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FLIGHT TEST ENGINEERING ANALYSIS REPORT
FOR
THE HEXAGON PROGRAM SATELLITE VEHICLE NUMBER TEN ~~(S)~~

Contract [redacted] ~~(S)~~

Prepared and Submitted by the
Satellite Vehicle Integrating Contractor

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FOREWORD

This report describes the performance of the tenth HEXAGON Program Satellite Vehicle (SV-10). The vehicle was launched 8 June 1975 and, after a 120-day primary mission and a 30-day solo mission, was deboosted on Rev 2436 on 5 November 1975.

This report does not explicitly cover the solo mission; however, results from solo are used as appropriate when they contribute to the understanding of primary mission events.

CONTENTS

Section I

SUMMARY

The tenth HEXAGON Satellite Vehicle (SV-10) was placed in a nominal orbit of 88.5 x 155 nm by the Titan IIID booster on 8 June 1975. Ascent events were nominal and proper stabilization of the SV allowed initiation of deployment of the solar arrays at the first station contact, INDI. [redacted] Subsatellite was properly ejected on Rev 2. The panoramic camera operated throughout the mission and its RVs were recovered on Revs 261, 829, 1429, and 1948, which occurred on Mission Days 17, 52, 89, and 121. All four RVs were caught in the air. All of the film was transported into the RVs. An anomalous relay contact caused an emergency shutdown (ESD) on Rev 433 and normal camera operations were not reestablished until Rev 461. A constraint on nested operations was imposed on Rev 867 until the end of Segment 3 on Rev 1429 because of the anomalous functioning of a take-up integrator reset signal. Normal photographic operation without anomaly continued throughout the remainder of the mission. On Rev 59 a K2 relay on the mapping camera supply and takeup motors remained in the power on position. Recycling made it operable on Rev 62 and it worked intermittently until Rev 153, after which it remained closed. During the remainder of the MCM operations the K1 relay was used to control the power, power being applied for several revs (10 to 9) and then turned off for an interval (6 to 7 revs). This kept the operating temperatures within acceptable limits, the photographic operations were carried out successfully, and all the film was transported to RV-5, which was successfully recovered in Rev 845. Solo tests were run and the SV was deorbited on Rev 2436 (during Mission Day 151).

Section II
MISSION OVERVIEW

2.1 PREFLIGHT PLANNING

Mission 1210 was the fourth of the HEXAGON Block II vehicles and panoramic systems and the sixth and last of the Block II mapping camera modules; no special flight experiments were scheduled. All four RCS tanks were filled and supplied the thrusters throughout the flight, with no transfer of fuel from the OA tank.

2.2 PREFLIGHT CONSTRAINTS

The Mission 1210 orbit was designed to accomplish the following:

A. Maintain solar angle (Beta) within -8 to +30 for a planned 150 days

B. Have orbit adjusts occur on a three-day cycle with every third OA to be a positive and negative burn for close control of argument of perigee

The following constraints were imposed on the panoramic camera:

A. Rewind velocity limited to 5 inches/second

B. No 30° scans at ±45 scan centers

2.3 LAUNCH BASE

SV-10 was delivered to the launch pad and mated to the BV on 14 May 1975. The launch was delayed on 7 June at T-31 sec due to a low voltage on the booster radio guidance battery. The battery was replaced and the vehicle was launched at 10:30:00.91 PST on 8 June 1975 at the opening of the launch window.

2.4 ASCENT

The BV successfully injected the SV into orbit. The targeted and achieved orbits and deviations were as follows:

		Targeted	Achieved	Deviation
Apogee Altitude	(nm)	153.643	157.125	+3.472
Perigee Altitude	(nm)	88.756	88.957	+0.191
Period	(min:sec)	88:51.84	88:53.76	+0:01.92
Eccentricity		0.009260	0.009725	+0.000465
Argument of Perigee	(deg)	141.51	135.54	-5.97
Inclination	(deg)	96.383	96.367	-0.016

2.5 ORBIT AND RECOVERY

2.5.1 1210-1 (16 Days Duration)

Solar array deployment was executed over INDI on Rev 1 with normal deployment and erection. Since the solar arrays were at the optimum position of +18° for the initial beta angle of +21.6° no repositioning was necessary. [redacted] Subsatellite was ejected on Rev 2.

Operational photography began on Rev 7 following successful completion of constant velocity and health checks on Revs 3 and 6 respectively. Operation throughout this segment was normal. Approximately 28,700 feet of film per camera (including pre-launch footage on the take up) were exposed and stowed in RV-1.

Post flight analysis (PFA) of the recovered film showed the overall quality of the acquired photography ranged from good to poor with the majority rated fair. The poor imagery was mostly attributed to adverse atmospheric and weather conditions. The imagery of the forward-looking camera appeared sharper than that of the aft looking. On-orbit Attitude Adjustment (OOAA) corrections were established for the forward looking camera skew angle determined by subjective analysis of smear slit imagery.

2.5.2 1210-2 (35 Days Duration)

This segment began with normal photographic operations. PFA determined OOAA correction for the forward looking camera was implemented on Rev 314. On Rev 433, an aft-looking camera emergency shutdown (ESD) shut down both cameras. Analysis of flight data showed that a relay contact in the power distribution system box failed to apply power to the aft-looking camera. Various health operations were conducted on Revs 440, 442, and 449 to restore power to the aft-looking camera with the operation on the latter rev being successful. Further successful health checks were performed on Revs 454, 456, and 458. Normal camera operation was resumed on Rev 461 and continued for the remainder of the segment. Approximately 29,800 feet of forward-looking camera film and 28,000 feet of aft-looking camera film were exposed and stowed in RV-2.

PFA showed overall quality of acquired imagery for this segment the same as for the preceding one, with haze and bad weather significantly affecting image quality.

Forward-looking camera imagery contined to appear sharper than that of the aft looking. Analysis of smear slit imagery showed the need for skew angle and velocity corrections for both cameras.

2.5.3 1210-3 (37 Days Duration)

Normal photographic operations were performed until Rev 867, when a constraint on nested operations was imposed for the remainder of the segment because of anomalous functioning of the aft-looking camera takeup integrator reset signal. This signal was observed to fail on Rev 852, to restore itself on Rev 917 to fail again on Rev 1206, and and finally to self restore on Rev 1302 for the remainder of the segment. This intermittent failure did not cause a system shutdown as did an identical failure in Segment 4 of SV-8 flight, but the nested operation constraint did impact operational efficiency.

OOAA corrections for both cameras were implemented on Rev 881. Approximately 29,600 feet of forward-looking camera film and 27,750 feet of aft-looking camera film were exposed in RV-3.

PFA showed a slight improvement of overall quality of acquired imagery, with the rating being poor to very good. Poor and fair imagery was again attributed to adverse atmospheric and acquisition conditions.

Forward-looking camera imagery was superior to that of the aft looking.

2.5.4 1210-4 (32 Days Duration)

The nested operations constraint imposed in the previous segment was eliminated and normal photographic operation without camera system anomaly continued throughout this segment.

Forward-looking and aft-looking camera film depletions occurred on Rev 1940 and Rev 1944 respectively. Approximately 27,250 feet of forward-looking camera film and 26,150 feet of aft-looking camera film were exposed and stowed in RV-4.

PFA showed image quality of acquired photography ranging from poor to good, with the majority rated fair to good. Adverse atmospheric and acquisition conditions produced the poor and fair imagery.

2.6 ANOMALY SUMMARY

Significant anomalies are listed chronologically in Table 2-1. The list includes a brief description of the anomaly and its effect on the mission. A more detailed discussion can be obtained in the reference paragraphs.

Table 2-1

SUMMARY ANOMALIES

Day	Description	Impact	Ref Paragraph
4	MCM K2 relay stuck. Power remained on to supply and takeup motors. Temperature of film increased. Power drain on SV (3.5 amp-hr/rev).	Recycling made it operable. Anomaly recurred intermittently until it stuck permanently on Day 10.	4.4
6	REA temperature monitors erratic.	Basis for thrust comparison changed. Redesign and improved inspection for Block III.	3.7.4
9	REA 6 pressure monitor read zero for rest of flight.	Method for computing thrust changed. Block III (SV-14 and up) pressure transducers will have Hi-Rel parts and increased testing.	3.3.5
10	MCM K2 relay stuck permanently.	Power controlled by K1 relay (main bus). All film utilized and no damage detected. Diodes added to circuits to eliminate contact pitting on SV-11 and up.	4.4
16	RV-1 SMDC line separation	SMCD lines separated from connectors on RV-1, RV-3, and RV-4 similar to failures on SV-4 and SV-6. Correction becomes effective on SV-13. No mission degradation — heat shield separated.	5.3
25	Battery 3 thermostat operated erratically	Battery 3 cooler than others, with resulting fewer K2s.	3.6.4
27	ESD caused by failure of power distribution system delay to apply power to aft-looking camera.	Health operations successful in restoring aft-looking camera power. Normal operations resumed on Rev 461 and continued.	2.5.2 and 4.1.3
35	MCM K3 relay stuck. Power remained on to terrain and stellar film transport clutches.	Relay stuck from Rev 561 to Rev 640, then operated normally.	4.4

Table 2-1 (Cont)

Day	Description	Impact	Ref Paragraph
47	MCM stellar terrain takeup clutch did not takeup film for two cycles. OK rest of flight.	No mission impact — thought to be induced by high temperature resulting from K2 failure — test and analysis continuing.	4.4
51	RV-2 main battery vented.	No mission impact. Additional seal tests on all RV pyro and main batteries on SV-11 and up.	5.3
51	Five of eight heavy load lines failed during retrieval.	Remaining lines adequate; redesign and test to avoid abrasion of lines underway.	5.3
53	TU integrator reset signal lost intermittently.	Operations resumed on 867, with nested operations eliminated for remainder of segment (Day 89).	2.5.3 and 4.1.1
62	REA 3 degraded performance.	Increased fuel consumption. Restricted mono ops to require both OBs to run. Normal ops resumed on Day 82 when transferred to RCS 2.	3.3.2
81	REAS 2, 3, 5, and 8 degraded.	Transfer to RCS 2. Thruster degradation was expected.	3.3.3
97	Anomalous reading of vehicle time code word.	Attributed to intermittent failure of first bit in Type 1 J-box register. Switched to redundant time code word on Day 117.	3.7.4
120–150	Several anomalies occurred as result of solo tests.	These items are included in solo report.	—

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Section III

SATELLITE BASIC ASSEMBLY SUBSYSTEMS

3.1 INTRODUCTION

The following paragraphs summarize the performance of the Satellite Basic Assembly (SBA) subsystems as verified from flight data.

