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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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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 ± 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

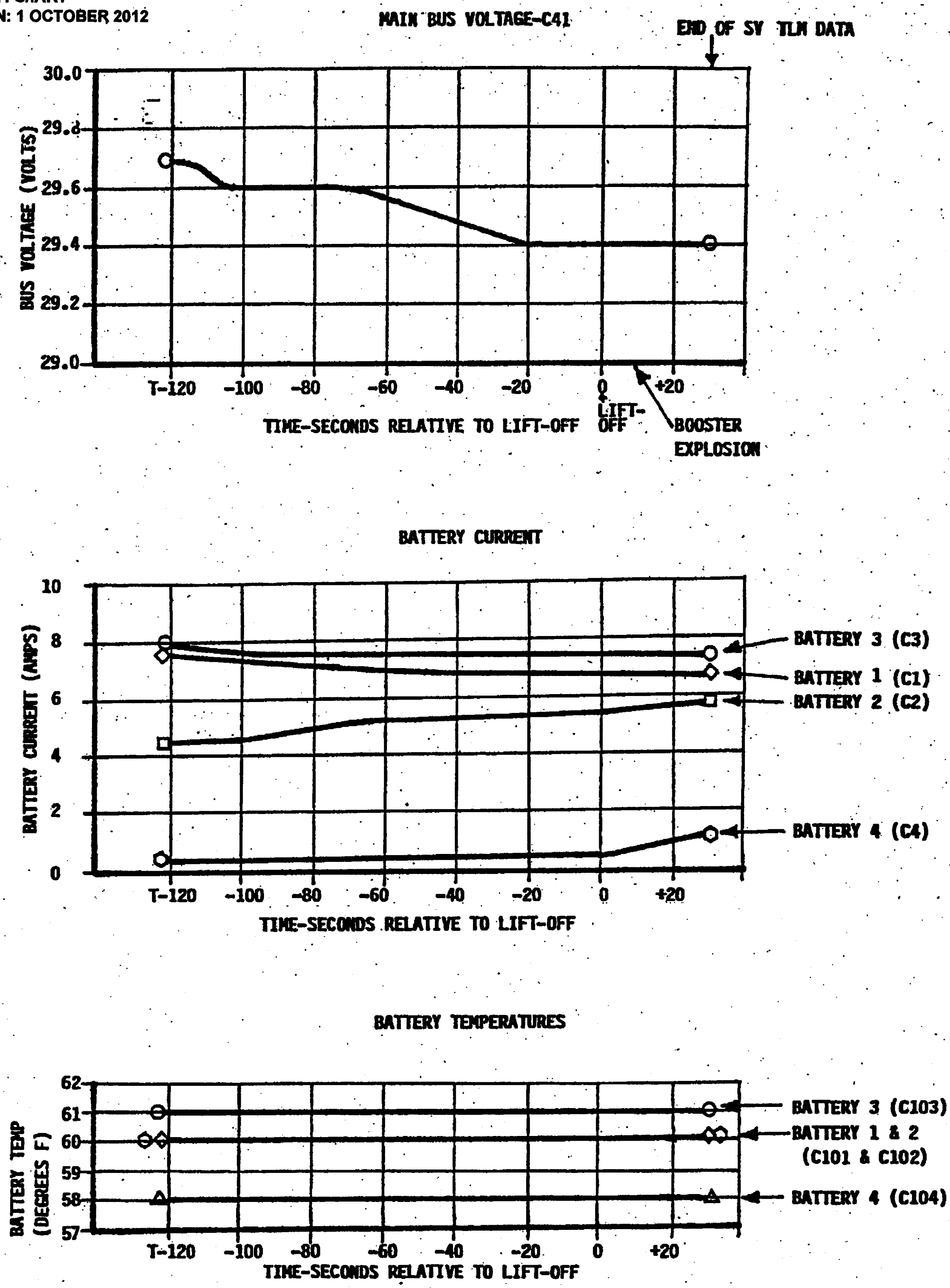

MAIN BUS VOLTAGE-C41
END OF SV TLM DATA
30.0
29.8
29.6
29.4
29.2
29.0
BUS VOLTAGE (VOLTS)
T-120
-100
-80
-60
-40
-20
0
+20
LIFT-OFF
TIME-SECONDS RELATIVE TO LIFT-OFF
BOOSTER EXPLOSION
BATTERY CURRENT
10
8
6
4
2
0
BATTERY CURRENT (AMPS)
BATTERY 3 (C3)
BATTERY 1 (C1)
BATTERY 2 (C2)
BATTERY 4 (C4)
T-120
-100
-80
-60
-40
-20
0
+20
TIME-SECONDS RELATIVE TO LIFT-OFF
BATTERY TEMPERATURES
62
61
60
59
58
57
BATTERY TEMP (DEGREES F)
BATTERY 3 (C103)
BATTERY 1 & 2 (C101 & C102)
BATTERY 4 (C104)
T-120
-100
-80
-60
-40
-20
0
+20
TIME-SECONDS RELATIVE TO LIFT-OFF

