiated in pulse mode at 0.2 deg/sec. The thrust from the APU 2 and 3 exhaust lines increased the rate of this maneuver to more than 0.5 deg/sec during the maneuver, and the roll/yaw effect of the flash evaporator made for additional attitude corrections at the completion of the maneuver. This maneuver could be performed using the APU pitch torques alone to start the maneuver. Once in attitude, the transition autopilot was placed in automatic to hold attitude against the thrust of the APU's and the high-load flash evaporators.

The vent doors were closed and verified closed by the ground. The Mission Control Center reported at Guam that no time increment was required to update the state vector. This gave us complete confidence that the Orbiter's position in space was normal for this first entry. The ejection seat and hatch safety pins were removed.

4.7.3 Entry Interface Minus 5 Minutes

The entry attitude was trimmed to zero-degree roll, zero-degree yaw, and 39-degree pitch on the attitude director indicator, using the manually controlled pulse mode. Auxiliary power unit no. 1 was started normally at entry interface (EI) minus 5 minutes, and all APU's were placed in the normal operate mode (3000 psi on the hydraulics) prior to the digital autopilot transition. The transition to the digital autopilot entry mode was made at about EI-4½ minutes.

Prior to the Guam loss of signal, slowly increasing amounts of static were noted on communications. Below 400,000 feet, yellow-orange flashes from the rear pod RCS thrusters were reflected in the front windows. Reaction control system engine firings and elevon surface positioning appeared to be normal during the transition to the autopilot. Both the pitch and roll/yaw axes and the speedbrake control were placed in the automatic control mode. The body flap was retained in manual.

At about 330,000 feet, the Commander started the 16mm camera at 2 frames/sec when he first saw a light pink air glow out the side windows. At this same time, both crewmen lowered their visors. The glow increased in intensity to pinkish-red. Out the front windows the glow was more reddish-orange. There were occasional streaks of orange white from the nose. Prior to initiation of the first roll, the sun rose on the pilot's side of the Orbiter. When this occurred, the sunrise completely wiped out the pilot's capability to see this obviously tenuous air glow. On the Commander's side, only momentarily, the dim sunlight horizon cut through the pinkish-red glow. Above and below the sunlight horizon, the pinkish-red air glow was clearly evident. The first roll reversal occurred on time at about 255,000 feet. When this happened, the Orbiter rolled to about 80° right into the sun. It was then no longer possible for either crewmen to see any entry air glow for the remainder of the entry phase. At a dynamic pressure of about 0.5 lb/ft^2, the body flap was positioned to automatic. Elevon body flap interaction was normal. The body flap automatically positioned itself to about 80 percent and appeared to remain there down to about Mach 15. The elevons were within their trim limits.

4.7.4 Entry

The first roll was made in automatic mode and was performed at 6 deg/sec. The inertial sideslip needle on the attitude director indicator pegged, indicating a better than 2-1/2 deg error. When the roll angle was achieved, the vehicle inertial sideslip oscillated with decreasing amplitude for about three cycles before damping. Much more than normal yaw thruster activity was exhibited during this roll damping event. Section 8.0, flight test problem report 35.) During the remainder of the hypersonic flight regime, entry/roll reversals were completely normal with regard to yaw thruster activity, and the vehicle exhibited essentially "deadbeat" damping (no oscillations) when the commanded roll angle was achieved. On DPS entry trajectory no. 1, the spacecraft symbol was initially positioned about 1/4 in. above the middle line. At about 1100 miles to go (completion of trajectory no. 1), the spacecraft symbol was about 1/4 in. below the middle line. The lift-to-drag performance of the Orbiter with respect to the anticipated vehicle performance was monitored by comparing the real-time computed roll reference angles of the Orbiter with the nominal roll reference angles on the entry cue card. Initially, in early entry, the Orbiter roll reference angles appeared to exceed those of the cue card by 2 or 3 degrees. However, by Mach 14 the calculation of the Orbiter roll reference angles were within a degree of the preflight cue card values, indicating that the vehicle lift-to-drag ratio was essentially what had been predicted pre-mission for 40° angle of attack.

When drag updating was incorporated, an error of only 2500 ft was indicated. The surface trim positions checks appeared normal on every scan of the surface position indicator during the entry. The g force slowly increased during entry to a level of about 1.5 during the latter part of entry. The highest equivalent airspeed noted was approximately 235 knots between Mach 2 and 1. On those bank reversals when the earth was in view from the window, the curving path of the groundtrack was easily discerned.

During hypersonic stabilized flight and during the hypersonic reversals, the Orbiter felt solid. No elevon surface oscillations were noted on the surface position indicator or sensed in the cabin. Evidently the true hypersonic stability of this remarkable vehicle has not been properly simulated yet. On the basis of STS-1 flight results, it appears possible that the vehicle can be flown hypersonically above a dynamic pressure of about 20 psf without using any reaction control system yaw thrusters. However, it would be prudent to keep the yaw thrusters available in a wraparound mode for unanticipated c.g. offsets that might occur.

All roll reversals occurred within 0.2 Mach of when predicted on the preflight normal end-of-mission entry trajectory. This was additional evidence that the lift-to-drag ratio of the vehicle compared well with that of the preflight estimates. During entry, the Commander had difficulty reading the instruments because of sun in his eyes; however, this problem was easily corrected by using the left hand to shadow the sun from the pressure suit faceplate.

The flight control system transients associated with the interception of the guidance constant drag phase and consequent commencement of the guidance transition phase seemed less severe than those experienced in the Shuttle mission simulator.

The crew heard the Mission Control Center giving rendezvous data to the chase aircraft on UHF at about Mach 11.8, out of blackout, and communications were established at that time. Speedbrake full deployment at Mach 10 and retraction to 65 percent at Mach 4 were normal. The Orbiter passed over the West Coast in a right bank at Mach 6.6 and from the landmark positions, the crew knew that the vehicle was on the normal groundtrack. The TACAN locked onto Edwards primary channel and, after discussion with Mission Control, was selected for incorporation into the vehicle navigation state at about Mach 6. At Mach 5, the pilot pressurized the engines with the pneumatic helium switch.

The Mach 4.8 roll reversal and the Mach 2.8 roll reversals were done with the roll/yaw modes in control stick steering. Both roll/yaw CSS takeovers were made just after the automatic system had commanded its reversals. In addition, both pitch and roll/yaw control stick steering were selected prior to the Mach 2.5 entry flight control system/ terminal area energy flight control system switchover to minimize any possibility for vehicle transients in this flight regime. In every case, the roll and/or pitch error needles were centered, and the Orbiter was returned to automatic mode control. These transitions were exceptionally smooth and with no evidence of control surface activity when switching from automatic to control stick steering and back. The ammonia boiler was activated at 120,000 ft.

The air data probes were deployed at Mach 3.8, and the air data were incorporated at about Mach 3. The Orbiter was checked for aileron trim, and the largest aileron trim that was noted was about 0.2° on the cathode ray tube display. There was no surface position evidence of any aileron/rudder force flight below Mach 3.5 when the rudder became active.

After the Mach 4.8 roll reversal to the left, the Commander could tell from comparison of the out-the-window landmark positions of Bakersfield, Lake Isabella, and Mojave Airport with pre-mission Mach number and attitude that the Orbiter groundtrack was normal.

At the terminal area flight control switchover, the vehicle was in a slight left bank to intercept the Edwards lakebed runway 23 heading alignment circle. About Mach 2.0, the crew felt the first slight evidence of transonic aerodynamic buffet. This buffet intensity steadily increased through the transonic flight regime and seemingly reached a peak at about Mach 0.9. Below 0.7 to 0.6 Mach number, the vehicle was totally free of aerodynamic buffet for the remainder of the approach and landing phase. The pilot had selected air data for his displays with no evidence of any attitude of Mach jump as the vehicle went subsonic. Glare from the sun had to be shielded by hand so that the Commander could monitor the critical angle of attack on the tape meter from Mach 2 to Mach 0.8. The flash evaporator was secured at 65,000 ft.

Between 40,000 and 35,000 ft., and approaching the runway 23 left heading alignment circle, control stick steering was selected in both pitch and roll/yaw. The immediate flying quality impression of the Orbiter in subsonic flight was that of solid control. When the vehicle wings were positioned in a bank they remained positioned in that bank. When the nose was put at an attitude, it remained at that attitude, with control both crisp and precise. While flying around the heading alignment circle, the guidance was both monitored and followed. Midway around the alignment circle, manual control of the speedbrake was taken. On the outer glide slope, acceleration and control of the navigational airspeed at 285 knots equivalent was an easy task. The chase pilot confirmed our airspeed readings. The raw guidance glideslope data were followed. The Commander's horizontal situation indicator compass card had frozen sometime earlier in entry.

Radar altimeter lockup was achieved at 5000 ft. At about 2800 ft, because the equivalent airspeed was reading 282 knots (three knots slow), the speedbrakes were retracted. Preflare was commenced at about 1750 feet above ground level.

The Orbiter accelerated after speedbrake closing and during preflare to in excess of 305 kts equivalent airspeed. The main gear was deployed at about 275 kts equivalent airspeed. Following this deployment, a radar altimeter check of the radar altimeter revealed an off flag on the meter.

The vehicle was slowly rotated to the landing attitude. At the low landing attitude, the airspeed was allowed to bleed while a very shallow flight path angle was maintained. Touchdown was an estimated 185 knots equivalent airspeed just to the left of the centerline. Touchdown vertical velocity at the cabin felt relatively soft. The speedbrakes were deployed full. Delayed pitchover was commenced at 2 deg/sec at 165 knots equivalent airspeed. When the nosewheel touched, full down elevons were applied. There was an impression of considerable deceleration during this rollout phase, although no brakes were applied. Approaching the far microwave beam landing system shack on runway 23, slight braking was applied. The Orbiter was stopped at the intersection of runways 23 and 15. Light braking was applied for about 30 seconds during the rollout, and just as the vehicle was stopped, the Commander noted a slight pull to the right. The vehicle landed about 3000 feet past the anticipated touchdown position. (Section 8.0, flight test problem report 37.)

4.7.5 Postlanding Activity

The crew unstrapped their shoulder harnesses to safe the OMS and RCS switches. The "swizzle stick" proved to be a great help in reaching the aft-mounted RCS logic and driver switches before seat egress.

The Commander could not insert his D-ring safety pin until after seat engress. A beveled open fitting around the D-ring fitting would significantly improve the crew's ability to make this blind connection during prelaunch activities, in flight, and postlanding. The problem of the BFS computer in failing to go to OPS 0 has been previously noted. Although deletion of the surface drive and engine stowing resulted in several late checklist changes, the changes were handled successfully.

System deactivation was performed ahead of time and monitored by the MCC, which noted that the Commander had missed APU/hydraulics heater deactivations. This illustrates the value of MCC's monitoring the postlanding checklist activity because its detailed sections will rarely be performed in sequence. The temperature on the flight deck was estimated to be in the mid-80's. The temperature on the middeck prior to hatch opening was estimated to be in the mid-60's. The Commander egressed his seat, performed his deactivation activity, and descended to the middeck while the pilot remained on the flight deck to handle communications.

Apparently because of a procedural error in operating the volume control, the Commander was unable to establish communications on the handheld radio using the 282.8 MHz frequency.

The time required to open the side hatch was excessive and should be decreased as much as practical.

5.0 BIOMEDICAL EVALUATION

Medical activities for STS-1 included the preflight and postflight examinations, training and deployment of the emergency medical subsystem, and conduct of the health stabilization program. Medical self-help courses were also given to the prime and backup crews.

The STS-1 prime crew were in good health throughout the preflight, in-flight, and postflight periods. No remedial action was required other than the programmed medication taken by the pilot, a single dose of scopolamine-dexadrine at launch plus 30 min. This was given for space-motion sickness prophylaxis and was included in the checklist. Because the pilot had no symptoms of space-motion sickness, further treatment was unnecessary. Neither the pilot nor commander had any symptoms of space-motion sickness during any phase of the flight. No symptoms of disorientation, perceptual illusions, poor coordination, or coriolis effects were experienced by either crewman at any time.

Sleep was a problem on the first night because of poor temperature regulation which resulted in an uncomfortably cold cabin. Subsequent sleep periods were normal. Sound levels on orbit were at the 65 dB level and did not affect the crewmen's sleep, performance, or ability to communicate.

Appetites were good and meals were reported as satisfactory, with 75 to 95 percent of each meal consumed. Particular mention was made of the food warmer, and both crewmen found it a good addition. The water potability was excellent, and no unusual odors were detected in the Orbiter; however, definitive toxicological data are pending. At this writing, no toxic level of any compound is suspected. Preliminary radiation exposure results show 20 mR delivered to each crewman. Microbiological testing of the Orbiter revealed no significant buildup of microbes, and no significant alteration of the crewmen's normal bacterial flora was observed. Tangentially related to the bacteriologic monitoring program was the failure of the Orbiter commode; however, no major health problem occurred during this short mission.

6.0 TRAJECTORY

The ascent and on-orbit phases of the trajectory are reported in the STS-1 Integrated Mission Report.

The descent phase trajectory for STS-1 followed the predicted trajectory very closely with very low magnitude descent winds and turbulence levels. The entry interface (400,000 ft altitude) was reached with a range to the runway of 4372 nmi compared to the pre-deorbit nominal of 4385 nmi. The range at the entry terminal area energy management (TAEM) interface was 58.9 nmi compared to the pre-deorbit nominal of 59.4 nmi. The drag profile was well within the 3σ dispersion envelope and can be seen in figure 6-1. The roll command and angle-of-attack commands were also well within the expected dispersion envelopes (figures 6-2 and 6-3). Figure 6-4 presents the late entry range-velocity data and shows a perfect overlay with the preflight data. The altitude and energy profile during TEAM were also as predicted and are shown in fugures 6-5 and 6-6. Figure 6-7 presents heading alignment circle turn are shown in figures 6-8 presents the approach and landing trajectory data. The Orbiter landed approximately 3100 feet long. Of the 3100 feet, approximately 1600 feet can be attributed to aerodynamic affects with a slightly heavier than predicted Orbiter weight. The remaining 1500 feet was a result of a combination of small dispersions such as speed at the preflare maneuver position at the preflare maneuver, speedbrake deflection, landing gear deployment time, and touchdown speed.

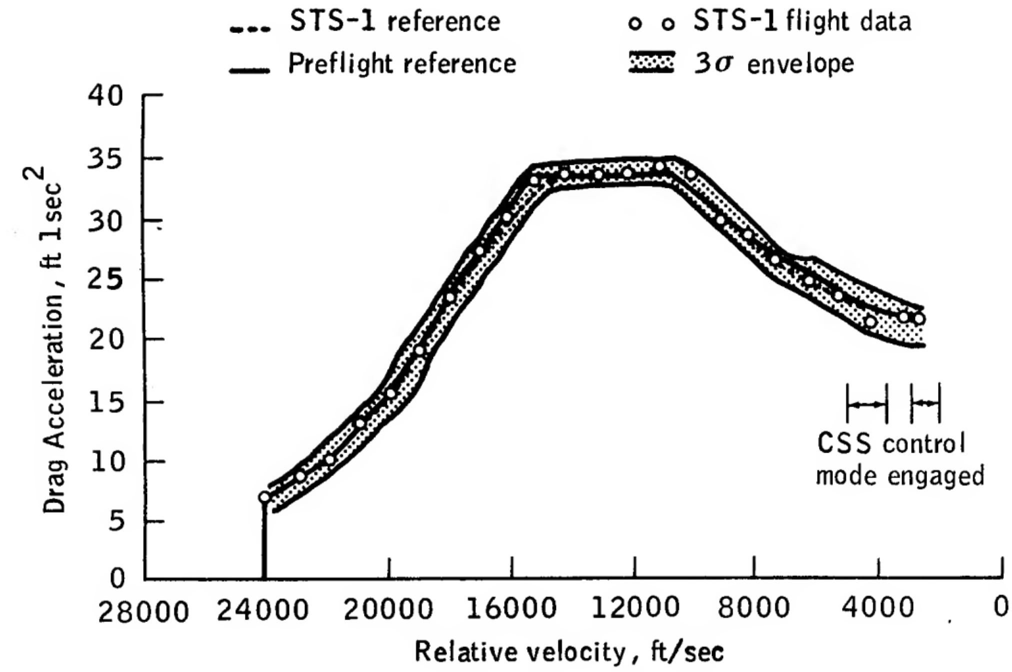


Figure 6-1.- Entry drag acceleration.

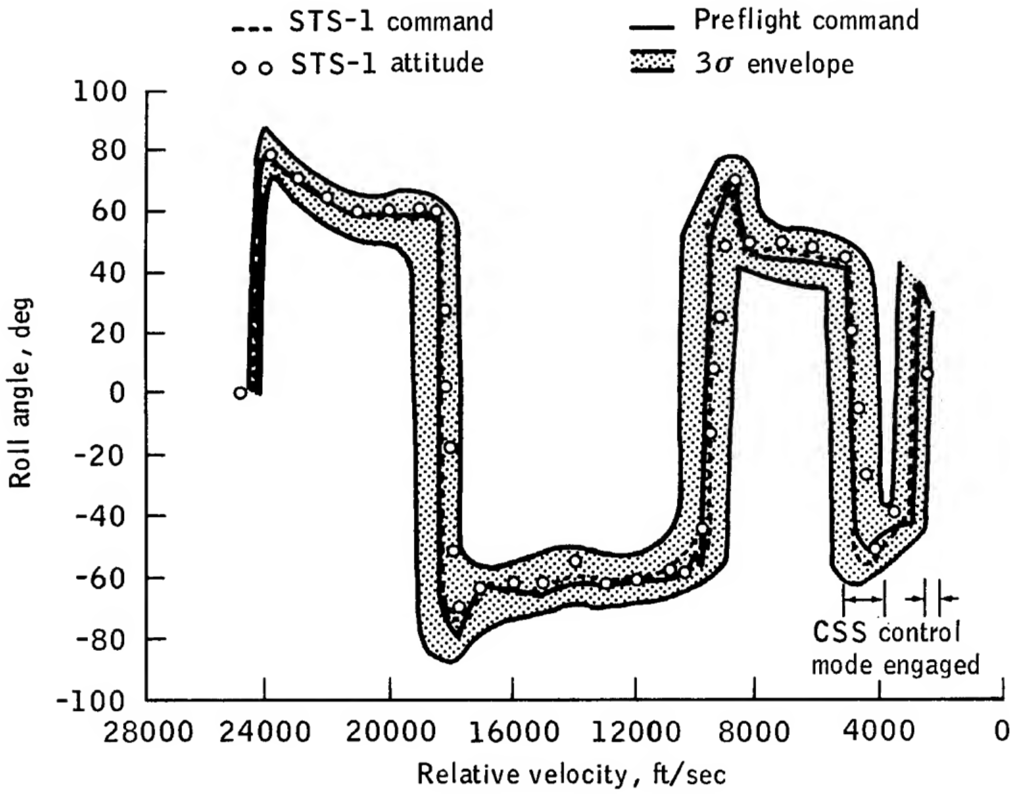


Figure 6-2.- Entry roll performance.

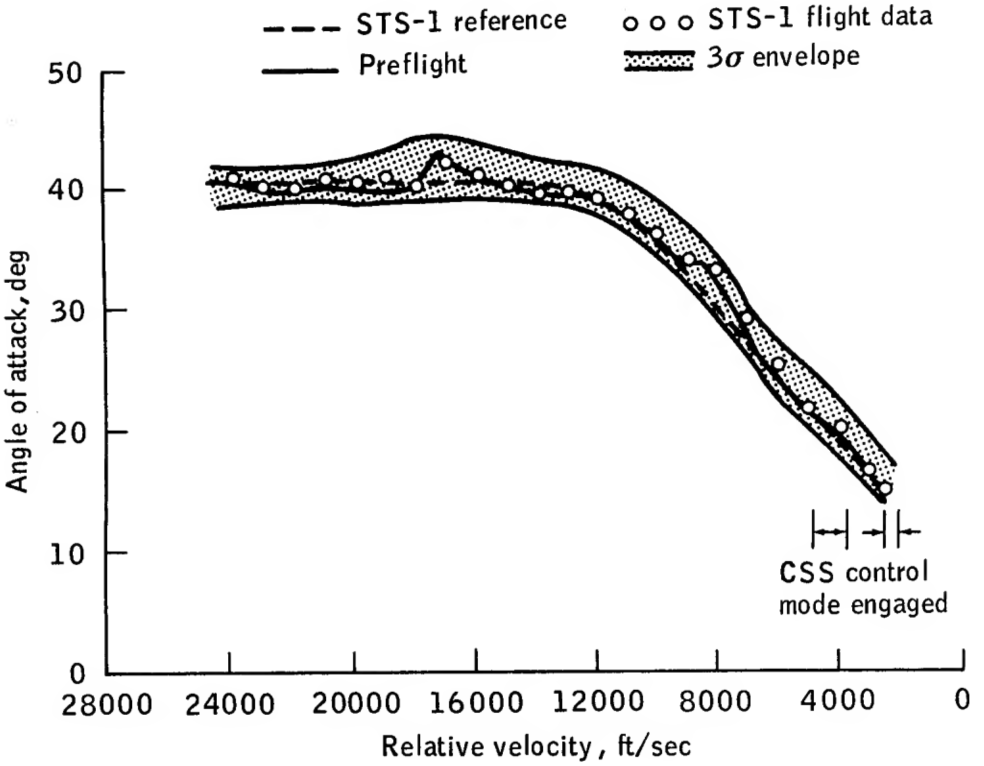


Figure 6-3.- Entry angle of attack performance.