3.2 ATTITUDE CONTROL SYSTEM (ACS)

The ACS performed within specification, and no anomalies are observed during the primary mission. Anomalies observed during SOLO will be discussed in the SOLO report,

3.2.1 BV/SV Separation

BV/SV separation was completed at approximately 545.7 seconds vehicle time (vehicle time started 67.0 seconds prior to liftoff). Master clear off, which enables the pitch, roll, and yaw integrators to accumulate angle, was at 509.8 seconds and SECO, which terminates BV attitude control, occurred at 533.7 seconds vehicle time. The SV attitude changes from SECO to BV/SV separation and the attitude and rates as measured at BV/SV separation are shown in Table 3-1; this table also presents the times in which the SV attitudes and rates came back within the specified limits following BV/SV separation (capture).

Table 3-1

BOOSTER VEHICLE/SATELLITE VEHICLE (BV/SV) SEPARATION

	Rate and Attitude at BV/SV Separation							Capture			
	Rate (Deg/Sec)		Attitude (Deg)					Attitude		Rate	
			H/S at Sep		Δ(SECO to Sep)						
	Spec	Actual	Spec	Actual	Spec	Actual[5] H/S	Actual[5] Integrator	Spec[1] (Deg)	Actual[2] (Time in sec)	Spec[3] (Deg/Sec)	Actual[4] (Time in sec)
Pitch	±0.752	-0.009	+13.0 to -21.7	+2.0	±3.5	0.32	-0.10	±0.70	(6)	±0.014	(6)
Roll	±0.786	-0.222	±10.6	+3.04	±3.5	0.80	0.37	±0.70	(6)	±0.021	(6)
Yaw	±0.752	+0.197	+11.1 to -11.4	–	+4.5 to -3.5	–	2.08	±0.64	(6)	±0.014	(6)

(1) Attitude in degrees to be achieved in 1500 sec.

(2) Actual time required to achieve specified attitude (switch to fine mode + settling time).

(3) Rate in degrees/second to be achieved in 1500 sec.

(4) Actual time required to achieve specified rate.

(5) Relative to the local horizontal.

(6) Nominal performance indicating the pointing requirements are satisfied was observed at a nominal settling time of 520 sec after the commanded switch to fine mode (661 sec after sep). The total 1181 sec is well within the spec of 1500 sec and no closer study was performed.

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3.2.2 Subsatellite/SV Separation

[redacted] Subsatellite separation occurred at 13716.6 sec vehicle time, on Rev 2.9. The ACS parameters just prior to the instant of separation are presented in Table 3-2.

Table 3-2

RATE AND ATTITUDE PARAMETERS [redacted]
SUBSATELLITE SEPARATION

Parameter	Specified	Actual
Pitch H/S	±1.0 deg	+0.02 deg
Roll H/S	±1.0 deg	+0.02 deg
Roll Integrator	—	0
Pitch Integrator	—	+0.11 deg
Yaw Integrator	—	+0.01 deg
Roll Gyro Rate	±0.1 deg/sec	0
Pitch Gyro Rate(1)	±0.1 deg/sec	0
Yaw Gyro Rate	±0.1 deg/sec	0
Maximum rates following separation:		
Roll Gyro Rate		+0.016 deg/sec
Pitch Gyro Rate		-0.004 deg/sec
Yaw Gyro Rate		-0.020 deg/sec

(1)Geocentric Program Rate is Connected.

3.2.3 Payload Operation

SV performance during payload operations was within requirements.

3.2.4 Mapping Camera Module (MCM) Operations

3.2.4.1 MCM Calibration Maneuvers

The calibration maneuvers on Revs 805 and 806 consisted of a 180-degree yaw maneuver, followed by a negative pitch maneuver of 123.0 degrees, followed by three inertial periods, one for each calibration. The duration of the inertial periods were 234, 234, and 250 seconds for calibrations 1, 2, and 3 respectively.

A negative roll maneuver with geocentric rate disconnected was performed after the calibration to return to nose forward horizontal flight. Upon return to geocentric control (horizon sensor connect) the pitch offset was +5.0 degrees indicating successful execution of the calibration sequence. Table 3-3 presents the three calibrations.

3.2.4.2 MCM Recovery

The ST-RV (RV-5) recovery is performed with the SV yawed 180 degrees and pitched down, with the release taking place along the SV X-axis. The vehicle rate and attitude parameters of RV-5 are listed in Table 3-4.

3.2.5 Recovery

The pitchdown maneuvers preceding RV-1 through RV-4 separations were all within specification and are summarized in Table 3-5. The RV separation performance summary is shown in Table 3-6.

Table 3-3

MAXIMUM VEHICLE RATES DURING MCM CALIBRATION

Rev 805

Calibration	Duration ST+ to ST- (sec)	Vehicle Time Frame 1 (sec)	Settling Time (Sec)	Maximum Vehicle Rates During Calibration (Deg/Sec)		
				Pitch	Roll	Yaw
1	219	96279	288(1) 23(2)	0.003	-0.013	0.001
2	219	96807	23	0.004	-0.014	0.001
3	253(3)	97335	23	0.003	-0.013	0.001
Spec	Not to Exceed 300	–	600 Allowed	±0.014	±0.021	±0.014

(1) Time from start of pitch down maneuver to Frame 1

(2) Time from removal of geocentric rate to Frame 1

(3) Time from ST+ to start of return roll maneuver

Table 3-4

RATE AND ATTITUDE PARAMETERS AT RV-5 SEPARATION

Rev 845

Axes	Attitude (Deg)			Rate (Deg/Sec)
	Required	Actual	Source	
Pitch	-63.4 ±3.0	-63.5	Integrator	+0.069(1)
Roll	±1.0	-0.12	H/S	-0.001
Yaw	±1.0	+0.09	Integrator	-0.001

(1) Includes orbital rate

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Table 3-5

PITCH DOWN PERFORMANCE PRECEDING RECOVERY VEHICLE SEPARATION

RV/Rev	Pitch Down Angle		Maneuvering Time To<0.1 Deg/Sec		Pitch Down Coast Rate		
	Required ±3.0 Deg	Actual PDWN	Spec (Sec)	Actual (Sec)	Command Rate (Deg/Sec)	Coast Rate Expected (Deg/Sec)	Coast Rate Actual- PGR (Deg/Sec)
1/261	-35.25	-34.6	150	83.0	-0.705	-0.75 ±0.05	-0.71
2/829	-39.03	-38.1	150	110.0	-0.705	-0.75 ±0.05	-0.69
3/1429	-36.9	-37.2	150	83.0	-0.705	-0.75 ±0.05	-0.72
4/1948	-38.8	-38.5	150	85.0	-0.705	-0.75 ±0.05	-0.71

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Table 3-6

SUMMARY OF RV/SV SEPARATION PERFORMANCE

RV/Rev	Peak Pitch Rate (Deg/Sec)	Max Pitch Integrator Angle (Deg)	Induced Impulse By RV (Lb-Sec)	Pitch Down Prior To Sep (Deg)	Pitch Up Following RV Sep to Removal of Maneuver Command (Deg)	Pitch Inertia After Sep (Slug-Ft^2)	RV Moment ARM (Ft)	Roll Angle	
								Spec (Deg)	Meas H/S (Deg)
1/261	1.34	7.5	127.8	-34.6	98.7	148659	27.2	±1.0	-0.04
2/829	1.40	10.8	137.0	-38.1	98.5	123925	22.1	±1.0	-0.04
3/1429	1.46	8.1	135.6	-37.2	98.6	94179	17.7	±1.0	-0.04
4/1948	1.11	7.1	147.9	-38.5	38.8	84720	11.1	±1.0	-0.04

3.3 REACTION CONTROL SYSTEM (RCS)

3.3.1 Flight Summary

SV-10 was loaded with a total of 543 lb of RCS hydrazine, 262 lb in Tanks 1 and 2 and 281 lb in Tanks 3 and 4. RCS-1 (primary) thrusters were used for attitude control through Rev 1299 when the expected degradation of thrust led to transfer to the RCS-2 (standby) thrusters. The RCS-1 thrusters were operated from Tanks 1 and 2, starting at a feed pressure of 235 psia and blowing down to 100 psia by Rev 1005, when the four tanks were manifolded together. The 100 psia in Tanks 1 and 2 when combined with the 271 psia in Tanks 3 and 4 resulted in a four tank system pressure of 143 psia.

Two anomalies were observed in RCS instrumentation readouts. Three REM temperature monitors exhibited erratic output similar to SV-9 (see par. 3.3.4) and one thrust chamber pressure monitor exhibited zero output (see par. 3.3.5).

3.3.2 Propellant Consumption

RCS propellant consumption averaged 3.1 lb/day through Day 50 when nominal consumption increased to 3.9 lb/day. The increased consumption rate, arising from the degraded REA 3 performance, continued until Day 62 when single bar mono payload operations were curtailed and mono operations were run with both bars operating. This reduced the rate to approximately 2.4 lb/day until Day 80 when RCS-2 thrusters were activated. Normal operation was resumed with RCS-2 thrusters and propellant consumption averaged 2.8 lb/day until Day 120.

Overall propellant consumption has decreased on the last three vehicles from 3.8 lb/day on SV-8 to 3.5 lb/day on SV-9 to an average of 3.0 lb/day on SV-10. Two factors contributing to this decrease have been progressively higher perigee altitudes and reduced atmospheric drag due to lower solar activity.

3.3.3 Thruster Performance

One RCS thruster (REA 3) operating at a high duty cycle and three (REAs 2, 5, and 8) operating at low duty cycles indicated performance degradation prior to the transfer to RCS 2 on Rev 1299. Figure 3-1 is a history of normalized RCS-1 thrust versus rev. The measured thrust at various feed pressures is normalized to a constant pressure of 220 psia and data are selected at a consistent temperature to provide trends as a function of time. The dashed lines represent a ±8 percent tolerance band around the initial on-orbit baseline thrust calculation.

Table 3-7 is a tabulation of thrust values for RCS 2 calculated from gyro rates. The thrust attained during qualification tests is shown with the respective fuel supply pressures available on those revs. Comparison is made for a pair of thrusters, since values of individual thrusters are sensitive to minor errors in roll gyro rate slope and center of mass predictions.

Estimated thruster pulse counts for both RCS-1 and RCS-2 are shown in Table 3-8. Accuracy of total pulse counts on the more active thrusters is estimated to be ±30 percent, while the less active thrusters are only a trend indicator. Pulse count sample frequency and rate preclude a more accurate accounting.

3.3.4 Anomalous Thruster Temperature Readings

Nozzle temperature monitors on REA 1 (B051), REA 5 (B055), and REA 8 (B058) of RCS 1 displayed intermittent high-temperature output discontinuities similar to the SV-9 anomaly. The anomalous readings were first observed during a double OA and yaw around maneuver series on Revs 112 and 113 as thruster temperatures reached between 600^{o}F and 1200^{o}F. These thermocouples are part of the same lot as identified in SV-9 anomalies and the data was typical of a variable resistance resulting from a break in the thermocouple wire.

