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HEXAGON PROGRAM
PRELIMINARY POST FLIGHT REPORT
FOR FLIGHT NO. 20

7 JULY 1986

Prepared by
The Technical Advisor Staff

Published by
The Technical Advisor

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FOREWORD

This document is prepared to support the HEXAGON Program analysis and reporting requirement established by the System Program Director. This document presents preliminary evaluation results of vehicle and ground system performances during this HEXAGON Program flight. The evaluation is based upon data recorded at Vandenberg Tracking Station [redacted]

This document presents the coordinated inputs from the HEXAGON Program Technical Advisor Staff at Sunnyvale, California. The Technical Advisor Staff is composed of the HEXAGON Program Sunnyvale Field Office Technical Advisor and the Satellite Vehicle Contractors who provided technical support during the mission. The data contained in this report were collected and analyzed subsequent to the Booster Vehicle explosion immediately after liftoff.

SECURITY

This HEXAGON Program Preliminary Post Flight Report has been prepared covertly in accordance with the requirements set forth in the BYEMAN Industrial Facility Security Manual, which establishes procedures and assigns responsibilities for the preparation of security plans for all program operations. Personnel should refer all security problems to the SAFSP Deputy Director. It is emphasized that security requirements take precedence over all other program requirements.

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TABLE OF CONTENTS

FIGURES

TABLES

SECTION 1

1.0 INTRODUCTION

This report describes the events and performance of the Twentieth HEXAGON Program Satellite Vehicle (SV-20). The vehicle was launched 18 April 1986, but did not achieve orbit due to a catastrophic booster failure approximately nine seconds after lift-off.

1.1 Launch Summary

The twentieth HEXAGON Satellite Vehicle (SV-20) was transported to the launch base on 6 March 1986 with launch scheduled for 18 March 1986. The launch was delayed due to technical problems until 18 April 1986.

SV-20 was launched from Vandenberg Air Force Base on 18 April 1986 at 10:45 A.M. Pacific Standard Time by a Titan 34D-9 Booster Vehicle as IRON 2037. Orbit was not achieved due to a catastrophic booster failure approximately nine seconds after lift-off.

The SBA telemetry system was in operation from approximately two and one-half hours prior to lift-off until Satellite Vehicle destruction at approximately twenth-eight seconds after lift-off. This telemetry data was analyzed to determine the SV integrity, and it has been concluded that the Satellite Vehicle was intact and performing normally until the time of its consequential destruction following the explosion of the booster vehicle.

This report describes the vehicle condition for the period prior to launch until destruction as a result of the booster failure just after launch. The data sources for this report is derived from telemetry recorded at the Vandenberg Tracking Station (VTS) [redacted]

SECTION 2

2.0 SATELLITE BASIC ASSEMBLY SUBSYSTEM

2.1 General

This section presents a summary of the performance of the various Satellite systems as derived from the available telemetry data.

Data was transmitted to the STC from the Vandenberg Tracking Station (COOK) [redacted]. Data was processed from both of these sources to obtain the most usable information possible. The last data obtained as a result of this processing was at an ECS time of 95.4 seconds, which is equivalent to 28.4 seconds after lift-off (T+28.4), or some 20 seconds after booster explosion.

The following table presents a correlation of events noted in this report:

EVENT	ECS TIME	SYSTEM TIME	UNIVERSAL TIME (GMT)
ECS Clock Start	0.0	67433.7	18:43:53.7
Opening of Launch Window	66.3	67500.0	18:45:00.0
SRM Ignition	66.9	67500.6	18:45:00.6
Lift-Off	67.38	67501.1	18:45:01.1

2.2 Electrical Distribution and Power System (EDAP)

Performance of the EDAP system prior to and after lift-off was nominal in all respects. Total battery capacity was above the K-2 level (216 A-H). At the time of external charge disconnect (T-120), Batteries 1 and 3 were indicating K-2 level, and Batteries 2 and 4 were indicating K-1 level. The Battery 4 State-of-Charge Indicator (SOCI) was reading 55, indicating a Battery 4 capacity of 55 A-H.

Battery and bus voltages were nominal from T-120 seconds until an ECS time of 95.4 seconds (T+28.4), which was the time of the last data received. These voltages are listed below:

MEASUREMENT ID	MEASUREMENT	T-120	T-67	LIFT-OFF T-0	T+28.4
C041	Bus Voltage	29.7	29.6	29.4	29.4
C011	Batt #1 Volt.	30.6	30.4	30.2	30.2
C012	Batt #2 Volt.	30.5	30.3	30.2	30.2
C013	Batt #3 Volt.	30.6	30.3	30.2	30.2
C014	Batt #4 Volt.	30.3	30.2	30.1	30.1

Bus loads and battery load shares compared well with previous missions. The bus load was a nominal 21.0 amps, with regular surges to about 27.0 amps. This was the result of the cyclic memory search of the command system. Figure 2-1 is a plot showing the main bus voltage (C042), the individual battery currents (C001, C002, C003, and C004), and the individual battery temperatures (C101, C102, C103, and C104).

In addition, discrete monitors (C211, C212, C213, C214, C817, C818, X651, and X659) which monitor individual pyro circuits enable/disable status, indicated none of the pyro circuits had been enabled. The monitor (A70), which monitors booster separation, indicated no separation had occurred.

The data available indicates the EDAP system was operating normally and no anomaly occurred prior to SV destruction. The main bus was at an average 21 amperes with minor cycling conforming to ECS operation.

Individual battery and main bus voltages were nominal. The four batteries were not discharging equally, but were adjusting toward equal load sharing. All battery temperatures were normal.

2.3 Structure Temperatures

Structure temperature monitors were analyzed from just prior to lift-off through the 28 second period for which data was available following lift-off. Shroud temperatures (Figure 2-2) were nominal and steady prior to booster explosion at T+9 seconds after which they increased at a moderate gradient until T+12 seconds when they exhibited a dramatic rise to transducer saturation levels of 580°F by T+22 seconds as the satellite vehicle was evidently engulfed by the fireball. Aft bulkhead temperature (A060, A063, B101, B102) remained stable near ambient temperature 75 $\pm$ 5°F) indicating very little, if any, hot gases penetrated into the SV envelope. This same lack of temperature rise was observed for the mid-section area (Figure 2-3). Also noted on this figure are the pressures of the mid-section pressure vessels, which remained constant for all data obtained. Data discussed in Paragraph 2.4 of this report further substantiates that very little, if any, hot gases penetrated the SV internal envelope, as well as substantiating the conclusion that there were no internal explosions or fire during the 28-seconds of available data.

2.4 Orbit Adjust, Reaction Control, and Lifeboat Systems

These systems, contain pressurized tanks, orbit adjust system propellant, and feed lines to the Reaction Control System (RCS). The data from these systems have been analyzed to verify their integrity. The Lifeboat tank pressure prior to lift-off was indicating a pressure of 2819 psia (Figure 2-4) and remained at that value throughout the period of available data. The temperature of this tank was heated to an indicated temperature of 175°F prior to