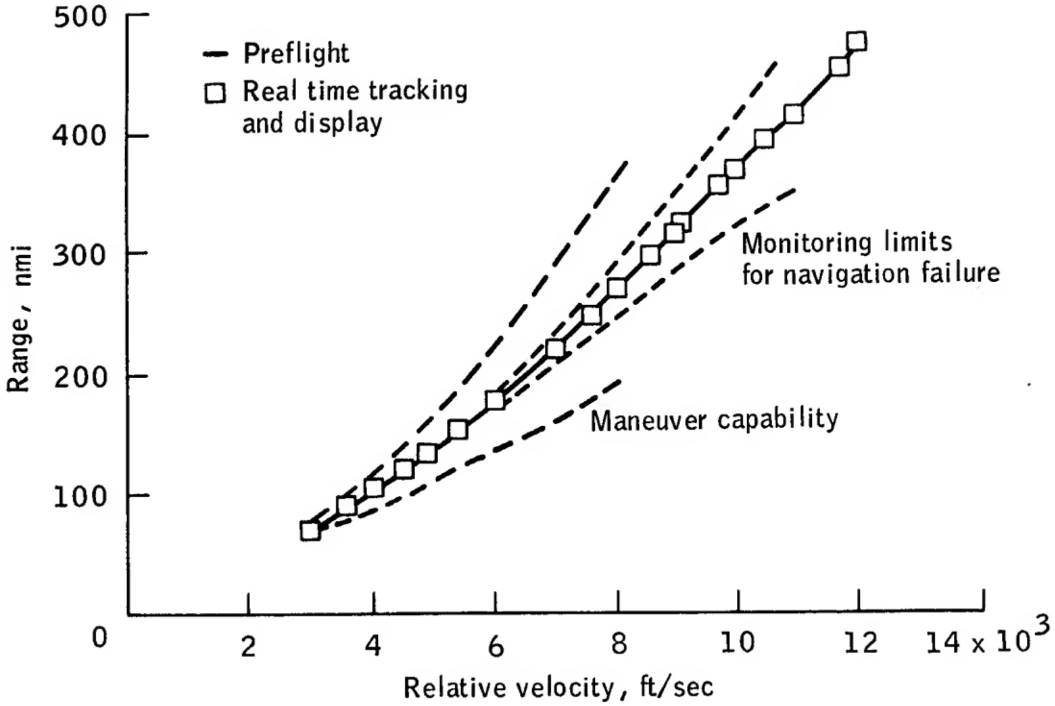


Figure 6-4.- Late entry energy management.

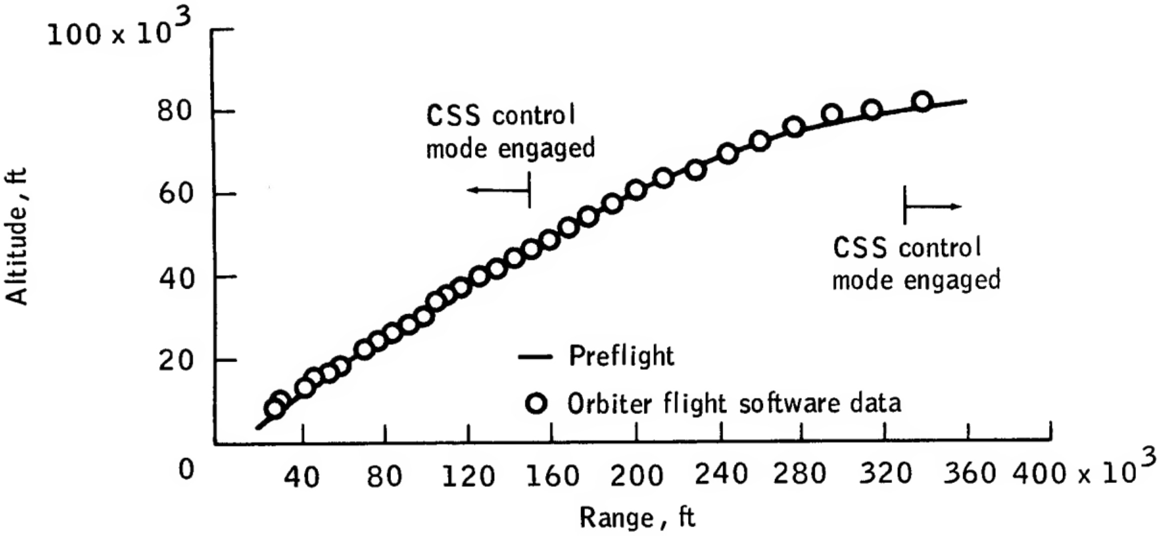


Figure 6-5.- Terminal area energy management altitude/range profile.

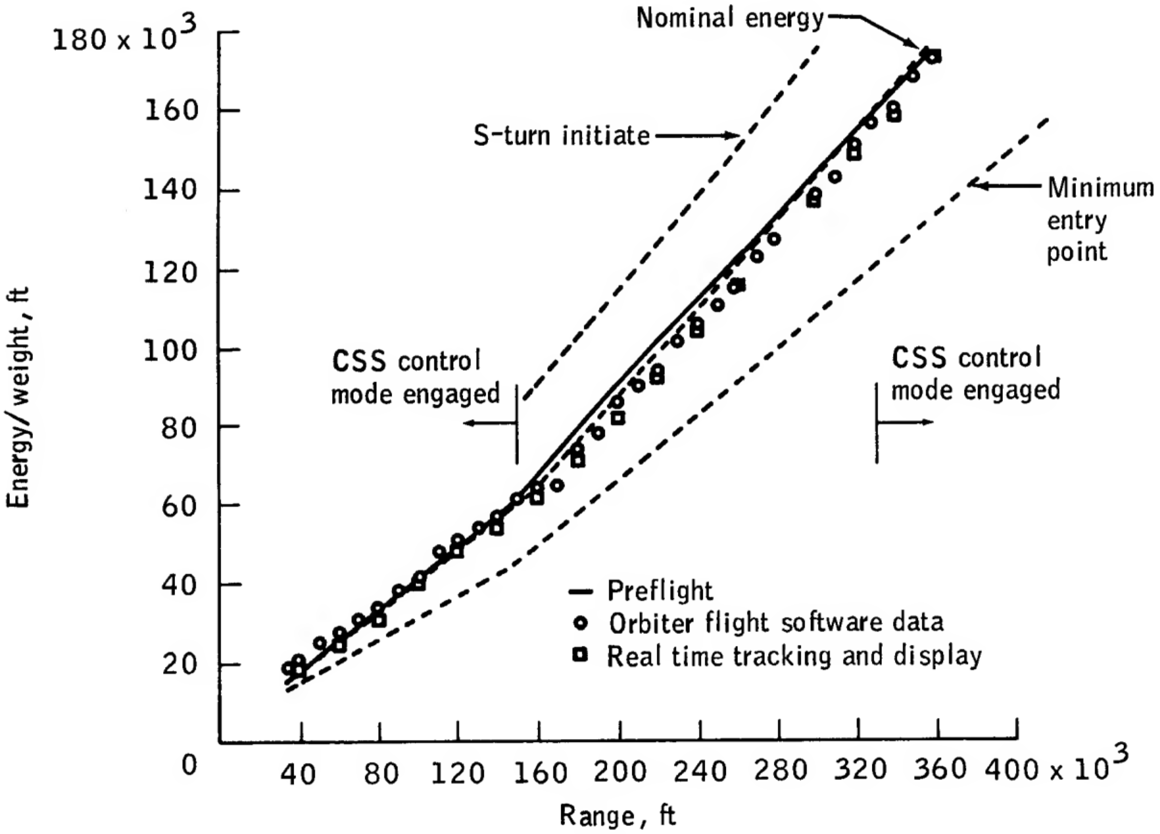


Figure 6-6.- Terminal area energy management.

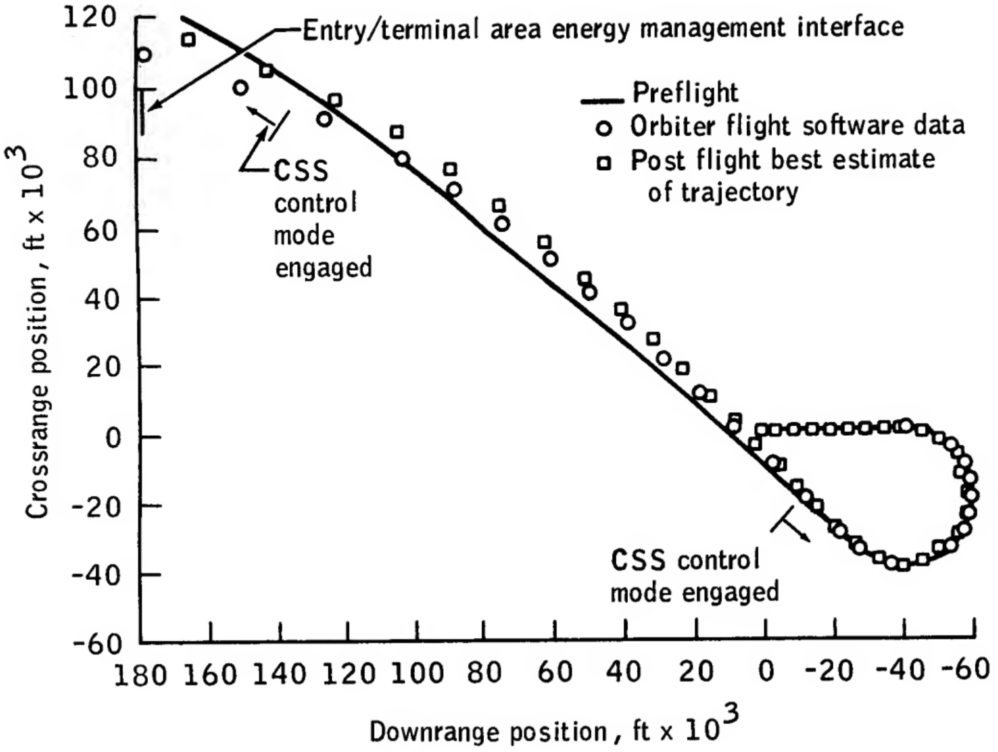


Figure 6-7.- Terminal area energy management approach and landing groundtrack.

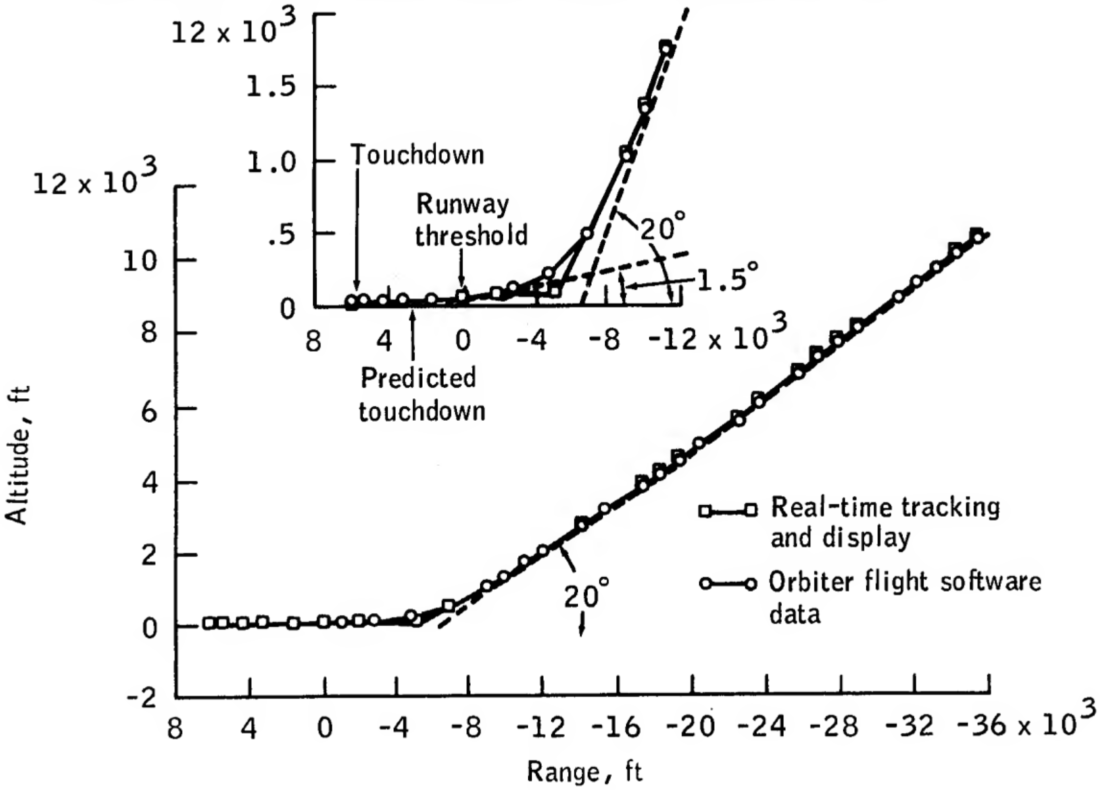


Figure 6-8.- Approach and landing altitude/range profile.

7.0 MISSION CONTROL AND FLIGHT CONTROL EVALUATION

Flight control operations were satisfactory for STS-1. The few anomalies that occurred did not affect vehicle systems operations, onboard or ground monitoring, or mission duration. Activities followed the planned timeline very closely throughout the flight. The as-flown flight plan is shown in figure 7-1.

The full mission control center (MCC) team support began at launch (L) -10 hr for the first launch attempt on April 10, 1981, and continued for several hours into the scrub/recycle sequence until the detanking process was completed, the vehicle safed, and the flight crew safety agressed. For the second launch attempt on April 12, 1981, the full MCC team support began again at L-10hur, with the MCC assuming full control of the mission at tower clear and continuing until about an hour after completion of the landing rollout, at which time control was handed back to Kennedy Space Center (KSC).

In general, communications and data flow between the ground and the vehicle were satisfactory throughout the flight. Theinterim teleprinter system was very effective in providing the crew with flight plan and procedures updates. Many caution and warning and fault detection and annunciation parameter limit changes were uplinked during the flight to prevent nuisance alarms; however, this was expected for the first flight.

The degradation, and in some cases actual loss, of UHF downlink voice during several site passes was an operational nuisance but did not seriously compromise mission conduct. Ground-based navigation was excellent throughout the mission. One anomaly that occurred was the loss of MILA S-band tracking for ascent; however, C-band skin tracking provided an adequate source for ground solutions.

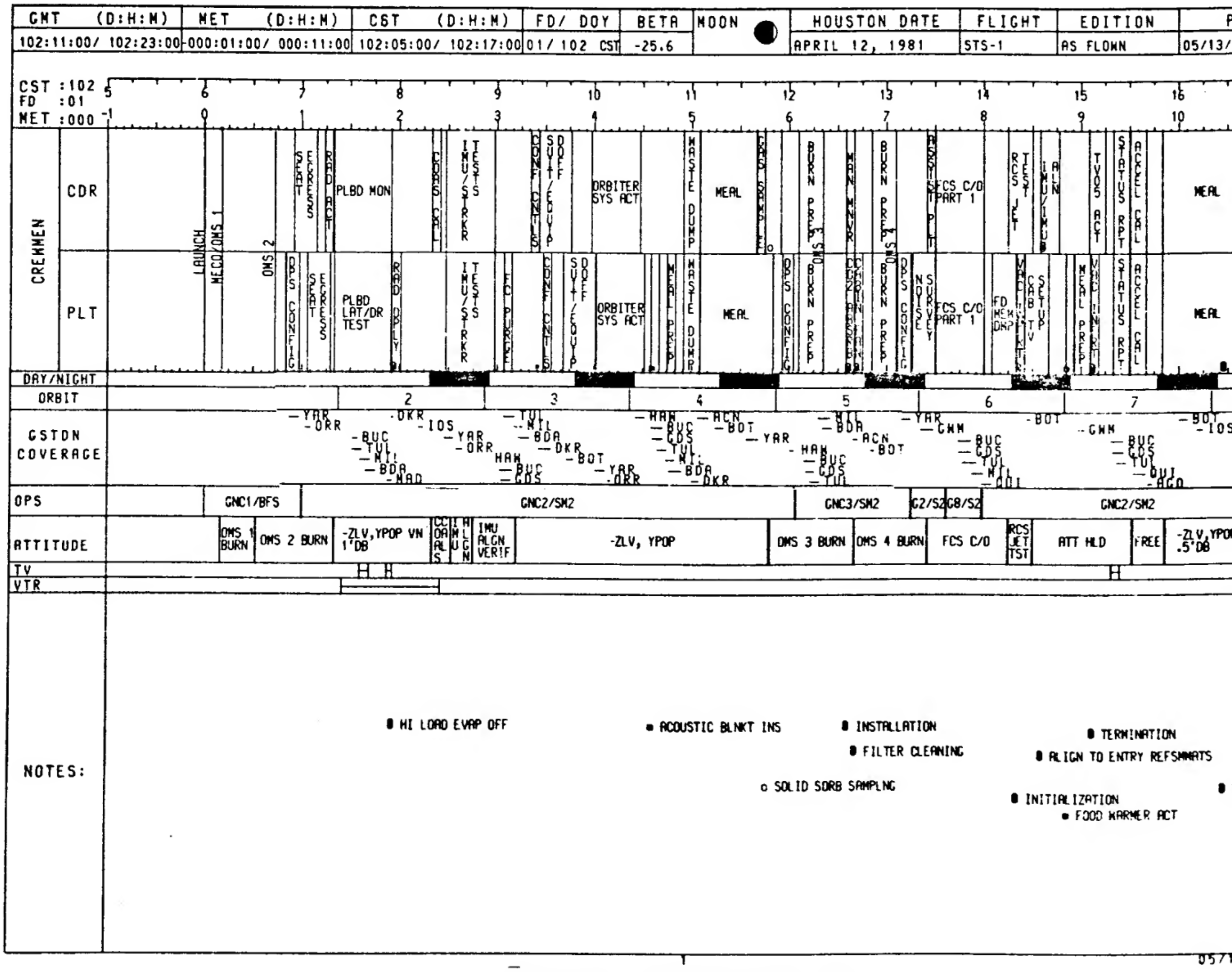


Figure 7.1.- As flown flight plan

GMT (D:H:M)	MET (D:H:M)	CST (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	P
102:23:00/ 103:11:00	000:11:00/ 000:23:00	102:17:00/ 103:05:00	01/ 102 CST	-25.1		APRIL 12, 1981	STS-1	AS FLOWN	05/13/8

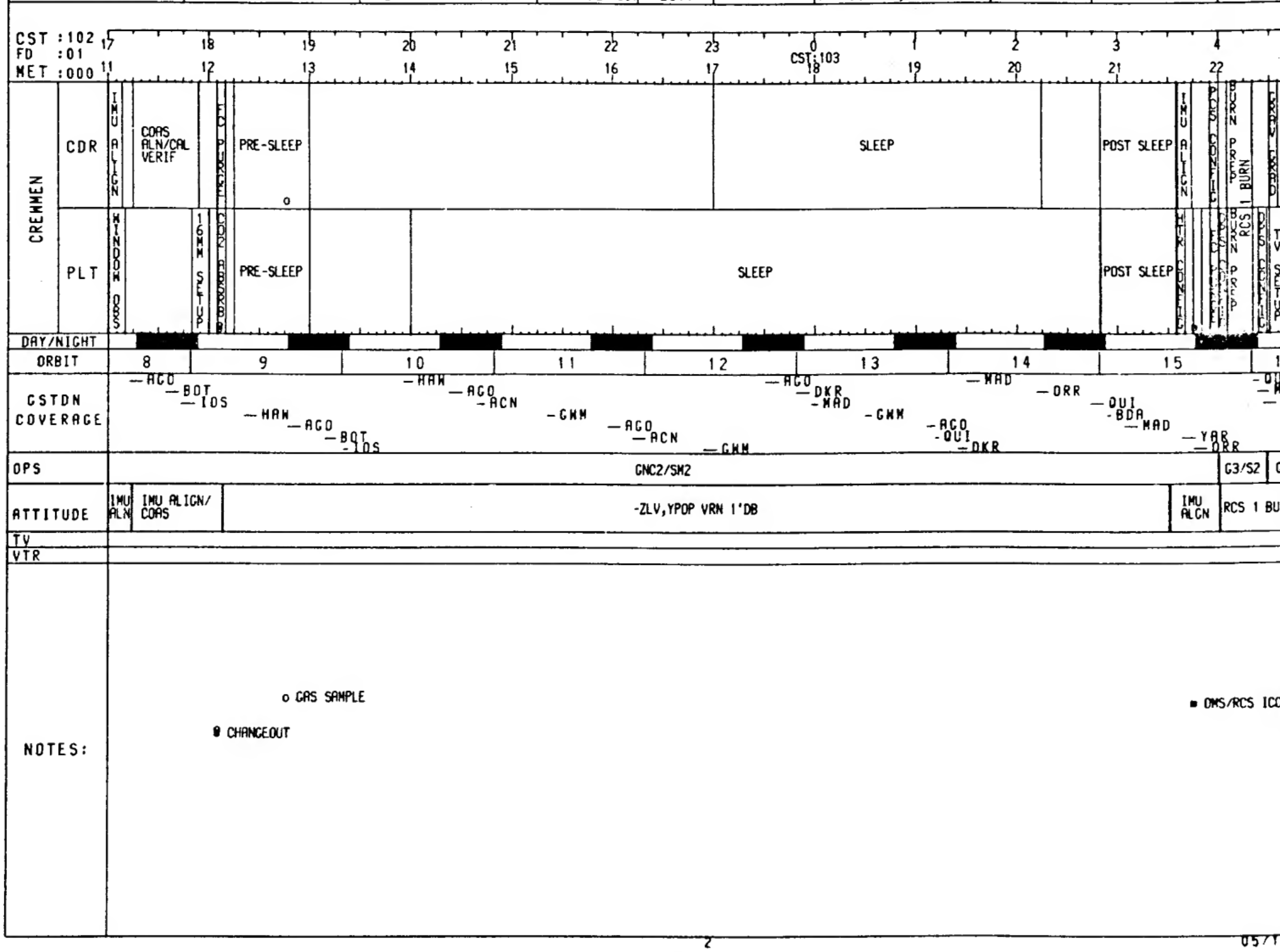


Figure 7-1.- Continued

GMT (D:H:M)	MET (D:H:M)	CST (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION
103:11:00/ 103:23:00	000:23:00/ 001:11:00	103:05:00/ 103:17:00	02/ 103 CST	-23.5	◐	APRIL 13, 1981	STS-1	AS FLOWN