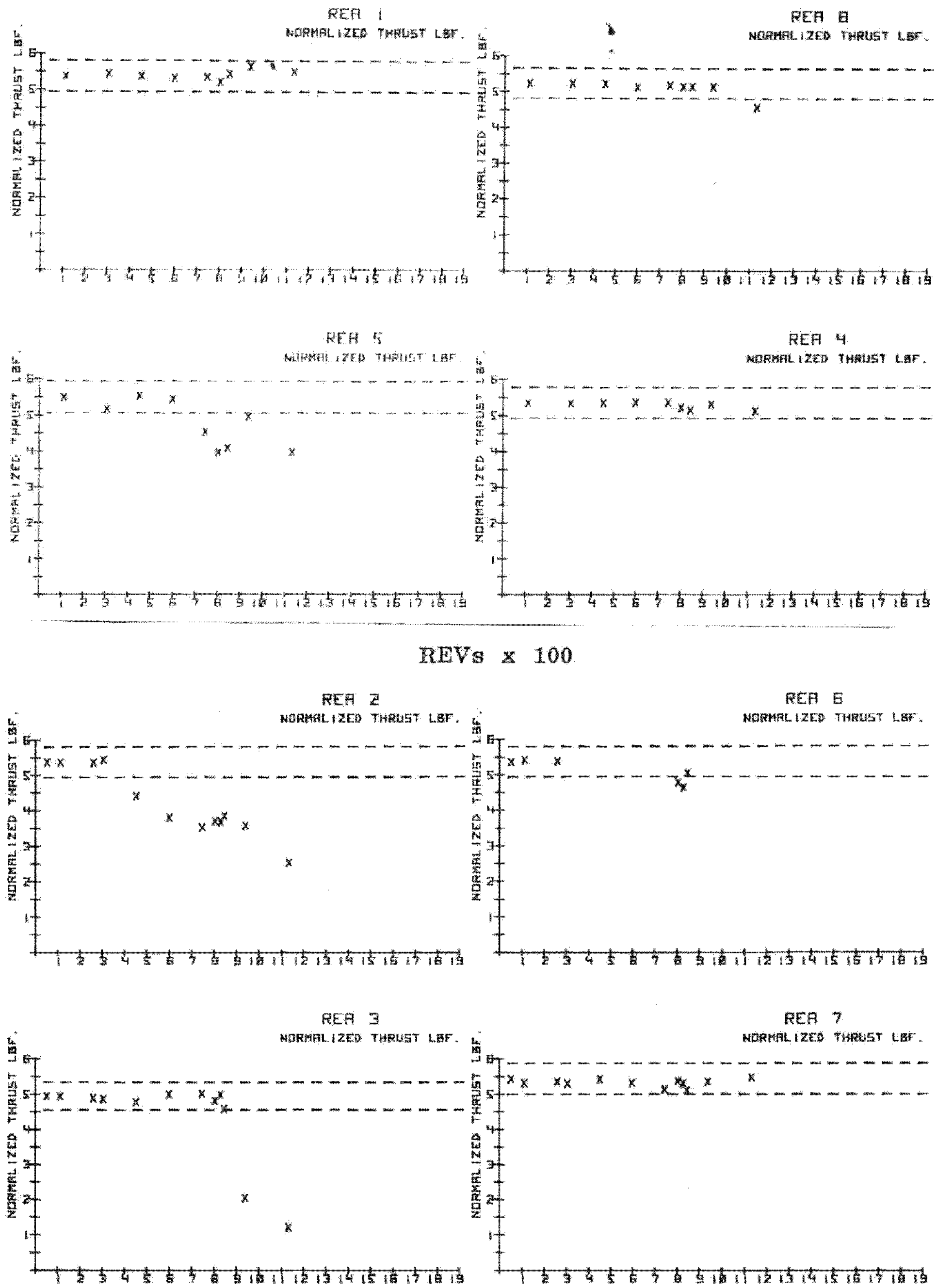

Fig. 3-1 Normalized Thrust vs Rev

RCS-1

Table 3-7

RCS 2 THRUSTER PERFORMANCE

Rev	Feed Pressure (psia)	Thrust – LB_F												Qual Thrust Level Per Pair (LB_F)
		1		8	2		3	4		5	6		7	
1330	132	3.2	(6.4)	3.2				2.6	(5.8)	3.2				(7.0)
1429	128				2.5	(5.9)	3.4				3.6	(6.2)	2.6	(6.8)
1622	119	3.3	(6.5)	3.2				2.8	(6.0)	3.2				(6.4)
1948	113				2.4	(6.1)	3.7				3.5	(6.0)	2.5	(6.4)

(   ) Bracketed values are for the thruster pair

Table 3-8

RCS THRUSTER PULSE COUNTS

Thruster Number	RCS-1 Thrusters (Rev 0 to 1299)		RCS-2 Thrusters (Rev 1300 to 1948)	
	Total Pulses	Pulses/Day	Total Pulses	Pulses/Day
1	54, 000	680	41, 000	1030
2	37, 000	460	17, 000	430
3	152, 000	1900	72, 000	1800
4	17, 000	210	9, 000	230
5	17, 000	210	11, 000	280
6	11, 000	140	6, 000	150
7	117, 000	1460	46, 000	1150
8	28, 000	350	11, 000	280

Table 3-9

OAS PERFORMANCE

OA Firing No.	Rev No.	Impulse Delivered (lb-sec)	Planned ΔV (Ft/Sec)	Achieved ΔV (Ft/Sec)	ΔV Error (Percent)
1	63	5,389	7.69	7.81	+1.6
2	111	30,458	43.98	44.33	+0.8
3	113	13,263	-19.25	-19.39	+0.7
4	159	7,402	10.86	10.85	-0.1
5	209	11,809	17.04	17.34	+1.8
6	263	9,077	14.23	14.38	+1.1
7	306	29,366	46.48	46.62	+0.3
8	308	19,643	-31.18	-31.42	+0.8
9	354	8,831	14.00	14.17	+1.2
10	403	12,416	19.61	19.98	+1.9
11	452	22,144	35.47	35.77	+0.9
12	454	13,726	-22.03	-22.26	+1.0
13	500	12,649	20.14	20.58	+2.2
14	549	10,401	16.77	16.97	+1.2
15	599	21,123	34.42	34.60	+0.5
16	601	11,659	-18.90	-19.17	+1.4
17	646	11,412	18.47	18.82	+1.9
18	695	10,262	16.74	16.97	+1.4
19	744	20,866	34.28	34.63	+1.0
20	746	12,145	-19.91	-20.23	+1.6
21	792	12,070	19.76	20.17	+2.1
22	847	10,176	18.82	19.04	+1.2
23	890	7,583	13.84	14.22	+2.8
24	938	25,199	46.85	47.47	+1.3
25	940	12,527	-23.56	-23.71	+0.6
26	986	9,364	17.47	17.78	+1.8
27	1036	13,495	25.24	25.72	+1.9
28	1084	8,726	16.33	16.68	+2.1
29	1133	23,478	44.64	45.09	+1.0
30	1135	8,683	16.79	-16.75	-0.2
31	1182	6,904	13.13	13.35	+1.7
32	1230	12,324	23.46	23.89	+1.8
33	1278	9,233	17.77	17.96	+1.1
34	1328	23,227	44.73	45.39	+1.5
35	1330	10,432	-20.42	-20.47	+0.2

Table 3-9 (Cont)

OA Firing No.	Rev No.	Impulse Delivered (lb-sec)	Planned ΔV (Ft/Sec)	Achieved ΔV (Ft/Sec)	ΔV Error (Percent)
36	1376	11,815	22.75	23.27	+2.3
37	1431	10,852	23.60	23.77	+0.7
38	1474	10,586	23.00	23.27	+1.2
39	1522	13,506	29.42	29.81	+1.3
40	1570	14,372	31.58	31.86	+0.9
41	1620	19,346	42.74	43.12	+0.9
42	1622	9,244	-20.76	-20.69	-0.3
43	1668	8,845	19.49	19.86	+1.9
44	1717	11,261	25.00	25.38	+1.5
45	1737	6,687	15.22	15.11	-0.7
46	1782	6,660	15.10	15.09	-0.1
47	1830	18,885	42.60	42.97	+0.9
48	1879	6,826	15.40	15.59	+1.2
49	1936	7,029	16.00	16.11	+0.7
End of Active Mission — Rev 1948					
50	1951	7,784	20.00	20.09	+0.5
51	1961	8,367	21.17	21.65	+2.3
52	1993	8,214	21.14	21.32	+0.9
53	2025	8,235	21.14	21.45	+1.5
54	2059	5,741	15.00	15.00	0
55	2090	8,081	21.26	21.17	-0.4
56	2123	6,957	18.24	18.29	+0.3
57	2154	7,450	19.04	19.65	+3.2
58	2187	6,006	15.69	15.66	-0.2
59	2220	11,073	29.31	29.41	+0.3
60	2300	24,909	66.00	65.670	-0.5
61	2436	45,349	123.1	Deboost	

To be consistent, the pressure for computing the REA thrust is read at 900°F. For the REAs with the unreliable thermocouples, the time at which the temperature reached 900°F was estimated and the thrust was calculated based on the pressure at that time. Redesign of the thermocouple and improved inspection techniques have been instituted for Block III REM's.

3.3.5 Anomalous Thrust Chamber Pressure Reading

The thrust chamber pressure monitor on REA 6 (B006) read zero on Rev 146 and then remained zero. This is the first time an in-flight pressure transducer zero output has occurred.

Failure analysis has identified the most probable failure mode as a short circuit caused by either (1) shorted output capacitor or (2) input diode and/or transistor open circuit. The only similar failure was during SV-5 ground tests when a faulty weld in a yaw transducer resulted in zero output.

The thrust for REA 6 was determined by evaluating gyro rate data for REAs 6 and 7 as a pair and then subtracting the thrust level of REA 7 derived from the REA 7 pressure instrumentation. Block III REM pressure transducers are being supplied by Electro Development Corporation rather than Bourns and starting with SV-14 will include hi-rel electronic parts that receive 250 hours of burn-in at the transducer level.

3.4 ORBIT ADJUST SYSTEM (OAS)

3.4.1 Orbit Control

During the active mission, the OAS was fired 49 times. The firings were all normal and engine performance was well within specifications. The catalyst bed pressure drop history was similar to that of other flight engines. As can be seen in Table 3-9, OAs occurred every 3 days, with an adjustment in perigee location every 9 days.

The average propellant usage during the active mission was 22.8 lb/day. A total of 2719 lb of propellant was used that resulted in 643,376 lb-sec of impulse being imparted to the SV. There were 12 additional firings during the solo mission.

3.4.2 Deboost

The deboost was successfully accomplished on Rev 2436 with a 200-second firing, followed in 5 seconds by a firing of 139.8 seconds. The engine was not run to fuel depletion.

3.5 LIFEBOAT II SYSTEM

Lifeboat magnetometer predictions (DG MAP), together with the observed values, are shown in Table 3-10. The Q magnetometer instrumentation bias is less than 3 milligauss so that no data corrections are required and the equivalent attitude error of the Q sensor is less than 1 degree. The equivalent attitude error of the P magnetometer was less than 0.5 degree and that of the R magnetometer less than 0.4 degree. The three rate gyros were within 0.04 degrees/sec of the rates monitored on the ACS gyros.