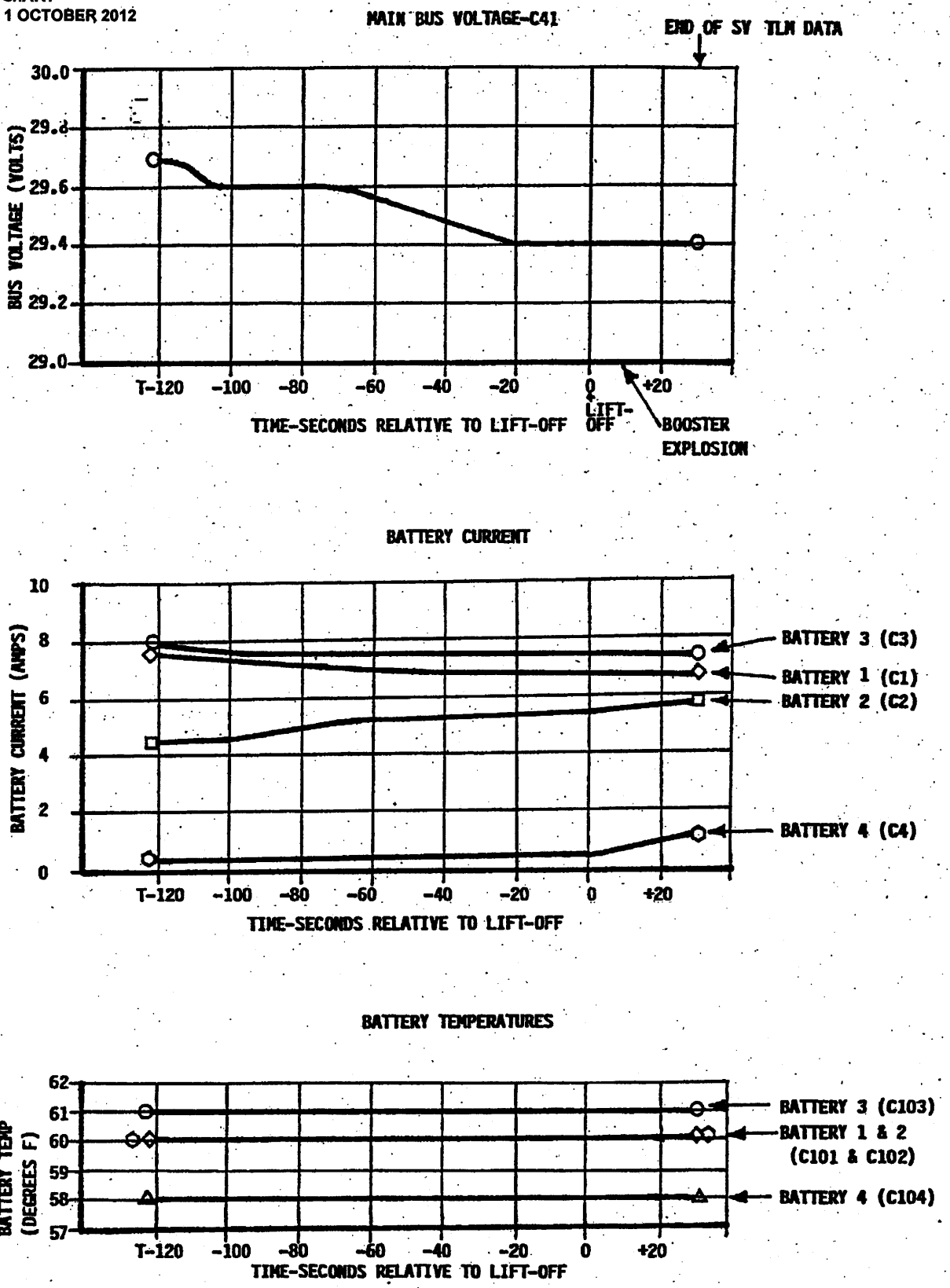


FIGURE 2-1

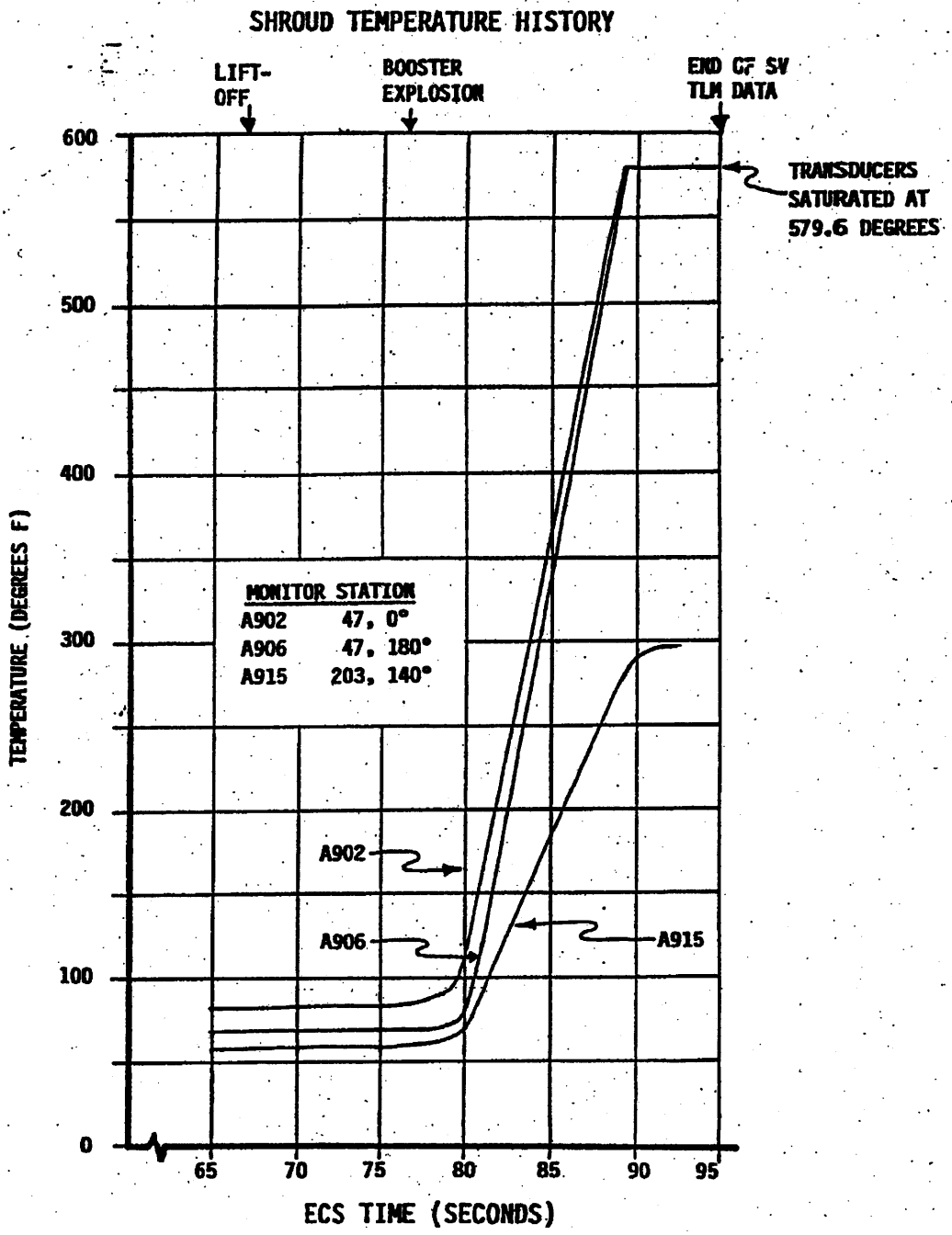
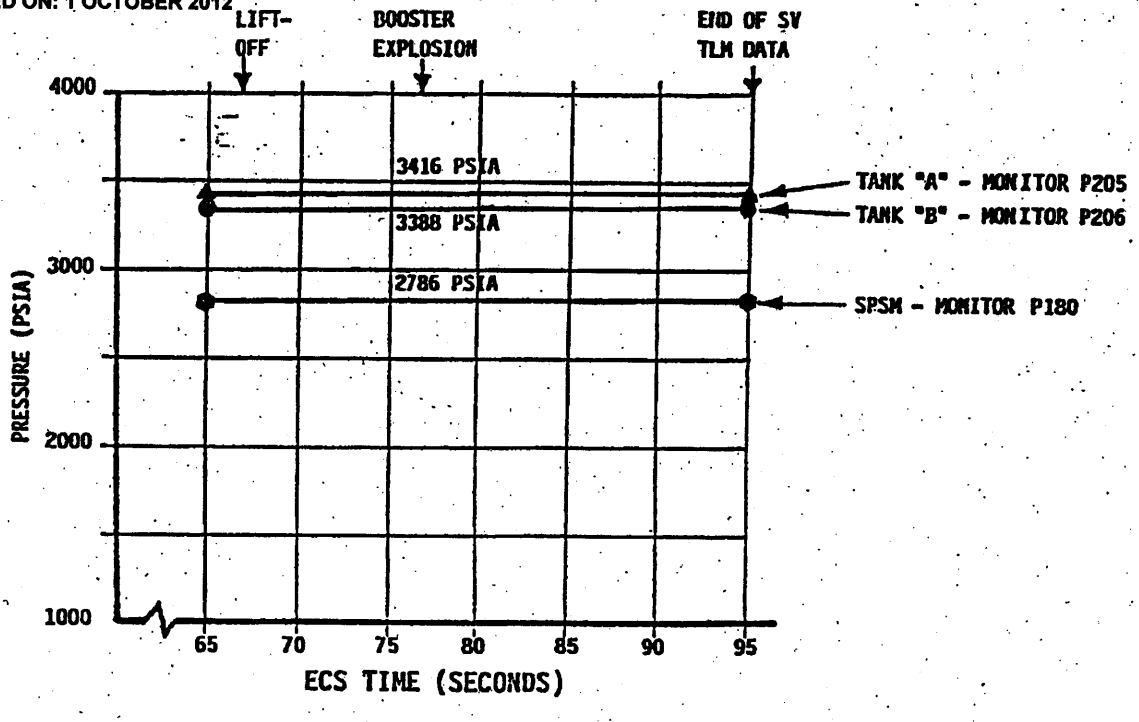