FIGURE 2-1

SHROUD TEMPERATURE HISTORY

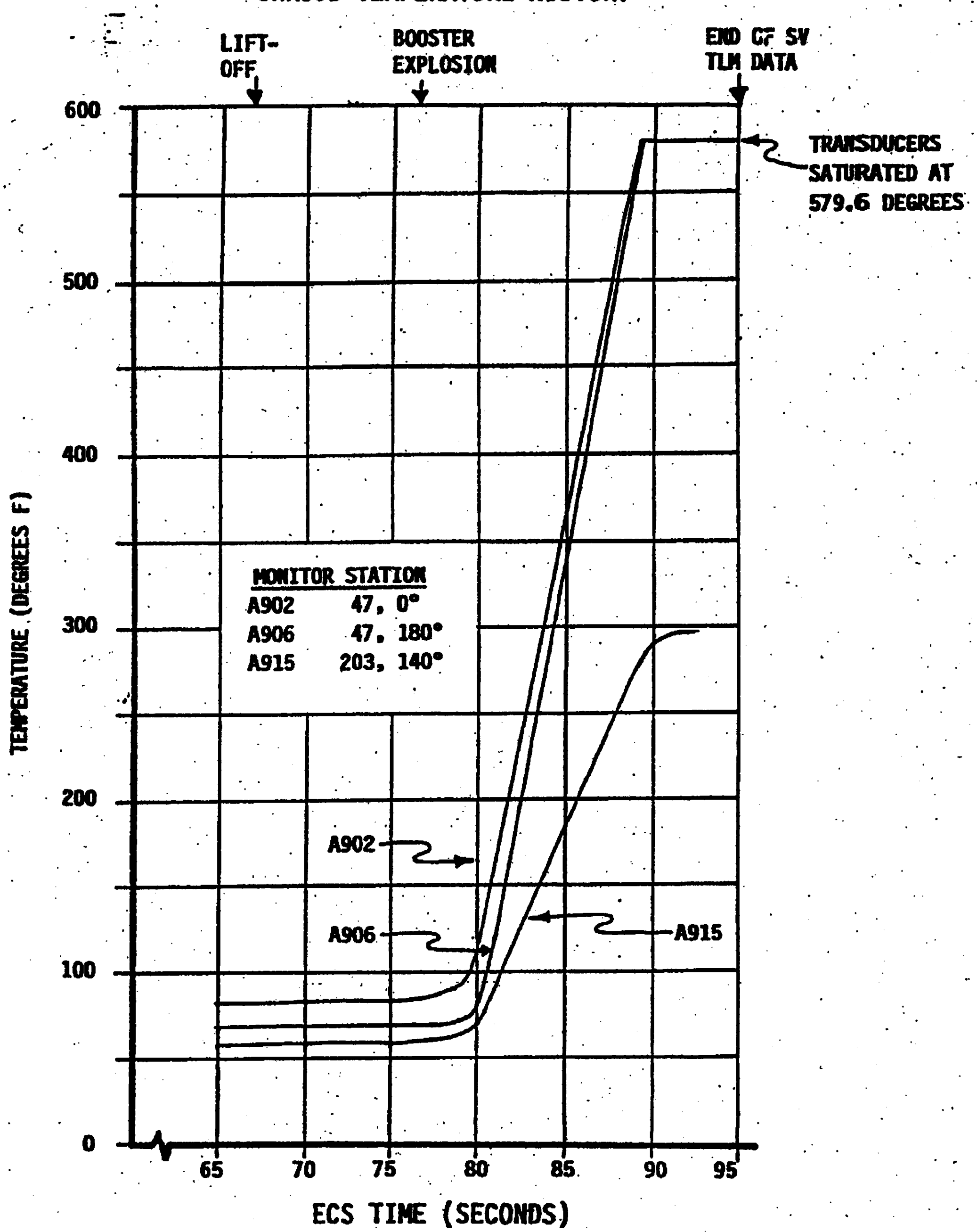
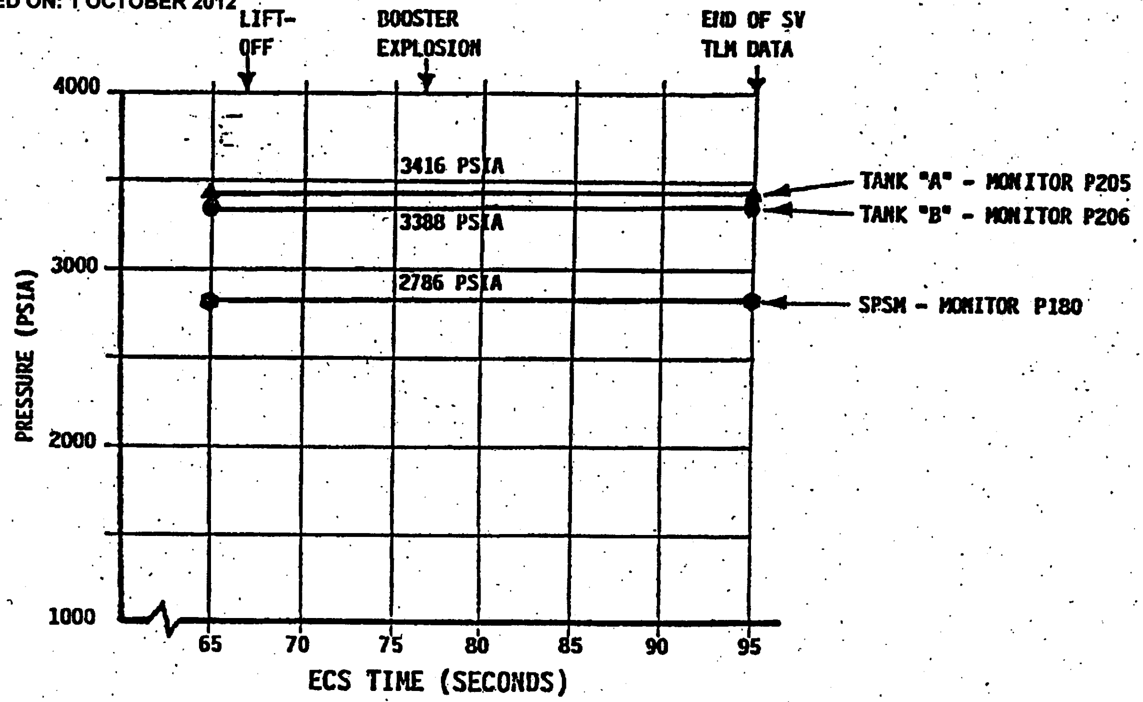