Due to failure of the RCS No. 1 to recapture the vehicle after it tumbled on Rev 2433, vehicle deboost was successfully accomplished under Lifeboat control on Rev 2436. No anomalies were noted.

3.6 ELECTRICAL DISTRIBUTION AND POWER (EDAP)

3.6.1 Solar Arrays

Solar arrays were extended on Rev 1. Power output from each leg exceeded the specification value. Degradation of the solar arrays was 2.3 percent in 30 days, 3.4 percent in 60 days, and 4.9 percent in 140 days.

Table 3-10

LIFEBOAT MAGNETOMETER PREDICTION CHECKS

Rev Location	Mode*	Milligauss						Degrees per Second					
		Q Magnetometer		R Magnetometer		P Magnetometer		Y Axis Gyro		X Axis Gyro		Z Axis Gyro	
		Observed	DGMAP	Observed	DGMAP	Observed	DGMAP	Observed	ACS	Observed	ACS	Observed	ACS
18 ≈22°N 163°W	S-N, DB S-N, RX S-N, DB	-29 -29 -26	-22.6 -22.6 -21.2	Positive Saturation Not in Use -206.7	 -211.5	Not in Use Negative Saturation Not in Use							
261 ≈58°N 148°W	N-S, RX	-41	-35	Not in Use		148	150						
829 ≈60°N 154°W	N-S, RX	-29	-26.1	Not in Use		192	190.9	1.41	1.37	0.04	0.029	-0.05	0.004
845 ≈48°N 152°W	N-S, DB	26	33.8	6	7.3	Not in Use							
1429 ≈64°N 149°W	N-S, RX	29	-26.1	Not in Use		Positive Saturation							
1966 ≈68°N 146°W	N-S, RX	32	-28.6	Not in Use		Positive Saturation		0.82	0.83	-0.01	-0.04	-0.03	0

*DB indicates deboost. RX indicates Recovery

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3.6.2 Main Bus Voltage

The main bus voltage varied from a low of 26.2 to a high of 31.6 volts. The allowable range is 25.5 to 33.0 volts. The minimum bus voltage was observed during payload operations, with a bus load of 94 amps. The high voltage was observed during charge cycles.

3.6.3 Power Capability and Usage

Power usage ranged from 312 to 425 amp-hours/day. The solar array generating capability (399 amp-hours/day) was exceeded on two occasions. The first K2 (90 percent capacity) was achieved on Rev 4 and K2s occurred periodically through Rev 22. Increased sensor system operations (20 percent more than experienced on previous vehicles) on Days 2 and 3 made power usage exceed generation and the main bus battery capacity reached a minimum of 65 percent. Recovery to 90 percent took 43 revs (K2 on Rev 66).

A mapping camera module (MCM) relay failed to release on Rev 59. It was freed on Rev 61 and then, after sticking several times, failed permanently during Rev 153. This anomaly added a load of 3.5 amp-hours per rev, reducing the available system capacity. Power usage exceeded generating capability until on-off cycling of the power to the MCM system through the MCM K-1 relay was instituted. By having the power on for several revs (during which the MCM operations were conducted) and then off for several revs, the MCM temperatures were limited to an acceptable range and power was conserved until RV-5 was recovered on Day 53. After the relay stuck, on Day 11, it took 16 revs to recover to 90 percent capacity. During this period the [redacted] were restricted to periods when the tape recorder was on for other reasons to conserve power. After RV-5 recovery, K2s occurred on essentially every rev.

3.6.4 Type 29 Battery Performance

Batteries 1, 2, and 4 operated at a temperature of 45° to 51°F. The thermostat on Battery 3 malfunctioned on Rev 400 and erratically turned the heaters on and off so that Battery 3 ranged in temperature from 40 to 48°F. Since Battery 3 was at a lower temperature than the other three batteries, it had fewer K2 openings. The malfunction is similar to the thermostat malfunction that occurred on SV-6; it is believed to be due to a condition known as "creep," which affects the bimetallic disk within the thermostat.

3.6.5 Pyro Battery Performance

The pyro batteries stabilized at a temperature of 48°F, which minimized self discharge during the mission. Liftoff capacity was 10.90 amp-hours. A total of 6.0 amp-hours per battery remained at the end of 121 mission days.

3.6.6 Lifeboat Battery Performance

The Lifeboat Battery operated normally in a 50°F environment throughout the entire mission. A total of 218.54 amp-hours remained at the end of 121 mission days from an initial 370.46 amp-hours at launch.

3.6.7 Current Signal Integrator (CSI) Evaluations

Four CSIs were added to SV-10, one to each Type 29 Battery circuit. Each CSI counts the solar array (SA) charge amp-hours and the main bus discharge amp-hours for its associated battery and the difference of the readings gives the change in the state-of-charge (SOC) during the period of observation. Summation of the four gives the SOC of the battery system.

SV-10 (as on previous vehicles) was instrumented with a solar array amp hour unit (SA-AHU) that counts the total amp-hours generated by the SA and a main bus amp hour unit (MB-AHU) that counts the total amp-hours used by the main bus. The difference gives the value of the SOC change of the battery system.

Table 3-11 compares the two systems by determining the rate at which the CSIs deviate from the SA-AHU and MB-AHU system. This rate shows a range of -0.219 to +0.140 amp hours per hour. This is much less than the specification requirement of one amp-hour per hour.

Two reliable systems for determining the SOC are now available; however, more effort and time is required using CSI data since 16 rather than 2 telemetry points are monitored.

3.7 TRACKING, TELEMETRY AND COMMAND (TT&C)

3.7.1 Tracking

Excellent tracking performance was maintained throughout the flight mission. Because of the low transmitter signal strength reported on SV 8, health tests were performed once a week on SGLS 2. Figure 3-2 is a plot of the signal strength measurements made at HULA throughout the mission.

3.7.2 Telemetry

Telemetry system performance was satisfactory throughout the flight mission.

3.7.3 Tape Recorders

Both tape recorders operated satisfactorily throughout the flight mission.

3.7.4 Instrumentation

Table 3-12 presents the instrumentation anomalies at liftoff.

Table 3-11

ERROR RATE FOR CURRENT SIGNAL INTEGRATORS

Revs Evaluated (1)	SA Generated Minus MB Usage (Amp Hrs) (2)	Sum of Four Battery CSIs (Amp Hrs) (3)	Difference Col (2) − Col (3) (Amp Hrs) (4)	CSI Error Rate Col (4) / Col (1) (in Hrs) (Amp-Hrs/Hr) (5)
6 - 14	0	-0.50	+0.50	+0.042
22 - 66	-14	-12.50	-1.50	-0.023
73 - 80	-2	-1.75	-0.25	-0.024
154 - 182	-15	-14.00	-1.00	-0.024
199 - 208	-8	-6.00	-2.00	-0.148
215 - 224	-10	-8.75	-1.25	-0.093
231 - 241	-3	-2.50	-0.50	-0.033
247 - 256	-3	-3.50	+0.50	+0.037
265 - 274	-1	-0.50	-0.50	-0.037
280 - 290	-4	-4.50	+0.50	+0.033
293 - 305	+1	-0.75	+1.75	+0.117
307 - 323	-12	-4.75	-5.25	-0.219
324 - 339	-3	-2.00	-1.00	-0.044
343 - 356	-3	-4.75	+1.75	+0.097
360 - 372	-3	-3.50	+0.50	+0.028
376 - 387	-3	-2.00	-1.00	-0.061
392 - 405	0	+1.25	-1.25	-0.064
407 - 419	-2	-0.50	-1.50	-0.028
425 - 436	-2	-0.25	-1.75	-0.106
442 - 451	-3	-2.75	-0.25	-0.019
456 - 467	-5	-3.00	-2.00	-0.121
477 - 483	+1	+1.00	0	0
490 - 500	-1	-0.25	-0.75	-0.050
506 - 516	-2	-2.75	+0.75	+0.050
803 - 810	-2	-1.50	-0.50	-0.048
2222 - 2241	-9	-13.00	+4.00	+0.140

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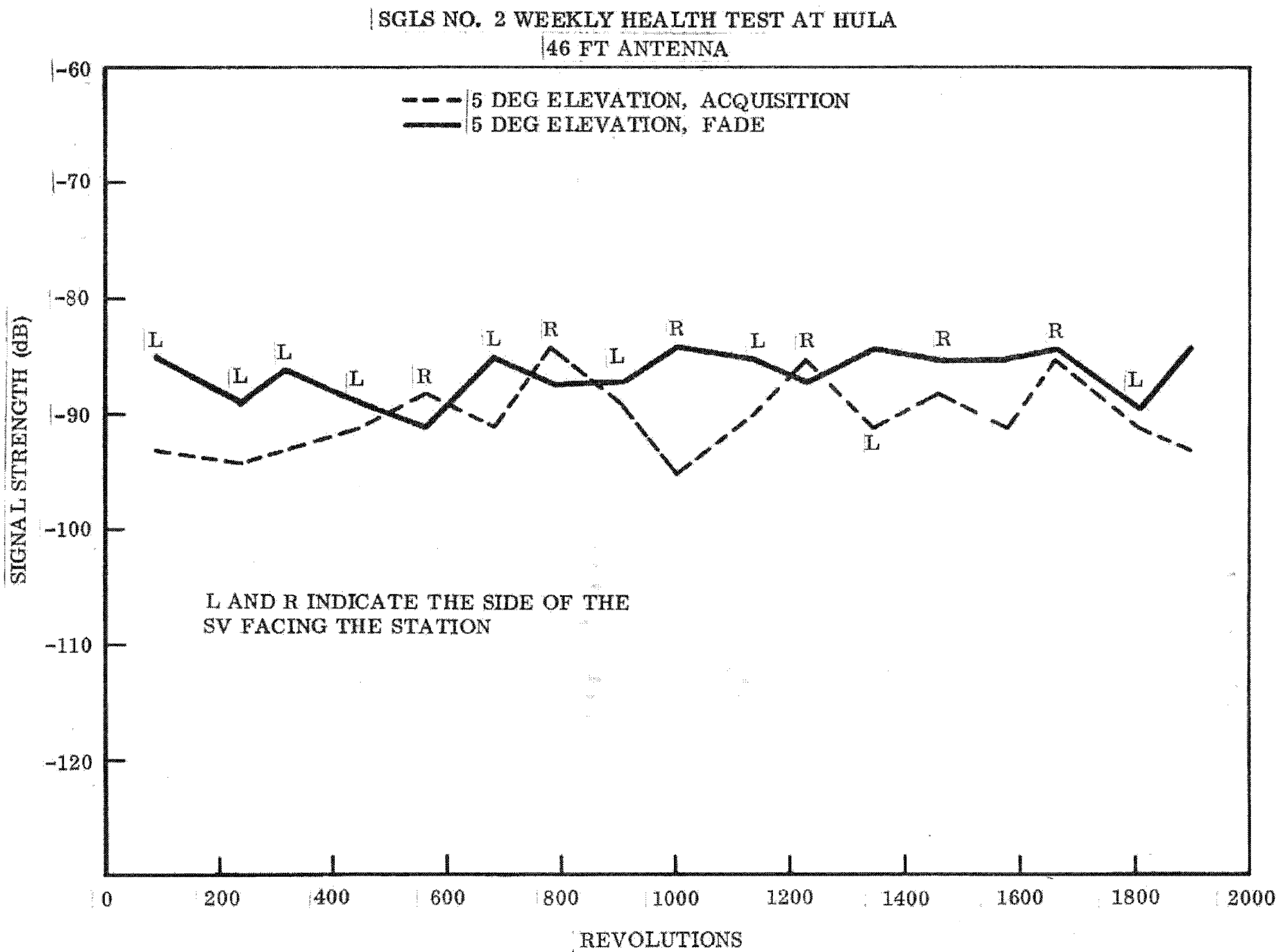