FIGURE 2-2

MID-SECTION PRESSURE VESSELS



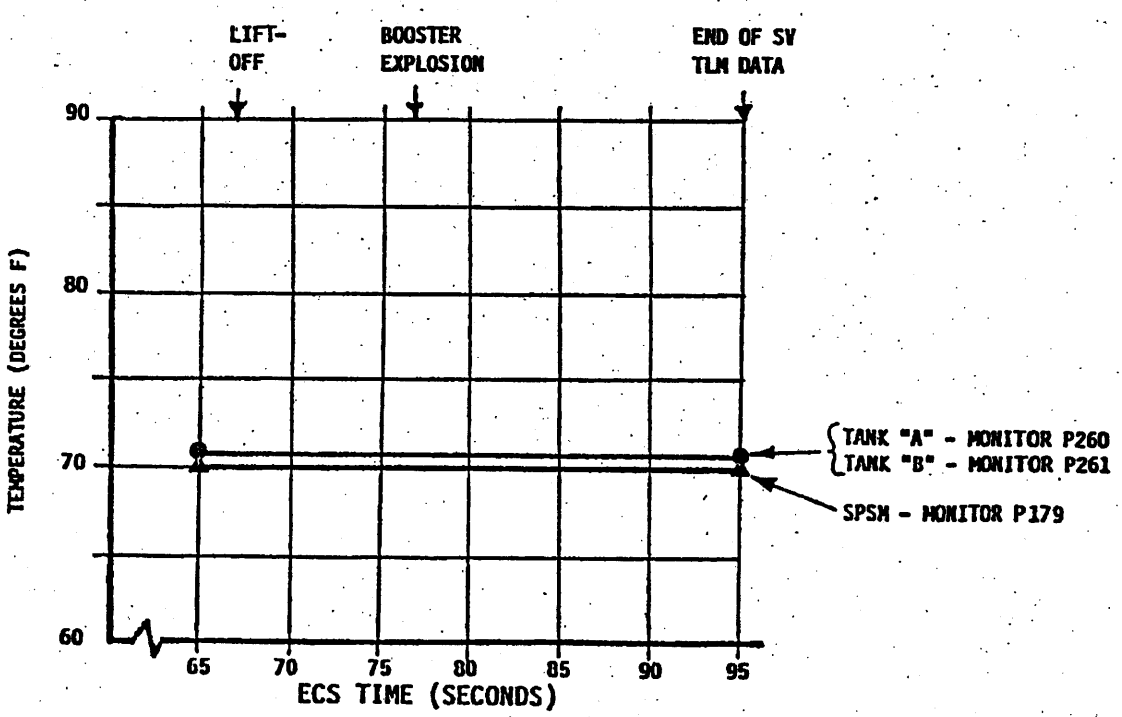


FIGURE 2-3

HYDRAZINE PROPELLANT SUPPLY SYSTEM

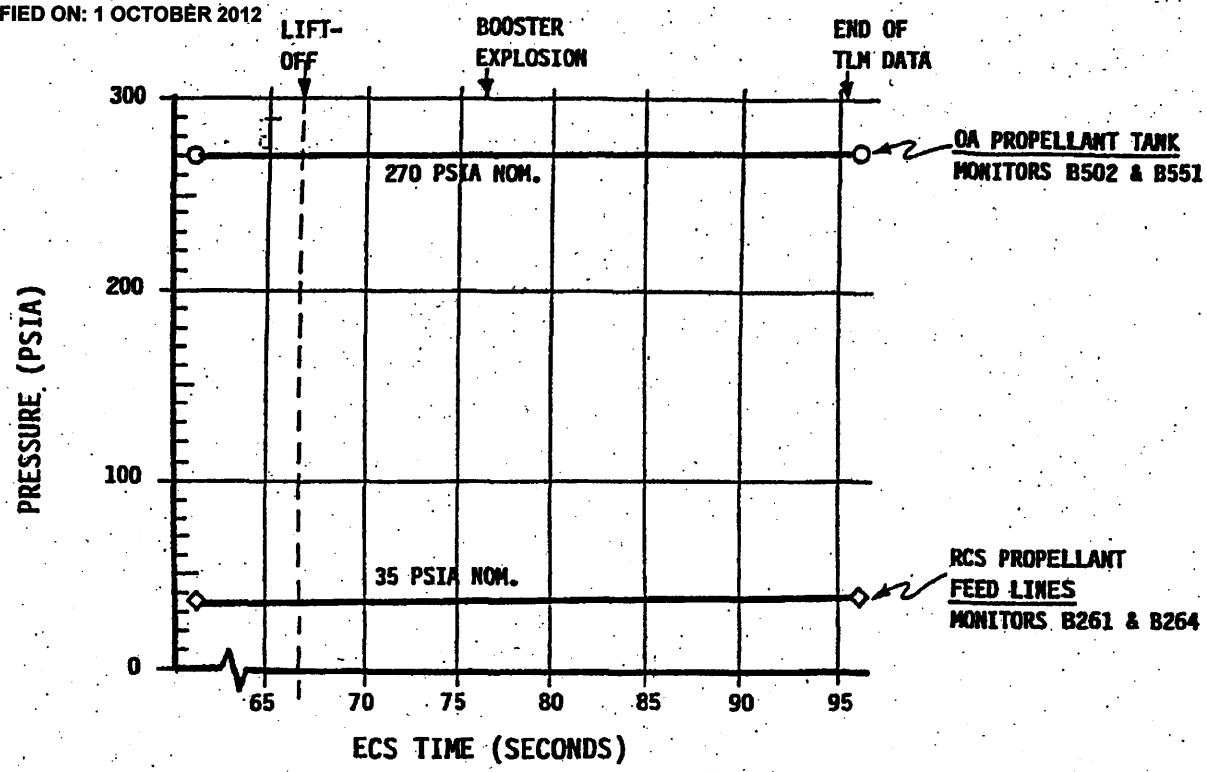


FIGURE 2-4

22 INCH DIAMETER PRESSURE VESSELS

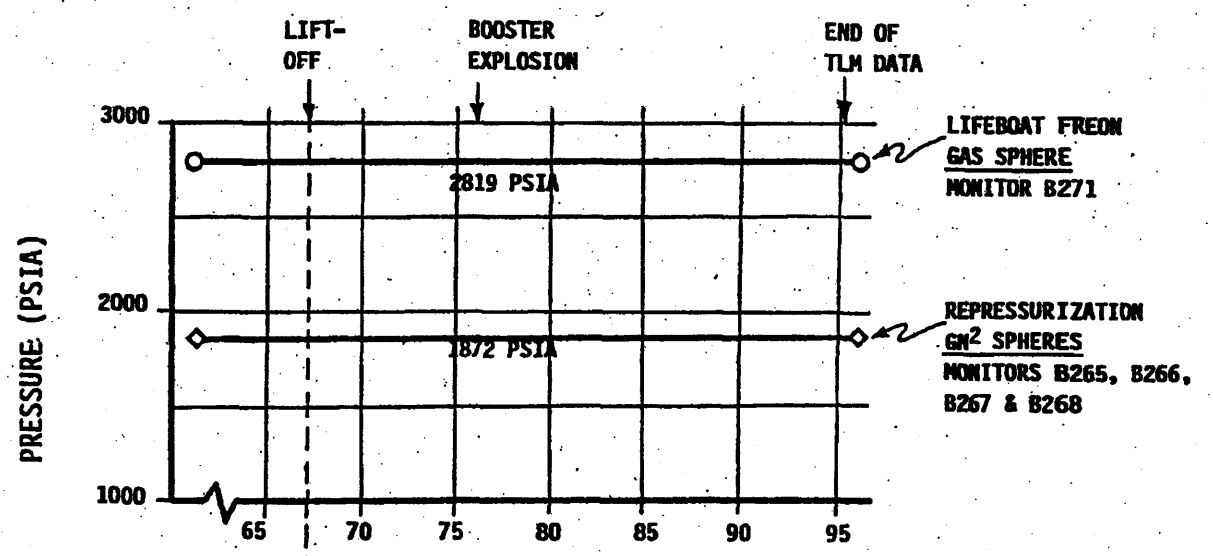


FIGURE 2-5

launch and remained at that temperature at the time of the last telemetry data. The pressure of the Orbit Adjust System repressurization tanks remained constant at 1872 psia from lift-off through the last data obtained (Figure 2-4). The same condition of constant pressure existed for the Orbit Adjust System propellant tank at 270 psia, and the RCS propellant feed lines at 35 psia (Figure 2-5). The temperature of the feed lines located in Bay 12 indicated a slight increase in temperature (15°F), while those located in Bay 6 indicated no increase (Figure 2-6). The temperature of the RCS thruster shells located in Bays 12 and 6 indicate a rise in temperature of 30 to 45°F in Bay 12, while those in Bay 6 indicated no temperature rise (Figure 2-7).

The fact that the pressure in the tanks and feed lines remained constant for all available data and the moderate rise of temperature in Bay 12 further substantiates that there was no internal explosion or fire in the satellite vehicle.

2.4.1 Orbit Adjust Tank Pressure History

Prior to lift-off, the pressure at the top of the Orbit Adjust tank (gas ullage, B502) versus the pressure at the bottom of the tank (B551) indicated a static head difference of approximately three psi. These pressures indicate a shift at lift-off followed by the normal static head difference (when thrust is on). Approximately 8 to 8.4 seconds after lift-off the pressure difference increased to a delta of eight psi indicating an occurrence of a dynamic event. This was followed at approximately 13 seconds after lift-off by a reduction of the pressure differential indicating a loss of thrust (acceleration on the tank). Figure 2-8 is an expanded scale plot of the Orbit Adjust Tank pressure indications to show the events noted above. Figure 2-9 is included to show the location of the Orbit Adjust tank pressure and temperature monitors.

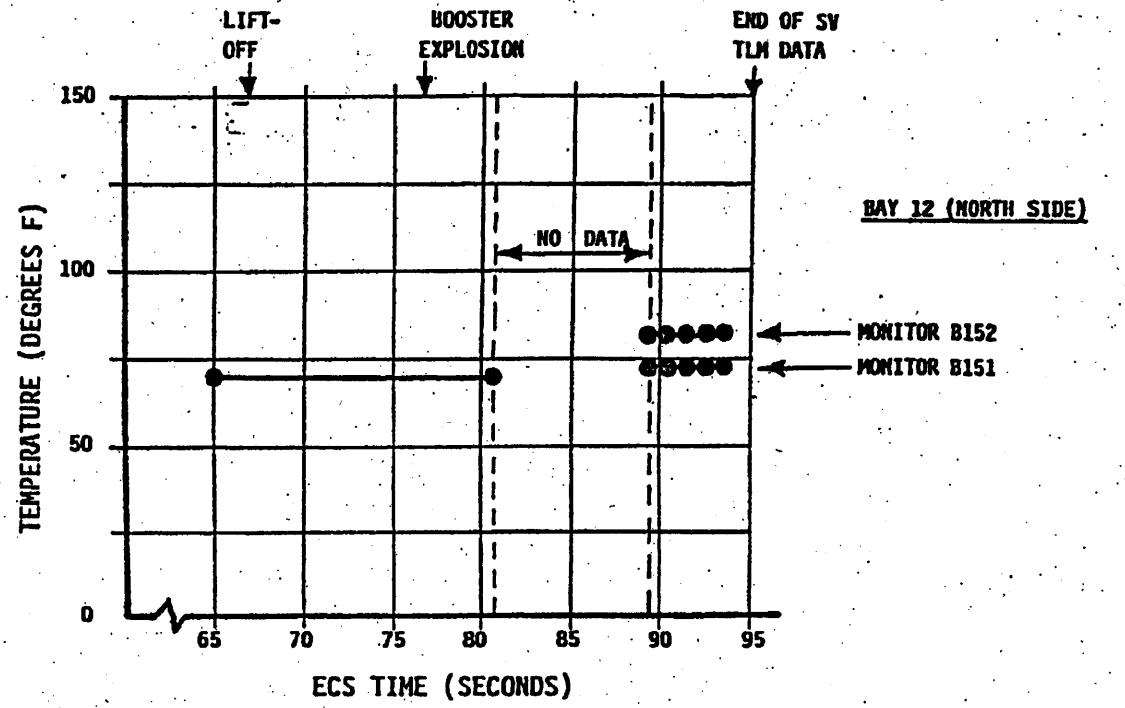
2.5 Attitude Control System (ACS)

The ACS data presented in this section was derived from an [redacted] dubbed tape. It indicates that both before launch and during the abbreviated flight, out to well past the apparent time of mishap, the ACS was operating normally. Large, anomalous, but meaningful rates were measured around the apparent time of mishap.

Northrop Mod II Inertial Reference Assemblies (IRA) were flown in both the primary and redundant attitude control systems.

Before and during launch the ACS was in the coarse mode with Master Clear On. The coarse mode increases the weight of the least significant bit in the digital rate monitor by a factor of 32 to a value of ±.0145 degrees per second. Prior to the launch the gyro data was noted to be switching between ±.0145 degrees/second (normal). After lift-off, rate activity is observed.

TEMPERATURE HISTORY - RCS PROPELLANT FEE



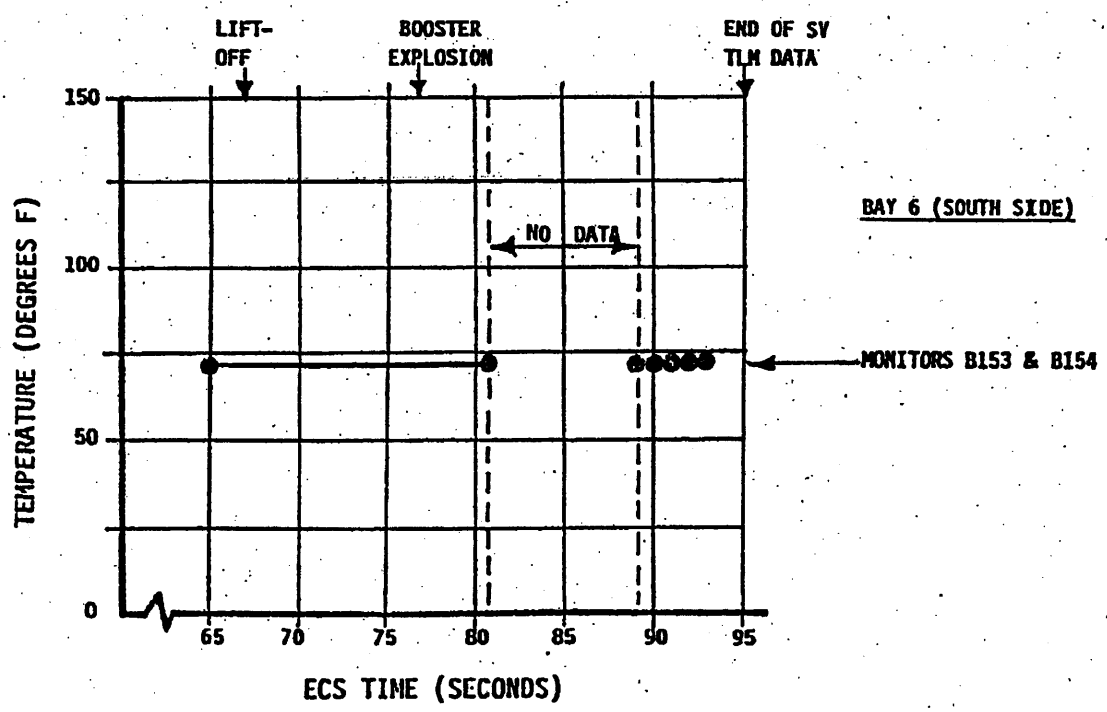
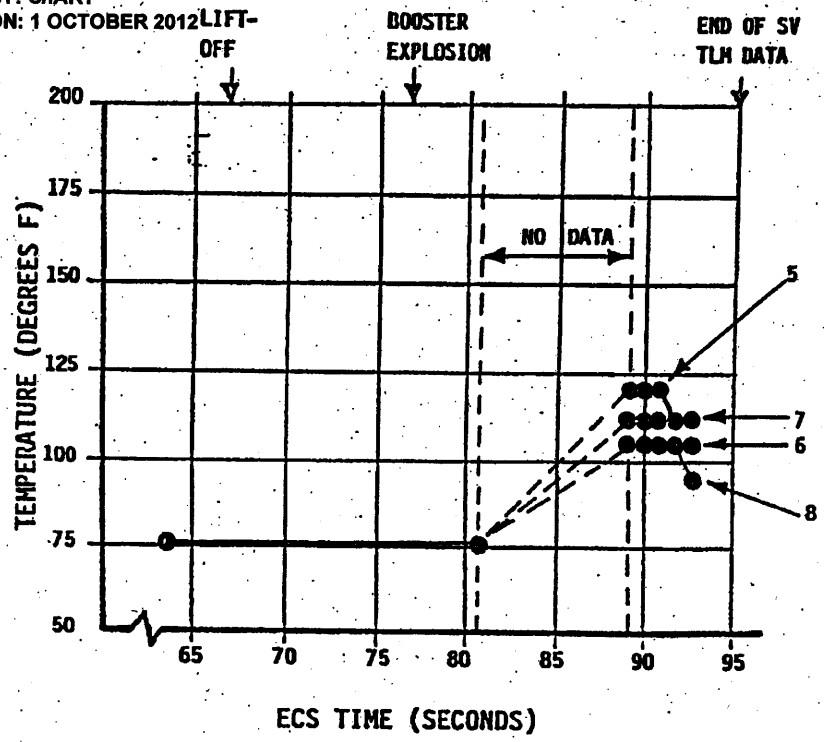