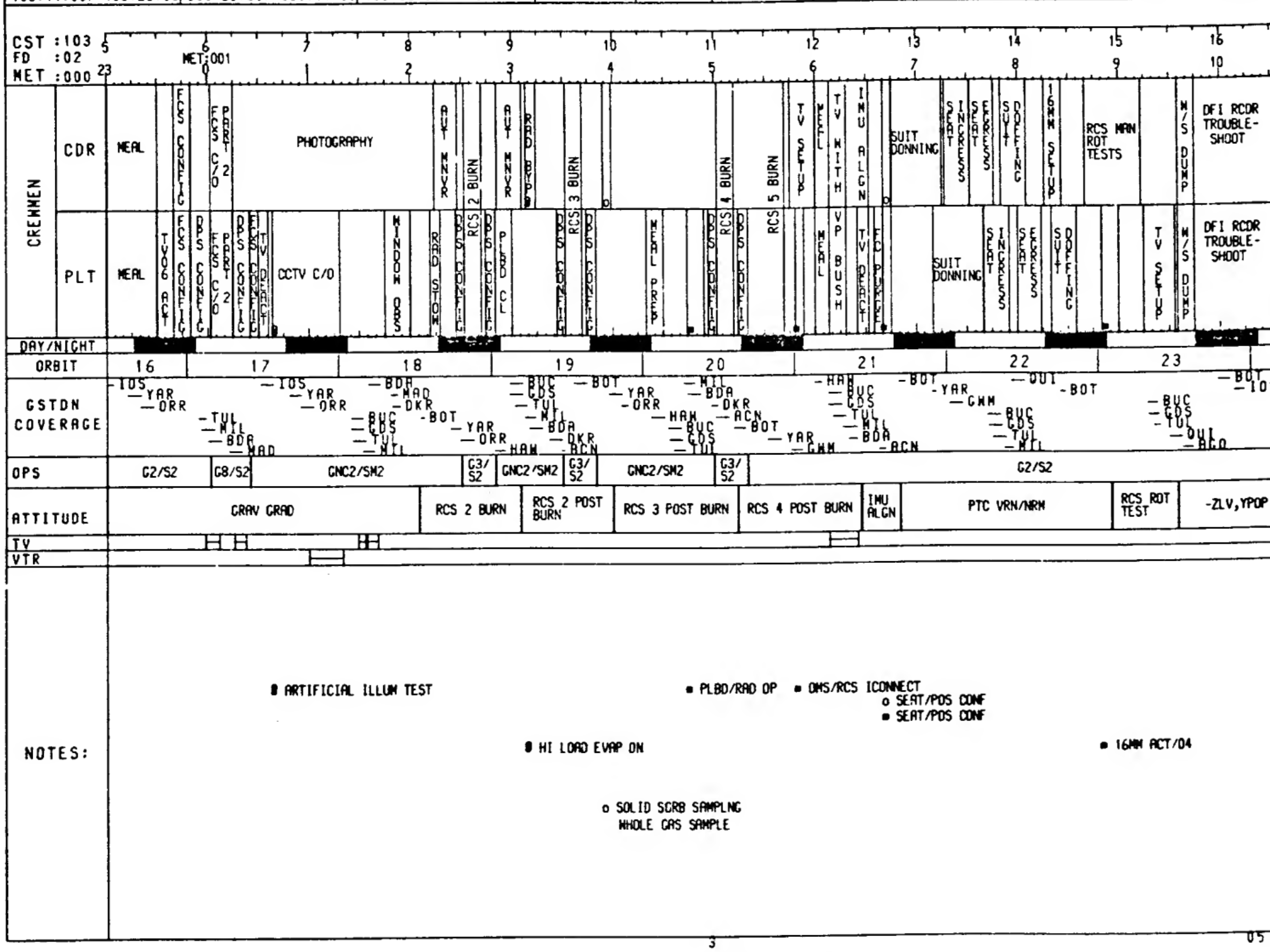


Figure 7-1.- Continued

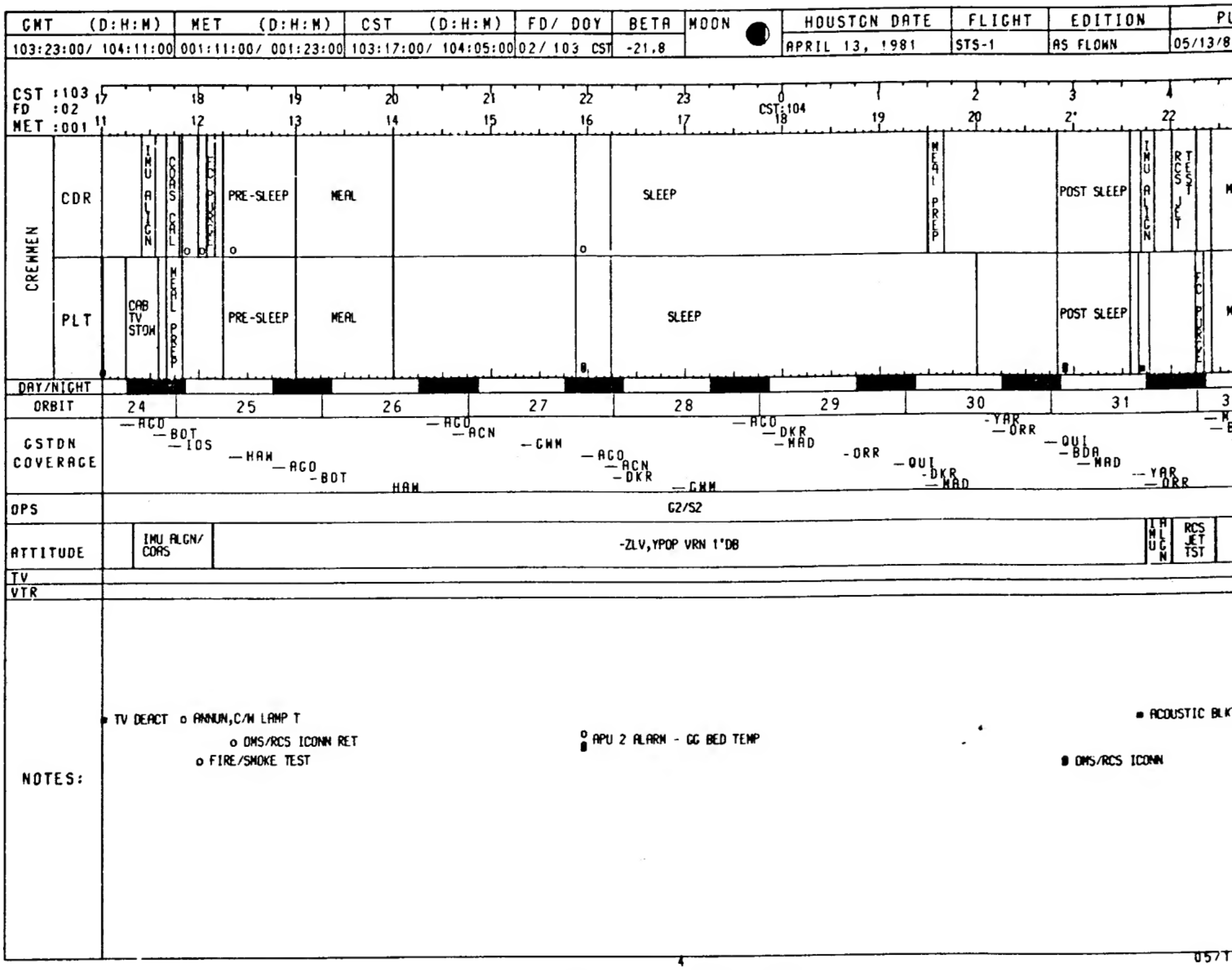


Figure 7-1 .- Continued

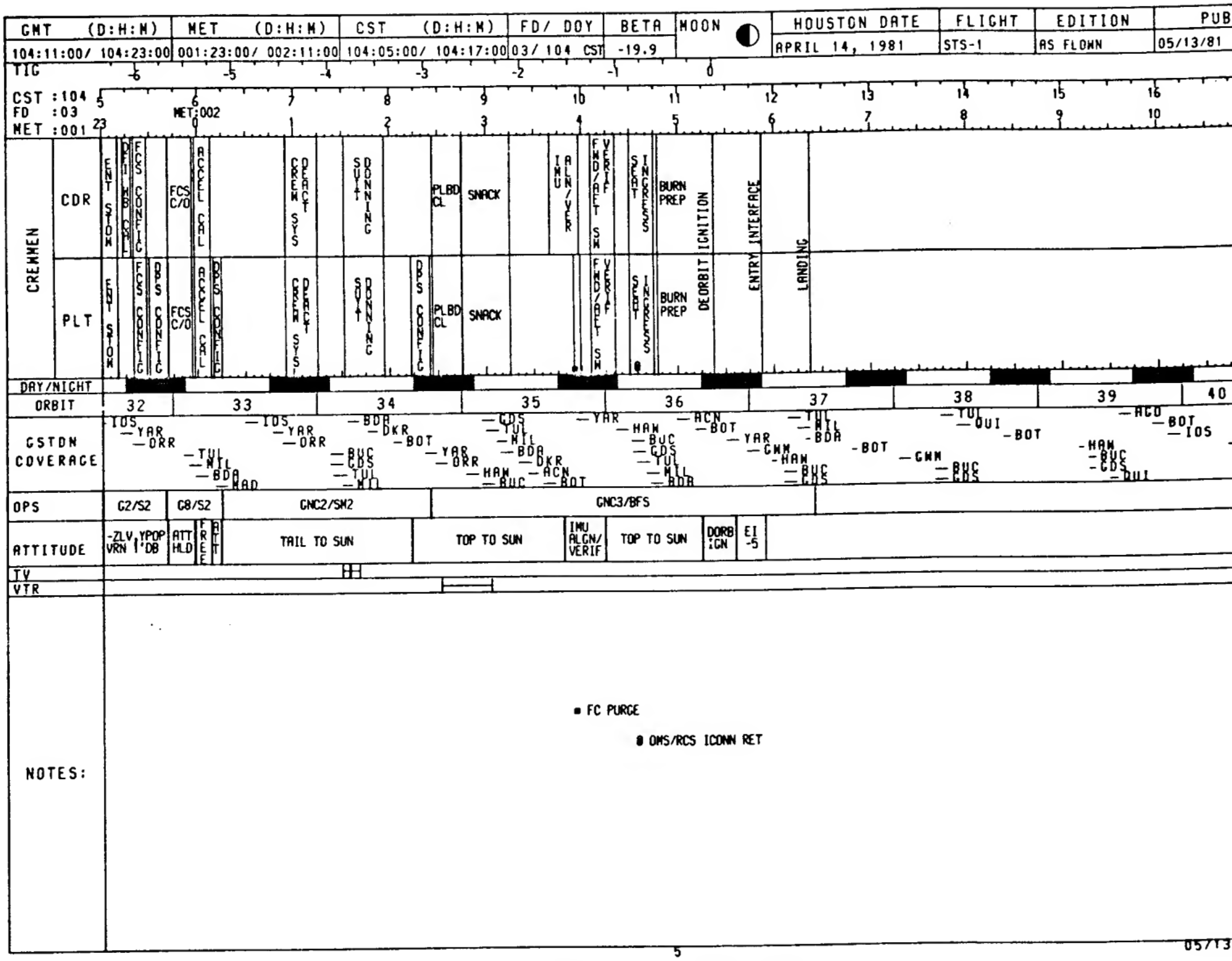


Figure 7-1.- Concluded

8.0 ORBITER ANOMALY SUMMARY

This section contains a summary listing of each anomaly defined during the mission, postflight testing, and during data analysis. Also included are the problem closeout reports with the status of each problem at the time of publication of this report.

STS-1 ANOMALY LIST FOR ORBITER			Date August 5,
No.	Title	G.M.T. D: H: M	Comments
1	Thermal Control System (TSC) heaters exhibited potential "creep" failures:		Postflight acceptance test was failed by 4 the removed thermo switches. Eight switch vendor for analysis. STS-2 environment be
	a) Flash Evaporator System (FES) feedwater zone 4 STBD #1 system (V63T1877)	100:09:47	Thermo switch failure. Removed and replac
	b) Auxiliary Power Unit (APU) No. 1 fuel feedline system B (V46T0104)	100:16:15	Crew switched to system A and temperature cycled normally. Removed and replaced syst thermostat.
	c) Orbital Maneuvering System (OMS) crossfeed high point fuel bleed line in aft and mid fuselage system A (V43T6238 and V43T6234) and OMS aft OX low point drain line (V43T6237)	102:14:30	Removed and replaced thermostats.
	d) APU No. 3 primary and secondary H_2O cooling system A (V46T0394 and V46T0393) and Gas Generator (GG) injector water cooling system (V46T0503A)	102:23:30	Removed and replaced system A thermostat.
	e) RCS fuel fwd panel heaters stayed on without temperature increase	Post Flight Data	POD circuits verified acceptable. Vehicle age and current checks to be performed. T analysis assumed non-metalic structures. C response due to metalic structure.
	f) RCS oxidizer fwd panel heaters did not come on	Post Flight Data	Flight temperatures were not low enough to activate heaters.

STS-1 ANOMALY LIST FOR ORBITER

Date
August 5,

No.	Title	G.M.T. D: H: M	Comments
2	Backup flight system (BFS) did not track primary software system.	100:11:31	The primary system was found to be initiat communications with Network Signal Process (NSP) 40 MSEC earlier than BFS expected. Problem resulted from Primary Avionics Sof System (PASS) timing skew during initializ PASS GPC's reinitialized and dumped to ver that timing skew problem cleared. Problem occurs on approximately 2 percent of initi tions. No postflight action required at KS If a change is made, it will be processed through the regular software control panel
3	Airlock to mid-body differential pressure read low. (V64P0101A)	102:12:01:00	Pressure did not increase during ascent. responded prelaunch. Suspect sense port to body is capped. Crew reported airlock and at same pressure. Port was not vented. R for flight with a vented cap.
4	Built-In-Test-Equipment (BITE) discrete on dedicated signal conditioners (DSC) OF1 and OF4.	102:12:10:00	Crew reported Circuit Breaker 2 panel 15 o Operated on redundant power supplies. CB w not reset. Found short in power supply (B of OF1 postflight. Vendor found a paper cl shorted the power supply to the case.
5	Only engine interface unit (EIU) for SSME #3 had port no. 1 bypass following MECO during EIU power down.	102:12:09	BITE telemetry data review confirmed EIU 1 did not go to bypass. Analysis postflight. Due to data word skew in the Vehicle Data Table (VDT).
6	Main propulsion system GH_2 outlet temperature went off scale high (V41T1261A) and outlet pressure went off scale low (V41P1260A) for left (#2) SSME.	102:12:00:38 and 102:12:01:35	The transducers on the left engine have ha history of failure at MPTA due to high vib levels. Removed and replaced failed pressu and temperature transducers. A new instal location for STS-3 will be provided for th pressure transducer where there is less vi tion.

STS-1 ANOMALY LIST FOR ORBITER

Date August 5,

No.	Title	G.M.T. D: H: M	Comments
7	OMS quantity gauging system was sticking (V43Q4331, V43Q5331 and V43Q5231)	102:12:10:32	Gauging systems for both OMS fuel tanks st at start of OMS-1, 2, 3, & 4 burns. Right total gauge stuck at start of OMS-5 deorbi (V43Q5231) and right fuel total quantity d were high by a factor of two (V43Q5331). fuel tank removed. Found glass broken in Failure occurred postflight due to a flaw glass. Evaluating sources of flaw. Probe placed for STS-2. Vent holes added in hea replacement probe.
8	Development Flight Instrumentation/ Pulse Code Modulation (DFI/PCM) recorder could not be turned off.		Circuit breaker pulled to stop recorder. Recorder was turned on prior to seat ingre before deorbit and CB pulled at seat egres after rollout. Recorder pulled and return Odetics for troubleshooting and tape playb A loose extra shim washer had jammed the t
9	OMS pod LRSI tiles and pieces of tile lost during ascent.	102:13:50	Charred RTV and SIP gave evidence of signi heating far outboard on the OMS pods where tile segments were missing. Where larger t were missing, the RTV and SIP appeared to a wake region of lower-than-expected heati Nine tiles on fwd right and 3 on left OMS will be replaced with densified tiles afte outer surface is repaired. These tiles wer undensified and diced on the vehicle.
10	Power Reactant Storage & Distribution subsystem (PRSD) for fuel cells, O_2 manifold pressure was about 100 to 125 psi below tank pressure during ascent. (V45P1145A and V45P1140A)	102:12:05	At GMT 12:05:00 manifold started dropping tive to tank pressure and reached max delt GMT 12:08:00, then recovered to normal del to 20 psi) at 12:12:00. Tests at Beech ind an instrumentation problem due to thermal ensation. A standoff was incorporated in t panel similar to the H_2 sensor design. To fixed inline.

STS-1 ANOMALY LIST FOR ORBITER			Date August 5,
No.	**Title**	**G.M.T. D: H: M**	**Comments**
11	Aft Main Bus C current (V76C3097) indicated open.	102:18:07	Sensor replaced. Replacement reading off high. STS-1 unit found to have open in an filter choke at the lead due to probable o crimping during manufacturing.
12	OMS gimbal fault indication.	102:18:06	Fault message issued during first gimbal profile test prior to OMS-3 burn. Data an indicated that the right OMS primary pitch actuator response was below spec rates. Troubleshooting at KSC confirmed problem. Vendor found interference caused armature slip on shaft. Modified design in work fo subsequent vehicles. STS-2 to fly with re actuator of original design.
13	Cabin Temperature Controller did not maintain selected temperature.	103:04:XX	No indication of any hardware failure. Sy responded as expected to heat load changes Procedures changed for dual water loop ope during sleep period. Temperature sensor w biased by adjacent avionics. Possible relo of cabin transducers. Thermometer to be ca on STS-2 to determine optimum location.
14	Crew reported Pressure Control System (PCS) primary O_2 regulator pressure rising.	103:10:23	N_2/O_2 control panel removed and replaced. N_2 shutoff valve showed leakage. Seals we posed to freon and damaged.
15	CDR Horizontal Situation Indicator (HSI) compass card stuck during flight control systems checkout.	103:11:55	Removed HSI. Troubleshooting at vendor sho high resistance in commutator winding on m Wrong configuration motor installed.
16	Water tank B quantity transducer (V62Q0420A) went from 80 percent to zero and back.	103:21:48:48	Probable cause is contamination. No troub shooting at KSC.

STS-1 ANOMALY LIST FOR ORBITER

Date
August 5,

No.	Title	G.M.T. D: H: M	Comments
17	RCS jet leak detector temperatures lower than predicted.	102:12:09:06	Subsequent to a firing, fuel dribble volum lowered leak detector temperature more tha dicted. Multiple firings could lead to a leak indication. No problems during deorbi entry. Evaluate STS-2 data.
18	Star tracker shutters did not cycle automatically.	102:16:53 103:10:26 and 104:09:35	-Z star tracker target suppression sensor the shutter one time because it was pointi at the sunlit earth. -Y star tracker bright object sensor did r close the protective shutter when pointed to the earth horizon, requiring the back u sensor to close the shutter, locking it or eral occasions. Part of the time, the ligh geometry was such that the horizon was not bright enough to trigger the bright object sensor but was bright enough to trigger th sensitive backup sensor. Evaluate limits. None of the conditions described indicates hardware failure. Data from subsequent mis may be used to support a design change.
19	APU 2 gas generator heater injector and bed temperatures (V46T9280 and V46T0222) triggered FDA alarm.	104:04:02:43	Problem isolated to heaters. ARGON gas le from heater container at weld. APU replac for STS-2. Improved inspection techniques being developed.
20	Squeal in crew's headsets	102:12:00	Feedback is normal when both SMU and heads used simultaneously. Plan interim GFE wire system for STS-2.