Fig. 3-2 Signal Strength Measurements at HULA

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Table 3-12

INSTRUMENTATION ANOMALIES AT LIFTOFF

Monitor	Item	Condition
A050	Horizon Sensor Shield Temp	Inoperative
B007	Primary REA 7 Chamber Pressure	May oscillate ±4 psi
B502	OAS Propellant Tank Pressure	At 17 psia, monitor oscillated ±4 psi in thermal vacuum chamber
D204	Y Axis Rate Gyro	May fail for one sample with FA Operate ON
H011	PCM MU 2 Format Indicator	Has up to 0.18 vdc offset in the power off state
S287	B Mode	a. May fail for one sample with FA Operate Off b. May fail with B mode select command
S288	SI Thermal Zone Monitor	May fail to a "1" state for one sample with FA Bus Off

During Rev 112 REA 5 Primary Chamber Temperature (B55) reading was inoperative at high temperatures. Also during Rev 146 REA 6 Primary Chamber Pressure indicated no pressure. The readings were found to be anomalous also when the redundant side of the telemetry remote unit was programmed and the failure is considered to be in the thermocouple and transducer assemblies.

During Rev 1573 anomalous readings of the primary vehicle time code word was observed. The anomalous readings continued until Rev 1894, when the redundant time code word was programmed. An analysis was accomplished and an intermittent failure of the first bit of the first 8-bit shift register in the Type 1 J-box is considered as the most probable cause. The failure is still under investigation.

3.7.5 T&T Equipment On/Off Cycles and Operating Time

The utilization through Rev 1948 of selected T&T equipment is provided:

Equipment	On/Off Cycles	Operate Time (hours)
SGLS 1	2215	205.50
SGLS 2	35	1.02
PCM 1	9702	657.25
PCM 2	23	1.98
T/R 1	9097	522.57
T/R 2	141	18.79

3.7.6 Command

3.7.6.1 GFE Command System (ECS)

The ECS executed all required SPCs in memory and realtime commands. The total SPC commands loaded during the primary mission were 279,802 of which 118,445 were executed. The remainder were erased.

3.7.6.2 Minimal Command System (MCS)

The MCS executed all commands correctly during the primary mission.

3.7.6.3 Remote Decoder/Backup Decoder

The remote decoder was used for each of the four recoveries. The performance of both channels was verified from telemetry to be proper in each case. The backup decoder operational capability was verified during health checks.

3.7.6.4 Command System

Usage summary through Rev 1948

System	Total Operating Time (Hours)
ECS	2880.8
MCS	4.5
Remote Decoder	17.1
Backup Decoder	0.05

3.8 MASS PROPERTIES

A history of SV mass properties throughout the flight is tabulated in Table 3-13.

3.9 PREFLIGHT WINDS ALOFT LOADS ANALYSIS

Table 3-14 presents a chronological tabulation of the prelaunch winds aloft loads analysis for SV-10; the results are plotted in Fig. 3-3. The analyses are based on Rawinsonde balloon soundings taken on the 7 and 8 June 1975. All parameters were well within limits at all times and all recommendations were "Go-Continue Count" and finally "Go For Launch."

3.10 SOLAR ARRAY (SA)

Deployment and erection of the left (-Y) SA is shown in Fig. 3-4 and for the right (+Y) SA in Fig. 3-5. The arrays were deployed at the first station pass, INDI, and since they were in the +18° position which is optimum for Beta angles greater than 10°, they were not repositioned for the Beta angles during the flight which began at +21.6 and ranged between +21.9 and +25.6 degrees for the entire flight.

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Table 3-13

SV-10 MASS PROPERTIES

Description	Weight (lb)	Center of Gravity (inches)			Moment of Inertia (slug-ft²)			Product of Inertia (slug-ft²)		
		SV Sta	$\overline{Y}$	$\overline{Z}$	I_x	I_y	I_z	I_{xy}	I_{xz}	I_{yz}
At Launch	25366	1978.2	1.41	3.94	7217	209046	208769	-818	-106	-76
Separated From S-2	22347	1989.9	1.61	4.44	5016	176441	176072	-720	188	-80
Arrays Deployed +18°	22347	1990.3	1.61	4.44	6201	177535	178295	-717	198	-305
After +Y Subsatellite Ejection	22217	1991.4	1.38	4.60	6137	176608	177348	-916	334	-275
Prior to Drop 1	21875	1980.5	1.40	5.19	6104	181801	182550	-992	626	-279
After Drop 1	20342	2003.4	1.51	4.28	5903	148739	149624	-844	-685	-273
Prior to Drop 2	19208	1984.8	1.59	5.28	5840	146309	147222	-981	-790	-279
After Drop 2	17628	2006.6	1.72	4.19	5631	124130	125183	-847	-1890	-272
After Drop 5	17221	2015.2	1.78	5.07	5505	110663	111819	-761	-687	-281
Prior to Drop 3	16291	1998.0	1.89	5.55	5476	108315	109461	-874	-185	-284
After Drop 3	14714	2018.5	2.09	4.28	5268	94304	95587	-742	-1045	-275
Prior to Drop 4	14020	2004.3	2.19	5.21	5285	91590	92843	-837	-933	-282
After Drop 4	12490	2020.5	2.46	3.74	5080	84862	86250	-733	-1526	-272
Prior to Deboost	11944	2013.4	2.57	3.91	5077	81821	83209	—	—	—

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Table 3-14

WINDS ALOFT ANALYSIS SUMMARY

	Balloon Release Time (Hrs)				
	T-30	T-12	T-6	T-3	T-0
	Available Computer Analysis at STC Time (Hrs)				
	T-24	T-8.5	T-3	T-1	---
SV Structural Loads:					
Bending Mom, % Limit Load	50.44	52.15	52.31	56.44	56.20
Critical SV Station	1902.	1902.	1902.	1902.	1902.
Elapsed Time, Seconds	63.60	60.93	49.65	58.20	52.59
Altitude, Feet	45,608.	41,961.	28,330.	38,548.	31,677.
SRM Side Force:					
% Allowable	34.84	35.79	38.61	43.40	36.75
SRM No.	1	1	1	2	2
Pitch or Yaw	Pitch	Pitch	Pitch	Pitch	Pitch
TVC Usage for Control:					
% Allowable Expended	56.61	63.92	49.05	50.67	51.51
SRM No.	1	1	2	2	2
Vehicle Response:					
Maximum $\bar{\alpha}$q, % Allowable	26.79	33.38	31.02	27.38	33.17
Maximum $\bar{\alpha}$q, deg-psf	924.24	1053.1	1271.7	1115.06	1292.55
Elapsed Time, Seconds	63.4	34.17	58.15	58.55	61.00
Altitude, Feet	45,312.	13,417.	38,497.	38,998.	42,167.

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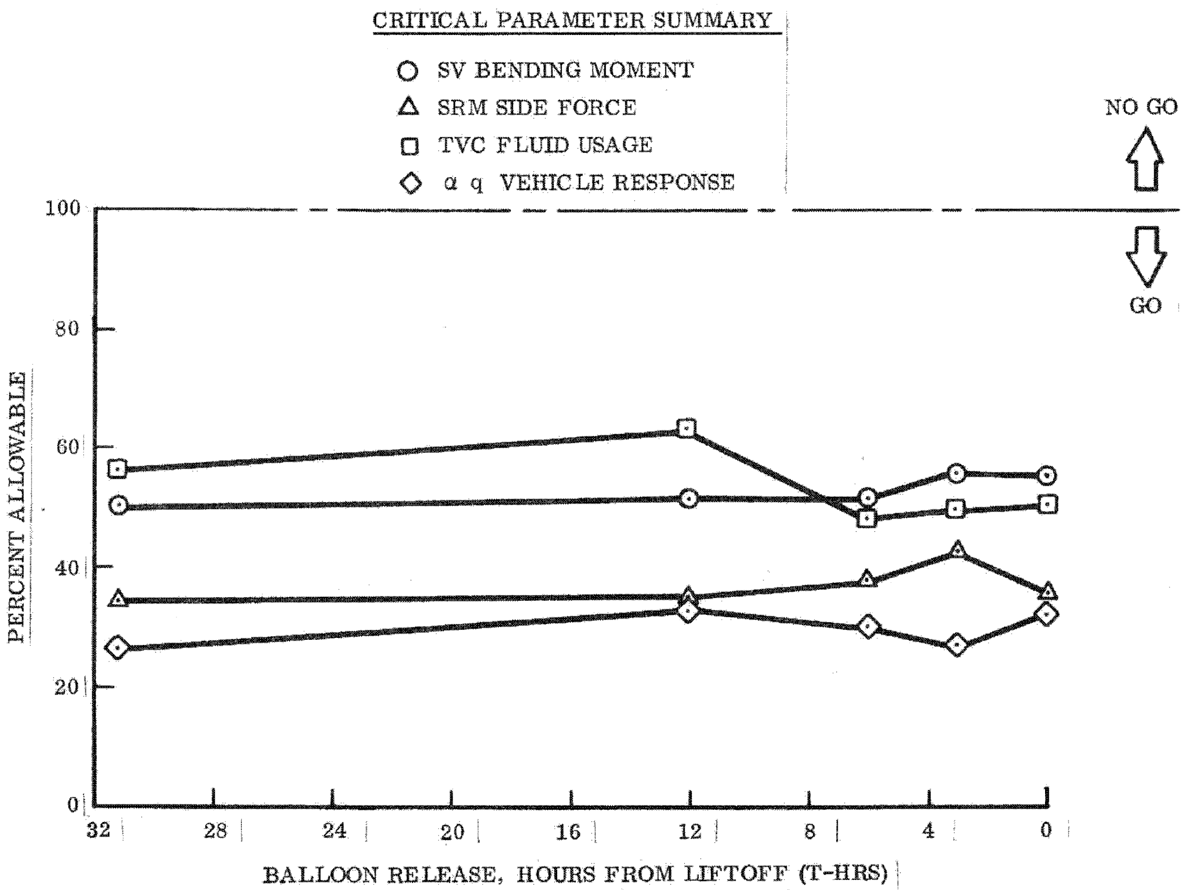