FIGURE 2-6

TEMPERATURE HISTORY - REACTION CONTROL THRU

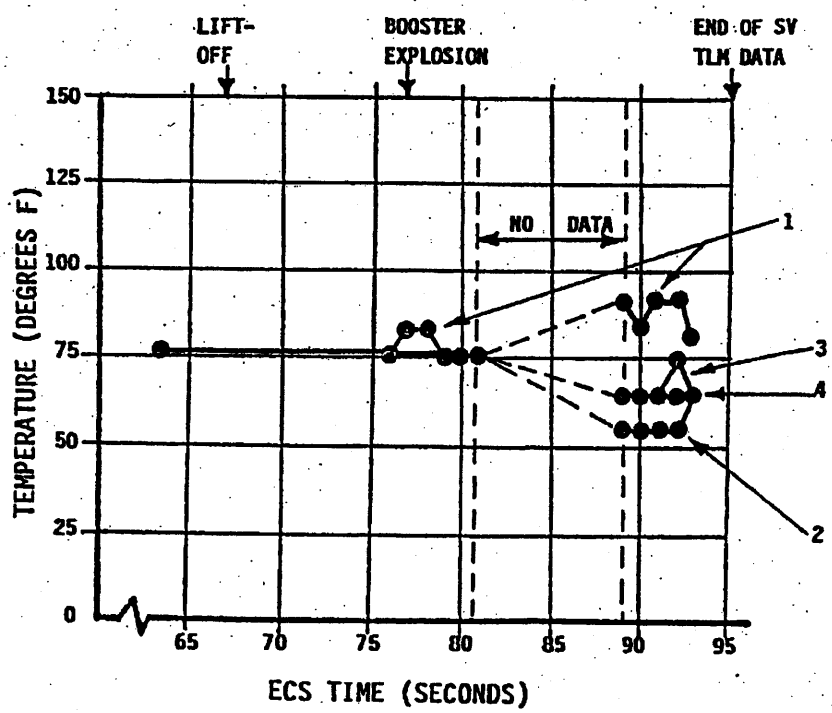


BAY 12 (NORTH SIDE)

REA NO.

B55 = No. 5
B56 = No. 6
B57 = No. 7
B58 = No. 8

NOTE: TELEMETRY RESOLUTION ON ALL SENSORS = 9 DEGREES F PER BIT



BAY 6 (SOUTH SIDE)

REA NO.

B51 = No. 1
B52 = No. 2
B53 = No. 3
B54 = No. 4

ORBIT ADJUST TANK PRESSURE HISTORY
(EXPANDED SCALE)

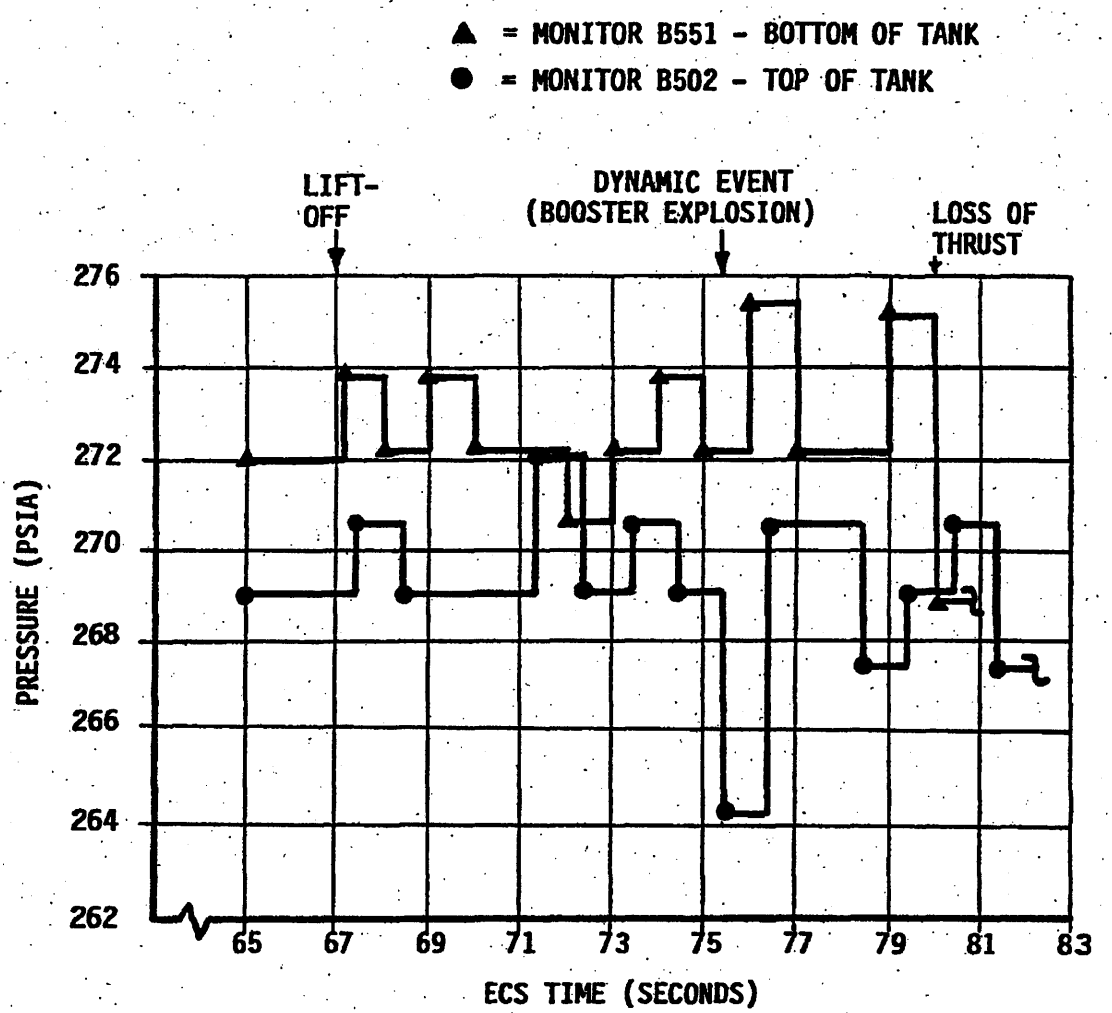
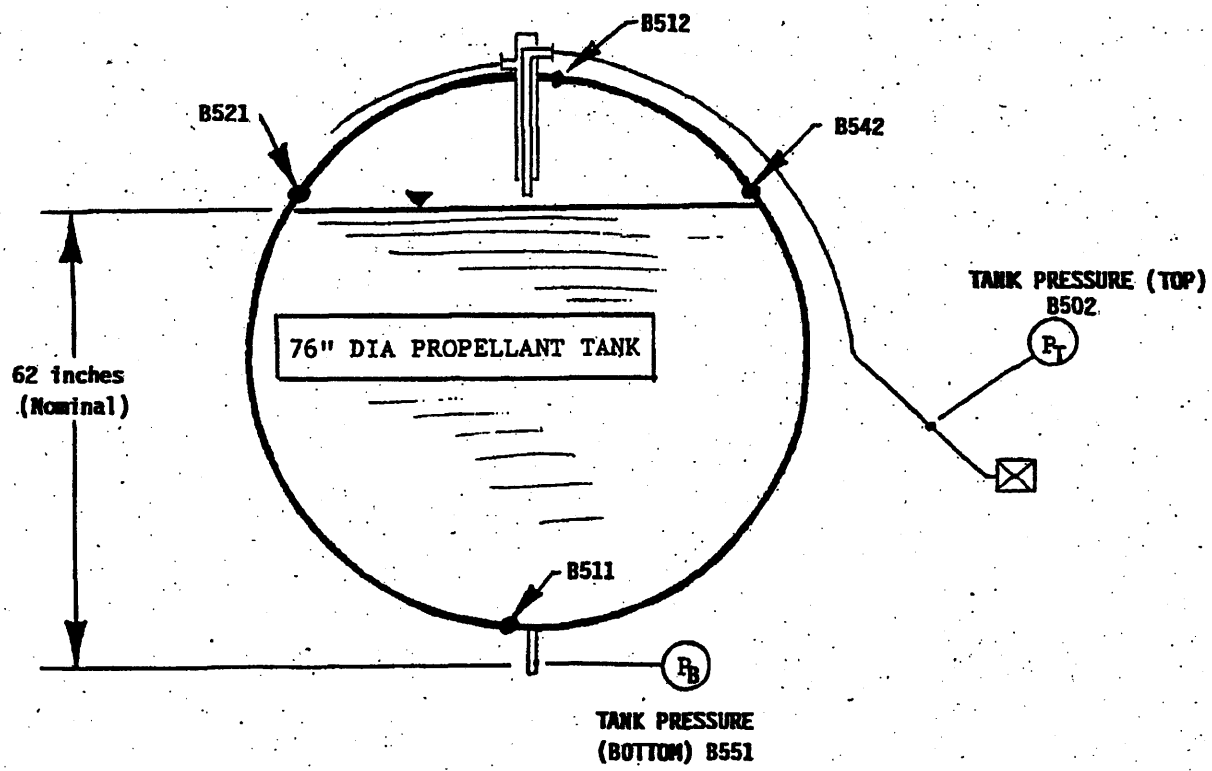


FIGURE 2-8

ORBIT ADJUST SYSTEM

PROPELLANT TANK INSTRUMENTATION



TANK SKIN TEMPERATURES

B511 (BOTTOM)
B512 (TOP)
B521 (UPPER SHELL)
B542 (UPPER SHELL)

FIGURE 2-9

Master Clear On forces the integrator values to be held at zero or within one or two telemetry counts away from zero. The ACS horizon sensor view ports are covered by the horizon sensor farings which produce the "two head inhibit" condition as indicated by the data output. The conditions and indications noted above show the ACS to be operating normally.

Table 2-1 shows the times of events and first anomalous rates. It also establishes the relationships between booster time, vehicle or Extended Command System (ECS) time, and Zulu time.

2.5.1 Rate Activity During Launch

At lift-off, extensive rate activity occurs. This is shown in Figure 2-10 for the primary Digital Rate Monitor (DRM) rate data. The redundant analog rate signals all track the primary rate monitors to expected tolerances. The data processing routine which created the plots shown in Figure 2-10 limited the rate values after about 76 seconds to provide a more detailed view. The time scale is in ECS, or vehicle time. Lift-off, Start Roll Rate, and the planned Stop Rate times are indicated.

a. Figure 2-11 shows the same data as Figure 2-10, except that it is from the SV-19 launch.