STS-1 ANOMALY LIST FOR ORBITER

Date
August 5,

No.	Title	G.M.T. D: H: M	Comments
21	Motor control assembly did not remove power from RT RCS TK ISO valve motor after opening.	104:16:5x	This assembly and 30 others will be replac units containing steel gears. Vendor foun contamination in limit switch.
22	TACAN #2 Bearing fail indication.	104:18:14:33	Redundancy Management (RM) responded corre due to low signal strength caused by vehic attitude with respect to ground station.
23	Fuel cell water relief nozzle temps exceeded upper limit of 450° F during entry. (V45T0455 and V45T0456).	104:18:09:40	After blackout both temps were reading abo per limit. Heaters were not turned off pr deorbit. After blackout temperatures quic returned to about 200° F. Outside of nozzl slight discoloration. Not detrimental to f
24	Right OMS Engine OX Inlet Pressure Dropped during OMS-1 Burn	102:12:10:36 to 102:12:12:06	Filter was found to have red particles. S being evaluated. System to be flushed. L OMS filter clean.
25	Left Hand Main Outboard Tire was cut through 5 out of 17 layers of cord.	104:18:20:58	Remove and replace all main gear tires at Runway to be policed for rocks and debris.
26	Up lock roller on right main landing gear had a broken sleeve and bearing.	104:18:20:35	Sleeve and bearing pieces found on lakebed landing about 1.5 miles before touchdown. processed for change in materials.
27	Right hand inboard Main Landing Gear (MLG) indicated unequal braking.	104:18:20:58 to 104:18:21:57	Data for inboard brake showed 1480 psi max versus about 600 psi for other wheel press Problem is in brake/skid control box. A ze diode in the hybrid regulator of the inter power supply failed a pull test at the ver

STS-1 ANOMALY LIST FOR ORBITER			Date August 5,
No.	**Title**	**G.M.T. D: H: M**	**Comments**
28	Cabin PCS O_2 supply system 2 and emergency O_2 pressure decayed during non use period when system was isolated.	About 103:21:XX	N_2/O_2 panel removed and replaced. Problem not be reproduced at vendor. No further corrective action required.
29	Orbiter's right hand External Tank (ET) Door center line latch observed to be discolored.	Post Landing	Tile being replaced to prevent tripping th boundary layer which caused discoloration.
30	Orbiter 8 inch T-0 H_2 umbilical leaked prelaunch.	102:XX	Will reshim the ground quick disconnect (Q STS-2. Testing confirmed that removing shi will stop the leak by increasing the seal
31	MPS H_2 topping valve indicated slow closure after dump.	102:12:XX +	Close switch indication occurred 88 second after power was removed. Normal ambient t ature closure time is less than 1 second. cycled normally for vacuum inerting and po flight. Slow closure can be expected at fl temperatures after propellant dump.
32	Approximately 20 by 40 inch aft section of right hand and a 14 by 16 inch section of left hand OMS pods graphite epoxy structure observed to be delaminated.	Post Landing	TPS redesign is in process. Will relocate transducer and add about 25 black tiles to pod. Aft pod skin sections replaced and re for tile work.
33	Waste Management System problems.	Crew Report Post Flight	Throughout the mission the commode air suc degraded until commode became unusable. Ur had insufficient air suction to work prope Indication is charcoal filter had water in System pulled and returned to vendor for r bishment . Recommended procedural changes kit for in line replaceable filter and la mesh screen.

STS-1 ANOMALY LIST FOR ORBITER

Date
August 5,

No.	Title	G.M.T. D: H: M	Comments
34	Radar altimeter data dropout at 75 feet, was reacquired 4 seconds later and was shifted to 20 feet.	104:18:20:3X	Probable lockup on ground and landing gear it deployed. Troubleshooting at KSC verifi electronics operating properly. Altimeter' inputs into Autoland being deleted for STS subs. Manually deselected for STS-2.
35	Vehicle response overshoot poorly damped during first roll.	Crew Report	Analysis at JSC and RI. Roll/yaw oscillati poorly damped with a max peak-to-peak beta 7° and a period of 13 seconds. Use CSS for STS-2, mod software for STS-3.
36	Smoke detection system A circuit test of "Flight Deck Left" failed several attempts and "Cabin" worked only once in several attempts.	102:16:10 and 102:16:35	Pre-flight history of defective or intermi smoke detection electronic assemblies whic contain the test logic circuits. (Left Fli Deck Sensor in return air duct, left conso Cabin sensor in cabin fan plenum outlet.) Sensors to be replaced by new design as th fail or after STS-3 when 800 hr life is ex
37	Orbiter Touchdown was about 3200 feet beyond planned point.	Landing	Trajectory effects have been analyzed. SM STA incorporating revised aero. Updating data base.
38	ET unlatch pyro did not fire.	ET Sep	Unspent NSI found in post-flight inspectic Probable cause is nominal system 2 millise skew between redundant NSI's. Troubleshoot KSC confirmed 2 millisecond skew. Open bri wire found on fired pyro. Charge found sep from bridgewire location. Tests show NSI stands mission shock levels.
39	Body flap extended to 14° exceeding planned trim attitude of 8 to 9° from Mach 22 through 12.	From Entry Interface On.	Aero pitch trim predictions in error. Adju elevon schedule on STS-2 to relieve body f heating.

STS-1 ANOMALY LIST FOR ORBITER

Date
August

No.	Title	G.M.T. D: H: M	Comments
40	Crew reported trouble locking doors on stowage lockers MF14K and MA9L for entry and opening waste management door.	Crew Report Post Flight	Stowage lockers were distorted and had t forcibly moved to line up the latch thre lock the doors for entry. The latch on t management door jammed every time it was and had to be opened with vice grips. Mi ment of door locks demonstrated on board Slide bolt on waste management door was for proper clearance. Locker doors to b shimmed.
41	Crew reported difficulty in securing safety pin in the ejection seat scramble handle.	Crew Report	Inspection at KSC. Pip pin button bent. during removal. Pin replaced.
42	APU Nos. 1 & 3 had low chamber pressures (Pc) during on orbit start up.	On Orbit	Pc was about 1000 psi versus a normal Pc about 1200 psi. Data analysis at RI and strand. Procedure changes for ground ser and flight to reduce gas bubbles in syst Tests to be run to determine APU operati margin with gas bubbles.
43	Umbilical release blast containers (2 of 6) have cracks	Post Flight Inspection	Removed and replaced. Crack caused by r NSI firing at a canted angle due to the signal skew. Fly as is for STS-2. Inco fix for STS-3 and subs.
44	Nose landing gear thermal barrier fell off during door deployment.	Landing	Post flight photos showed loss and barri recovered on the lakebed about 1.5 miles touchdown. Replace for STS-2. Modified c for STS-3 and subs in work.
45	Payload Bay (PLB) door closure overlap on rehearsal and entry days more than anticipated.	On Orbit	Crew comments, pictures and postflight e tion indicates PLB door closure overlap than anticipated for the temperature env Use theodolite to measure overlap on STS

STS-1 ANOMALY LIST FOR ORBITER			Date August 5,
No.	Title	G.M.T. D: H: M	Comments
46	Temperature on OMS nozzle bell off scale high during SRB firing and high during OMS burns.	Launch and On Orbit	Off scale indicated greater than 3000° F o V43T9111, the OMS nozzle lip temperature. Grounding problem in signal conditioner. et welded to columbian nozzle (supporting measurement wiring) found loose. Removed replaced nozzle. Found a wiring error in DFI signal conditioner.
47	DFI data dropout after SRB ignition	102:12:00:04.3	DFI ascent recorders dropped launch data f 3 frames (0.03 sec) on the PCM recorder an seconds from the wideband recorder. Probab cause was transient separation of the tape the recorder head. Fly as is.
48	Hydraulic dynatube fitting on APU #1 pump found to be leaking and crack found in pump suction tube.	Post Flight Inspection	Fitting retorqued at DFRC and leak stopped Probable cause is improper initial install torque. Pump suction tube inspection deter suspected crack did not exist.
49	Right hand landing gear main door buckled.	Post Flight Inspection	Remove and replace. Probably due to therma protection system (TPS) leak caused by for facing steps. Reworked TPS.
50	Fwd RCS F2R oxidizer injector temperature did not respond correctly. (Lagged fuel).	Post Flight Data	Thruster removed. Return to vendor for re Temperature sensor was not in contact with oxidizer line.
51	Cracks noted in both right and left wing vents.	Post Flight Inspection	Pulled and shipped to Downey. 50 cps organ problem. Will change skin thickness and a local stiffeners for STS-2.
52	Development flight instrumentation (DFI) measurement discrepancies.	Post Flight Analysis	About 40 PCM and 35 wideband discrepant DF measurements. Troubleshooting in process KSC.

STS-1 ANOMALY LIST FOR ORBITER			Date August 5,1
No.	Title	G.M.T. D: H: M	Comments
53	Lateral oscillation at about 1.6 Mach	104:18:14	Roll/yaw oscillation with a peak-to-peak r rate of 4°/sec and about a 4 sec period la for about 6 cycles. Potential instability STS-2 with the pilot test inputs (PTIs). PTIs redefined.
54	Cabin dp/dt exceeded -0.05 psi/min and triggered C&W. (V61R2401A)	102:12:00:46.3 to 102:12:01:11.3	Cabin dropped to -0.061 psi/min. Cause of pressure drop was cabin expansion with alt C&W alarm can be expected on STS-2.
55	Payload bay door hinge 7 exceeded max. temperature limit of 1200 deg by 200° during entry.	104:17:49 thru 104:18:08	Will change emissivity coating on all bare hinges. Pin hardness checked and lubrican inspected OK.
56	Over temperature experienced on rub plate of body flap.	104:17:49 thru 104:18:08	Temperature reached 390°, and design limit 350°. Local heating effects on the carrie plate and adjacent waffle skin structure e uated. Structure OK at flight temperature
57	Current traces indicate payload bay lights inoperative	Post flight data	KSC tests verified 3 of 5 lights inoperati Vendor found a misrouted wire and excessiv at a joint in the electronics assembly. W modify for STS-2.
58	FWD RCS Ox tank Z strut found deformed.	Post flight	Caused by high Z load at SRB ignition. Bo strips were added to double load capabilit 4 struts.
59	APU 2 & 3 vibration levels higher than expected.	102:12:09:54	APU-2 replaced. Hydraulic pump removed, r placed and verified OK. APU-2 turbine whe found slightly out of balance. Investigat determined vibration levels are typical ar units show near normal wear.

STS-1 PROBLEM TRACKING LIST				Date August 5,19
No.	Title	G.M.T. D: H: M	Comments	
60	Video Tape Recorder vibration isolation system bottomed out.	Launch	Postflight inspection of VTR after removal demonstrated vibration isolation system da	
61	OMS H_e purge flow inoperative	Entry	Data show OMS purge did not occur during e	

Prepared by Robert L. Blount
Robert L. Blount

Approved by Joseph E. Mechelay
Joseph E. Mechelay

STS-1 ANOMALY LIST FOR INTEGRATION

Date
August 5,1

No.	Title	G.M.T. D: H: M	Comments
1	First stage performance variations resulted in lofting	102:12:46	Attitude error, lofting, and engine perfor variations were observed during ascent fro 45 to 60 seconds after lift off with a pit attitude error up to about 5.2°. STS-2 dat will be biased for half of STS-1 variation
2	SSME helium tank system pressure decayed 450 psi.	102:20:14	The left helium tank pressure decayed 450 after second MPS vacuum inerting. System d leak during post-flight check. Procedure w around.
3	MPS GOX flow control valve pressure drop less than normal.	102:12:01	The GOX flow control valve pressure drop w 40% of nominal - Similar response during F Problem caused by out of tolerance stroke. Valve replaced with one tested for proper tion a high inlet pressures.
4	ET rupture at lower than expected altitude.	102:12:15	The external tank rupture occurred at 60,0 80,000 feet lower than expected altitude.
5	ET tumble system did not operate.	102:12:09	ET assessment showed that the ET tumble sy did not function (ET accelerometers indica tumble valve pyros fired). Revised proced should prevent moisture intrusion.
6	Ignition overpressure higher than expected.	SRB Ignition	Preliminary data indicates overpressures u to 3 psi were noted after SRB ignition. Or aft heat shield and body flap overpressure reached 2 psi compared to 1.32 psi aft hea shield design. Continue analysis and desi
7	ET forward Bipod did not swing forward at separation	ORB/ET Separation	Spray on foam insulation (SOFI) rigidized spring. Requirement is not to move backwar

STS-1 ANOMALY LIST FOR INTEGRATION				Date August 5,198
No.	Title	G.M.T. D: H: M	Comments	
8	ET Debris	Launch	Design change being implemented on ET. Orb cameras being repositioned in the window.	

Prepared by Robert L Blount
Robert L. Blount

Approved by RH Kohrs 8-
Richard H. Kohrs

FLIGHT TEST PROBLEM REPORT

NO. 1

Statement of problem:
Thermal control system (TCS) heaters exhibited potential "creep" failures.

Discussion:
Thermostatically controlled heaters/instrumentation at 11 locations exhibited anomalous or unexpected performance on the flash evaporator system (FES) feedwater zone 4 STBD 1 system, the auxiliary power unit (APU) no. 1 fuel feedline system B, the orbital maneuvering system (OMS) crossfeed high point fuel bleed line in aft and midfuselage system A and the OMS aft O_2 low point drain line, the APU no. 3 primary secondary H_2O cooling system A and gas generator (GG) injector water cooling system, and the RCS fuel and oxidizer forward panel heaters.

Eight thermostats were removed and replaced. Four of those removed failed postflight acceptance tests. The RCS fuel forward panel heaters stayed on in flight without a temperature increase. Thermal analysis had assumed nonmetallic structure. Orbiter response was correct for metallic structure. RCS oxidizer forward panel heaters did not come on during flight. Postflight analysis indicates temperatures were not low enough to activate these heaters.

Required date for resolution: CLOSED for STS-2 7/22/81 Scj 8/5/81

Personnel assigned: T. Taylor/ES3 X-3676, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:
None for STS-2 due to benign thermal environment.

Conclusions:
Eight TCS heaters exhibited "creep" failures. Four of the thermostats did not pass a postflight acceptance test.

Corrective action:
Eight anamolous TCS heater thermostats were removed and replaced for STS-2. Evaluation is continuing.

JSC Form 1143C (Dec 78)

NASA-JSC

FLIGHT TEST PROBLEM REPORT

NO. 2

Statement of problem:

Interface timing skew between primary and backup computer software during countdown.

Discussion:

The primary avionics software system (PASS) was found to be initiating communications with the network signal processor (NSP) 40 milliseconds earlier than the backup flight system (BFS) expected. A timing skew can occur on approximately 2 percent of the first PASS general purpose computer (GPC) initializations.

Required date for resolution: CLOSED Aaron Cohen 6/2/81

Personnel assigned: B. Hood/EH7 X-3254, R.J. Ward/WA3 X-4323

Action progress:

An operations (OPS) program note, dated 4/11/81, titled "Cycle Shift in Phase Scheduled Processes" defined how to verify proper phasing of processes and input/output (I/O) in the PASS following initialization of the first GPC.

Effect on subsequent missions:

No effect.

Conclusions:

At primary software initialization (IPL), a one cycle skew was introduced into the phasing of the NSP I/O timing interface preventing the BFS from synchronizing with the PASS.

Corrective action:

Verify proper phasing following IPL of first GPC.

FLIGHT TEST PROBLEM REPORT

NO. 3

Statement of problem:

The airlock-to-payload bay differential pressure sensor did not respond to changes in the payload bay pressure.

Discussion:

The pressure sense port to the payload bay was found capped.

Required date for resolution: CLOSED 5/20/81

Personnel assigned: F. H. Samonski/EC3 X-4823, A. Reubens/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Sense port was capped.

Corrective action:

A revised cap with a vent port is being provided for STS-2 and subsequent.

FLIGHT TEST PROBLEM REPORT

NO. 4

Statement of problem:
Built-In-Test Equipment (BITE) discrete on dedicated signal conditioners (DSC) OF1 and OF4.

Discussion:
Crew reported circuit breaker 2 on panel 15 was open. DSC's continued to operate properly by obtaining power from internal redundant power supplies.

Post-mission troubleshooting isolated a short in DSC OF1. Failure analysis at the manufacturer's plant revealed that a paper clip shorted a point in the 28-volt supply line EMI filter to the case. Cards were removed from the failed box and installed in a box originally assigned to OV-099. This unit will be installed in OF1 slot on OV-102.

Required date for resolution: SC 6/10/81 CLOSED A. Cohen 6/10/81

Personnel assigned: Frank Rotramel/EH4 X-2851, A. Reubens/WA3 X-4323

Action progress:
None

Effect on subsequent missions:
None

Conclusions:
Short caused by paper clip in power supply.

Corrective action:
Power supply to be recycled and placed in inventory.

JSC Form 1143C (Dec 76)

NASA-JSC

FLIGHT TEST PROBLEM REPORT

NO. 5

Statement of problem:

Improper engine interface unit (EIU) port bypass indication during EIU powerdown following main engine cutoff (MECO).

Discussion:

The EIU is the interface assembly between the general purpose computer (GPC's) and the main engine controllers. When the EIU's are power down, bypass conditions are expected on EIU ports 1 and 4. However, at 102:14:40 G.m.t., EIU 3, port 1 was bypass, port 4 was not, and no ports were bypassed on EIU's 1 and 2. The redundancy management data indicated that both PASS and backup flight system had the same port bypass indications.

Main engine controller 3 power was turned off within a vehicle data table (VDT) transmission to EIU 3, causing the EIU to reset which in turn caused PASS/BFS to baypss EIU 3. However, EIU's 1 and 2 were not bypassed because power was turned off when no VDT was being transmitted.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: B. Hood/EH7, A. Reubens/WA3

Action progress:
None

Effect on subsequent missions:
None

Conclusions:

Condition can vary as a function of data activity at the time of power down. This condition occurs after main engine shutdown and has no effect on performance.

Corrective action:

None required.

FLIGHT TEST PROBLEM REPORT

NO. 6

Statement of problem:

Main propulsion system GH_2 outlet temperature vent offscale high (V41T1261A) and outlet pressure vent offscale low (V41P1260A) for the left no. 2 Space Shuttle main engine (SSME)

Discussion:

The no. 2 SSME GH_2 temperature and pressure transducers operate in a vibration environment that is more severe than their qualification level. There is a history of failure in the main propulsion test article (MPTA) due to vibration. During STS-1, both measurements were lost between 102:12:00:38 and 102:12:01:35 G.m.t.

Post-mission troubleshooting verified that both transducers failed. The pressure transducer was removed and replaced. The temperature transducer was removed and will be replaced as soon as a spare becomes available.

Required date for resolution: SCJ 6/10/1 CLOSED Aaron Cohen 6/10/81

Personnel assigned: F. Rotramel/EH4 X-2351, A. Reubens/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

These two measurements act as backup to other MPS and SSME data and are not considered critical measurements.

Conclusions:

Vibration levels exceeded qualification levels rendering both transducers inoperative.

Corrective action:

For STS-2, remove and replace both transducers. Also for STS-2, the temperature transducer will remain in its present location since this location is the most benign in the area. For STS-3, the pressure transducer is to be relocated to an area that has less vibration.

FLIGHT TEST PROBLEM REPORT

NO. 7

Statement of problem:

OMS quantity gaging system was sticking during flight, and right fuel probe was found broken postflight.

8/24/81

Discussion:

Sticking of the OMS fuel gages at the start of each OMS burn was due to improper venting in the head of the forward fuel probes. Sticking of the right-hand fuel and oxygen gages at the start of OMS-5 was due to improper drainage in the aft end of the forward probes.

After the right OMS fuel tank was removed, the glass in the probe was found to be broken. The failure occurred postflight at the HMF due to a flaw in the glass. A broken probe glass will not allow propellant leakage, and there is no material compatibility problem.

Required date for resolution: CLOSED 7/24/81 Aaron Cohen

Personnel assigned: C. E. Humphries/EP2 X-6429, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

OMS forward probes will stick at start of OMS maneuver until vent hole size is enlarged.

Conclusions:

Vent openings in the upper and lower ends of the gaging probes are not large enough to prevent capillary action from retaining fluid. Right fuel probe failure was caused by a flaw in the glass.

Corrective action:

Replacement right fuel probe on STS-2 has enlarged vent holes in the head. Future probes will have enlarged vent holes. Probe glass screening will be improved for detection of flaws.

FLIGHT TEST PROBLEM REPORT

NO. 8

Statement of problem:

The development flight instrumentation/pulse code modulation (DFI/PCM) recorder could not be turned off.

Discussion:

Available data indicated that the recorder was not responding to normal controls. The recorder circuit breaker was activated in an attempt to record entry data.

The DFI PCM recorder was returned to the vendor from JSC for evaluation of the failure to transition from continuous record to the high sample rate mode in response to the Orbiter mode switch position change.