Fig. 3-3 SV-10 Critical Launch Parameter Summary

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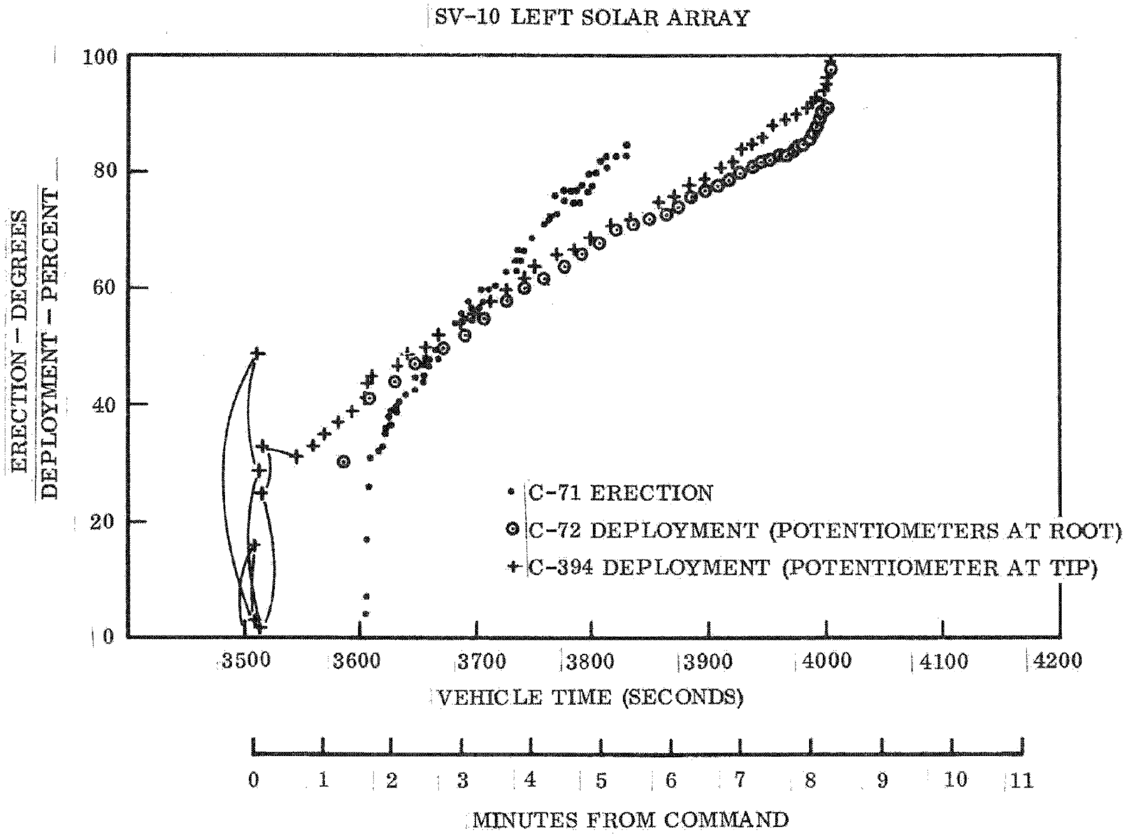

Fig. 3-4 Left Solar Array Erection and Deployment Time Histories

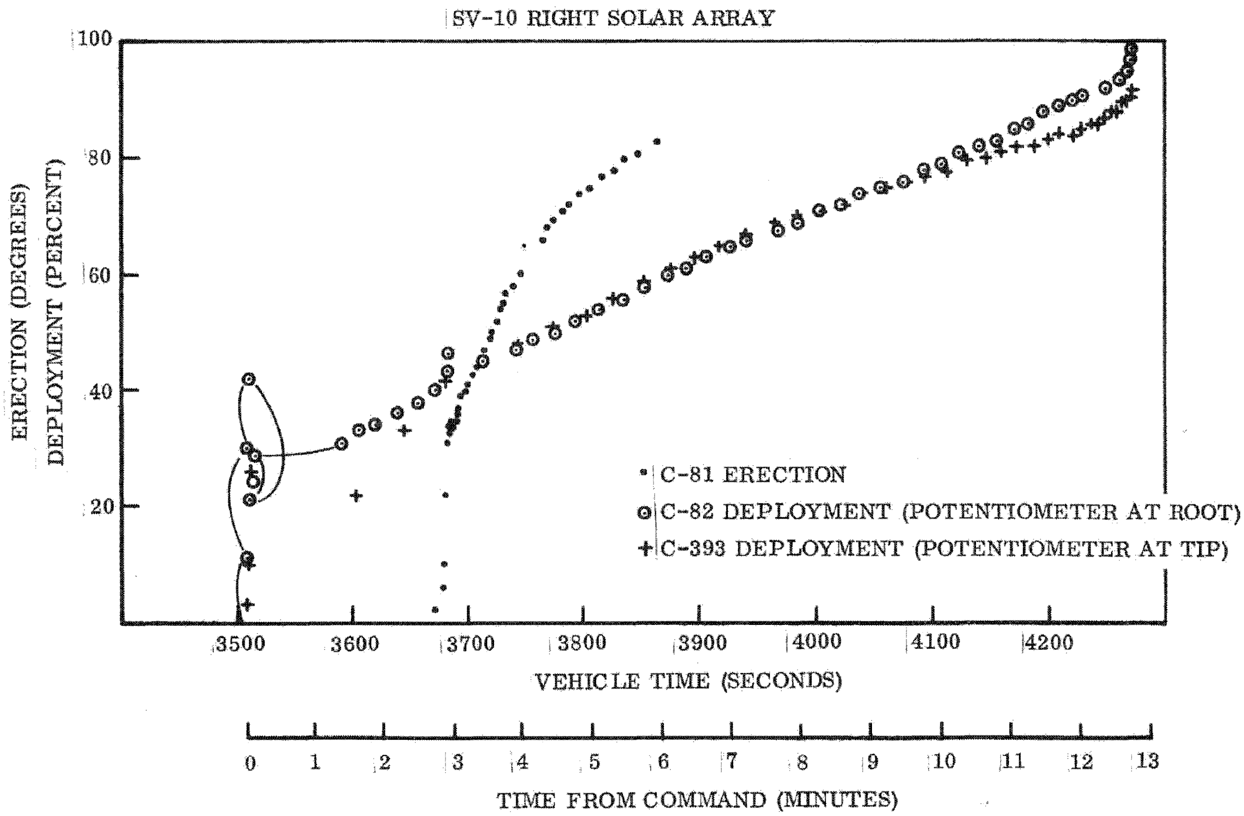

Fig. 3-5 Right Solar Array Erection and Deployment Time Histories

3.11 THERMAL CONTROL

3.11.1 Mid and Forward Sections, Including MCM

The flight temperatures together with design limits are summarized in Table 3-15. These data show that the average section temperatures are well within the design limits, except for the ST-RV takeup unit after the K-2 relay failure on the MCM. The T_{ENC} temperature exceeded the design limit for short periods during the duty cycling of the MCM equipment using the K-1 relay with concurrence of MCM personnel. For effect on MCM see par. 4.4.

3.11.2 Aft Section

Acceptable aft section temperature control was maintained throughout the flight. All equipment temperatures remained within design limits as shown in Table 3-16.

The thermal design of the SV-10 aft section was the same as SV-8 and SV-9. The resulting flight temperatues were similar to SV-8 at the beta range of 21.2 to 25.4. There were no thermal anomalies.

Figure 3-6 shows orbit average flight temperatures with preflight predictions made for two cases: (1) uncontaminated surface properties, and, (2) contaminated properties representative of the maximum levels of contamination observed in previous flights. The overall level of contamination on the equipment sections (as inferred from these predictions) is higher than has been observed on any previous flight. Recent flight history is being examined to determine if higher contamination levels are to be expected. ?

Table 3-15

THERMAL DATA SUMMARY

Vehicle Section	Parameter	Design Limits	SV-10 Actual	
Mid Section	T_{TCA}	44/91	64*	
	T_{SU}	47/93	67*	
	$T_{SU}-T_{TCA}$	5/-4	3	
Forward Section	T_{FWD}	47/93	70/72*	
	$T_{FWD}-T_{TCA}$	±20	8	
MCM			Rev 59 Before MCM Anomaly	Rev 277 After MCM Anomaly
	T_{ENC}	32/69	52	68
	T_{TP}	30/85	42	133
	DBS Panel	32/90	60	74

T_{TCA} = Orbit average radiation temperature of the TCA compartment structure

T_{SU} = Orbit average radiation temperature of the SU compartment structure

T_{FWD} = Orbit average temperature of each forward section bay based on the average temperature of the bulkheads

T_{ENC} = Orbit average temperature of the MCM enclosure

T_{TP} = Orbit average temperature of the ST-RV takeup

(Temperatures are in ^{o}F)

*Based on orbit average temperatures from Rev 278 (stabilized thermal conditions). During remainder of active mission these temperatures did not change by more than $3^{o}F$.

Table 3-16

AFT SECTION CRITICAL COMPONENT TEMPERATURES (°F)

Critical Component	Design Limits	SV-10 Predictions (1)	SV-10 Actuals (2)
Power Distribution Junction Box	-30/165	76	72/84
Charge Current Controller 2	-30/170	87	90/103
Type 29 Batteries, Bay 3	35/70	48(3)	41/50
Type 30 Battery	30/90	48(3)	50/53
Type 31 Batteries	40/90	48(3)	45/49
Type 29 Batteries, Bay 4	35/70	48(3)	40/50
Horizon Sensor Assembly Heads	0/130	68/77(4)	77/88
Inertial Reference Assembly	50/130	101/106(4)	102/112
Pulse Code Modulator Master	-30/170	90	72/102
Tape Recorders	20/120	77/81	79/97
Transmitters	-30/170	88/79	81/95
Extended Command System Clocks	40/153	105/111	103/112
Programmable Memory Unit A	-40/145	93	90/98
Programmable Memory Unit B	-40/145	103	101/108
Inertial Reference Assembly Gyros	50/200	–	138/161
Minimal Command System	-40/149	84	75/88
Reaction Control System Tanks	40/140	71/103	69/105
Plumbing, Bay 6	35/140	89/94	79/96
Plumbing, Bay 12	35/140	81	79/90
Orbit Adjust Tank	70/100	87	70/99
Positional Drive Assembly	-30/160	47	58/97
Solar Arrays	-125/225	–	-76/152
Quad Valve	40/225(5)	–	107/202

(1) Predicted temperature is for the orbit average; multiple temperatures indicate multiple points

(2) Stabilized temperature ranges not including launch transients

(3) Temperature controlled by heaters

(4) Prediction assumes dual IRA operation (primary ACS and redundant IRA only)

(5) 200°F has been used for thermal checks on previous vehicles. Review of this value in view of the SV-10 actuals indicates that 225°F more nearly represents the value demonstrated in ground tests