The roll rates for both SV-19 and SV-20 have a sinusoidal component of about 3.2 hertz (hz) riding on a sinusoidal component of 0.4 hz. The initial amplitude of both the 3.2 hz and the 0.4 hz sinusoids are about the same for the two cases. The 3.2 hz sinusoid for both vehicles damps out in a similar manner, for both. However, for SV-20, the 0.4 hz motion persisted although for SV-19 it did not. Also, for SV-19 the rate ramp down consists of a more uniform acceleration value than what appears for SV-20.

The pitch rate activity is quite similar for the two cases.

The yaw rate activity is similar for the two cases except that SV-20 has a lower amplitude disturbance than SV-19. Also, SV-20 has a persistant sinusoid of about 4 hz during the roll rage ramp down that is not seen for SV-19. Its amplitude is about 0.1 degree/second peak to peak.

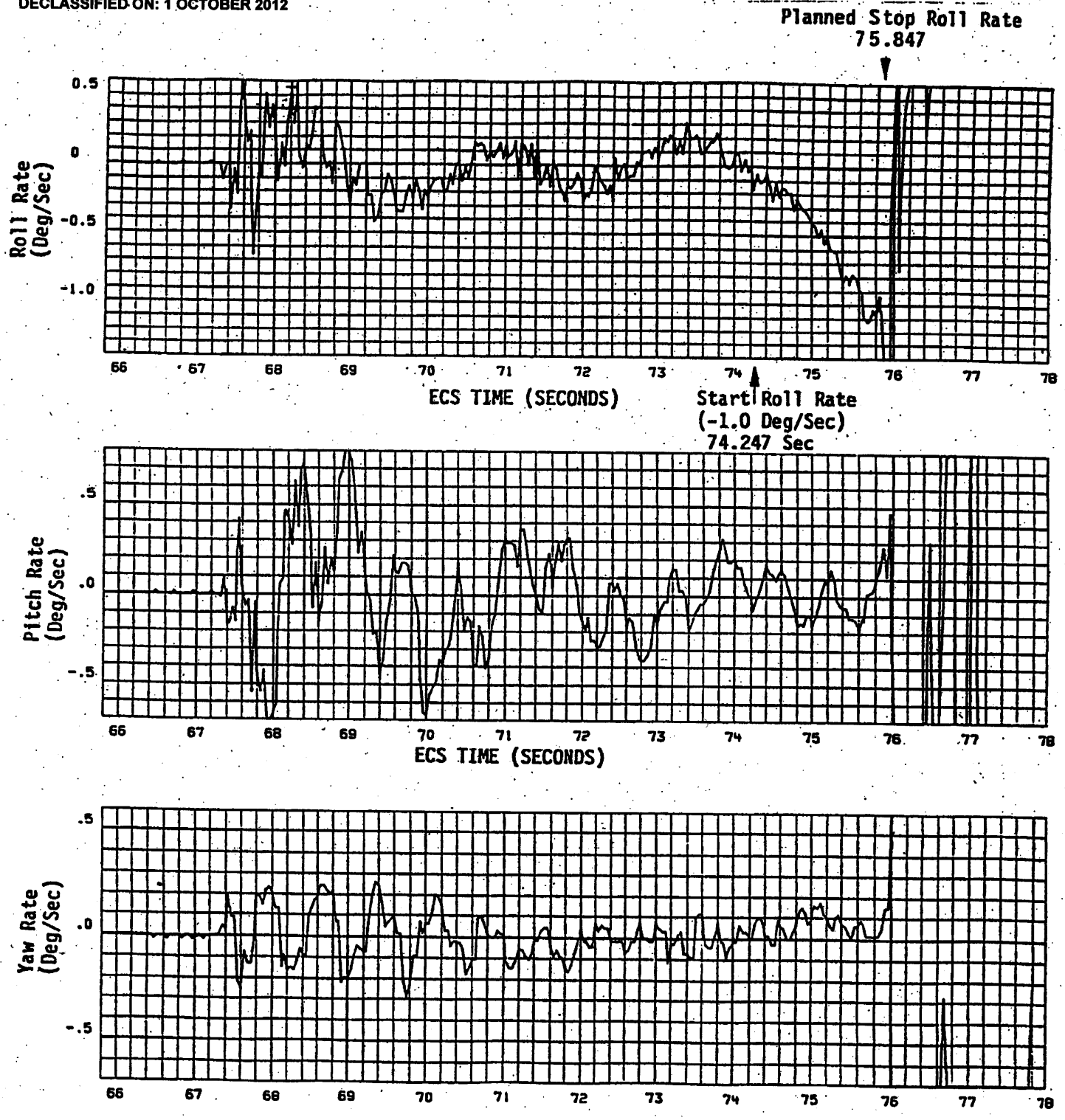
b. Table 2-2 indicates the rotational rate dynamics before and just after the time of mishap. These points are shown plotted in Figure 2-12. It can be seen that in the roll channel, the first anomalous rates are negative but that they quickly ramp positive with a sinusoidal component of about 6 hz (which can be assumed to be a body bending rate) riding on the ramp. At about the same time that the roll acceleration switches from negative to positive, the pitch and yaw rates become anomalous in the positive direction. These positive pitch and yaw accelerations are then quickly replaced by negative accelerations.

TIMES OF EVENTS AND FIRST ANOMALOUS SV ATTITUDE RATES
(SATELLITE VEHICLE PRIMARY ATTITUDE CONTROL SYSTEM)

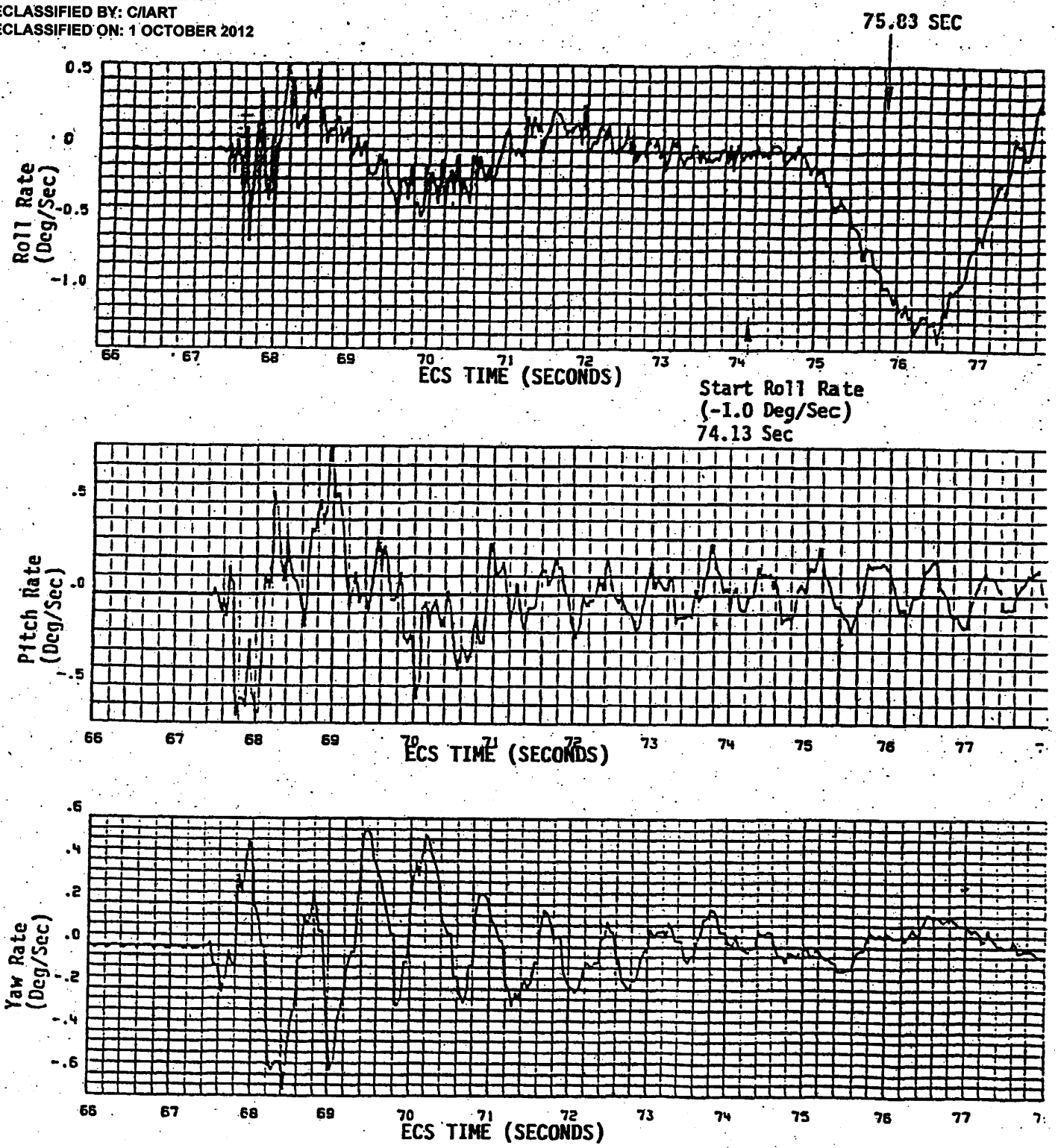
EVENT	TIME OF EVENT			LAST NORMAL AND FIRST TWO ANOMALOUS RATES (DEG/SEC) (SATELLITE VEHICLE)		
	BOOSTER TIME (SECONDS)	VEHICLE TIME (ECS) (SECONDS)	UNIVERSAL TIME (SECONDS AFTER 18:45:00.)	ROLL	PITCH	YAW
IGNITION	0.0	66.923	.650			
ICIE DISCONNECT (UMBILICAL	.457	67.380	1.110			
ROLL ON (-1 DEG/SEC)	7.324	74.247	7.977			
ROLL OFF (UNVERIFIED)	8.924	75.847	9.574			
FIRST ANOMALOUS ROLL	8.97	75.89	9.62	- .9332 (Norm) -1.6181 -2.6102		
FIRST ANOMALOUS YAW	9.02	75.94	9.67			.1458 (Norm) 1.0645 1.8518
FIRST ANOMALOUS PITCH	9.05	75.97	9.70		.4664 (Norm) - .3791 -1.2536	

NOTES:
1. BOOSTER AND UNIVERSAL TIMES OF FIRST 3 EVENTS SHOWN WERE PROVIDED BY MARTIN MARIETTA.
2. VEHICLE TIME OF IGNITION PROVIDED BY LAUNCH SUPPORT.
3. RATE DATA SAMPLE PERIOD IS .04 SECONDS.
4. ROLL OFF TIME ESTIMATED BY ADDING REQUIRED ROLL RATE DURATION, 1.6 SECONDS TO TIME OF ROLL ON.