FIGURE 2-2

MID-SECTION PRESSURE VESSELS



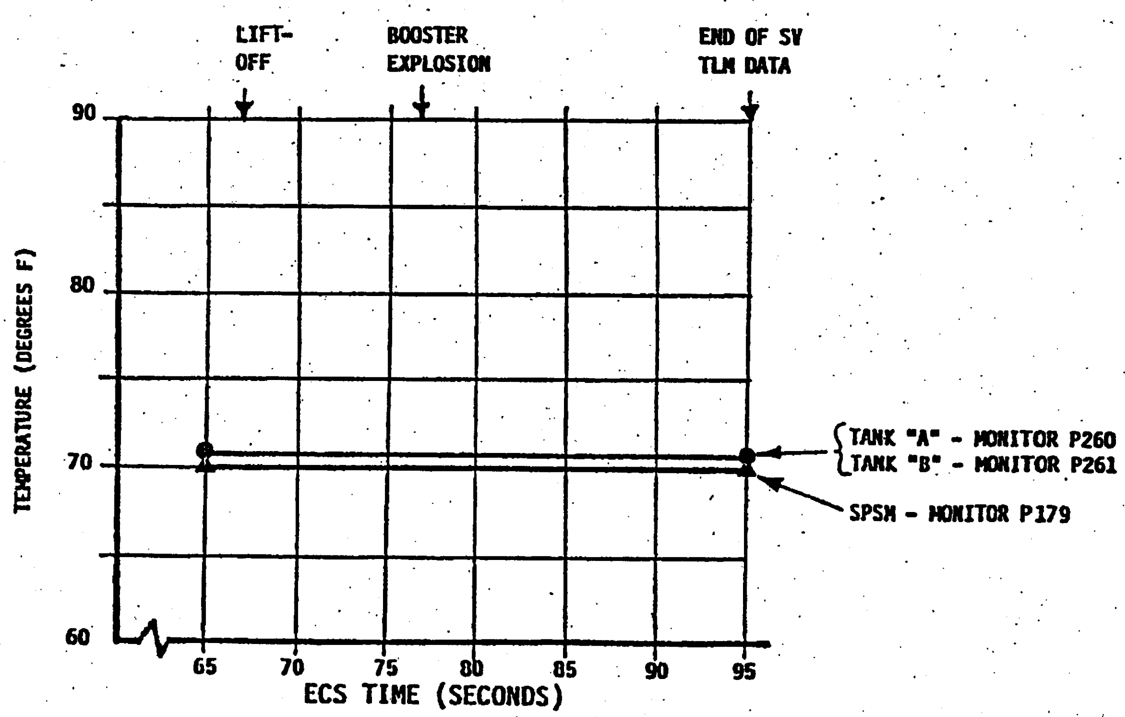


FIGURE 2-3

HYDRAZINE PROPELLANT SUPPLY SYSTEM

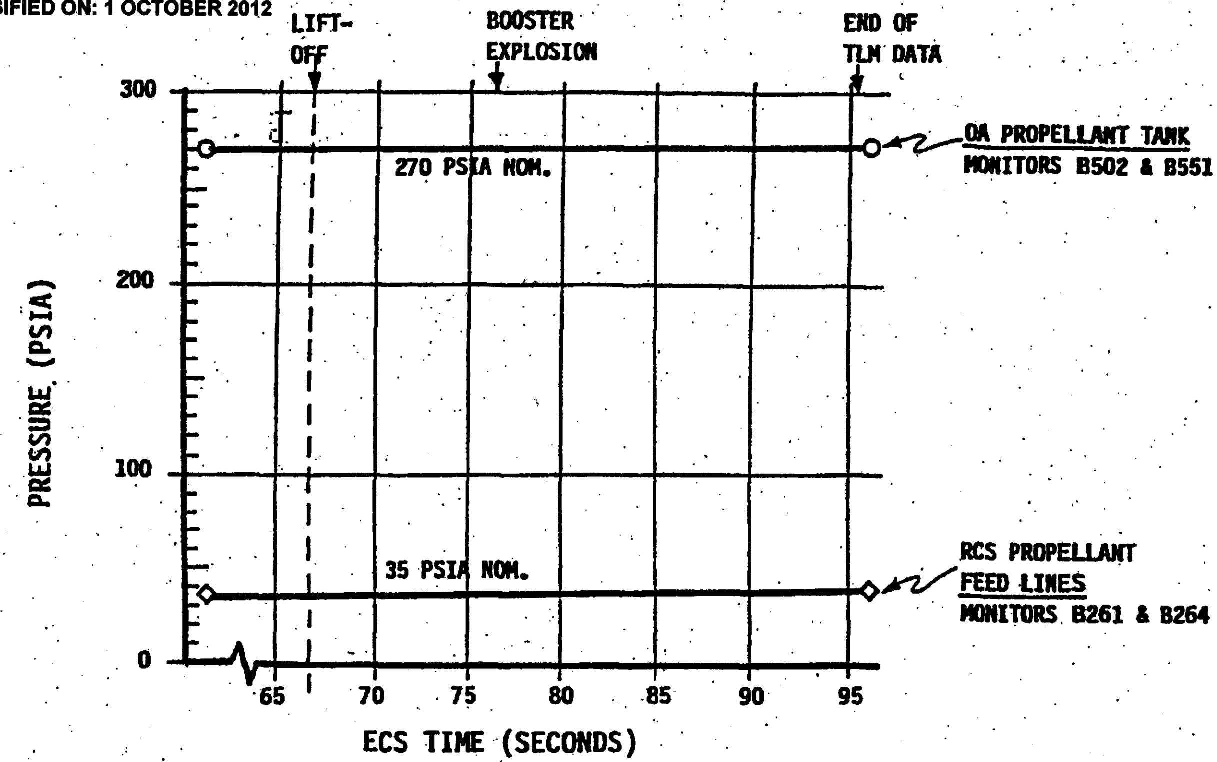