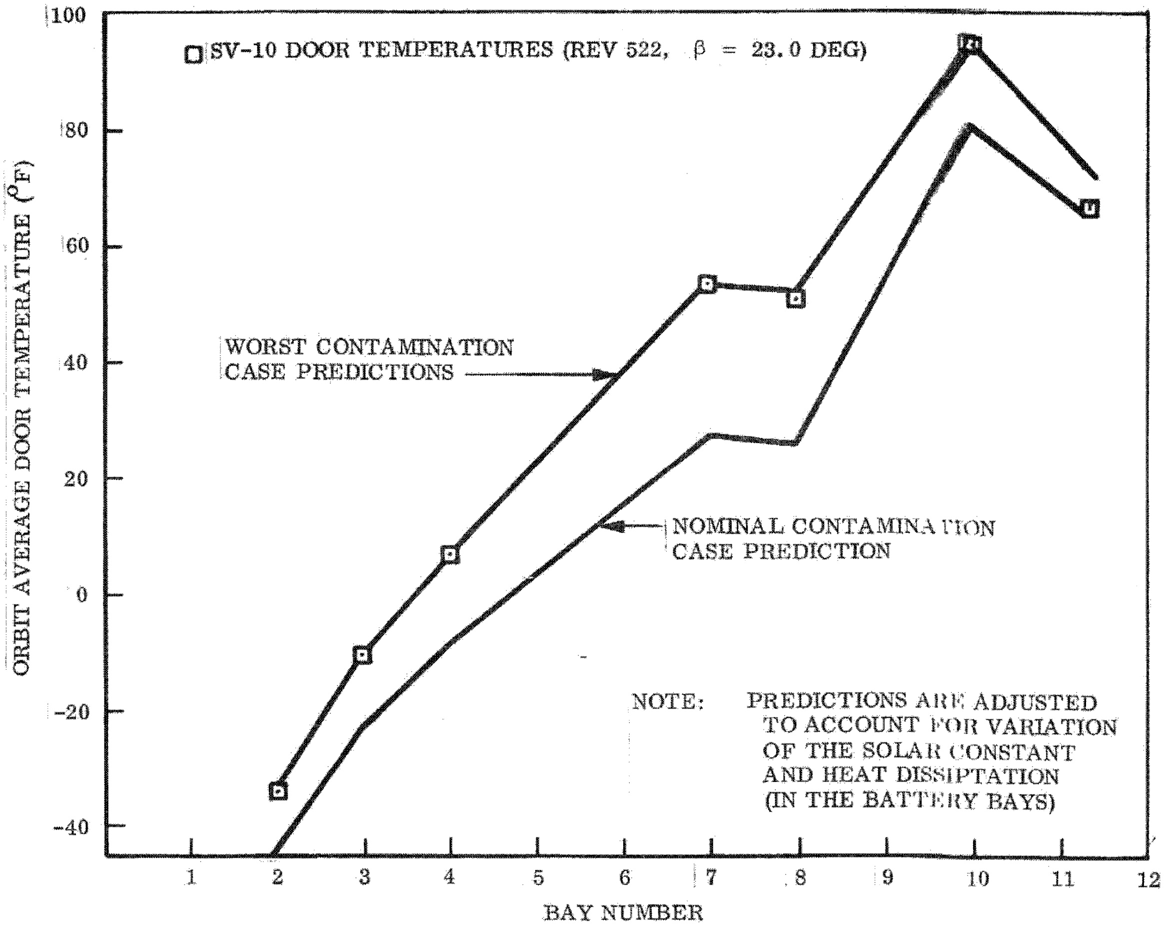

Fig. 3-6 SV-10 Equipment Section Door Temperatures

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Section IV
PAYLOADS

4.1 SENSOR SUBSYSTEM

4.1.1 Coarse Film Path

Both coarse film paths (supply, loopers, steerers, articulators, and takeups) exhibited nominal operation throughout the mission except for an aft-looking camera takeup malfunction in segment 3. This malfunction was determined to be the loss of the takeup integrator reset signal identical to that experienced in segment 4 of SV-8. Camera subsystem performance was not affected, but nested operations were constrained for the remainder of Segment 3 after the failure was observed.

4.1.2 Fine Film Path

Both fine film paths performed nominally throughout the mission.

4.1.3 Command and Control

The command and control subsystem functioned nominally through the mission, except for a malfunction of a power distribution system relay, which caused an ESD on Rev 433 in Segment 2. Analysis of data showed that power to the aft-looking camera was not being properly applied. Various health operations succeded in restoring power to the aft-looking camera; normal operations were resumed on Rev 461 and continued throughout the remainder of the mission.

On-orbit attitude adjust corrections determined by post-flight analysis were implemented in Segments 2 and 3.

4.1.4 Optical Bar Performance

Mechanical and optical performance of both optical bars was nominal throughout the mission with the optical performance of the forward looking camera being superior at all times.

4.1.5 Pneumatics Subsystem

The pneumatics subsystem performed normally throughout the mission.

4.2 TERTIARY PAYLOADS

[redacted] system performed satisfactorily throughout the planned mission. Vehicle support of the system (power, commands, telemetry, tape recorder, thermal environment, etc.) was provided satisfactorily in accordance with the system requirements. Six calibrations were successfully accomplished through Rev 1680.

4.3 SUBSATELLITE PERFORMANCE SUMMARY

[redacted] subsatellite was carried into orbit on SV-10. The 148.8 lb P-226 subsatellite (130.4 lb separable) was carried on the +Y side of the SV-10 forward section. Separation of this subsatellite occurred at Rev 2.9 (31.5 degrees south latitude on an ascending node). [redacted] subsatellite separation was accomplished at 118 seconds after the third SV apogee (vs requested separation time of 53 seconds ±30 seconds, based on predicted nominal SV orbit parameters). The subsatellite went on to achieve its intended orbit.

4.4 MAPPING CAMERA SUBSYSTEM

There were three anomalies encountered in the performance of the sixth ST camera system flown on SV-10.

The first was the sticking of the K-2 relay on Rev 59 which after intermittent operation closed permanently on Rev 153. This resulted in continuous power being applied to the takeup and supply torque motors whenever K-1 (main bus) was closed for power to be supplied to the MCM. This caused the film and associated hardware to rise in temperature. Realtime management and control of temperatures was accomplished by cycling power on to the MCM by operating K-1. Camera and film temperatures were kept within limits that from post flight inspection of the film indicate neither photographic degradation nor grammetric distortion.

The second anomaly was a sticking of the K-3 relay, which supplies power to the terrain and stellar film transport clutches. This stuck closed (power on) from Rev 561 to Rev 640. There was no detrimental effect from the failure, as it worked to keep temperatures up on equipment that cooled excessively when power was off to the MCM (K-1 open).

The third anomaly was a failure of the stellar transport to takeup film for two cycles on Rev 755. It performed perfectly for the rest of the flight. The result was a jamming up of two frames of film, which then straightened out and no deterioration of the film was observed in post-flight analysis. Further testing is being conducted, but the anomaly is thought to be due to a momentary mechanical bindup in the takeup possibly induced by the increased operating temperature arising from the K-2 anomaly.

The sticking of the relays (K-2 and K-3) was attributed to contact pitting. Consequently, Zener diodes have been added to the coil circuits of the K2 and K3 relays and blocking diodes to the MISEA box to eliminate the contact pitting.

Section V
REENTRY VEHICLE SUMMARY

5.1 SUMMARY

The recovery statistics are shown in Table 5-1 and Fig. 5-1. Performance of the RV subsystems is summarized in Table 5-2. All RV on-orbit and reentry events occurred as planned, and the RV flights followed the predicted trajectories. All four recoveries terminated in aerial retrieval at locations near the PIP.

The takeup core pins were sheared on both sides on all RVs. Aerial retrieval loads exceeding the core pin strength are expected.

All subsystems performed satisfactorily and met all mission requirements, see Table 5-2.

5.2 REENTRY VEHICLE PERFORMANCE

All RV on-orbit functions were normal and occurred on time. The SV provided a satisfactory pitch angle for each RV separation. All other SV/RV interface functions were nominal.

The RVs were adequately spin stabilized during the vacuum coast phase and aerodynamically stable during the atmospheric phase of the reentry trajectory. Figure 5-1 shows the entry conditions at the time of drogue deployment which are also within the design envelope. Post-flight examination revealed three secondary discrepancies as noted in par. 5.3.

Table 5-1

RV RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
RV Serial Number	44	45	42	41
Recovery Rev Number	261	829	1429	1048
Recovery Date	24 June 1975	29 July 1975	4 Sept 1975	6 Oct 1975
Payload Weight (lb) (Measured Weight from Recovered RV)				
Forward	226.7	236.6	232.3	213.6
Aft	228.8	232.4	234.7	211.2
Unbalance Percent	0.8	1.5	0.8	0.9
SV Orbit (hp X ha/ωp)*	88.5 x 155.1/111.6	88.6 x 152.7/126.5	88.3 x 148.5/123.9	88.4 x 152.4/106.2
SV Pitch Angle (degree)	-35.3	-39.0	-39.2	-38.9
Nominal PIP Latitude (°N)	15.01	20.00	25.00	25.00
Impact Location Error (EPPD versus Teapot Evaluation)				
Overshoot (nm)	7.1			4.22
Undershoot (nm)		12.7	3.6	
Cross Track (nm)	4.7W	5.3W	1.6E	6.0W
Recovery (Aerial)				
Altitude (ft)	12,300	12,200	7,500	12,200
Parachute Condition	3 Cone and 1 Main Tear	5 Load Lines Broken – par. 5.3	1 Main Tear	1 Cone Tear
Retrieval Pass	1	1	2	1
BC/Payload Condition	Good	Good	Good	Good

*hp = Altitude of Perigee (nm), ha = Altitude of Apogee (nm), ωp = Argument of Perigee (deg)