After removal of the tape transport assembly from its sealed enclosure, it was determined that the tape had become slack as the result of the gears in the tape tensioning system being jammed by a loose shim. The shim was an extra part that had apparently fallen into the reeling assembly at the time the flight tape was installed by the vendor. After removal of the shim and verification that the gear teeth had not been damaged, the recorder was reassembled and functionally tested.

It was determined that approximately 31 minutes of prelaunch and ascent phase data was successfully recorded prior to the failure. The failure prevented any subsequent recording of data.

Required date for resolution: CLOSED Aaron Cohen

Personnel assigned: R. Irvin, D. Suiter

Action progress:

The recorder (SN1006) will be returned to the vendor for refurbishment prior to being returned to the Shuttle program inventory.

Effect on subsequent missions:

None

Conclusions:

The tape tensioning mechanism was jammed by a loose shim washer.

Corrective action:

None

FLIGHT TEST PROBLEM REPORT

NO. 9

Statement of problem:
Tile failure on OMS pod.

Discussion:

During STS-1, approximately 16 segments (2.5 in by 2.5 in.) of undensified diced tiles were lost during ascent. These diced tiles, unlike the diced tiles elsewhere, were diced after they had been installed. No densified tiles were lost.

Undensified tiles on the OMS pod are being replaced by densified tiles, and no further dicing of tiles on the vehicle will be permitted.

Required date for resolution: CLOSED 6/17/81 Aaron Cohen

Personnel assigned: P. Glynn/ES2 X-3076 R. J. Ward/WA3 X-4323

Action progress:
None

Effect on subsequent missions:
None

Conclusions:

Problem was caused by the "on the vehicle" dicing procedure where a dull plastic knife is used to cut the RSI down to the SIP. This can cause local delamination around each diced segment which propagates into total segment failure when the maximum dynamic pressure of ascent is experienced.

Corrective action:

No further dicing of tiles on vehicle.

Tiles on OMS pod are to be densified.

FLIGHT TEST PROBLEM REPORT

NO. 10

Statement of problem:

The O_2 manifold pressures were about 100 to 125 psi low compared to tank pressure during ascent on the power reactant storage and distribution subsystem (PRSD) for the fuel cells.

Discussion:

The O_2 manifold pressure (V45P1145A and V45P1140A) started dropping relative to tank pressure soon after lift-off, reaching a maximum difference 5 minutes later. At lift-off plus 10 minutes, manifold pressures had recovered to within 10 to 20 psi of tank pressure as expected for normal operation.

Postflight tests at Beech Aircraft showed the pressure shift to be caused by the thermal chill down transient imposed on the O_2 manifold pressure transducers. A standoff similar to the H_2 sensor design provided proper temperature compensation for the O_2 sensors.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: R. Rice/EP5 X-4027, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

No effect on STS-2 through 4. Incorporate fix for STS-5 and subsequent.

Conclusions:

Instrumentation problem due to inadequate thermal isolation of the O_2 manifold pressure transducers.

Corrective action:

A standoff for the O_2 manifold pressure transducers will be incorporated into STS-5 and subsequent.

FLIGHT TEST PROBLEM REPORT

NO. 11

Statement of problem:

Aft main bus C current sensor (V76C3097) indicated open.

Discussion:

The dc-to-dc power converter in each current sensor has an input EMI filter. One of the three 100 microhenry chokes in the filter, L101, opened at lift-off plus 6 hr. This open choke disconnected the remainder of the current sensor from spacecraft power.

The standard practice for small chokes is to use a large enough wire to provide 500 to 1,000 circular mils per ampere. This choke's no. 40 wire carries 0.07 A and provides only 143 circular mils per ampere which could cause some heating. The heat would not dissipate in a vacuum due to the loss of convective cooling.

The wire was found to be vaporized near one lead leaving a gap of 1/32 in. Vaporization would require current in excess of 1.77 A.

Since this choke is marginally designed for weight saving, any crimping or narrowing of the wire at the lead could cause further heating to failure. Therefore, it is probable that the choke, as designed, is intolerant of any manufacturing errors such as overcrimping the wire at the lead.

Required date for resolution: CLOSED 7/1/81

Personnel assigned: F. Rotramel/EH4 X-2851, A. Reubens/WA3, X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

Current sensor power input filter choke, L101, was found open.

Overheating and vaporization of the choke wire was probably due to accidental overcrimping and narrowing during manufacture combined with reduced heat dissipation in a vacuum.

Corrective action:

None required. Twenty-three similar units were flown on STS-1 without problems.

FLIGHT TEST PROBLEM REPORT

NO. 12

Statement of problem:

OMS gimbal fault indication

Discussion:

A fault message occurred during the first gimbal profile test prior to OMS-3 maneuver at 102:18:06 G.m.t. The right OMS primary pitch actuator did not respond to the positive command, but did respond to the negative command. On the second test, the actuator did respond in both directions, but the extend rate was 0.9 deg/sec below the specified 3.2 deg/sec.

Postflight trouble-shooting of the Orbiter isolated the problem to the actuator. The problem was caused by:

1. The small gap between the armature and stator in the radial plane of the actuator rotor position synchronizer.
2. The axial dimensions of the motor/synchronizer interface permitted contact between the motor shaft and the synchro shaft at the dog coupling.

(continued page 2)

Required date for resolution: CLOSED for STS-2 Aaron Cohen

Personnel assigned: J. Vernon/JH6 X-5126 A. Reubens/WA3 X-4323

Action progress:

STS-2: Replace with present design actuator.

Subsequent vehicles and replacement actuators: Design and fabricate new shorter double-dog coupling from dc motor to rotor position synchronizer.
Increase clearance gap between armature and rotor.
Design motor end bell as a one piece unit and increase motor bearing shim shoulder.

Effect on subsequent missions: Minor risk of mission success on STS-2. No catastrophic risk involved. Adequate redundancy exists in each actuator should the failure repeat. Further redundancy exists in the OMS pods themselves. Additionally, should both OMS pods become disabled, the RCS system could be used to compensate for the offset thrust vector.

Conclusions:

Excessively tight axial and radial tolerances in the actuator combined with a cracked end-fitting mono ball caused rotor/stator rubbing, impact, contamination and slipping of primary synchronizer windings. This in turn caused sluggish response and occasional jamming of moving parts in the actuator.

Corrective action: STS-2: Go with present design

Subsequent vehicles and replacement actuators: Replace actuators with an improved design and a larger synchronizer air gap which will provide more clearance for dynamic deflections. A shorter double-dog motor-to-synchro coupling and motor end bell modifications will provide additional axial clearance.

DISCUSSION (continued)

3. A cracked end-fitting mono-ball due to an excessive impact load during manufacturing buildup combined with the deflection intolerant design described in 1 and 2.

The effect was:

1. Synchronizer rotor rubbed and impacted stator laminations.
2. Particulate contamination generated by rubbing/impact and becoming caught between rotor and stator.
3. Motor-to-synchronizer coupling damaged by motor shaft impactions.
4. Synchronizer armature windings slipped on shaft.

It should be also noted that the secondary synchronizer showed the effects of rubbing between the rotor and stator.

FLIGHT TEST PROBLEM REPORT

NO. 13

Statement of problem:

Cabin temperature controller did not maintain selected temperature.

Discussion:

The indicated cabin temperature was between 76° F and 83° F during the on-orbit operations. However, the crew reported cold cabin conditions during, and for a time after, the first sleep period.

During the first sleep period, starting at 103:01:00 G.m.t., the cabin equipment was powered down, thus allowing the cabin to cool down. At 103:01:21 G.m.t., the cabin temperature selector was moved from the 45-percent to the 52-percent position. Subsequently, the selector was moved to the 89-percent position (103:02:40 G.m.t.) and then to the 100-percent "full warm" position (103:03:42 G.m.t.). During this time, the cabin heat exchanger air outlet temperature decreased from 52° F to 45° F (lower sensor limit) indicating that the air bypass valve had moved from the "full cool" (no bypass) to the "full warm" (maximum bypass) position. Air outlet temperatures consistent with the full cool and full warm bypass valve positions were determined from the data obtained when the bypass valve was pinned in these positions. Although the bypass valve was in the "full warm" position, the cold cabin condition existed.

(continued)

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: F. Samonski/D. Suiter

Action progress:

Procedures have been developed to provide greater flexibility in management of cabin temperature.

Effect on subsequent missions:

A portable temperature measurement instrument will be flown on STS-2 to find an acceptable transducer location.

Conclusions:

Cabin temperature sensor was biased high because of its location.

Corrective action:

None required.

FLIGHT TEST PROBLEM REPORT NO. 13 (Continued)

At the end of the first sleep period, the interchanger flowrate was reduced from 1038 to 712 lb/hr to warm the cabin (103:09:08 G.m.t.). However, the small decrease in cabin heat exchanger effectiveness due to the decreased water flowrate was offset by the cooler water temperatures from the interchanger. Reduction of the interchanger flowrate from 1038 to 712 lb/hr resulted in the interchanger water outlet temperature being decreased from 41° F to 38° F. After the first sleep period, the cabin temperature control selector had been placed in the full cool position. Again, in an attempt to warm the cabin, the selector was moved to the 23-percent, 49-percent, and finally 100-percent "full warm" position at 103:15:08 G.m.t. By this time, the cabin temperature sensor, which is biased hot due to its proximity to powered avionics, was above the control temperature of the "full warm" selector position. With the sensor temperature above the control setting temperature, the cabin heat exchanger bypass valve remained in the "full cool" position. The simultaneous "full warm" position of the cabin temperature selector and "full cool" position of the bypass valve was verified by the crew. Thus, to warm the cabin, the crew manually pinned the exchanger bypass valve in the "full warm" position. To provide cooler air to the avionics bays, the interchanger water flowrate of loop 2 was increased from 712 to 1200 lb/hr. With the combination of the pinned cabin heat exchanger bypass valve in the "full warm" position and with the increased interchanger water flowrate providing warmer water to the cabin heat exchanger, the crew reported that they were comfortable during the remainder of the mission, including the second sleep period.

FLIGHT TEST PROBLEM REPORT

NO. 14

Statement of problem:

System 1 O_2/N_2 control valve leaked when closed causing system 1 O_2 regulator to read high (215 psia)

Discussion:

Subsequent to day 2 on-orbit configuration (from system 1 to system 2) at 103:10:23 G.M.T., the O_2 regulator pressure (V61P2115A) was observed to increase from 120 psia to 215 psia. The problem was caused by the failure of the O_2/N_2 control valve to seat properly when closed. The specification pressure differential of 5 psid was not present to close the check valve to prevent N_2 pressure to build at the O_2 regulator.

Required date for resolution: CLOSED

Personnel assigned: F. Samonski/N.Prince

Action progress:

The N_2/O_2 control panel has been removed from the Orbiter and sent to the vendor for anomaly investigation. Testing of the O_2/N_2 control valve (system 1) revealed a large leakage both in the panel configuration and in a component bench test. Disassembly and inspection of O_2/N_2 control valve revealed a slight separation of the silocon seat as well as a discoloration and distortion similar to the degradation that would be present with exposure to freon. The silicon seat was removed and replaced. The replacement was retested several times to verify the assembly procedures did not contribute to the damage. Exposure of the silicon seat to freon

(continued page 2)

Effect on subsequent missions:

None

Conclusions:

Leakage caused by distortion of silicon seats as a result of a trace contaminant (freon).

Corrective action:

A new panel has been installed for STS-2 and the STS-1 panel is being reassembled to latest configuration for OV-099. Warning notes will be added to test documentation to prohibit use of freon during manufacturing and test operations.

ACTION PROGRESS (cont)

in another test however did show similar damage as that seen from the STS-1 valve seat. The check valve was also tested and found to operate properly even at small differential pressures. An inspection of the check valve revealed it had traces of a contaminant (freon). The testing indicated the check valve could be exposed to freon and the seal would distort; however, after drying out, the seal would return to original size and shape and operate properly.

FLIGHT TEST PROBLEM REPORT NO. 15

Statement of problem:

Commander (CDR) horizontal situation indicator (HSI) compass card stuck.

Discussion:

During high-low test on orbit, the compass card stuck when it went to the low position. Troubleshooting at the vendor showed that an experimental servo motor without self-lubricating brush material had been inadvertently installed in the CDR's HSI. This motor was incompatible with the flight environment and has been replaced.

Required date for resolution: CLOSED 6/24/81 Aaron Cohen

Personnel assigned: R. Burghduff/EH5 X-2766, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

An experimental servo motor incompatible with the flight environment was inadvertently installed in the flight HSI.

Corrective action:

All servo motors have been checked and no other experimental motors are in flight hardware.

FLIGHT TEST PROBLEM REPORT

NO. 16

Statement of problem:

Water tank B quanity transducer went from 80 percent to zero and back.

Discussion:

The momentary change was reported by the crew. This problem is caused by contamination in the measurement potentiometer which is used to indicate the water tank bellows position for the tank quantity. A cycle of the potentiometer through the full scale is self-cleaning and will occur in the normal tank servicing for the STS-2 flight. No further action or analysis is required.

Required date for resolution: Closed Aaron Cohen 6/3/81

Personnel assigned: F.H. Samonski

Action progress:

Tank B was cycled at Dryden Flight Research Center and will receive another cycle at KSC when the tanks are serviced for STS-2. No other instances of this change have been recorded.

Effect on subsequent missions:

None.

Conclusions:

See above discussion.

Corrective action:

None required.

FLIGHT TEST PROBLEM REPORT

NO. 17

Statement of problem:

The reaction control system (RCS) engine leak detector temperatures were lower than predicted.

Discussion:

The primary thruster fuel leak detectors were cooling at a greater rate than expected from injector residuals. Ground tests indicated no more than 2° F drop whereas flight data showed a maximum drop of about 25° F with a minimum temperature of 37° F. The RCS redundancy management (RM) will automatically deselect a primary thruster, if the temperature falls below 30° F. No deselection occurred on STS-1. However, analysis indicates deselections may occur, if the right RCS pulsing frequency is commanded. Low temperatures, due to injector residuals, are a transient condition, since the temperature increases as soakback occurs.

Required date for resolution: Closed for STS-2. Aaron Cohen 6/3/81

Personnel assigned: C. Hohmann/EP4 X-3852, R.J. Ward/WA3 X4323

Action progress:

Tests are being run with an upfiring engine in a hard vacuum chamber (greater than 300,000 ft. altitude) at JSC trying in an attempt to duplicate the flight response.

Effect on subsequent missions:

If RCS primary thrusters are deselected, ground coverage can diagnose the cause, and the crew can reselect the thrusters.

Conclusions:

The current 30° F RCS engine leak detector temperature setting is acceptable for STS-2, based on ground and flight test data and analysis.

Corrective action:

Fly as is for STS-2. Continue to evaluate 30° F setting, based on ground tests and flight tests on STS-2.

FLIGHT TEST PROBLEM REPORT

NO. 18

Statement of problem:

Star tracker shutters not cycling open and closed as expected.

Discussion:

The star tracker shutter closed upon receipt of a bright object sensor alert and/or target suppression discrete. The sensor is set to the light intensity of the brightest horizon expected, -21 visual magnitude, and the discrete is set at a -8 visual magnitude. (For comparison, Sun is -28.8, Moon -12.6, Venus -4.4, Sirius -1.6, Aldeberan +0.9.)

At 102:16:53 G.m.t., the -Y star tracker shutter had been closed for over an hour, and the target suppression bit was set. The shutter was opened by an override command.

A simultaneous -Y star tracker target suppress bit was set and the shutter closure was observed at 103:10:26:20 G.m.t., indicating that the shutter was not being closed by the bright object sensor. At 104:09:35:03 G.m.t., the -Z star tracker shutter target suppression bit was found set after power up. The crew used the override to open the shutter and align the inertial measurement units. Analysis indicates that the -Z star tracker was pointed towards sunlit earth at that time.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: D. Brown/EH7 X-3254, A. Reubens/WA3 X-4323

Action progress:

Reexamination of alert and suppression design thresholds for later missions.

Effect on subsequent missions:

May require manual override.

Conclusions:

Low earth brightness at certain geometries was the cause of target suppress activation, but not sufficiently bright to activate the bright object sensor.

Corrective action:

Fly as is for STS-2.

JSC Form 1143C (Dec 76)

NASA-JSC

FLIGHT TEST PROBLEM REPORT NO. 19

Statement of problem:

APU gas generator heater injector and bed temperatures triggered the failure detection annunciator (FDA) alarm.

Discussion:

Argon gas had leaked at a weld in the gas generator heater case. Loss of the heat transfer gas causes the calrod heater element to overheat and melt at the break point. Loss of the argon caused both heater elements to fail.

Required date for resolution: CLOSED 6/24/81 Aaron Cohen

Personnel assigned: R. J. Lance/EP4 X-3851, R. J. Ward/WA3 X-4323

Action progress:

Techniques are being developed to determine that the argon is still in the heater. Improved weld inspection techniques are also being developed.

Effect on subsequent missions:

None

Conclusions:

Argon gas leaked at a weld in the heater case causing both calrod heater elements to overheat and fail.

Corrective action:

Fly replaced APU as is until APU requires replacement. Should heaters fail again, APU activation can be managed to maintain acceptable temperature ranges. Improved inspection techniques are being developed for all APU's prior to installation in a flight vehicle. A new heater design is also being developed.

FLIGHT TEST PROBLEM REPORT

NO. 20

Statement of problem:

Squeal in crews headsets

Discussion:

The crew reported squeals in the headsets. Acoustic feedback, causing squeal, occurs when a crewman speaks into a headset microphone and speaker-microphone unit (SMU) with both devices activated simultaneously. Turning off either one of the two systems eliminates the problem.

Required date for resolution: Closed

Aaron Cohen 6/3/81

Personnel assigned: R. Hood/EH7 X-3254, A. D. Travis/EE3 X-2128, A. Reubens/WA3 X-4323

Action progress:

Wireless microphone development is in progress.

Effect on subsequent missions:

None.

Conclusions:

Squeal caused by acoustic feedback.

Corrective action:

1. Minimize usage of speaker-microphone unit.
2. If speaker-microphone unit use is necessary, operate on separate voice channel from headsets.
3. Wireless microphone will be available for STS-2 and will minimize SMU requirements.

FLIGHT TEST PROBLEM REPORT

NO. 21

Statement of problem:

Motor Control Assembly did not remove power from right RCS tank isolation valve motor after opening.

Discussion:

There are two valve position microswitches on the ac motor valve. One of these is used for telemetry to the ground. The second switch is used to terminate power to the valve motor when the commanded position is reached and to provide on-board position talkback. This latter microswitch failed resulting in a hard cycle on the valve and damage to the nylon gears. Post flight inspection of the valve revealed that a small piece of butyl rubber had become lodged on the contact preventing the microswitch from functioning.

An in-process procedure to inert the switch utilized butyl rubber hoses. Apparently small slivers of hose material was injected into the switch cavity. Butyl rubber is known to acquire static charge. In one-g the sliver weight overcomes electrostatic forces but in zero-g the particle can move under the influence of the electric field between the switch contacts.

Required date for resolution: CLOSED for STS-2 Aaron Cohen

Personnel assigned: C. Hohmann

Action progress:

Inerting process procedures and materials are being revised.

Effect on subsequent missions:

Conclusions:

Electrostatic charged contaminant caused microswitch failure.

Corrective action:

Inerting process procedures and materials are being revised to prevent future switch contamination. All actuators have been replaced with valves having steel gears thus precluding damage if power terminating microswitch fails - valve position can be obtained on the ground through telemetry.

FLIGHT TEST PROBLEM REPORT NO. 22

Statement of problem:

TACAN 2 bearing fail indication

Discussion:

The bearing value during terminal area energy management (TAEM) was in error in multiples of 40 degrees. There were 10 such errors in a row followed by one good value and then another error. After 10 seconds of unreasonable data, the redundancy management (RM) deselected the TACAN 2 bearing data.

The TACAN 2 (automatic gain control AGC) indicated low signal strength, but systems 1 and 3 AGC signal strengths were up and they were locked on the same ground station (Edwards AFB) as system 2. Data indicates all 3 systems were operating on lower antennas.

The Orbiter's turn and banking angles, at TAEM caused the system 2 antenna not to have the optimum look angle to the ground station. (System 2 antenna is on the starboard side of the underside of the orbiter.) Immediately after the errors, the system 2 bearing data were good and could have been manually reselected by the crew.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: B. Hood/EH4 X-3254, R. Drown/EE6 X-5561, A. Reubens/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

At or near TAEM, the Orbiter attitude maneuvers caused the Orbiter-to-ground station look angles to be in low gain zones of the airborne antenna radiation pattern. This results in low signal strength and resultant dropouts with the characteristic bearing errors in multiples of 40°.

Corrective action:

None required. The deselected TACAN system could have been manually reselected immediately, but was not required. (After the 12-second period, system 2 bearing data agreed with the other 2 systems.)

FLIGHT TEST PROBLEM REPORT

NO. 23

Statement of problem:

Fuel cell water relief nozzle temperatures exceeded the sensor upper limit of 450° F during entry.

Discussion:

During entry, the fuel cell water relief nozzle temperatures, measurement numbers V45T0455A and V45T0456A, exceeded the upper measurement limit of 450° F. The primary concern was the RTV seal between the nozzle and the fuselage. Nozzle heater functioned properly after landing.