FIGURE 2-4

22 INCH DIAMETER PRESSURE VESSELS

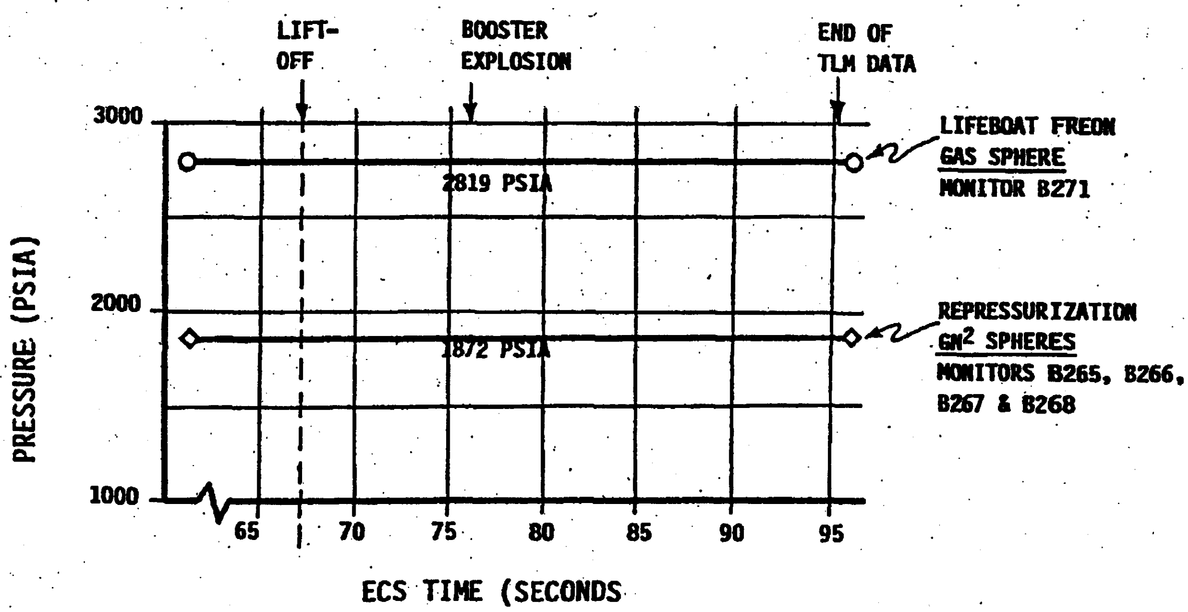


FIGURE 2-5

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.