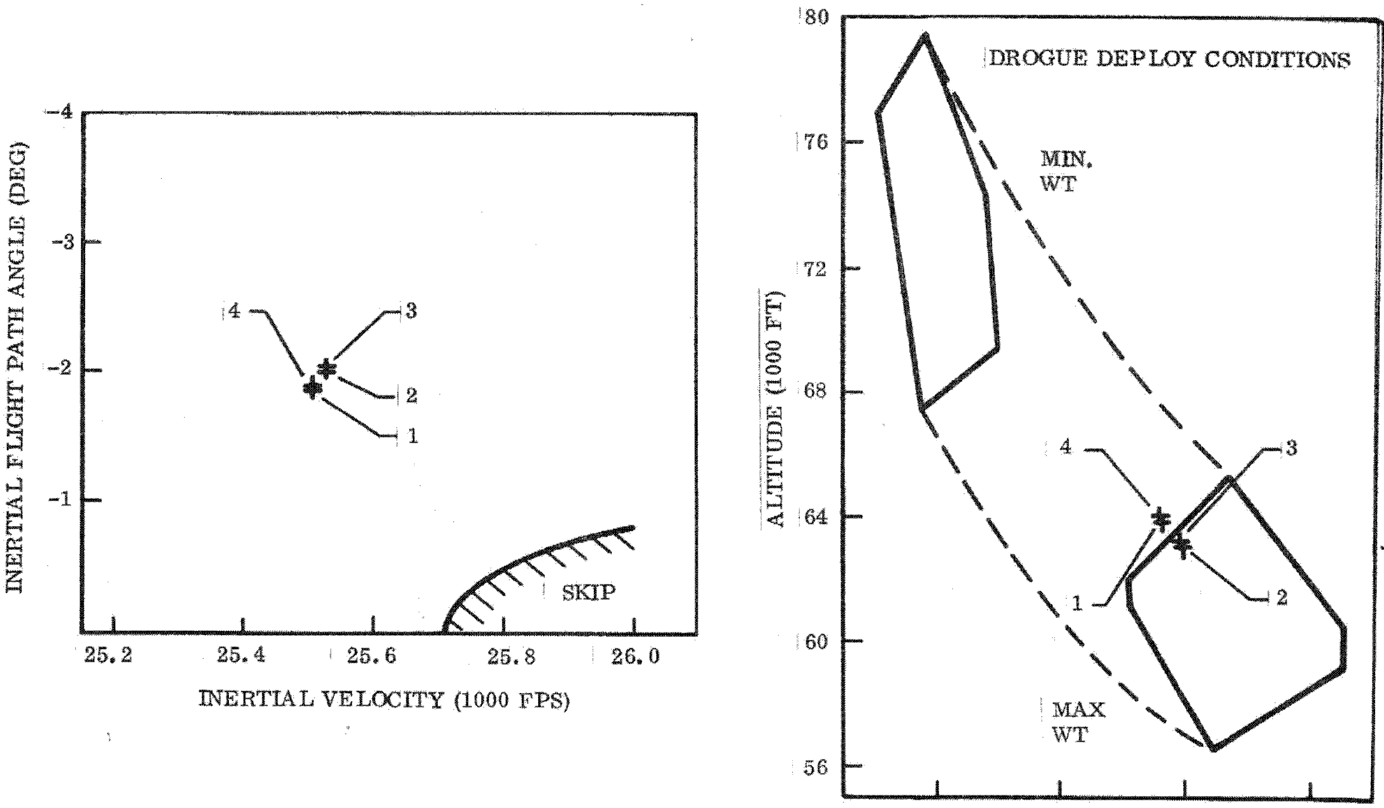

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Fig. 5-1 SV-10 Reentry Parameter Comparisons

Table 5-2

RV SUBSYSTEM PERFORMANCE SUMMARY

RV Subsystem/Function	Performance Assessment
On Orbit Thermal Protection	Normal T_{PL} Container = T_{REF} $+0^{o}F$, $-5.4^{o}F$ Power Usage — Watts/RV (Average of 4 RVs) Maximum 16.9 (First day in orbit) Stabilized 6.6 (Fifth day in orbit) Allowable 20
Trim and Seal	Normal
Electrical Power and Distribution	Normal All Batteries Activated All Batteries at Least 23.9 Volt Open Circuit Voltage Main Battery on RV-2 Vented Electrolyte See par. 5.3
Structure	Normal
Pyro Subsystem	Normal All pyrotechnics functioned normally but several heat shield SMDC lines separated from the brass connectors, par. 5.3.
Spin Stabilization	Normal
Retro Motor	Normal
Tracking, Telemetry and Instrumentation	Normal
Heat Shield	Normal
Base Thermal Protection	Normal
Sequential	Normal
Recovery	Normal RV2 (First usage of a PDI system) had 5 heavy load lines abraded during retrieval, par. 5.3.

5.3 REENTRY VEHICLE SUBSYSTEM PERFORMANCE

All subsystems performed normally, but post-flight inspection revealed the following discrepancies:

- SMDC Line Separation: During heat shield separation on RV1, 3, and 4, shielded mild detonating cord (SMDC) lines separated from the brass connectors. In all cases bolt fracture and propagation of SMDC line detonation occurred normally. This condition previously occurred on RV-4 of SV-6 and on RVs 1 and 4 of SV-4 and corrective action was taken. This will show up on SV-13 where the aluminum nut joining the SMDC line and brass connector will be replaced by a stainless steel nut resulting in a 50 percent increase in joint strength.
- Battery Venting: After separation from the SV, the RV-2 battery vented a quantity of electrolyte into the space between the aft pressure bulkhead and the base thermal protection panels. Venting is attributed to on-orbit battery case pressure loss. This occurred previously on RV-4 of SV-8 and resulted in a more stringent manufacturing leak test that is in effect on both the pyro and main batteries on SV-11 and up. RV-4 of SV-10 had been subjected to these tests.
- Broken Load Lines: On RV-2, five heavy load lines on the new* chute were broken near the skirt band. Data indicate the lines failed during retrieval because of abrading on the skirt band and was a function of the long tow distance. Higher than anticipated drag of the collapsed chute tow configuration caused increased payout, resulting in longer than normal tow distance. Effective on RV-13 and up, a design change will provide significantly increased abrasion protection. It should be noted the three remaining lines still maintained a factor of 2 above the maximum dynamic loads occurring during steady-state tow and showed no significant abrasion.

*Different vendor.

5.4 STELLAR TERRAIN RECOVERY (RV-5)

RV-5 (S/N 1806) was successfully recovered on Rev 845 after 52 days of orbital flight. Recovery statistics are shown in Table 5-3. All RV subsystems performed normally. The SV provided a satisfactory pitch angle after a yaw reverse and all other interface functions were nominal.

The predicted impact point (PIP), the estimated point of parachute deployment (EPPD), and the air snatch point are shown in Fig. 5-2. The miss distance between the PIP and EPPD was calculated to be 13.43 nm short and 0.20 nm East of the ground track. The capsule was recovered at 11,800 feet on the first pass.

Table 5-3
ST-RV (RV-5) RECOVERY SUMMARY

Recovery Rev	845
Date	30 July 1975
Payload Weight (100 percent)	68.19 lb
SV Recovery Orbit	
Perigee (nm)/ Apogee (nm)/Argument Perigee (deg)	88.637/150.450/122.68
SV Pitch Angle (after yaw around) (deg)	-63.4

	PIP	EPPD	Air Catch
Latitude	17° 55.8'	18° 09'	18° 08'
Longitude	160° 00.6'	159° 58'	159° 55'
Altitude	—	—	11,800 ft

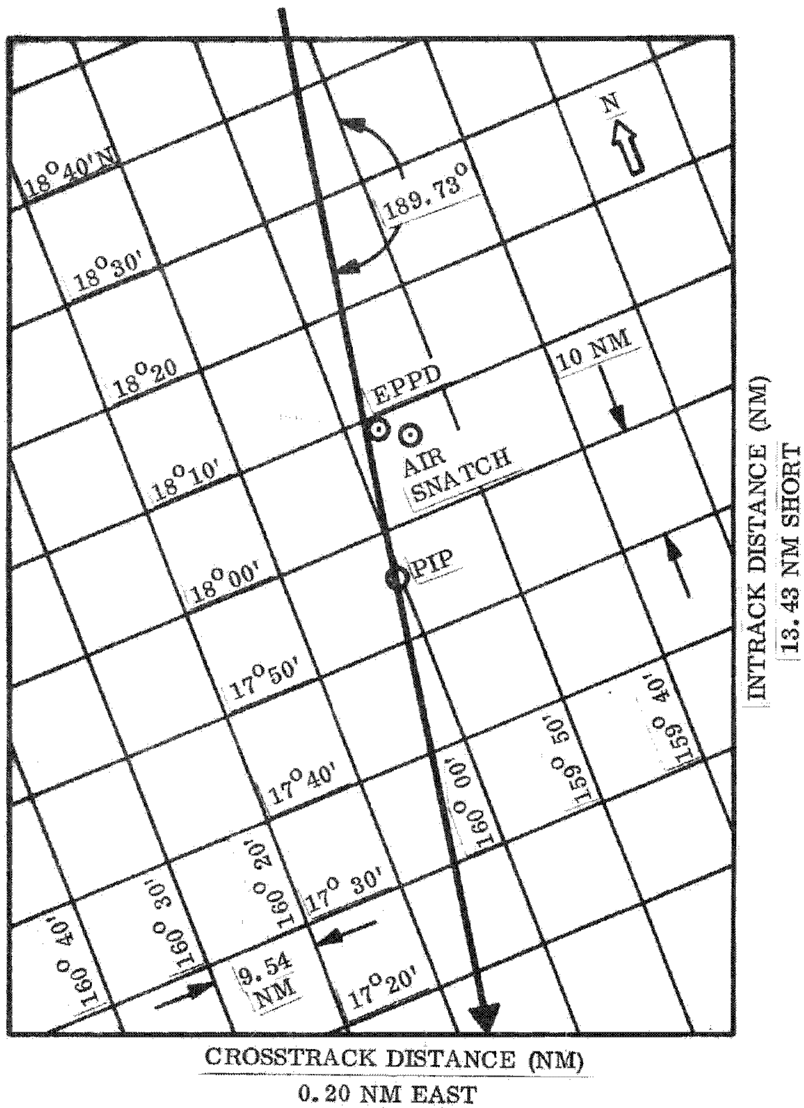

Fig. 5-2 ST - RV (RV-5) Recovery Locations

APPENDIX A

GLOSSARY

ACS	Attitude Control System
BV	Booster Vehicle
BV/SV	Booster Vehicle/Satellite Vehicle
CSI	Current Signal Integrator
DBS	Doppler Beacon System
ECS	Extended Command System
EDAP	Electrical Distribution and Power
EPPD	Estimated Point of Parachute Deployment
ESD	Emergency Shutdown
FCEA	Flight Control Electronics Assembly
GFE	Government Furnished Equipment
H/S	Horizon Sensor
MISEA	Main Instrument Systems Electronic Assembly
MCM	Mapping Camera Module
MCS	Minimal Command System
MU	Master Unit
OA	Orbit Adjust
OAS	Orbit Adjust System
OB	Optical Bar
OOAA	On-Orbit Attitude Adjustment
PCM	Pulse Code Modulator
PDWN	Pitch Down
PFA	Post Flight Analysis
PGR	Pitch Gyro Rate

PIP	Predicted Impact Point
PST	Pacific Standard Time
RCS	Reaction Control System
REA	Reaction Engine Assembly
REM	Reaction Engine Module
Rev	Revolution
RV	Reentry Vehicle
SA	Solar Array
SBA	Satellite Basic Assembly
SECO	State II Engine Cut-Off
Sep	Separation
SGLS	Space Ground Link System
SI	Stellar Index
SMDC	Shielded Mild Detonating Cord
Solo	Systems Engineering Test after Fourth RV Separation
SOC	State of Charge
SPC	Stored Program Command
SRM	Solid Rocket Motor
ST	Stellar Terrain
ST-RV	Stellar Terrain-Reentry Vehicle
SV	Satellite Vehicle
T/R	Tape Recorder
TT&C	Telemetry, Tracking and Command
TVC	Thrust Vector Control
TU	Take Up