The nozzle heater and adjacent area were inspected at KSC. The nozzle heater had a slight bluish discoloration which indicated the nozzle temperature may have reached 600 to 800° F. The RTV seal was inspected and a comparison was made with preflight pictures of the area. There was no change in the integrity of the seal of adjacent area.

Required date for resolution: SL 6/10/81 CLOSED Aaron Cohen 6/10/81

Personnel assigned: F. Plauche, R. Ward/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

Entry did not degrade the RTV seal, water relief nozzle, or adjacent area.

Corrective action:

None required.

FLIGHT TEST PROBLEM REPORT NO. 24

Statement of problem:

Right OMS engine oxidizer inlet pressure dropped during OMS-1 maneuver.

Discussion:

A sudden drop of 6.5 psi in the right OMS engine oxidixer inlet pressure occurred 12 seconds into the OMS-1 maneuver. Engine chamber pressure experienced a corresponding drop of 0.7 percent, and a small decrease in fuel injector temperature was also noted (indicating a decrease in the engine mixture ratio). Following this step change, the pressures remained constant for the remainder of the OMS-1 maneuver.

Postflight, the right OMS feed system/engine interface filter was found to be about 50 percent blocked with an amber crystalline solid. Contamination was evident inside the line toward the propellant tank and in the engine line. The contamination was identified as a polyethylene known as Surlyn, used on food wrapping.

Cleaning operations were completed on the right OMS oxidizer filter and system feed line. The engine oxidizer inlet line will be replaced. The left OMS oxidizer interface filter, the right engine ball valve, and injection inlet line were clean.

Required date for resolution: CLOSED 6/17/81 Aaron Cohen

Personnel assigned: J. C. Hooper/EP2 X-6420, R. J. Ward/WA3 X-4323

Action progress:

Manufacturing processes and procedures will be evaluated to determine how the contaminant could have been introduced into the system. Testing to evaluate the impact/sensitivity of the contaminant in $N_2 O_4$ is underway.

It has been recommended that the right oxidizer interface filter be inspected after STS-2 to verify no further contamination.

Effect on subsequent missions:

None

Conclusions:

Polyethylene particles partially blocked the right OMS oxidizer interface filter.

Corrective action:

The contaminated filter and system feed lines were flushed and cleaned. The right engine oxidizer inlet line will be replaced. Manufacturing and inspection processes are being reviewed to identify areas for improvements.

FLIGHT TEST PROBLEM REPORT

NO. 25

Statement of problem:

The left-hand outboard tire was cut during landing or towing to the Mate-Demate (MDM) facility.

Discussion:

A 1¼" long x 3/8" wide x 11/32" deep cut was found on the left-hand outboard tire after the Orbiter was towed back to the MDM facility.

All STS-1 main gear tires will be returned to the vendor for inspection and test. Redesigned tires will be flown on STS-2.

Required date for resolution: [illegible] CLOSED Aaron Cohen 6/10/81

Personnel assigned: W. Petynia/EW, R. Ward/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

Tire cut was caused by lakebed debris.

Corrective action:

All main tires are to be replaced for STS-2. Runway is to be policed for rocks and debris.

FLIGHT TEST PROBLEM REPORT

NO. 26

Statement of problem:
The right-hand main gear uplock roller split into several prices and fell to the runway during gear deployment.

Discussion:
The hardened uplock roller sleeve around the right main gear uplock roller split sometime during use and was found 1.54 miles prior to the touchdown point. The part has a hardened wear surface around the uplock roller bolt which carries the roller loads.

Required date for resolution: CLOSED 6/10/81

Personnel assigned: C. Campbell/EW3 X-3375, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:
None

Conclusions:
The roller material was too brittle for the application.

Corrective action:
New rollers will be installed on both nose and main gear roller bolts for all subsequent flights.

FLIGHT TEST PROBLEM REPORT

NO. 27

Statement of problem:

Right hand inboard main landing gear (MLG) indicated unequal braking.

Discussion:

The right hand inboard brake received approximately 600 psi more than commanded on one of its two hydraulic pressure channels. This effect was compensated for by the commander with a slight adjustment to the pedal command to the left hand brake pedal to steer down the runway center line.

The failure was isolated to the brake/skid control electronic box. The box was removed and returned to the vendor. A zener diode in the hybrid regulator circuit of an internal power supply failed a pull test at the vendor. All zener diodes in the brake/skid control electronic boxes have passed a pull test at the vendor after mounting.

These control boxes are standard equipment on most current commercial airliners and military transports. NASA coats the printed circuit cards for humidity and corrosion protection.

Required date for resolution: CLOSED 7/15/81

Personnel assigned: C. Campbell/EW3 X-3375, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

The over pressure command was due to an attachment failure of a zener diode in the brake/skid control electronic box.

Corrective action:

The control box was replaced with a spare. Twenty-three other zener diodes were flown in the two control boxes on STS-1 without a problem.

FLIGHT TEST PROBLEM REPORT

NO. 28

Statement of problem:

Oxygen system 2 crossover valve leakage

Discussion:

Following the day 1 on-orbit operational configuration of the pressure control system at 102:16:36, the system 2 O_2 crossover valve was observed to be leaking. The leakage was again observed during reconfiguration for day 2 operation and during emergency O_2 use in rehearsal day activities. The leakage was calculated to be 17 sccm's (specification leakage is 1 sccm).

The N_2/O_2 control panel was removed from the Orbiter and sent to the vendor for anomaly investigation. At the vendor facilities, the system 2 crossover valve was leak checked in the panel configuration and found to be leaking less than the 1 sccm specification. A component inspection and bench test also revealed within specification limit leakage. Valves have been disassembled and no contamination has been found

Required date for resolution: CLOSED

Personnel assigned: F. H. Samonski/N. Prince

Action progress:

Effect on subsequent missions:

Leakage was small and would not impact Orbiter operations.

Conclusions:

Unexplained anomaly.

Corrective action:

A new panel has been installed for STS-2. The STS-1 panel is being reassembled to latest configuration for OV-099.

FLIGHT TEST PROBLEM REPORT

NO. 29

Statement of problem:

The strike plate for the forward latch of the Orbiter's right external tank door was discolored.

Discussion:

The forward latch strike plate of the right ET door was exposed to entry heating because the outer edge protruded outside the outer mold line (OML) of the thermal protection system (TPS) and exerienced some melting, distortion, and discoloration.

The rest of the latch assembly was well protected by the TPS and was not affected. At the three other latch locations (two on each door), the strike plate outer edge was flush with the OML and no evidence of excess heating was noted.

Required date for resolution: CLOSED 6/10/81

Personnel assigned: N. Jevas/EW3 X-3375, R. Dotts/ES3 X-2376, J. D. Lobb/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

The latch strike plate which protruded outside the OML of the TPS was discolored, warped, and partly melted as the result of the outer edge being exposed to entry heating. Latch performance was satisfactory.

Corrective action:

The replacement strike plate for STS-2 will be installed with the outer edge flush with the OML of the TPS.

FLIGHT TEST PROBLEM REPORT

NO. 30

Statement of problem:

Orbiter T-0 Hydrogen umbilical 8-in. disconnect leaked during propellant loading.

Discussion:

During the LH_2 tanking a leak appeared at the 8-inch disconnect when the tanking sequence went from topping at approximately 13 psi to the replenish mode at approximately 5 psi. The leakage went from 200 ppm to 34,400 ppm in 19 seconds. Through procedure changes the immediate problem was solved. Testing confirmed that the leak was the result of insufficient load on the interface seal.

Required date for resolution: CLOSED 7/15/81 Aaron Cohen

Personnel assigned: M. Buchanan/.EP2 X-5495, D. Suiter/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Leakage was caused by insufficient load on the interface seal.

Corrective action:

The seal load was increased by removing 0.150 in. of shims.

JSC Form 1143C (Dec 78)

NASA-JSC

FLIGHT TEST PROBLEM REPORT

NO. 31

Statement of problem:

The H_2 topping valve for the main propulsion system (MPS) indicated slow closure after the propellant dump.

Discussion:

The close switch indication occurred 88.5 seconds after power was removed from the H_2 topping (replenish) valve solenoid, venting the actuator and allowing the spring to close the ball valve. Normal ambient temperature closure time is less than a second. The valve cycled normally for vacuum inerting and during postflight tests. Slow closure is the result of the low temperatures, about 25° R, during the propellant dump.

The topping valve function is used to provide proper loads during the servicing operation and a slow response for closing on orbit is not detrimental to the system performance.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: W. Brasher/EP2 X-5495, R.J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Slow H_2 topping valve closure is caused by the low temperatures.

Corrective action:

None

FLIGHT TEST PROBLEM REPORT

NO. 32

Statement of problem:

OMS Pod graphite epoxy structure delamination

Discussion:

Approximately 20 x 40 in. aft section of right-hand and a 14 x 16 in. section of the left-hand OMS pods graphite epoxy structure was delaminated. The degradation of the FRSI appeared to result from a high temperature for a short duration. A series of simulated tests to duplicate the FRSI degradation were conducted and the condition most closely simulating the degradation was a 5-second duration exposure to a surface temperature of 1600°F. It is not known whether the delamination occurred because of water entrapment in the honeycomb core, or because of the temperature (postulated to have exceeded 500°F locally) on the outer face sheet, or a combination of both.

Required date for resolution: CLOSED FOR STS-2

Personnel assigned: J. Smith, H. Kavanaugh, W. McMullen

Action progress:

Effect on subsequent missions:

The redesign will be evaluated on STS-2 through the temperature measurement and postflight inspection.

Conclusions:

The temperature measurement should be adequate to enable determination of the cause and the design fix should be adequate to prevent a subsequent occurrence.

Corrective action:

The aft panels on each pod have been replaced and 25 HRSI tiles will cover the area on each pod. One of the tiles on the left-hand pod will contain a surface temperature measurement for use in determining the magnitude and duration of heating exposure on STS-2.

FLIGHT TEST PROBLEM REPORT NO. 33

Statement of problem:

Waste collection system had low urinal flow and low commode air flow.

Discussion:

Throughout the mission, the commode air suction degraded until the commode became unusable. The postflight crew report indicated there was low urinal flow and a feces separation problem.

Postflight inspection verified (a) the urinal hose screen was blocked with lint, (b) a carry-over flow path of urine existed from the fan to the odor/bacteria charcoal filter, (c) the presence of urine in the odor/bacteria filter, and (d) fecal matter collected on the back side of the transport tube.

The post landing one-g drain of urine from the odor/bacteria filter flooded the fan cavity, verifying the presence of liquid in the odor/bacteria filter. Liquid carry-over into the odor/bacteria filter blocks the air flow through the urinal and commode. A blocked urinal hose screen can result in a liquid carryover into the odor/bacteria filter. A flooded fan cavity can keep a fan/separator from operating. Improper alignment of user with commode can result in fecal matter being collected on the back side of the transport tube. (continued page 2)

Required date for resolution: CLOSED 6/10/81

Personnel assigned: H. Rotter/EC3 X-5234, J. D. Lobb/WA3 X-4323

Action progress:

See corrective action.

Effect on subsequent missions:

See corrective action.

Conclusions:

a. A prelaunch water flow ground test may have caused initial liquid carryover and initial commode problem.

b. Some lint may have collected on the screen during ground testing.

(continued page 2)

Corrective action:

a. Delete prelaunch water flow ground test.

b. Change urinal hose screen to coarser mesh.

c. Add replaceable in-line urinal filter upstream of existing screen and provide spares. (continued page 2)

DISCUSSION (continued)

After the screen was cleaned postflight, the air flow was within specification.

CONCLUSIONS (continued)

c. The lint-blocked urinal hose screen can cause liquid flow into the odor/ bacteria filter.

d. A wet odor/bacteria filter can block the total air flow causing problems with transportation in both the urinal and commode.

CORRECTIVE ACTION (continued)

d. Add spare odor/bacteria filter

e. Add Apollo fecal collection assemblies in stowage.

f. Add QD adapter for urine cup to contingency hose for contingency voiding overboard through the waste water dump nozzle.

g. Increase crew training for seat alignment, use procedure, and inflight maintenance.

FLIGHT TEST PROBLEM REPORT

NO. 34

Statement of problem:

Radar altimeter data dropout at 75 feet.

Discussion:

During landing gear deployment at an altitude of approximately 75 feet, both radar altimeters broke lock, reading invalid zero altitude for 4 seconds. Upon reacquisition, the altitude indicated by both units was less than the actual vehicle height above the ground. This erroneous output remained until main gear touchdown (altimeter height of approximately 20 feet), at which time both units returned to proper tracking through rollout.

Postflight test at KSC performed and verified both altimeters operating properly.

Required date for resolution: CLOSED FOR STS-2 6/24/81

Personnel assigned: B. Hood/EH4, X-3254, A. J. Pajak/EE6 X-2189, A. Reubens/WA3 X-4323

Action progress:

A test with full-scale mockup of antennas and nose landing gear is being proposed to duplicate the problem and evaluate a modified antenna design. A change to the altimeter gain is being studied to optimize ground returns with respect to unwanted reflections from the nose gear.

Effect on subsequent missions:

Radar altimeter data will not be used by the guidance system.

Conclusions:

Reflections from the nose landing gear and/or door assembly mixed with proper returns from the ground resulted in erroneous data from 75 feet to touchdown.

Corrective action:

A software change has been approved for STS-3 to remove altimeter data from autoland guidance. Units will be manually deselected for STS-2.

FLIGHT TEST PROBLEM REPORT

NO. 35

Statement of problem:

Vehicle response overshoot poorly damped during first roll.

Discussion:

Lateral roll/yaw oscillation after the first roll maneuver at a dynamic pressure of about 12 psf was poorly damped with a maximum peak-to-peak beta of 7° and a period of 13 seconds.

An unexpected roll torque from the yaw engines is the primary cause. The estimated roll torque is much closer to vacuum thrust levels at low dynamic pressure than provided for in the Aero Data Book. This results in an inability of the autopilot to coordinate the maneuver properly due to inadequate roll authority.

For STS-2, the initial roll will be performed manually at a reduced rate allowing for additional data gethering before modifications are made to the flight control software.

Required date for resolution: CLOSED for STS-2 6/10/81

Personnel assigned: D. Gilbert/EH4 X-3254, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

Dependent on STS-2 results.

Conclusions:

Roll torque from the yaw engines exceeds autopilot roll authority at low dynamic pressure.

Corrective action:

Use manual control at reduced rates for STS-2.

Modify flight control software for STS-3 and subsequent after evaluation of STS-2 manual flight test data.

FLIGHT TEST PROBLEM REPORT

NO. 36

Statement of problem:

Smoke detection system A test of "flight deck left" failed several self-test attempts and "cabin" worked only once in several attempts.

Discussion:

The crew reported the smoke detection matrix self-test light failed at 102:16:10 and 102:16:35 G.m.t.

The problem is caused by the detector's air-pump bearings that bind occasionaly because of the lubricant used. When the torque-load exceeds the design limit, the drive motor current exceeds the self-test limit. Repeating the self test will normally clear the fault.

An improved-design detector is in production and 8 units will be available in June.

Required date for resolution: ~~STS-2~~ Aaron Cohen 6/3/81

Personnel assigned: F. Samonski/EC3 X-4823, H. Rotter/EC3 X-5324, A. Reubens/WA3 X-4323

Action progress:

All detectors passed self-test per the OMRSD at KSC on May 6, 1981. Smoke detectors are limited life items (800 hours) and none require replacement prior to STS-3.

Effect on subsequent missions:

Replace all detectors prior to STS-3.

Conclusions:

Intermittent bearing problem in smoke detectors air pumps. Fly as is on STS-2.

Corrective action:

New improved air pump in production.

FLIGHT TEST PROBLEM REPORT

NO. 37

Statement of problem:

Orbiter touchdown was about 3200 ft beyond planned point.

Discussion:

The Orbiter touched down 6053 ft past the threshold on EDW Runway 23. This touchdown point was about 3000 ft farther down the runway than premission planning had predicted even though the touchdown speed and approach trajectory were near nominal. Analysis based on the onboard trajectory data, ground based measurements of touchdown point, wind and atmospheric density from a balloon released 2 minutes after landing, and onboard speed brake position information indicated that the Orbiter lift-to-drag ratios were higher than expected both in and out of ground effects.

Postflight reconstruction simulations indicated that about 2000 ft of the 3000 ft deviation could be accounted for the additive minor operational and environmental dispersions and the higher lift-to-drag ratios appear to account for the remaining 1000 ft. Additional analyses based on control stick inputs and aerodynamic coefficient identification techniques generally confirmed that the Orbiter's basic drag was lower than expected and ground effects normal force and axial force coefficients were slightly different than those defined in premission aero data books.

(continued, page 2)

Required date for resolution: CLOSED for STS-2 7/22/81 SCJ 8/5/81 Aaron Cohen

Personnel assigned: J. West, B. Redd, L. Hayman/EX3 X-5181, R. J. Ward/WA3 X-4323

Action progress:

Simulations continuing using the revised aerodynamics.

Effect on subsequent missions:

None

Conclusions:

Predicted landing aerodymanics were different from the actual for STS-1.

Corrective action:

Aerodynamic data base being revised to reflect STS-1 results. SMS and Shuttle training aircraft to include revised data base. Steep glide slope being revised from 20° to 19°.

#37 (continued)

Discussion:

Postmission simulations confirm that these aerodynamic coefficient adjustments result in the equivalent of 900 to 1000 ft more range at touchdown.

The aerodynamic coefficients which have been adjusted include:

a. Axial force coefficient CD_0 reduced 0.0040.

b. Speed brake drag effectiveness higher than predicted.

c. Ground effects for normal and axial force coefficients less than expected.

FLIGHT TEST PROBLEM REPORT

NO. 38

Statement of problem:

Pyrotechnic external tank unlatch at the outboard position on the LH_2 umbilical plate did not fire at external tank separation.

Discussion:

One NASA standard detonator (NSD) was found unspent in postflight inspection. The wiring and the associated detonator connectors were destroyed by shrapnel from the successful functioning of the companion or redundant detonator in the frangible nut. Sufficient time skew existed between firing circuits A and B to allow detonation products from the first unit fired to impact the second detonator and/or wiring.

Nominal NSD function time is 100 microseconds. Anticipated skew is 1.5 to 2 milliseconds. Postflight troubleshooting confirmed 2 milliseconds skew.

An open bridge wire was found in the unfired pyro, confirming that the signal did reach the device. The reason for nonfiring was that the charge had been separated from the bridgewire by the shock from the detonation prior to the signal's reaching the bridgewire. Postflight shock tests at up to 100g demonstrated that NASA standard initiators will withstand mission shock levels.

Required date for resolution: CLOSED 7/22/81 Aaron Cohen

Personnel assigned: B. Hood/EH7 X-3254, T. Graves/EP4 X-3918, R.J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

The two millisecond timing skew between redundant initiators allowed the first NSD to fire, breaking the frangible nut and producing shrapnel that prevented the redundant NSD from functioning.

Corrective action:

No corrective action required. System functioned as designed.

FLIGHT TEST PROBLEM REPORT

NO. 39

Statement of problem:
Body flap exceeded planned trim attitude by over 5° at hypersonic entry speeds

Discussion:
The body flap extended to 14°, exceeding the planned trim attitude of 8 to 9° during entry from Mach 22 through 12. Postflight analysis of longitudinal trim characteristics indicates that aerodynamic predictions for pitch trim at hypersonic speeds were in error. The additional body flap deflection increased the body flap heating environment. Elevon trim position will be changed from -1° to +1° above Mach 10 for STS-2.

Required date for resolution: CLOSED 6/3/81

Personnel assigned: L. Hayman/EX3 X-5181, R. J. Ward/WA3 X-4323

Action progress:
Body flap pulses during aero stick inputs (ASI's) on STS-2 will provide data to evaluate longitudinal effectiveness of individual control surfaces.

Effect on subsequent missions:
None

Conclusions:
Aero pitch trim predictions in error.

Corrective action:
Elevon schedule will be adjusted on STS-2 to relieve body flap heating.

FLIGHT TEST PROBLEM REPORT

NO. 40

Statement of problem:

Crew reported trouble locking doors on two stowage lockers for entry and opening waste management door.

Discussion:

The STS-1 Orbiter mission had 27 modular stowage lockers installed on the middeck forward and aft bulkheads, 23 and 4, respectively. The crew experienced difficulty in locking the doors of lockers MA9L and MF14K during preparation for return. The door fasteners (2 per door) were misaligned, thus causing the crew to physically move the door to the locker frame to engage the locks. Postflight inspection showed that an out of plane condition exists in the vehicle structure at the locker interface causing distortion of the locker during installation.

The slide bolt on the waste management door jammed when latched.

Required date for resolution: CLOSED 7/22/81 Aaron Cohen

Personnel assigned: F. McAllister/EC3 X-3343, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

Modular lockers may exhibit difficulty in door closure due to the vehicle structure inflight movement.

Conclusions:

Modular lockers were distorted by middeck bulkhead wire tray out of plane irregularities caused by the structure movement. Slide bolt clearance setting was inadequate on the waste management door.

Corrective action:

Slide bolt on the waste management door was adjusted for proper clearance. Locker doors will be reshimmed for STS-2.

FLIGHT TEST PROBLEM REPORT

NO. 41

Statement of problem:

The flight crew experienced difficulty in installing the ejection seat scramble handle safety clip during the STS-1 mission.