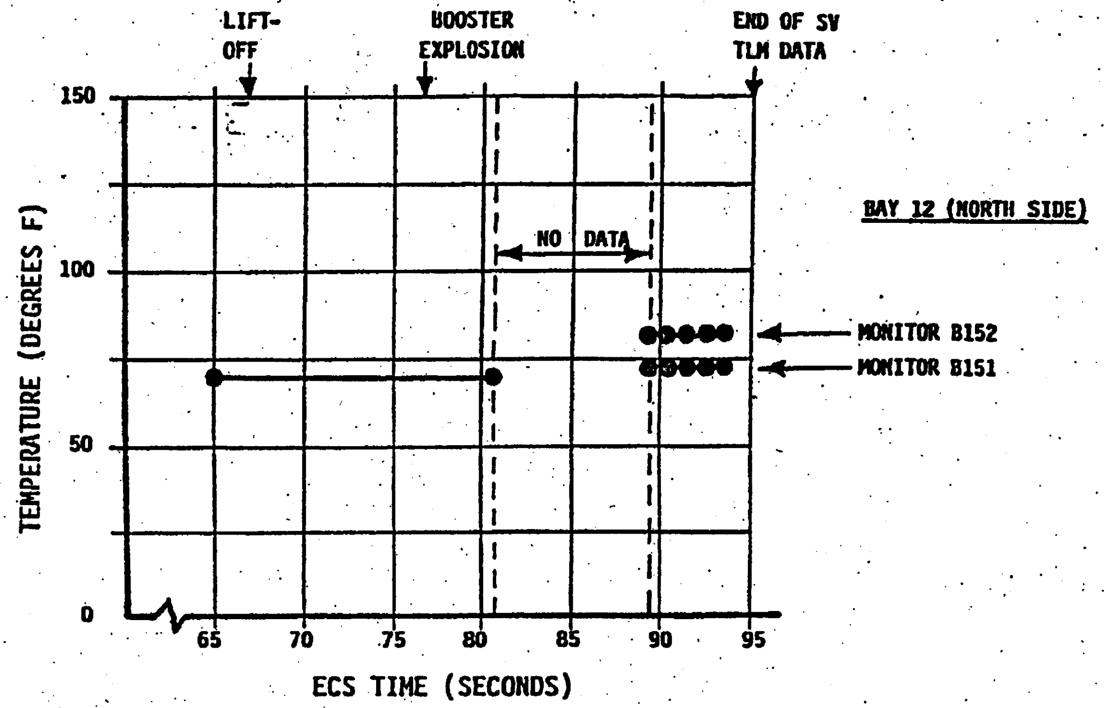
2.5 Attitude Control System (ACS)

The ACS data presented in this section was derived from a[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 $\pm.0145$ degrees per second. Prior to the launch the gyro data was noted to be switching between $\pm.0145$ degrees/second (normal). After lift-off, rate activity is observed.

TEMPERATURE HISTORY - RCS PROPELLANT FEE



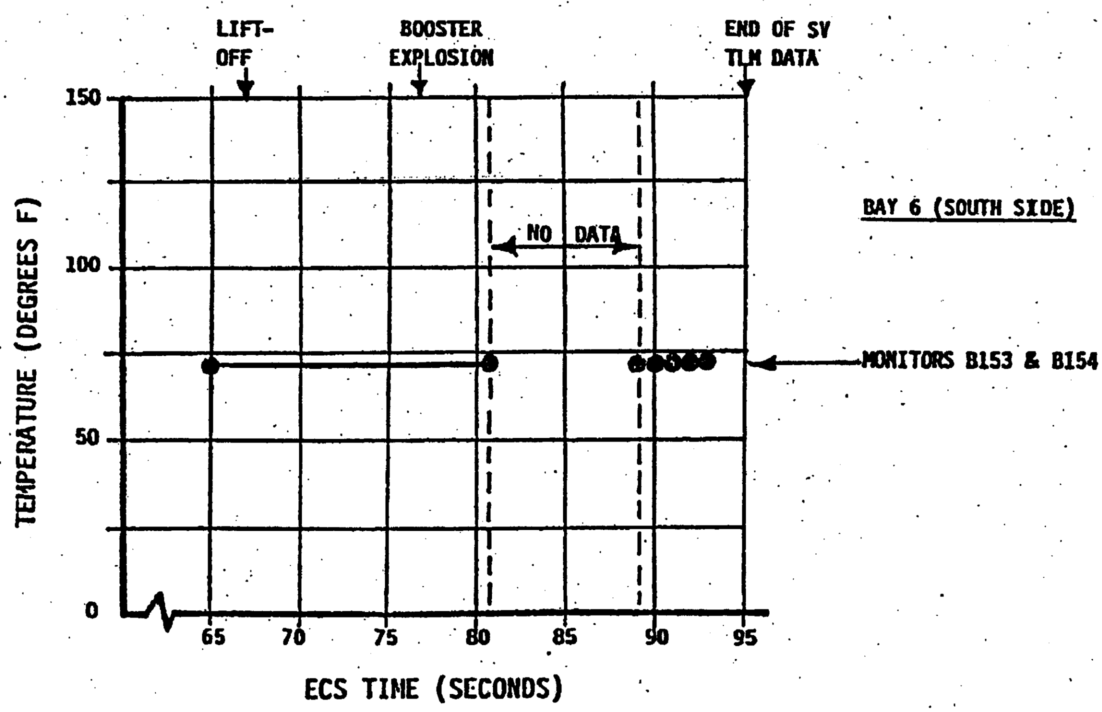
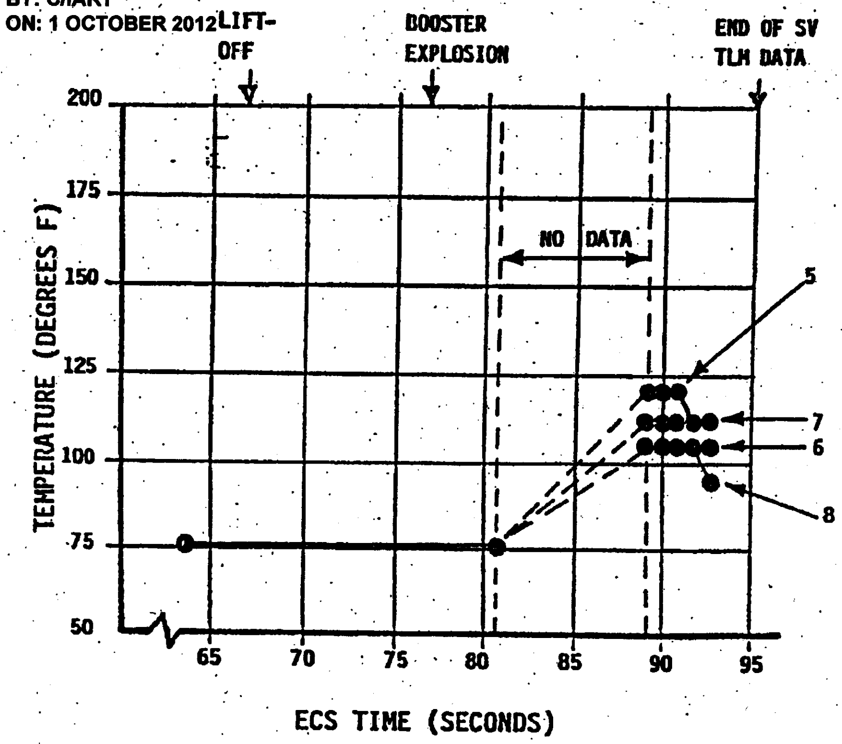