TABLE 2-1



Roll, Pitch and Yaw Rates After Lift Off, 9033
FIGURE 2-10



ROLL, PITCH, AND YAW RATES AFTER LIFT OFF, 9032

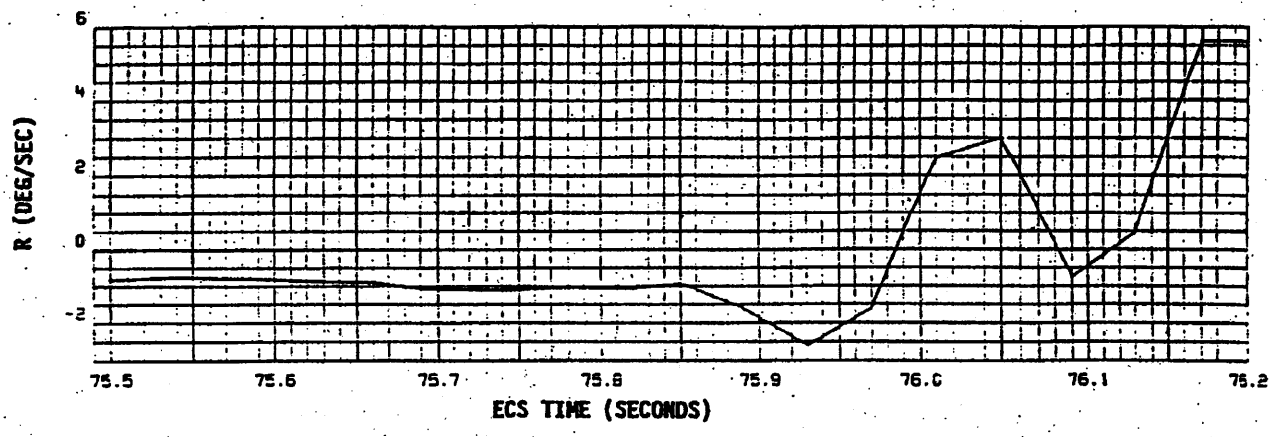
FIGURE 2-11

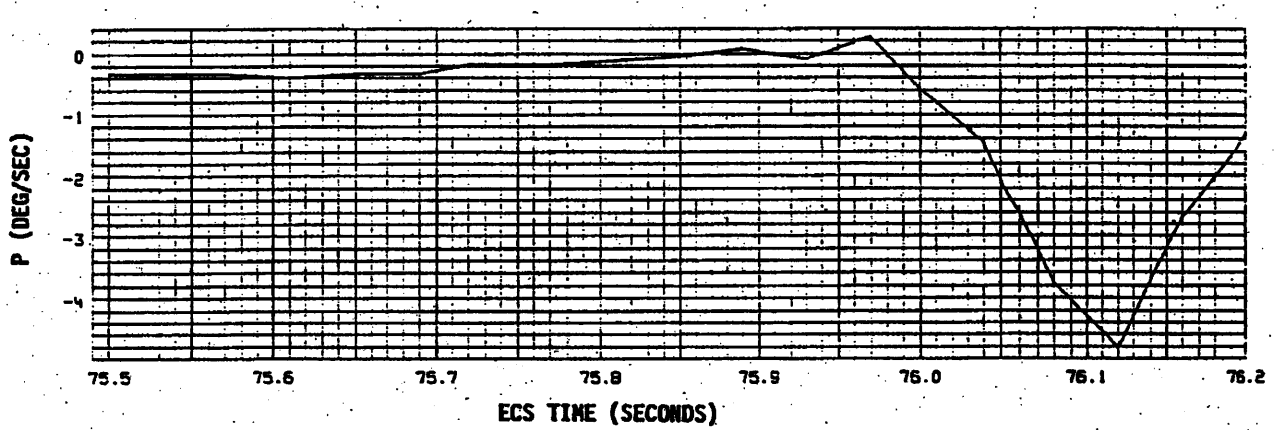
ECS Time (Sec)	PACS, DRM Rates (Deg/Sec)		
	PITCH	ROLL	YAW
75.82	.0874	-1.0933	.0145
75.85	.1457	- .9323	*
75.87	*	*	.0437
75.89	.2769	-1.6181	*
75.91	*	*	.1457
75.93	.1166	-2.6093	*
75.94	*	*	1.0641
75.97	.4664	-1.6035	*
75.99	*	*	1.8513
76.00	- .3790	*	*
76.01	*	2.4927	*
76.02	*	*	-1.5598
76.04	-1.2536	*	*

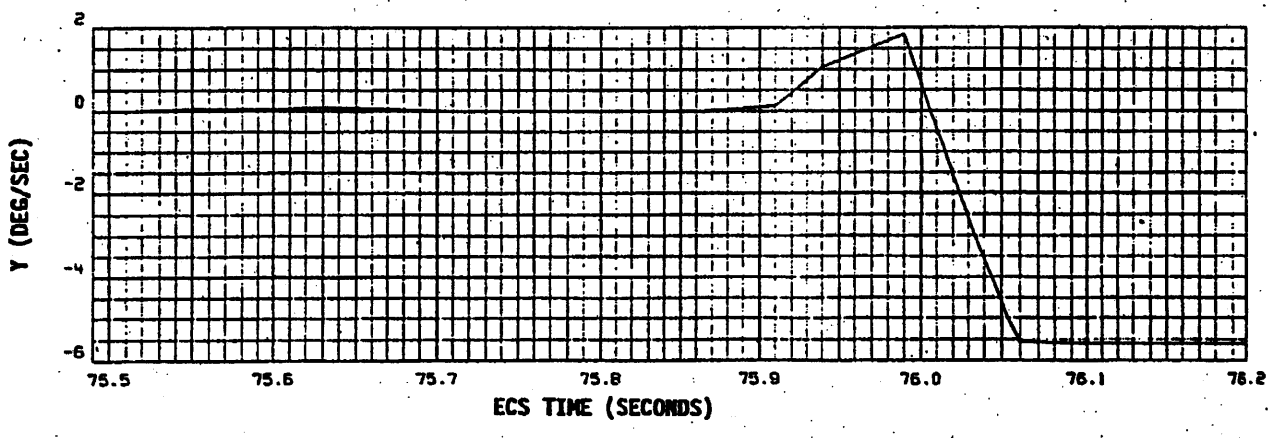
RATES BEFORE AND JUST AFTER MISHAP

*Indicates Data Repeat

TABLE 2-2







PACS, DRM RATES WITH EXPANDED TIME SCALE.

FIGURE 2-12

These events and their timing, in ECS time, are summarized in Table 2-3. The table also shows accelerations, computed from rate changes and disturbance torques, computed using the ascent vehicle's (AV) mass properties.

2.6 Tracking and Telemetry

At approximately 8:13 A.M. Pacific Standard Time on 18 April 1986, the Satellite Control Facility started receiving SBA telemetry data. The data being received at that time was from Task 22, SV/VTS Flight Load and Conditioning, in preparation for vehicle launch. The Satellite Vehicle was conditioned to its launch configuration, and the flight sequences required for ascent and early rev activities were loaded in the Command System Memory. Data from this task was evaluated to determine that the telemetry system was performing as required, that the various SBA systems had been configured properly, and that the ascent and early rev flight sequences had been correctly loaded in preparation for launch. This data indicated the SBA to be correctly conditioned for launch and the telemetry system was functioning properly. The telemetry system continued to function normally until an ECS time of 95.4 seconds (T+28.4) or some 20 seconds after the booster vehicle explosion.

TIMING, ACCELERATIONS, AND TORQUES

EVENT	OCCURS BETWEEN.... ECS TIMES (SECONDS)	ACCELERATION DEG/SEC^2	NET TORQUE (10^6 FT-LBS)
Anomalous Roll Rate	75.85 and 75.89	- 21.0	- 1.58
Anomalous Yaw Rate	75.91 and 75.94	30.6	16.9
Roll Acceleration Reversal	75.93 and 75.97	17.9 ①	1.35 ①
Anomalous Pitch Rate	75.93 and 75.97	8.75	4.26
Pitch Acceleration Reversal	75.97 and 76.00	- 39.7	-19.3
Yaw Acceleration Reversal	75.99 and 76.00	-106.0	-58.6

① Utilizes the underlying ramp rate, assumed to be the ridgid body rate.

TABLE 2-3

SECTION 3

3.0 EXTENDED COMMAND SUBSYSTEM (ECS)

The Extended Command System responded properly in all modes into which it was commanded during Task 22. Two messages, the Flight Macro and the SPC Flight Load, were loaded into the ECS during this Task. A total of 2541 SPCs were stored for readout from the PPMUs. Of the 2541 SPCs loaded, 1269 were stored in PPMU-A and 1272 stored in PPMU-B. From the commands which were loaded, five commands were output from the PPMUs for processing by the Decoders; four commands from PPMU-A and one command from PPMU-B. The commands which were executed and time of execution are listed below:

REF. TIME	CLOCK TIME/SEC	COMMAND	NOMENCLATURE	DECODER	PPMU CPT.
T-51	15.6	[redacted]	RCS IV 1A/4A Close	A/B	B4
T-47	19.9		Clock Control Disable	A	A4
T-40	26.8		TR 1 ON TR 2 OFF	A/B	A4
T-30	36.8		TR 1 ON TR 2 ON	A/B	A4
T+2.8	69.8		C-	A/B	A4

From analysis of available data, the ECS was operating properly when the telemetry output terminated. The CIU and Decoders were on and the ECS clock was incrementing normally until the final time word readout from telemetry at 94.4 seconds. All temperatures and voltages were within specification.

3.1 Minimal Command Subsystem (MCS)

The MCS was not turned on.

3.2 Remote Decoder/Backup Decoder (RD/BUD)

These units were not turned on.

SECTION 4

4.0 PAN CAMERA

4.1 All mid-section instrumentation was nominal at lift-off. Ascent telemetry was received for 27.4 seconds after lift-off. The supply and chute differential pressure monitors indicated a decrease in pressure approximately 20 seconds after lift-off. The supply and chute pressure history are shown in Table 4-1. It is impossible to determine if the reduced pressure differential is the result of the failure of the containers integrity or a change in pressure created by the fireball. All other monitors, including the pneumatics tanks, indicated normal value until loss of telemetry signal.

TABLE 4-1. SUPPLY AND CHUTE DIFFERENTIAL PRESSURE HISTORY

	TIME (SECS)	SUPPLY PRESSURE (PSID)	CHUTE PRESSURE (PSID)
L.O.	0		.23
	7.4	.48	.40
	12.4	.83	.77
	13.4	.90	.76
	20.4	.51	.42
	21.4	.49	.38
	25.4	.40	.22
	27.4	.09	-.06

SECTION 5

5.0 RECOVERY VEHICLES

5.1 All of the telemetry data available from the COOK Tracking Station [redacted] have been analyzed. All data, with two exceptions, looked nominal. Both exceptions occurred near the end of the flight and were due to loss of telemetry carrier signal.

The first abnormal reading occurred at a vehicle time of 78.4 seconds. The R45B monitor (RV4 relay monitor) went from it's normal state of 024 to a reading of 020 and back to 024 at time 79.4. The reading of 020 would indicate that a latch status relay unlatched and relatched. This indication was seen only on the COOK Tracking Station tapes, during a period of telemetry dropouts, [redacted].

The other dubious readout occurred at a vehicle time of 94.4 seconds. The EATC monitor indicated 200 (vice 360) indicating the RV 2, 3, and 4 heaters came on, or that they were separated. Again, this indication was seen only on the COOK data during a period of telemetry dropouts, [redacted]. There was no other heater activity.