Discussion:

The crew was able to depress the handle and install the safety clip.

The inspection by the installation team revealed that the Pilot's scramble handle release button was bent and could stick down. The Commander's scramble was inspected and was normal.

Required date for resolution: CLOSED Aaron Cohen 6/10/81
SCJ 6/10/1

Personnel assigned: W. Lofland/EW3, R. Ward/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

Scramble handle release button was bent during use resulting in difficulty in installing safety clip.

Corrective action:

Defective part has been replaced. Future crews will be given additional training on the installation of the safety clips.

FLIGHT TEST PROBLEM REPORT NO. 42

Statement of problem:

APU Nos. 1 and 3 had low chamber pressures during on orbit startup.

Discussion:

The low chamber pressure of about 1,000 psi versus a normal Pc of about 1,200 psi was determined either to be caused by gas bubbles in the feed system or to be generated by heat in the fuel pump or valve. Ground servicing and in-flight procedures have been changed to reduce gas bubbles in the system. Tests will be run to determine APU operating margins with gas bubbles.

Required date for resolution: CLOSED 7/1/81 Aaron Cohen

Personnel assigned: R. J. Lance/EP4 X-3851, R. J. Ward/WA3 X-4323

Action progress:

STS-1 and 2 profiles will be tested in an attempt to generate decomposition bubbles. Another test will inject bubbles into the inlet of the fuel pump to determine how the APU runs with the bubbles.

Effect on subsequent missions:

None

Conclusions:

Gas bubbles in the APU propellant system caused low chamber pressure during startup.

Corrective action:

Ground servicing and in-flight procedures have been changed to reduce gas bubbles in the system.

FLIGHT TEST PROBLEM REPORT

NO. 43

Statement of problem:

Umbilical release blast containers have cracks.

SCJ 8/3/81

Discussion:

Postflight inspection revealed a crack or fracture in the sidewall of two of the six blast containers removed from the LH_2 umbilical disconnect assembly.

The LH_2 umbilical aft separation blast container had a ½-in. fracture in the sidewall above the threaded portion of the canister. The LH_2 umbilical forward separation blast container had a 3/8-in. fracture in the sidewall in the same approximate area. All fragments were contained within the blast containers. The blast containers were returned to Rockwell-Downey. Tests at JSC have verified that the blast containers are acceptable for single mission usage.

Required date for resolution: CLOSED for STS-2 7/1/81 Aaron Cohen

Personnel assigned: R. B. West/EW3 X-3051, R. J. Ward/WA3 X-4323

Action progress:

Each of the blast containers, including the 4 undamaged containers, will be subjected to thread checks, dye penetrant inspections, and material verification.

Effect on subsequent missions:

None

Conclusions:

Blast containers for STS-1 operated acceptably but must be replaced after each mission.

Corrective action:

Blast containers will be replaced for STS-2. Redesign being evaluated to provide 10 mission capability for STS-3 and subs.

FLIGHT TEST PROBLEM REPORT

NO. 44

Statement of problem:

Nose gear door thermal barrier fell off during landing gear deployment.

Discussion:

The forward nose gear door thermal barrier was torn loose just before landing when the nose gear door was opened. This was observed on films of the landing and the thermal barrier was found on the lakebed approximately 1-1/2 miles before the touchdown point.

An inspection of this barrier and the adjacent tile surfaces revealed thermal damage on the left-hand side of the barrier at the location between the first and second tile from the edge. The thermal barrier (ten mil) inconel stiffener within the AB312 cover was burned through as was most of the thermal barrier.

There was two factors leading to this failure - the alignment of adjacent tile joints and the stiffness of the thermal barrier which inhibited proper compliance of the thermal barrier with the irregularities of the tile surface.

Required date for resolution: CLOSED 6/3/81

Personnel assigned: N. Piercy EW3 X-4916, R. J. Ward/WA3 X-4323

Action progress:

The replacement thermal barrier will be modified to reduce the ten-mil thick inconel stiffener in the thermal barrier to two mils. This should allow better conformance of the thermal barrier to the tile surface.

Effect on subsequent missions:

Possible replacement may be required after each flight until a completely new design with reshaped surrounding tile is adopted.

Conclusions:

Poor thermal barrier installation was the cause of the problem. A modified, less stiff, assembly should fit properly and stay in place for STS-2.

Corrective action:

Improved design for STS-2 and a new design for operational flights.

FLIGHT TEST PROBLEM REPORT

NO. 45

Statement of problem:

The Payload Bay Door (PLBD) closure overlap on rehearsal and entry days was more than predicted.

Discussion:

During door operations on rehearsal and entry days, the crew reported an overlap in excess of 3 in. at the number 12 latch location.

The maximum design capability is 4 in. and the pre-flight predictions indicated a gap.

Post flight measurements of the gap on the left door mechanical stops and the switch transfer point on the left aft door switch module indicate that the door rigging was correct. A theodolite will be installed on STS-2 for more accurate deflection measurements. Flight data from STS-2 will be correlated with the math model.

Required date for resolution: CLOSED for STS-2 6/10/81 Aaron Cohen

Personnel assigned: R. D. Langley/WT5 X-4859, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

STS-2 thermal environment for PLBD operations is similar to STS-1. Vehicle attitude constraints may be required on some missions to achieve PLBD closure.

Conclusions:

A more accurate measurement of PLBD deflections is required for correlation with the math model to determine when vehicle attitude constraints are required for PLBD change.

Corrective action:

A theodolite will be installed on STS-2 so that more accurate PLBD deflection measurements can be correlated with the math model. Vehicle attitude constraints for PLBD closure will be evaluated for STS-3 and subsequent based on STS-2 results.

FLIGHT TEST PROBLEM REPORT

NO. 46

Statement of problem:

Temperature on left OMS nozzle bell was off-scale high during SRB firing and high during OMS burns.

SA 8/3/81

Discussion:

There are three DFI temperature measurements on the left OMS engine nozzle: V43T9111A and V43T9112A approximately 90° apart on the nozzle lip and V43T9110A near the nozzle flange connecting the thrust chamber to the nozzle extension. V43T9112A was not responsive to the thermal environment. V43T9111A indicated temperatures much higher than expected, going off-scale high (>3000° F) during boost and again during the OMS-1 burn. The maximum temperature expected at the nozzle lip during boost was 1600° F and during engine firing 1250° F. The nozzle flange measurement indicated a maximum temperature of 900° F during boost and 1800° F during OMS-1, approximately as expected.

Inspection at KSC indicated that the sensor mounting assembly and a measurement wiring support bracket welded to the nozzle were loose. Visual inspections of the nozzle did not indicate any damage due to overheating.

Required date for resolution: CLOSED 7/15/81 Aaron Cohen

Personnel assigned: W. C. Boyd/EP2 X-5437, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Physical examination of the nozzles did not show any evidence of high temperature. The excessive temperature readings were due to the loose sensor mounting assembly.

Corrective action:

The left OMS engine nozzle has been changed out, and the nozzle bell sensors have been checked out with a heat gun and an improved voltage to verify proper end-to-end response.

FLIGHT TEST PROBLEM REPORT

NO. 47

Statement of problem:

During STS-1, the DFI wideband ascent and DFI PCM recorders exhibited a dropout of approximately 400-milliseconds duration 350 milliseconds after SRB ignition.

Discussion:

A review of the vibration environment induced into the crew cabin during launch shows a larger than expected 15-to-18 Hz component in the vehicle Z axis. The flutter of the DFI wideband ascent recorder exceeded 20 percent peak-to-peak during the dropout period.

Analysis of the vehicle-induced vibration input to the recorders was performed in an attempt to find a frequency to which the recorder shock isolators could be tuned. A low-level sine vibration (0.25 g peak-to-peak input) test was performed on the DFI PCM recorder to determine the isolator resonant frequency. Results of these tests and analysis show that the present design (45 to 50 Hz resonance) is about optimum.

Any effort to change the isolator system on the recorders will require a major redesign to provide sufficient sway space. This would result in a delta qualification program which could not be completed before STS-3.

Required date for resolution: CLOSED Aaron Cohen 6/10/81

SCJ 6/10/1

Personnel assigned: J. F. Melugin, R. Ward/WA3 X=4323

Action progress:

None

Effect on subsequent missions:

Minor data loss is expected.

Conclusions:

Loss of data is the result of the recorders being susceptible to the frequencies experienced following SRB ignition.

Corrective action:

No corrective action is required. The DFI PCM data during this time period is backed up by real-time telemetry. The dropout in the FDM data has no backup, but no critical data were lost.

FLIGHT TEST PROBLEM REPORT

NO. 48

Statement of problem:

Hydraulic dynatube fitting on APU No. 1 pump found to be leaking and surface crack found on suction line.

Discussion:

Postflight inspection indicates that approximately 1/2 gallon of hydraulic fluid was lost from APU No. 1. The dynatube connection at hydraulic pump No. 1 suction line was retorqued at DFRC to stop the leak prior to ferry back to KSC. Both the pump and the APU had been replaced prior to flight. Probable cause of the leak is improper torque during installation. The suction line was returned to the vendor. The surface crack was found to be superficial and was burnished out.

Required date for resolution: CLOSED 7/1/81 Aaron Cohen

Personnel assigned: C. D. Haines/EP4 X-5451, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Leaking hydraulic dynatube fitting probably caused by improper torque during installation.

Corrective action:

All pump dynatube connections will be retorqued and the torque values recorded.

FLIGHT TEST PROBLEM REPORT

NO. 49

Statement of problem:

Right-hand main landing gear door buckled.

Discussion:

A localized region of excessive gap heating occurred on the forward portion of the right main landing gear door. The excessive heating resulted in severe tile sidewall shrinkage (4 tiles), charred filler bar, and a localized buckle in the door structure.

Required date for resolution: CLOSED 6/10/81

Personnel assigned: S. Weiss/ES2 X-6156, R. Dotts/ES3 X-2376, R. J. Ward/WA3 X-4323

Action progress:

The structural buckle has been repaired using a doubler with blind fasteners. The tiles will be reinstalled (4 replaced) with specification steps and gaps. Gap fillers will be used to fix out-of-tolerance step/gap conditions. The flow restrictor has been extended.

Effect on subsequent missions:

None.

Conclusions:

A forward facing step, a tile gap, a tile-to-filler bar gap, and an inadequate flow restrictor resulted in excess heating of the main landing gear structural surface.

Corrective action:

Structure and thermal protection system on door are being refurbished. Flow restrictor has been modified.

FLIGHT TEST PROBLEM REPORT

NO. 50

Statement of problem:

Forward RCS F2R oxidizer injector temperature did not respond correctly.

Discussion:

Postflight data review on this thruster leak detector indicated that thruster F2R was different in that the oxidizer logic detector did not follow the fuel in the post firing evaporative cooldown caused by the dribble volume. A significant thermal lag was noticed.

Engine was removed from the vehicle and returned to the supplier for failure analysis.

Inspection showed the leak detector was not installed in the boss provided for it. It was bent and installed beside the injector tube.

Required date for resolution: CLOSED 6/24/81 Aaron Cohen

Personnel assigned: C. Hohmann/EP4 X-3851, D. Suiter/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Corrective action:

The leak detector was reinstalled on the engine. ATP pass/fail criteria has been added to the Acceptance Data Review.

FLIGHT TEST PROBLEM REPORT

NO. 51

Statement of problem:

Left-hand and right-hand wing vent ducts structural failure.

Discussion:

During postflight change-out of the wing vent doors, inspection of the vent ducts revealed structural damage had occurred in both ducts. The left duct had an extensive crack along the bottom rivet row and across the panel to the upper rivet row. A piece about 2½ in. x 4 in. was missing. The right duct had a similar crack with a piece about 1½ in. x 3 in. missing. (The cross section for each duct is about one square foot.)

With a resonant frequency of about 54 Hz for the duct panels, a measured center frequency of 50 Hz at a microphone in the mid-fuselage during flight, and a calculated open-end duct frequency of about 42 Hz at about Mach 1 during ascent, it appears the cracks and holes in the 0.020-in. thick aluminum ducts were the result of fatigue.

Thicker aluminum duct walls will stiffen and strengthen the ducts.

Required date for resolution:

CLOSED 6/3/81

Personnel assigned:

J. Janney/ES3 X-2376, J. D. Lobb/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

The thin walled ducts failed in fatigue because resonance frequency was almost the same as that of the launch environment.

Corrective action:

The wall thicknesses of the replacement ducts have been increased to 0.040 in., and to 0.063 in. where required for vent door loads.

FLIGHT TEST PROBLEM REPORT

NO. 52

Statement of problem:

Development flight instrumentation measurement discrepancies.

Discussion:

Approximately 40 PCM and 35 wideband DFI measurements were found to be discrepant as a result of the STS-1 data review. Where access has been available and schedule permits troubleshooting, corrective actions have been implemented.

Required date for resolution: September 1, 1981

Personnel assigned: H. Gallanes/RI, R. Sinderson/EE4 X-2918

Action progress:

A plan is being developed to define the measurements which have not been repaired, the priorities for the FTR effect of each, and the planned corrective action and its schedule.

Effect on subsequent missions:

Measurement repair will be required during the turnaround activities for STS-3 and 4.

Conclusions:

Corrective action:

JSC Form 1143C (Dec 78)

NASA-JSC

FLIGHT TEST PROBLEM REPORT

NO. 53

Statement of problem:
Lateral oscillation at about 1.6 Mach.

Discussion:
An unexpected, a larger rolling moment from the rudder and a lower than expected aileron rolling moment appear to have caused a 0.2 Hz, 4 deg/sec peak-to-peak oscillation with a period of 4 seconds which started about Mach 1.8 and persisted for about 6 cycles. Control margins are lower than desired in this region.

Required date for resolution: CLOSED FOR STS-2 6/10/81

Personnel assigned: M. Contella/EH2 X-2767, R. J. Ward/WA3 X-4323

Action progress:
PTI's planned in this region on STS-2 will allow data extraction to facilitate a software fix for STS-3.

Effect on subsequent missions:
Dependent on STS-2 results.

Conclusions:
Unexpected rolling moment from rudder and lower aileron rolling moment at about 1.6 Mach resulted in reduced control margins.

Corrective action:
Consider software modification for STS-3 and subsequent based on STS-2 evaluation.

PTI's for STS-2 have been reduced to 1/3 of original magnitude and are of a shorter duration.

FLIGHT TEST PROBLEM REPORT

NO. 54

Statement of problem:

Cabin dp/dt exceeded -0.05 psi/min during ascent.

Discussion:

After STS-1 lift-off, from T + 42 to 67 seconds, the dp/dt sensor telemetry indicated a cabin pressure drop rate sufficient to trigger atmosphere warning and the caution and warning klaxon alarm. The maximum rate was -0.065 psi/min.

The pressure resulted from cabin expansion that was caused by an increasing pressure differential between the cabin and ambient with increasing altitude.

The dp/dt caution and warning limit is -0.05 psi/min. The crew did not report a klaxon actuation. Four master alarms occurred at 102:12:00:49 G.m.t. when the dp/dt was -0.049 psi/min. The crew reset the master alarm within 2 seconds.

The klaxon was not heard because the crew wore special ear plugs that carried only the master alarm tone, and therefore the klaxon was not heard. Also, the crew was wearing helmets with earphones; the visors were closed and breathing system was flowing oxygen. The klaxon has short-tone duration and with the launch noise, could not be heard. (Continued page 2)

Required date for resolution: CLOSED 6/24/81 Aaron Cohen

Personnel assigned: F. Samonski/N. Prince/EC 3 X-5234, A. Reubens/WA3 X-4323

Action progress:

None

Effect on subsequent missions:

None

Conclusions:

Alarm caused by cabin pressure drop which in turn was caused by cabin volume increase with altitude.

Corrective action:

Crew will be informed to expect caution and warning during ascent.

DISCUSSION: (continued)

Flight rules state for dp/dt from 0.00 to -0.12 psi/min, no action is required. Reset of master alarm was proper action.

FLIGHT TEST PROBLEM REPORT

NO. 55

Statement of problem:

Payload bay door hinge 7 exceeded maximum temperature limit of 1200° F during entry.

Discussion:

The Payload bay hinge 7 temperature measurement reached 1530° F during entry. Peak temperatures on adjacent structures dod not exceed 285° F. The subject measurement sensor is attached to a small platinum tab which is spot welded to the hinge clevis. This installation technique is subject to question as to the actual "contact resistance" of the sensor to the structure. By varying the contact resistance term analytically, the measurement could be reading up to several hundred degrees F higher than the hinge clevis itself. Thermal analysis shows that the addition of a high-emittance coating to the hinge clevis would reduce the peak temperature by 125° F. Hinge pins 7 and 9 were inspected in parallel, hardness tested, and reinstalled. The lubricant (Vitrolube), with an upper temperature limit of 1000° F, also passed inspection and testing. Black high-emittance paint (Pyromark) has been applied to all bare hinges.

Required date for resolution: CLOSED 7/24/81 SCJ 8/5/81 Aaron Cohen

Personnel assigned: J. Smith/ES2 X-3676, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Postflight inspection and testing indicate that payload bay door hinges 7 and 9 could not have exceeded maximum temperature during entry. High "contact resistance" of the sensor to the structure probably resulted in the high temperature reading.

Corrective action:

Payload bay door hinge 7 temperatures will be extrapolated from adjacent measurements. Black high-emittance paint has been applied to all bare hinges.

FLIGHT TEST PROBLEM REPORT

NO. 56

Statement of problem:

Over temperature experienced on plate of body flap.

Discussion:

During STS-1 entry DFI sensor V09T9874A indicated considerably hotter response than predicted. Peak measured temperature was 395° F on the tile carrier plate aluminum structure on the aft fuselage stub. Postflight inspection showed severe gap filler degradation adjacent to the carrier plate tiles and some indication of subsurface flow. Postflight thermal analysis of local heating effects on the carrier plate and the adjacent waffle skin structure indicated that flight temperatures did not exceed structural capability.

Required date for resolution: CLOSED 7/22/81 SCJ 8/5/81 8/5/81

Personnel assigned: J. Smith/ES3 X-3676, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Post-STS-1 thermal analysis combined with detailed visual inspection of the tiles and gaps in the stub region indicates that the over temperature was limited to the carrier plate. The over temperature is acceptable for the carrier plate structure.

Corrective action:

The stub carrier plate TPS will be left as is for STS-2, with carrier plate removal/ inspection planned after STS-2.

FLIGHT TEST PROBLEM REPORT NO. 57

Statement of problem:

Payload bay floodlights not operating.

Discussion:

PCA bus current data showed that three of the payload bay floodlights did not operate during the flight.

The lighting system consists of two electronic packages and five metal halide light assemblies. Three light assemblies were connected to one electronic package and two lights were connected to the other electronic package. Each package has four electronic ballast circuits, each one for starting one light assembly. Each package consists of current sensing transistors, one of which controls the operation of an inverter, the output of which is fed to a power transistor and thence through a transformer to a pulse forming network (PFN) which supplies high voltage (1500 - 2000 volts) to strike the arc in the floodlight lamp. After ionization, the lamp operates at reduced voltage (approx. 100 volts); and the current reduces from an initial value of 10 amperes to about 6 amperes.

Failure analysis of the electronic package revealed that one unit operated properly. In the other unit, two transistors failed in the electronic ballast circuits.

Required date for resolution: CLOSED 7/22/81 Aaron Cohen

Personnel assigned: A. J. Farkas/EH5 X-2766, D. L. Suiter/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Power transistor has a generic failure mode due to over heating. Current sensor transistor failed because high voltage lead from the PFN was improperly routed too close to the base lead and arcing occurred.

Corrective action:

A power factor correction circuit will be added to limit the current through the power transistors, thus reducing its operating temperature below failure levels (130° C). The output of the PFN will be routed away from the base lead; and, in addition, vent plugs will be added to the electronic package housing to reduce the outgassing pressure below the critical pressure of corona onset prior to floodlight operation. Modified units to be installed for STS-2.

FLIGHT TEST PROBLEM REPORT

NO. 58

Statement of problem:

Forward RCS oxidizer tank aft Z strut found deformed.

SCJ 8/3/81

Discussion:

The forward RCS oxidizer aft Z strut failed in Euler buckling due to the lift-off dynamic response from the SRB overpressure. The forward and aft Z axis tank struts on both the fuel and the oxidizer tanks were replaced with struts reinforced by plies of boron/epoxy. The rod end diameter of the fuel tank struts was increased by 1/16 in. to be the same as the diameter of the ozidizer struts.

The base heat shield left and right struts were reinforced and replaced. All other large mass support systems were reassessed for positive margins.

Required date for resolution: CLOSED 7/22/81 Aaron Cohen

Personnel assigned: E. W. Sandars/ES2 X-6156, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:

None

Conclusions:

Z axis accelerations exceeded design limits due to SRB overpressure which resulted in deformation of the forward RCS oxidizer tank aft Z strut.

Corrective action:

Forward RCS struts were modified and replaced. Base heat shield left and right struts were reinforced and replaced. All large mass structures were analyzed and found to have positive margins of safety.

FLIGHT TEST PROBLEM REPORT

NO. 59

Statement of problem:
Vibration levels were higher than expected on auxiliary power units 2 and 3.