FIGURE 2-6

TEMPERATURE HISTORY - REACTION CONTROL THRU

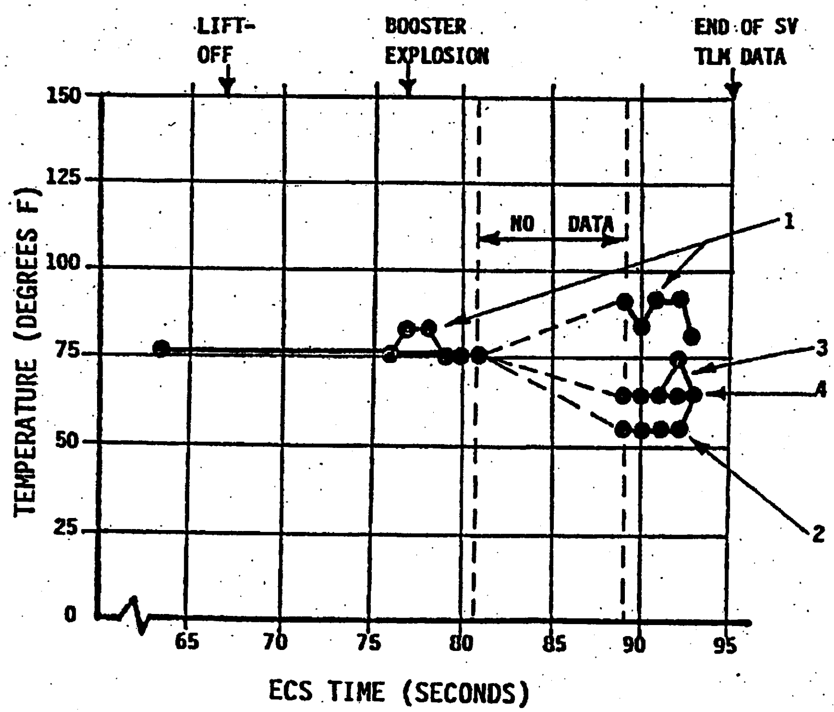


BAY 12 (NORTH SIDE)

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)