Both of these abnormal readings are assumed to be due to telemetry signal dropout. The last readout of any of the telemetry occurred at a vehicle time of 94.4 seconds.

From a vehicle time of 0.4 to 94.4 seconds (lift-Off time was 67.00). The RV data indicated as follows:

RV100	SV Unregulated Voltage to RV-1	28.8 (Nominal)
RV200	SV Unregulated Voltage to RV-2	29.0 (Nominal)
RV300	SV Unregulated Voltage to RV-3	29.0 (Nominal)
RV400	SV Unregulated Voltage to RV-4	28.8 (Nominal)
C700	RV Reference Temp. 74.7 to 74.4 Deg F	(Nominal)
C702	RV-1 Heater Temp. 74.7 to 75.1 Deg F	(Nominal)
C703	RV-2 Heater Temp. 74.4 Deg F	(Nominal)
C704	RV-3 Heater Temp. 74.7 to 74.4 Deg F	(Nominal)
C705	RV-4 Heater Temp. 74.7 to 74.4 Deg F	(Nominal)
R106	RV-1 Payload Container Temp. 75 Deg F	(Nominal)
R206	RV-2 Payload Container Temp. 75 Deg F	(Nominal)
R306	RV-3 Payload Container Temp. 74 Deg F	(Nominal)
R406	RV-4 Payload Container Temp. 74 Deg F	(Nominal)

RT03, R104, R105	RV-1 Batteries	0.0 Volts (Nominal)
R203, R204, R205	RV-2 Batteries	0.0 Volts (Nominal)
R303, R304, R305	RV-3 Batteries	0.0 Volts (Nominal)
R403, R404, R405	RV-4 Batteries	0.0 Volts (Nominal)

RV Relay monitors R150, R158, R250, R258, R350, R358, R450, and R458 all indicated nominal, except as discussed above.

The RVPB (RV Pyro Bus Monitor) indicated nominal.

The TLM2 Monitor (RV Sep Enable Command) indicated nominal. The TSVM (RV Trim and Seal) monitor indicated nominal. The CPRM (Core Pin) Monitor indicated nominal.

The EATC (RV Heater ON/OFF) monitor indicated no RV Heater activity excepted as discussed above.

SECTION 6

6.0 PRE-FLIGHT ACTIVITY

6.1 SV Configuration Changes

6.1.1 Extended Command System Changes

a. The flight program was placed in a PROM rather than the plated wire memory.

b. Parity check of SPC readouts and majority vote logic for critical scratch pad parameters were added.

c. The ECS simulator used for validation of the flight software was reprogrammed from a VAX computer to an IBM personal computer for use by operational personnel at the STC.

6.1.2 [redacted]

6.1.3 [redacted]

6.1.4 [redacted]

6.1.5 Dual-panel doppler beacon system was installed.

6.1.6 MCS Operate Command via ECS capability was added.

6.2 TUNITY Software Modifications

6.2.1 Modifications were made to the TUNITY software to provide the capability to load the ECS scratchpad locations, to avoid loading failed PPMU locations in the SPC and MACRO compartments, and to compare all PPMU memory locations.

6.2.2 Modifications were made to provide a new event generator and to process [redacted].

6.3 Development Schedule

6.3.1 TUNITY Software Development

a. Modifications for [redacted]:

Milestone 1 - April 1984
Critical Design Review - November 1984
Integrated Test - March 1985
Milestone 8 Delivery - June 1985

b. Modifications for ECS:

Milestone 1 - January 1985
Critical Design Review - March 1985
Integrated Test - July 1985
Milestone 8 Delivery - October 1985

6.3.2 Data Base Development

Data Base NOM20DB1 Build - 25 February 1985
Data Base NOM20DB2 Build - 2 May 1985
Data Base NOM20DB5 Build and Validate - 3 September 1985
Data Base NOM20DB6 Build and Validate - 15 November 1985
Data Base NOM20DB7 Build and Validate - 29 December 1985
Data Base FLT20DB1 Build and Validate - 10 February 1986

6.3.3 Telemetry Mode Development

Initial Start - May 1985
Prepass ALPHA Delivery - July 1985
Prepass BRAVO Delivery - December 1985
Prepass CHARLIE Delivery - January 1986
Prepass CHARLIE Validated - 31 January 1986
Prepass DELTA Validated - 14 May 1986

6.4 Orbit Case Study

6.4.1 Total mission duration = 540 days

a. Primary Mission = 300 days

b. Solo Mission [redacted] = 240 days

c. Propellant Margin = 880 lbm

6.4.2 Injection-Orbit

a. Inclination = 96.4°

b. Perigee = 91 nm, Apogee 148 nm

6.4.3 Mission Orbit

a. Perigee 95 nm, Apogee = 127 nm

b. Period = 88.5 minutes

c. Orbit Adjust Cycle = 3 days

6.4.4 Orbit Segments

a. RV-1 Mission = 65 days
Orbit Q = 16 11/39

b. RV-2 Mission = 100 days
Orbit Q = 16 22/79

c. RV-3 Mission = 85 days
Orbit Q = 16 11/41

d. RV-4 Mission = 55+ days
Orbit Q = 16 22/83

e. Solo Mission = 240(-) days
Orbit Q = 16 1/15
Altitude = 143 nm circular
Orbit Adjust Cycle = 21 days

6.5 Satellite Vehicle Considerations

6.5.1 Maintain solar angle (beta) within +30° to -8° throughout the mission.

6.5.2 Accomplish single orbit adjust burns on a three day cycle within dual orbit adjust burns as required, depending on atmospheric drag, for control of perigee position.

6.5.3 SGLS2 and PCM2 to be used for first two weeks to minimize spurious command execution.

6.5.4 [redacted] software to be completely reloaded with a new version on the second day.

6.5.5 Lifeboat tank heaters to remain OFF until needed to protect reliability of the thermostat.

6.5.6 [redacted] to be powered ON to protect against a possible relay failure.

6.5.7 Redundant OFF commands are to be provided for all equipment using expendables to protect against PPMU bit-flips.

6.5.8 The planned total mission duration of 540 days was constrained by component shelf-life, primarily the batteries.

6.6 Flight Documentation

6.6.1 Orbital Requirements Document

Update letter published 18 November 1985.

6.6.2 Mission Operating Instructions

Final version published 6 December 1985.

6.6.3 [redacted]

Published 22 January 1986.

6.6.4 System Test Objectives

All annexes published by 31 January 1986.

6.6.5 Test Operations Order

Published 3 February 1986.

6.6.6 Flight Profile Addendum

Final updates published 10 February 1986.

6.7 Development Test Facility Tests

6.7.1 First Test - September 1985

a. Compatibility between SCF system and new ECS.

b. All test objectives attained.

c. Problems encountered were link margins, configuration, personnel, and telemetry mode.

6.7.2 Second Test - January 1986

a. Training for new RTS personnel.

b. Reverify SCF/ECS interface.

c. Software compatibility.

d. All test objectives were achieved.

e. Problems encountered were personnel errors, and telemetry modes.

6.8 Rehearsals and Command Exercises

6.8.1 Command Exercise - January 1985

The objective was to test TUNITY/[redacted] interface.

6.8.2 Command Exercise - July 1985

The objective was to test TUNITY changes for ECS.

6.8.3 Rehearsal #1 - July 1985

The objective was a full system test.

6.8.4 Command Exercise - October 1985

The objective was to test TUNITY options.

6.8.5 Rehearsal #2 - November 1985

The objective was to stress the system.

6.8.5 Rehearsal #3 - December 1985

The objective was a full system test.

6.8.5 Rehearsal #4 - February 1986

The objective was a dry run for Dress Rehearsal.

6.8.8 Dress Rehearsal - April 1986

Objective was to demonstrate readiness for launch.

6.9 Planned Early Rev Sequence of Events

REV	STATION	ACTIVITY	EVENT
0	COOK	Padload Injection	Lift-off [redacted]
	INDI	SPC INH RLS [redacted] RTM	SPC Inhibit Test Solar Array Deployment [redacted]
1			[redacted]
1	POGO	Load	Command Exercise [redacted]
2	POGO/HULA		Health and Status
3	POGO	SPC INH RLS	SSC Constant Velocity Test [redacted] Health Test 1 [redacted]
4	POGO	SPC INH RLS	SS Health Test [redacted] Health Test 2
	GUAM	Real Time	ECS/UHF Health Test
5	BOSS		Health and Status
	POGO	Load (2)	First Operational Message Start SS Payload Operations
6			[redacted]
6	BOSS		SSU Abort (inhibited)
	POGO	Load	SE Message Last TS Record
7	POGO	Low Elev.	Health and Status

REV	STATION	ACTIVITY	EVENT
8	COOK	Load	[redacted]
9	No Contacts		
10	HULA	Load	SE Message
11	No Contacts		
12	GUAM	Load (2)	[redacted]
18	POGO	Load (MCS)	MCS Operate and Load
18	HULA		MCS Only Contact LB Health Test
19	POGO		[redacted]
20	POGO	Load	[redacted]
21	POGO		MCS Memory Off
29	GUAM	Load (2)	Reload MACRO Compartment
54	POGO	Load	[redacted]

APPENDIX A

ABBREVIATIONS

ACS	Attitude Control System
A-H	Ampere Hour
AV	Ascent Vehicle
BUD	Back-Up Decoder
DRM	Digital Rate Monitor
ECS	Extended Command System
EDAP	Electrical Distribution and Power
IRA	Inertial Reference Assembly
MCS	Minimal Command System
OA	Orbit Adjust
PACS	Primary Attitude Control System
PPMU	Parallel Programmable Memory Unit
RCS	Reaction Control System
RD	Remote Decoder
RV	Re-Entry Vehicle
SBA	Satellite Basic Assembly
SOCI	State of Charge Indicator
SPC	Stored Program Command
SRM	Solid Rocket Motor
SV	Satellite Vehicle
TT&C	Tracking, Telemetry and Command
VTS	Vandenberg Tracking Station

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
1201 Launched 15 June 1971 Deboosted 6 August 1971	FIRST HEXAGON MISSION Normal ACS/RCS config. Restricted rewind-Pan Cam. Beta Angle -20° to +10°. RV unbalance 60%.	Primary 31 days Solo 21 days	RV-1 5 days 6/20/71 Water-Parachute damage RV-2 6 days 6/26/71 RV-3 14 days 7/10/71 Lost-parachute failure RV-4 6 days 7/16/71 Restricted to 45% capacity.	Thermal contamination High temperatures reduced batt. capacity--limited payload operations. Main parachute damage RVs 1, 2, 3. Camera ESDs - resumed operation each time. Degraded RCS thruster pulse shapes - Control OK.
1202 Launched 20 January 72 Deboosted 28 February 72	Beta angle +18° to +30°. [redacted] Parachutes modified. Rewind limited to 35 ips.	Primary 40 days Solo 0 days	RV-1 6 days 1/26/72 RV-2 13 days 2/8/72 RV-3 9 days 2/17/72 RV-4 11 days 2/28/72	Film path break Camera B RV 3 & 4 Monoscopic operation. RCS thruster degradation SV tumbled two times. Deboost used Lifeboat. Thermal contamination verified.
1203 Launched 7 July 72 Deboosted 13 Sept 72	Laboratory quality Hydrazine. Higher perigee, minimum maneuvers and OAs. Redundant RCS tanks empty - filled from OAS when needed. Beta angle +34° to +26°. [redacted]	Primary 48 days Solo 11 days	RV-1 8 days 7/15/72 RV-2 14 days 7/29/72 RV-3 14 days 8/12/72 RV-4 21 days 9/2/72	Film edge folds - both cameras. Film path disturbance at high rewinds. High RCS thruster leaks, primary and redundant.