8/8/81

Discussion:

Six to 8 minutes after lift-off, flight data showed a rise in APU 2 X- and Z-axis vibration levels at 1200 Hz and a similar, but lower-level, vibration rise in APU 3.

Inspection showed hydraulic pump 2 to be normal, with slight erosion and no evidence of cavitation. APU 2 was found to be normal except that the turbine wheel balance was slightly out of tolerance. Rerun performance was satisfactory on both units. Data from other APU units show similar vibration, although APU 2 had the highest vibration during ATP, with APU 3 next. APU 2 data were comparable during rerun to ATP and flight data in normal speed range.

Required date for resolution: CLOSED for STS-2 8/5/81 Aaron Cohen

Personnel assigned: R. Colonna/WA X-6233, R. J. Ward/WA3 X-4323

Action progress:

Effect on subsequent missions:
None

Conclusions:
STS-1 APU/hydraulic pump 2 and 3 vibration levels are typical, and units show near nominal wear.

Corrective action:
APU-2 has been replaced. (See flight test problem report 19.)

FLIGHT TEST PROBLEM REPORT

NO. 60

Statement of problem:

Video tape recorder vibration isolation system bottomed out.

Discussion:

Although the video tape recorder (VTR) operated properly throughout the STS-1 mission, KSC reported failure of the VTR either to record or to play back audio during a pre-STS-2 checkout. While changing out the VTR, KSC also found structural damage to the VTR housing. Both the VTR and and VTR housing were returned to JSC for evaluation and analysis. Significant damage was found in the VTR mounting rails and vibration isolators. These problems and potential solutions are now under investigation.

Required date for resolution: September 1, 1981

Personnel assigned: K. Land/EE2 X-6154, R. J. Ward/WA3 X-4323

Action progress:

Reevaluating the design of the VTR vibration isolation system.

Effect on subsequent missions:

Conclusions:

Corrective action:

FLIGHT TEST PROBLEM REPORT

NO. 61

Statement of problem:
OMS Helium purge flow inoperative.

Discussion:
The aft compartment and OMS pod comparison of pressure data during entry indicates that the helium purge to the OMS pod did not occur.

Required date for resolution: September 1, 1981

Personnel assigned: Neider/JSC, Koch/RI

Action progress:
Flow tests are planned at KSC to verify if any blockage exists in the purge line.

Effect on subsequent missions:

Conclusions:

Corrective action:

FLIGHT TEST PROBLEM REPORT

NO. I-2

Statement of problem:
An excessive amount of helium was lost from the engine 2 helium system during the second vacuum inerting.

Discussion:
During the second vacuum inerting, the engine 2 helium system lost 6 lb of helium, dropping in pressure to 1630 psi from 2130 psi. This corresponds to a leak rate of 0.003 lb/sec compared to a nominal leak rate of 4×10^{-5} lb/sec. If this leak rate was sustained during entry, there would be insufficient helium to perform all required functions. Therefore, only the pneumatic regulator and line was used for STS-1 entry purges and repressurization. This sacrificied regulator redundancy.

Leakage has been isolated to the engine 2 helium system. The most likely location of the leak is the seals of the engine pneumatic actuated valves. The high leak rate was only seen during the second inerting. Operations of the system before and after showed no large leak rate. This behavior can be explained by an increasing flow area resulting from seal shrinkage when cold.

Required date for resolution: CLOSED 6/10/81 Aaron Cohen RHKohrs

Personnel assigned: K. Kroll/EP2 X-5495, R. J. Ward/WA3 X-4323

Action progress:
Relocate DFI measurements on STS-2 to determine temperature characteristics of the seals. Conduct ground tests to define cold engine seal leak rates. Utilize data to establish time period for successful vacuum inerting with redundant regulators for operations missions.

Effect on subsequent missions:
Normal operation of helium system except using only pneumatic regulator during optional second inerting.

Conclusions:
Increased leakage due to cold engine seals can be expected. This would only cause a problem when a vacuum inerting is performed after engine seals have been cold soaked. Entry is no problem because engine seals are heated by warm hydraulic flow.

Corrective action:
During second vacuum inertings, only use the pneumatic regulator. Use engine 2 regulators as backup if the pneumatic regulator fails.

FLIGHT TEST PROBLEM REPORT

NO. I-3

Statement of problem:

Flow control valve not opening fully during flight conditions for engine 1.

Discussion:

The problem developed during the Flight Readiness Firing (FRF) when the valve failed to open all the way. A check-out of the valve after FRF indicated the valve's poppet to not be sticking. The decision was made to go with STS-1 without changing out the valve. The problem recurred during STS-1. The pressurization system was still able to maintain the required external tank ullage pressure with the reduced maximum flow rate capacity. The valve was removed after STS-1 for a failure analysis.

The valve has a pressure unbalance at high inlet pressures. Testing has indicated the valve (flight orifices) will only open to 40 percent increased flow at inlet pressures of 2700 psi and greater. After disassembly of the flight valve, dimension checks were made. They were all nominal values or within tolerances with the exception of the spring. It had a lower spring rate than the specification value. The spring force was nominal.

Required date for resolution: CLOSED for STS-2 6/24/81 Aaron Cohen

Personnel assigned: Gene R. Grush/EP2 X-5495, R. J. Ward/WA3 X-4323

Action progress:

A replacement valve has been tested for proper operation at high inlet pressures and will be used for STS-2.

A redesign of the valve is being considered for future flights.

Effect on subsequent missions:

See Action Progress

Conclusions:

Design spring force is marginal for proper valve operation at high inlet pressures.

Corrective action:

A valve tested for proper operation at high inlet pressures has been installed on STS-2.

JSC Form 1143C (Dec 76)

NASA-JSC

FLIGHT TEST PROBLEM REPORT

NO. I-7

Statement of problem:

External tank bipod did not swing forward at separation

Discussion:

The bipod interface requirement states that the bipod will not move aft of its separation position and that it must react a "-X" force of 2 lb at the top of the bipod. Springs and heaters were installed at the pivot point to assure that the bipod would spring forward. Flight films of the ET seperation showed that the bipod did not move forward.

Required date for resolution: CLOSED Aaron Cohen 6/3/81

Personnel assigned: J. Odom/MSFC, B. Roberts/EX3 X-4701, R. J. Ward/WA3 X-4323

Action progress:

The sprayed-on foam insulation (SOFI) "rigidized" the strut such that the springs could not move the strut forward.

Effect on subsequent missions:

None

Conclusions:

The bipod did not move aft of its separation position.

Corrective action:

None required. Clearance is adequate for separation.

9.0 CONCLUSIONS

The Columbia completed a nearly flawless orbital flight of just under 54.5 hours. STS-1, the first of the four currently planned orbital test flights, successfully accomplished the primary objectives of a safe ascent, orbit, entry, and landing and completion of all planned mission events. In addition, data collected on operating environments and subsystem operations will be used both to initially approve the further flight testing planned for the remaining three flights of the orbital flight test program and, ultimately, to support the verification of the full Shuttle operational capabilities. Specific conclusions include:

1. The Shuttle vehicle provided a safe ascent and return by accurately placing the Orbiter into orbit and accomplishing a precise deorbit to the landing point on Runway 23 at Edwards AFB, CA.

2. The ability of the vehicle to withstand the ascent and entry loads environment was qualitatively demonstrated by the intact survival of the vehicle.

3. The payload bay doors, latches, drive motors, and other mechanical parts, including the radiators, performed flawlessly.

4. The Orbiter navigation subsystems all operated well within tolerances.

5. All modes of attitude operations were exercised successfully during the mission. All steering and control functions were very near predictions.

6. The Z acceleration levels experienced as a result of the overpressure wave during the initial boost phase resulted in design exceedances which require corrective action prior to STS-2.

APPENDIX A
WEIGHTS AND MASS PROPERTIES

Table A.1-I contains the mass properties and weights for the Shuttle vehicle and Orbiter at significant events during the STS-1 mission.

TABLE A-1-I.- STS-1 MASS PROPERTIES

Event	Weight, lb	Center of gravity, in			Moments of inertia, slug-ft^2			Products o	
		X	Y	Z	I_{XX}	I_{YY}	I_{ZZ}	P_{XY}	
Prelaunch	4482687.2	1409.8	.4	416.6	42959412.4	316968784.7	347832455.5	24422.8	
Start main engines	4477415.2	1410.9	.4	416.6	42957949.4	315959450.6	346824445.2	24275.0	
SRB Ignition	4465495.2	1413.2	.4	416.7	42960995.8	313985158.8	344847112.2	23587.2	
Lift-off	4463252.4	1413.3	.4	416.7	42943895.7	313774765.6	344620802.2	23787.4	
Maximum dynamic pressure	3220164.9	1377.9	.4	423.1	27569549.8	233106803.9	249384358.9	10413.2	
Maximum g	2153221.3	1257.4	.3	434.6	14305516.5	156906622.0	160950473.8	-9478.1	
End of web action time	1852065.8	1230.1	.7	440.2	10939929.6	140115588.6	141179117.2	64538.7	1
Shuttle - SRB separation	1840022.7	1232.7	.7	440.5	10912681.2	139405263.9	140451019.5	66736.1	1
Oribter & ET-SRB separation	1475299.7	1092.6	.7	450.2	5428440.5	84980966.1	81209453.8	99363.2	1
Main engine velocity cutoff	326084.8	1712.6	3.4	627.0	2599414.9	18253142.5	17309154.8	-46570.0	
Pre ET separation	324156.2	1714.2	3.4	628.1	2580533.5	18061332.4	17136157.0	-46996.0	
Post ET separation	221284.2	1125.9	.1	379.4	968661.2	7512482.8	7789638.1	4552.8	
Post maneuver to OMS 1 burn attitude	220894.8	1125.9	.1	379.3	967684.9	7495410.6	7772629.5	4949.5	
Post maneuver to OMS 1 burn attitude	212520.8	1115.2	-.1	378.4	948642.2	7332263.2	7611005.8	4030.1	
Payload bay doors open	209598.9	1111.2	.2	373.9	955037.0	7252547.1	7577992.8	2381.4	
Payload bay doors closed	209495.9	1111.3	-.1	377.1	936119.0	7263225.8	7542313.7	4027.7	
Post maneuver for OMS test burns-payload bay doors	208904.9	1111.8	.2	373.8	953448.7	7212870.3	7538390.8	2164.3	
OMS test burns completed	207689.9	1110.1	.1	373.2	948142.6	7183583.4	7509487.5	1749.5	
Payload bay doors closed	205624.9	1109.2	-.1	375.8	922345.9	7129430.9	7408735.1	3827.5	
Post maneuver to deorbit burn attitude	205089.9	1109.7	-.1	375.7	921146.7	7103659.4	7383193.5	4017.2	
Post maneuver to entry attitude	199188.7	1100.4	.0	372.8	899446.8	6951994.4	7232826.0	5079.3	
Mach 3	198262.7	1098.7	.0	372.4	895699.5	6920417.1	7201452.7	4527.7	
Landing	197792.7	1100.0	.0	369.6	924117.6	6933456.4	7190081.1	4524.7	

APPENDIX B
ASSESSMENT OF ORBITER FLIGHT TEST REQUIREMENTS

Table B-1 lists the Orbiter-related Orbital Flight Test (OFT) Flight Test Requirements (FTR) and their priority with respect to STS-1. A total of 168 FTR's were identified for the OFT program, 138 of which were assigned to STS-1. Of the 138 STS-1 FTR's, 112 were sponsored by JSC.

B.1 GENERAL ASSESSMENT

Data from more than one flight are required to complete all of the Orbiter FTR's; therefore, none have been completed. However, all of the test conditions specified by these FTR's for STS-1 were accomplished, and sufficient data were acquired so that the remaining three flights of the OFT program can be flown as planned.

B.2 ASSESSMENT BY FTR PRIORITY GROUP

The FTR's were each assigned a priority of either A, B, or C, and that priority reflected the programmatic importance of accomplishing the FTR on STS-1. Accomplishment of priority A FTR's was considered essential to the planned OFT program. Accomplishment of priority B FTR's was considered important, but not essential, and accomplishment of priority C FTR's was considered the least important. The following paragraphs provide an assessment of each priority group of FTR's.

B.2.1 Priority A Flight Test Requirements

Only five FTR's were assigned to priority A and all required developmental flight instrumentation (DFI) pulse code modulation (PCM) data. All five were affected to a degree by the loss of data during blackout because of the loss of the DFI PCM recorder. Three FTR's (08VV001, 08VV016, 08VV018) gathered data on entry loads primarily in the post-blackout regime where thermal and mechanical loads are greatest and where data were available. The data loss during blackout is not considered serious for these FTR's. The remaining two FTR's (07VV024 and 09VV001) concerned entry heating and TPS verification and were heavily dependent upon data in the blackout regime where the data were lost. While this data loss was serious, extrapolation of the post-blackout data back through blackout indicates that heating and thermal protection system performance were as predicted during blackout, and this provides sufficient confidence that the entry testing can proceed as planned and be completed in the remaining three OFT flights.

B.2.2 Priority B Flight Test Requirements

There are 41 priority B FTR's. All were accomplished, but some DFI PCM data were lost between sites, again due to the recorder problem. This data loss affected only the 13 thermal FTR's (06VVXXX) and none of them critically.

B.2.3 Priority C Flight Test Requirements

There were 67 priority C FTR's. All were accomplished, but some DFI PCM data were lost between sites, and this loss affected three thermal FTR's.

TABLE B-I. - STS-1 FLIGHT TEST REQUIREMENT ACCOMPLISHMENT

FTR	Title	STS-1 PRIORITY			Remarks
		A	B	C	
06VV002	Propul Eng Therm Soak			X	DFI PCM lost between sites
06VV005	ET/ORB Att Inter Thermal			X	DFI PCM lost between sites
06VV010	Orb TCS Capability Assessment		X		DFI PCM lost between sites
06VV011	Fwd RCS Thermal Control		X		DFI PCM lost between sites
06VV012	Star tracker Control			X	DFI PCM lost between sites
06VV013	Structure/Cabin Thermal Inter		X		DFI PCM lost between sites
06VV014	FCP/PRSD/Struct Thermal Int		X		DFI PCM lost between sites
06VV015	NLG Thermal Design		X		DFI PCM lost between sites
06VV017	PLBD Seals/Gradients		X		DFI PCM lost between sites
06VV018	PLB Thermal Interact		X		DFI PCM lost between sites
06VV019	TPS Bondline Temperature Resp		X		DFI PCM lost between sites
06VV023	Orb/Eng Thermal Interact		X		DFI PCM lost between sites
06VV024	APU Thermal Control		X		DFI PCM lost between sites
06VV026	PV&D TCS		X		DFI PCM lost between sites
06VV027	OMS PLB Kit Lines TCS				
06VV028	Hydraulics TCS		X		DFI PCM lost between sites
06VV029	Mech Act TCS		X		DFI PCM lost between sites
06VV032	Water Boiler TCS			X	DFI PCM lost between sites
06VV033	KU Antenna Thermal Control				
07VV001	Ascent Aero		X		
07VV002	Launch Veh Base Drag		X		
07VV005	Hypersonic Lat/Dir			X	
07VV006	Transonic H/M			X	
07VV007	Hypersonic Viscous P/M			X	
07VV008	Supersonic Lat/Dir			X	
07VV009	Trim Charact		X		
07VV011	Transonic Lat/Dir			X	
07VV013	Mach 4.5 Lat Trim		X		
07VV014	Rudder Effectivity			X	
07VV015	Push Over/Pull Up				
07VV020	Aero Heating AOA			X	
07VV024	Entry Heating	X			DFI PCM lost during blackout
07VV025	Cross Range Constraints				

TABLE B-I. - STS-1 FLIGHT TEST REQUIREMENT ACCOMPLISHMENT (Continued)

FTR	Title	STS-1 PRIORITY			Remarks
		A	B	C	
08VV001	Load & Stress	X			DFI PCM lost during blackout
08VV002	POGO Stability		X		
08VV003	Acoustic Environment		X		
08VV003a	Zone Environment			X	
08VV004	Acoustic Fatigue			X	
08VV005	Environment Vib Levels		X		
08VV007	Payload Environment			X	
08VV008	Mid Door Deflect		X		
08VV009	Lift/Contr Surf Flutter Asc		X		
08VV010	Lift/Contr Surf Flutter Desc			X	
08VV011	Buffet Eval - Ascent			X	
08VV012	Buffet Eval - Descent			X	
08VV013	Lift-Off Loads		X		
08VV014	End Boost-Second Stg. Lds		X		
08VV015	High Q Loads Eval		X		
08VV016	Entry Loads Eval	X			DFI PCM lost during blackout
08VV017	Ignition Overpressure		X		
08VV018	Aero Press Dist	X			DFI PCM lost during blackout
09VV001	TPS System Verification	X			DFI PCM lost during blackout
38VV001	Vent System			X	
38VV002	Window Cavity Condition			X	
41VV002	MPS Helium Subsystem			X	
41VV003	LO_2 Pressure System			X	
41VV004	LH_2 Pressure System			X	
41VV005	Main stage LO_2 Inlet Verification		X		
41VV006	Main stage LH_2 Inlet Verification		X		
41VV007	MPS Relief Valve			X	
41VV009	Orb/ET Sep Sequence			X	
41VV010	Propellant Dump Time			X	
41VV011	Eval of LO_2 Resid			X	
41VV012	Eval of LH_2 Resid			X	
41VV013	MPS Line Inerting			X	
41VV019	Eval LO_2 Load Accy			X	
41VV019a	Eval LH_2 Load Accy			X	

TABLE B-I. - STS-1 FLIGHT TEST REQUIREMENT ACCOMPLISHMENT (Continued)

FTR	Title	STS-1 PRIORITY			Remarks
		A	B	C	
41VV023	MPS Perform Evaluation			X	
41VV024	Pogo Supress System		X		
43VV002	OMS Perf Verification			X	
43VV004	OMS Crossfeed			X	
43VV005	OMS Quantity Sensor			X	
43VV006	OMS Kit & Low Sensor				
43VV010	OMS Restart				
43VV011	OMS Vib Environment			X	
43VV012	OMS/RCS Interconnect				
45VV001	Cryo Tank Heat Leak			X	
45VV003	PRSD Distribution System			X	
45VV004	PRSD Pressure/Quantity Inter			X	
45VV005	PRSD Fluid Temperature Inter			X	
45VV006	Fuel Cell Performance			X	
45VV010	Fuel Cell Purging			X	
45VV011	Fuel Cell Vent			X	
48VT013	ET Separation		X		
54VV001	PDRS Payload Handling				
54VV002	RCS Plume Impinge				
54VV007	PBD Mech Perfection			X	
54VV011	Contam Monitor			X	
54VV019	PB Environment Measurement			X	
58VV006	Hyd Res Press			X	
58VV007	Hyd Fluid Condition				
61VV001	ECLSS Perf			X	
63VV001	ATCS Perf			X	
63VV002	ORB Inherent Thermal Capacity			X	
63VV003	ATCS Flash Evaporator			X	

TABLE B-I. - STS-1 FLIGHT TEST REQUIREMENT ACCOMPLISHMENT (Continued)

FTR	Title	STS-1 PRIORITY			Remarks
		A	B	C	
67VV001	Cabin Noise		X		
67VV002	Anti-G Suit				
67VV003	Exercise Equipment			X	
67VV004	Cabin Atmos Evaluation		X		
67VV005	Electrophoresis				
67VV006	Crew Restraint and CPR Equipment				
70VV001	On-Orbit Nav Perf				
70VV002	Nav Perf - GPS				
71VV001	GNC Launch & Ascent		X		
71VV002	IMU Perf & Align			X	
71VV004	GNC Deorbit Perf			X	
71VV005	Entry GNC			X	
71VV006	Orbit Rendezvous				
71VV008	TAEM Perf			X	
71VV023	Air Data System Perf			X	
71VV025	Autoland				
71VV026	BFS Perf				
74VV001	S Band PM/FM Perf			X	
74VV002	S-Band TDRSS Perf				
74VV003	Rend Radar ACQ/Track				
74VV004	SRB/MPS Plume Effects			X	
74VV005	High Altitude TACAN			X	
74VV006	UHF Voice Perf			X	
74VV007	EVA Voice/Data Performance				
74VV008	CCTV Perf			X	
74VV009	KU/Wide Band Perf				
74VV012	Orb/Payload Comm				
74VV013	S-Band PM FM Dir. Link				
74VV014	Rend. Radar				
74VV015	S-Band PM FM Ant. Pat.			X	
74VV016	MSBLS Performance		X		
75VV003	OPS. Recorder Perf			X	

TABLE B-I. - STS-1 FLIGHT TEST REQUIREMENT ACCOMPLISHMENT (Concluded)

FTR	Title	STS-1 PRIORITY			Remarks
		A	B	C	
79VV002	Long Control Resp		X		
79VV003	Lat/Dir Control Resp		X		
79VV011	Orbit Attitude Hold		X		
79VV012	RCS Attitude Maneuver			X	
79VV013	RCS Translation			X	
79VV014	OMS Maneuvers			X	
MC1	Ascent Perf		X		
MC2	Proximity OPS				
MC6	Orbital Alt Mod			X	
MC7	Crossrange			X	
MC8	Mission Duration				
MC9	Extended Missions				
MC15	Direct Deorbit			X	
MC18	EVA				