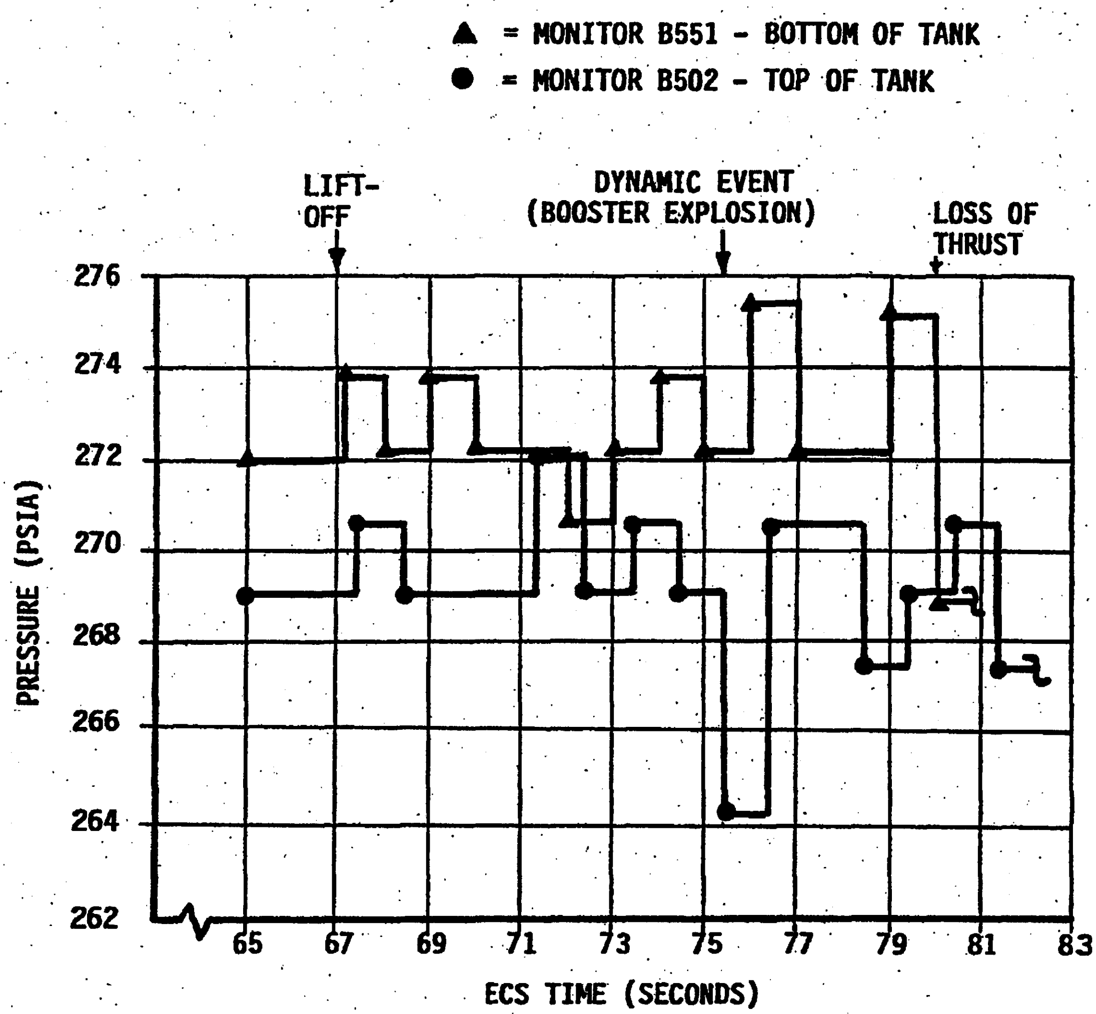
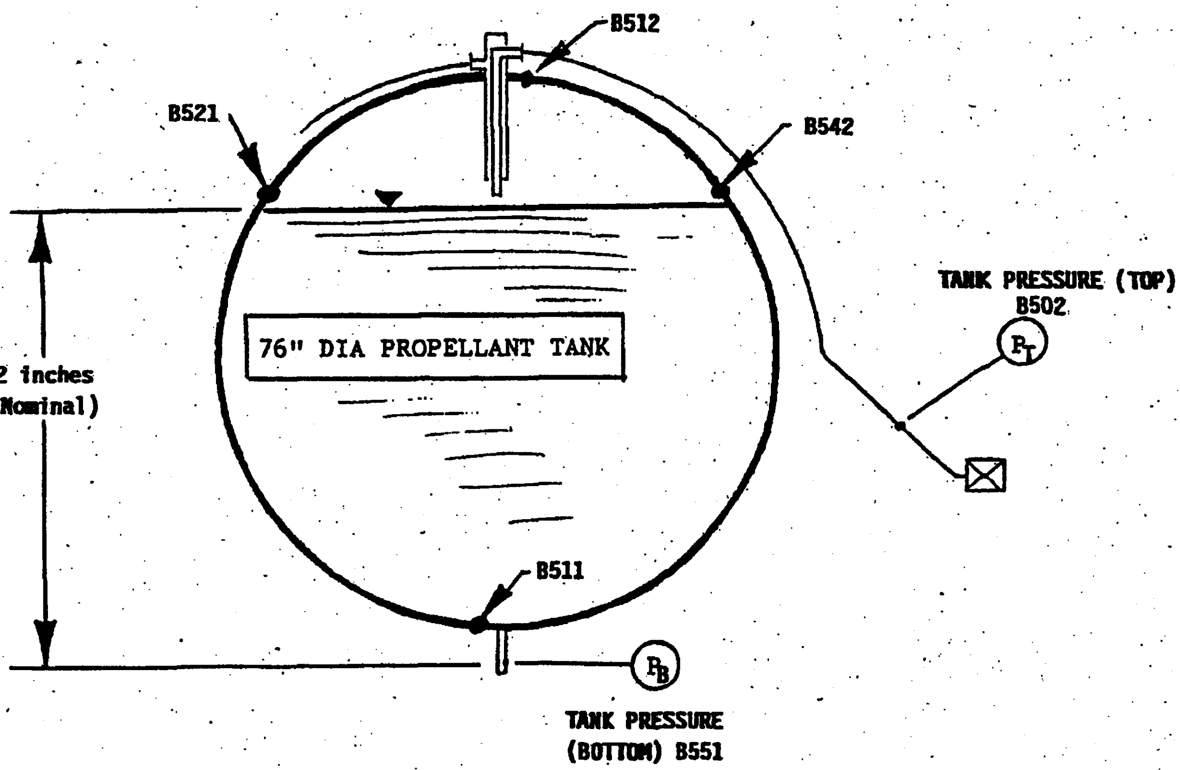