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
1204 Launched 10 October 72 Deboosted 8 January 73	10,000' color - Camera A. RCS tanks 3 and 4 capped. Beta angle +30° to +24°. Minimum SV maneuvers. [redacted] RACS control RCS 1 at L.O.	Primary 68 days Solo 22 days	RV-1 11 days 10/21/72 RV-2 16 days 11/5/72 RV-3 18 days 11/23/72 RV-4 24 days 12/17/72	Improper OB stow degraded early photography. Yaw bias RACS Day 35. Yaw bias PACS Day 68. Pyro battery leaks RV-2 and RV-4.
1205 Launched 9 March 73 Deboosted 18 May 73	First mapping mission. 2000' color - Camera A. RCS operated from OAS. [redacted] Beta Angle +2° to -8°.	Primary 61 days Mapping 43 days Solo 9 days	RV-1 12 days 3/22/73 RV-2 14 days 4/5/73 RV-3 14 days 4/19/73 RV-4 22 days 5/9/73 RV-5 43 days 4/21/73	Primary ACS pitch error. Redundant ACS yaw bias (degraded photography). ST terrain thermal door (restricted ST operations) (no ST calibration) ST quality excellent. SGLS 2 (Cubic) failure.
1206 Launched 13 July 73 Deboosted VASP 12 October 73	21,000' color - Camera B in five segments. RCS 1 & 2 operate from OAS. Propellant in RCS Tank 2 only. (Emergency use.) Beta angle +2° to -8°. 50 hour batteries in RVs. Modified ST terrain therm.	Primary 74 days Mapping 42 days Solo 17 days	RV-1 19 days 8/1/73 RV-2 12 days 8/13/73 RV-3 26 days 9/8/73 RV-4 17 days 9/25/73 RV-5 42 days 9/24/73	Primary ACS yaw bias on Day 3 - Transferred to RACS. Thrust level decay REA #4 and 8 - no effect. ST calibration successful. VASP deboost/impact successful. RV-1 recovery one day after trimmed seal.

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
1207 Launched 10 November 73 Deboosted 13 March 74	Soft seat REM valves. RCS 1 supplied from RCS tanks 1 and 2. PACS and RACS torquers isolated. SGLS 1 and 2 Cubic. [redacted] Pan Camera commandable filter. 5000' color and 500' IR. Special ST terrain film for test.	Primary 101 days Mapping 57 days Solo 21 days	RV-1 14 days 11/24/73 RV-2 24 days 12/17/73 RV-3 27 days 1/13/74 RV-4 37 days 2/20/74 RV-5 57 days 1/8/74	RCS 1 used until Day 90. All mission objectives satisfied. 58 OAs executed during mission and Solo. All expendables used. [redacted]
1208 Launched 10 April 74 Deboosted 28 July 74	RCS Tanks 1-4 filled. SGLS 1 G.D. unit. TR1 & 2 stored commands via MCS. B/U ECS/UHF command receiver. [redacted] 2600' color and 3400' of IR film for Pan.	Primary 106 days Mapping 61 days Solo 5 days	RV-1 15 days 4/2/74 RV-2 28 days 5/21/74 RV-3 27 days 6/26/74 RV-4 36 days 7/24/74 RV-5 61 days 6/9/74	RCS 1 used until Day 62. All mission objectives satisfied. 43 OAs executed. All expendables used.
1209 Launched 29 October 74 Deboosted 18 March 75	RCS Tanks 1-4 filled. SGLS 1 & 2 Cubic Mfg. [redacted] 8150' color and 3400' IR film for Pan camera.	Primary 129 days Mapping 60 days Solo 12 days	RV-1 20 days 11/17/74 RV-2 36 days 12/23/74 RV-3 29 days 1/21/75 RV-4 44 days 3/7/75 RV-5 60 days 12/27/74	RCS 1 used until Day 70. All mission objectives satisfied. 54 OAs executed. All expendables used. LB Deboost Rev 2274 after ACS 2 Power Supply failure. H/S Inhibit failure on ACS 1 on Rev 1118.

Cress

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
SV-10 Launched 8 June 75 Deboosted 5 November 75	RCS Stuffed Tanks. SGLS 1 & 2 Cubic Mfg. [redacted] Current Sensor Integrator. Added 9150' color, 3150' IR and 3750' Hi Res for Pan Camera.	Primary 121 days Mapping 53 days Solo 28 days	RV-1 17 days 6/24/75 RV-2 35 days 7/29/75 RV-3 37 days 9/4/75 RV-4 32 days 10/6/75 RV-5 53 days 7/30/75	RCS 1 used until Day 81. 61 OAs executed during mission and Solo. ST Camera Pwr Relay Failure limited performance. Lifeboat Deboost after RCS 2 degradation.
SV-11 Launched 4 December 75 Deboosted 1 April 76	RCS Stuffed Tanks. SGLS 1 & 2 Cubic Mfg. S/A to Lifeboat Buss [redacted] 4500' color, 4500' IR and 5000' Hi Res film for Pan Camera. VVSA Experiment. Split Q Orbit.	Primary 117 days Mapping 61 days Solo 3 days	RV-1 35 days 1/7/76 RV-2 20 days 1/27/76 RV-3 25 days 2/21/76 RV-4 37 days 3/29/76 RV-5 61 days 2/2/76	RCS 1 used until Day 69; RCS 2 until Day 116; dual RCS thereafter. ECS Clock jumps. MCS used as B/U for negative OAs and RV-5. 43 OAs executed during mission and Solo. Pan Camera Side A failure Day 20. Mono A resumed in RV-4. HSA failure and RCS leak (Day 120).

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
SV-12 Launched 8 July 76 Deboosted 13 December 76	SGLS 2 and PCM1 MUX, ACS/ HSA 2 were Blk 2 units. [redacted] 4500' color, 4500' IR film and oversize stacks for Pan Camera. Split Q Orbit. Low alt (80 NM) orbit.	Primary 155 days Mapping 63 days Solo 4 days	RV-1 27 days 8/3/76 RV-2 34 days 9/6/76 RV-3 43 days 10/19/76 RV-4 51 days 12/9/76 RV-5 63 days 9/8/76	RCS 1 used until Day 102. 66 OAs executed during mission and Solo. EDAP Relay failure limited [redacted] during early revs. Pan SCC #1 failure. ECS Remote Decoder failure. ECS/ACS Deboost.
SV-13 Launched 27 June 77 Deboosted 23 December 77	Block III [redacted]	Primary 176 days Mapping 113 days Solo 4 days	RV-1 37 days 8/2/77 RV-2 34 days 9/5/77 RV-3 42 days 11/4/77 RV-4 45 days 12/19/77 RV-5 113 days 10/17/77	B-side shutter problem. A-side RV-1 TU too full. B-side spurious IESD. RV-2 water recovery. Sensor System film path vent valve problem.
SV-14 Launched 16 March 78 Deboosted 11 Sept 78	[redacted]	Primary 178 days Mapping 118 days Solo 2 days	RV-1 36 days 4/20/78 RV-2 42 days 6/1/78 RV-3 51 days 7/22/78 RV-4 49 days 9/9/78 RV-5 118 days 7/11/78	Type-35 TR failed to respond at BOT. Possible Type -34 RT frequency shift. SS B-side platen hit stops. ST heater zone control circuit failed ON.

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
SV-15 Launched 16 March 79 Deboosted 22 Sept 79	OAS Repressurization. 2 ECS secure words per command [redacted] RV 1-4 flashing light deleted RV-4 Delta 2 beacon inoperative.	Primary 188 days Mapping 119 days Solo 3 days	RV-1 37 days 4/20/79 RV-2 50 days 6/10/79 RV-3 51 days 7/31/79 RV-4 50 days 9/19/79 RV-5 119 days 7/12/79	PMU-B hard failure: Minor ECS clock frequency shifts attributed to same cause. RV-3 drogue mortar end-cap penetrated capsule. ST thermal shutter door failed to open: heater zone tripped. Spurious noise from ECS-UHF receiver caused random MCS RTC execution. Marginal MESA data.
SV-16 Launched 18 June 80 Deboosted 6 March 81	IMC Enable/Disable MOD-II IRA (ACS-2) [redacted] Last Mapper Mission	Primary 261 days Mapping 119 days [redacted] Solo 1 day	RV-1 37 days 7/24/80 RV-2 45 days 9/7/80 RV-3 47 days 10/24/80 RV-4 [redacted] days 3/5/81 RV-5 119 days 10/14/80	Dec A/PCM1 Format Select Logic failure. Marginal MESA data. ST Thermal Shutter Door failed to open. Insensitive SGLS-1 receiver. DIU-B erroneous counts. RV-3B sticky TU brake. PMU-B failure. RCS-1 REA 4 degradation. Remote Decoder A failure.

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
SV-17 Launched 11 May 1982 Deboosted 5 December 1982	Large Looper (LLOP). Solid State Stellar (SQ) Camera. Supplementary Pneumatics Module (SPSM). MOD-II IRA (ACS-1 only). Single Lifeboat Tank. Downlink Encryption. Pitch/Roll Coupling Disconnect. [redacted]	Primary 203 days Solo 5 days	RV-1 35 days 6/15/82 RV-2 48 days 8/2/82 RV-3 58 days 9/29/82 RV-4 62 days 11/30/82	RCS-1 used until Day 187; REA-4 degradation. Cone bag cutter failures and water recoveries of RVs 2, 3, and 4. Loss of SQ system redundancy. DBS failure. Intermittent Structure Current. Intermittent HPIVB Closure. Fwd Camera (A) System failure. Mono-B for remainder of RV-4. Aft Camera (B) System ESD.
SV-18 Launched 20 June 1983 Deboosted 21 March 1984	Single integrated RCS/OAS tank. [redacted]	Primary 271 days Solo 5 days	RV-1 66 days 8/24/83 RV-2 75 days 11/7/83 RV-3 63 days 1/9/84 RV-4 67 days 3/16/84	[redacted] Bit flip in Hybrid PPMU-A program section.

APPENDIX B
PROGRAM SUMMARY

MISSION	CONFIGURATION UPDATE	DURATION	RECOVERIES	COMMENTS
SV-19 Launched 25 June 1984 Deboost 11 October 1984	[redacted] Uplink encryption	Primary 108 days Solo 0 days	RV-1 42 days 8/5/84 RV-2 26 days 9/24/84 RV-3 17 days 10/11/84 RV-4 not used	RV-1 water recovery: minor hole in chute. Serious bit failures in plated wire memories of PPMU-A and B. PPMU-B lost by Day 4, and PPMU-A was lost by Day 105. Mission activity was accelerated to compensate for anticipated short life. Uplink encryption unit caused numerous spurious RTC executions. Sensor System TU Brake problem in RV-2 resulting in Mono-A for part of the segment. Lifeboat recovery and deboost.
SV-20 Launched 18 April 1986	[redacted] ECS PPMU Modified	Primary 0 days		SRM failure during lift-off followed by BV explosion at approximately L.O. +9 sec.

SECRET / H