FIGURE 2-8

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.

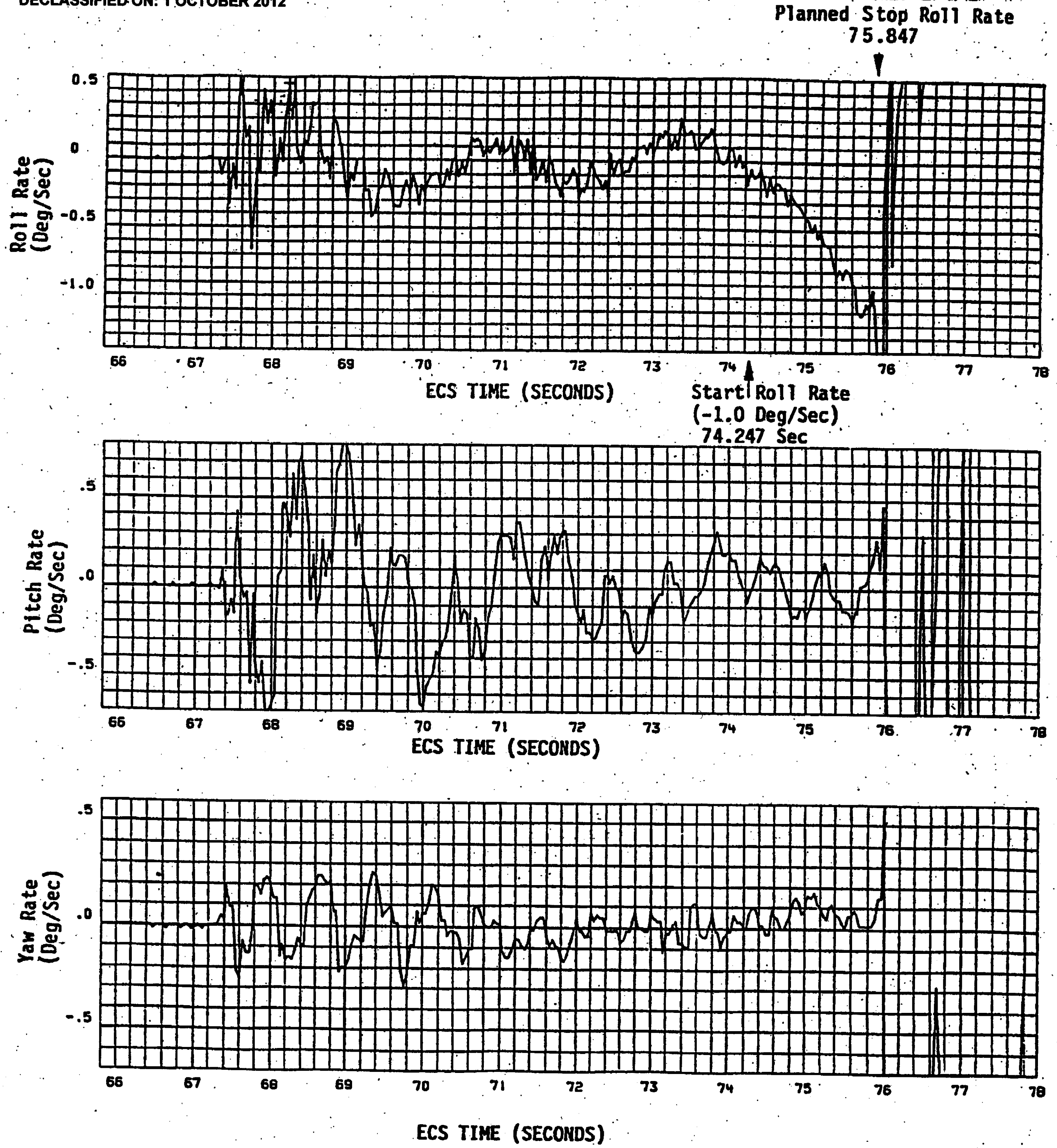
b. Table 2-2 indicates the rotational rate dynamics before and just after the time of mishap. These points are shown plotted in Figure 2-12. It can be seen that in the roll channel, the first anomalous rates are negative but that they quickly ramp positive with a sinusoidal component of about 6 hz (which 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	

<u>NOTES</u>:
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