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

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Prepared and Submitted by the
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HANDLE VIA BYEMAN
CONTROL SYSTEM ONLY

FOREWORD

This report describes the performance of the sixth HEXAGON Program Satellite Vehicle (SV-6). The vehicle was launched 13 July 1973 and after a 75 day primary mission and a 16 day SOLO mission was deboosted on Rev 1471 on 12 October 1973.

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

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ABBREVIATIONS

ACS	Attitude Control System
ARM	Attitude Reference Module
ATC	Active Thermal Control
BV	Booster Vehicle
BUFT-	Backup Film Transport Off Command
CCC	Charge Current Controller
DBS	Doppler Beacon System
DIU	Data Interface Unit
ECS	Extended Command System
EDAP	Electrical Distribution and Power
EPPD	Estimated Point of Parachute Deployment
F/S	Forward Section
FOSR	Flexible Optical Solar Reflector
FTFD	Field Test Force Director
H/S	Horizon Sensor
HSA	Horizon Sensor Assembly
IC	Integrated Circuit
IRA	Inertial Reference Assembly
MCM	Mapping Camera Module
MCS	Minimal Command System
MSTCLR	Master Clear-Off
MG	Milligauss
MMC	Martin Marietta Corporation
M/S	Mid Section
NVR	Non Volatile Residue
OA	Orbit Adjust
OAS	Orbit Adjust System
OB	Optical Bar
OOAA	On-Orbit Attitude Adjust
PDA	Positional Drive Assembly
PDJB	Power Distribution Junction Box

PDWN	Pitch-Down
PFA	Post Flight Analysis
PACS	Primary Attitude Control System
P/B	Playback
PCM	Pulse Code Modulator
PGR	Pitch Gyro Rate
P/L	Payload
PIP	Predicted Impact Point
PMU	Programmable Memory Unit
RACS	Redundant Attitude Control System
RCS	Reaction Control System
REA	Reaction Engine Assembly
RTS	Remote Tracking Station
RV	Reentry Vehicle
SBAC	Satellite Basic Assembly Contractor
SCO	Sub Carrier Oscillator
SECO	Stage II Engine Cut-Off
SEP	Separation
SGLS	Space-Ground Link System
SPC	Stored Program Command
SRM	Solid Rocket Motor
SS	Sensor System
ST	Stellar Terrain
ST-RV	Stellar Terrain Recovery Vehicle (RV-5)
STC	Satellite Tracking Command
SV	Satellite Vehicle
TM	Telemetry
TMV	Telemetry Volts
T/R	Tape Recorder
TT&C	Tracking, Telemetry and Command
TVC	Thrust Vector Control
VAST	Vehicle Atmospheric Survivability Test
VTT	Vandenberg Targeting Team

Section 1

SUMMARY OF GENERAL SYSTEM PERFORMANCE

1.1 SV MISSION PERFORMANCE

The SV-6 was injected into a nominal 88 by 140 nm orbit on 13 July 1973 by a Titan IIID Booster Vehicle. Ascent events were all nominal and proper stabilization of the SV allowed initiation of deployment of the Solar Arrays at the first station contact, INDI. The four RVs were successfully recovered in the air on Revs 310, 505, 926 and 1202 which occurred on Mission Days 20, 32, 58 and 75 respectively. The ST-RV (RV-5) was successfully recovered in the air on Rev 683 in Mission Day 42 43. Following a 16 day SOLO operation (which is not described in this report), the SV was successfully deboosted on Rev 1471 in the 91st day on orbit. The performance of the SV with respect to the primary mission objectives is summarized for each of the four mission segments and for the ST-RV as follows:

Segment 1

Operational photography began on Rev 5 following successful completion of the constant velocity tests and health checks. As on the previous flight the SS was to be operated with constraints of 5 inches-per-second (ips) maximum rewind velocity and neither 120 deg scan angles nor 30 deg scan angles at ±45 deg center-of-scan locations to preclude mistracking. However, the aft-looking camera optical bar drive servo torque appeared to be increasing during the first half of this segment and further restrictions on operation were imposed to protect the SS from potential catastrophic failure. These restrictions initially were a limitation of one 120-second maximum length operation per rev and subsequently a modified operating sequence terminated with a Backup Film Transport Off (BUFT-) command. This latter shuts down the system immediately thus precluding nested operations and eliminating all rewind. All other SS operations throughout RV-1 demonstrated normal characteristics. No adjustments of V_y or OOAA were made to compensate for the SV ACS yaw attitude error which was present on

Revs 45 through 66 since the yaw attitude error was erratic and did not exhibit a correctible bias during this relatively short interval as can be seen in Table 2-2. Experience on SV-5 was that a considerably longer and more consistent bias had to be exhibited before it was advisable to introduce a correction. Approximately 28,700 ft of film per camera (including prelaunch footage) were exposed and stowed in RV-1. Post-flight analysis (PFA) showed the overall quality of the acquired photography to range from very good to poor with the majority rated as good. The poor imagery was attributed primarily to the effects of the illumination/launch time relation which produced shadowless photography and high reflections particularly on the aft-looking camera. Some correlation between poor imagery and SV attitude error has been initially reported; however, these incomplete reports do not appear consistent with the attitudes in Table 2-2.

Segment 2

Operational photography was continued with the constraints imposed during RV-1 but it was established that the aft-looking OB drive torque had stopped increasing and had stabilized at a safe level and the extra constraints could be deleted. Normal operation, with only the initially planned constraints was resumed on Rev 362. As determined by RV-1 PFA, the aft-looking camera OOAA in-track and cross-track nominals were adjusted on Rev 376. Approximately 26,700 feet of film per camera were exposed and stowed in RV-2 including 5000 feet of SO-255 color film on the aft-looking camera during Revs 443 through 464. PFA showed photographic quality good to poor with the majority rated as fair. The lowering of quality was attributed to increased haze. The unfavorable illumination geometry continued to produce poor imagery on the aft-looking camera.

Segment 3

Operational photography continued under the same conditions as at the end (post Rev 362) of RV-2. On Rev 557, the focus of the aft-looking camera was adjusted 6 microns for color photography as recommended by PFA. Approximately 28,140 feet of forward-looking camera film and 24,700 feet of aft-looking camera film were exposed and stowed in RV-3 (the difference in footage was produced by mono operation of the forward-looking camera to balance the two 5000 foot lengths of color film utilized in the aft looking camera during this segment). PFA again showed image quality ranging from very good to poor but with an improvement in overall quality to good. This improvement was attributed to:

- Reduced haze
- Better than average cloud free coverage
- Fewer acquisitions beyond ±45 deg of scan
- Improving illumination geometry with the lower solar declination associated with the approach of the autumnal equinox which reduced reflections and increased shadowing.

Segment 4

Nominal operational photography continued with the same restraints as in Segment 3. The minor telemetry anomaly discussed in Section 7.5 did not affect operations. On the basis of RV-3 PFA, the aft-looking camera OOAA cross-track nominal was adjusted for all remaining color film and a refined exposure bias curve for the color film was used. Approximately 25,950 feet of forward-looking camera film, including the 500 foot end piece of SO-130 (infrared) film and 22,210 feet of aft-looking camera film, including 6000 feet of color film, were exposed and stowed in RV-4. PFA showed the black and white photography slightly improved; very good to fair with the majority good. Color photography was good to poor but improved over that of the previous segment. For both types of photography the improvement was attributed to better atmospheric conditions and illumination geometry. The image quality of the SO-130 photography was fair to poor but the infrared information was lost because of fogging that occurred during supply spooling inspection at the vendors.

Stellar Terrain Cameras

During 42 days of operation, 2057 frames were exposed on both stellar and terrain cameras of which 16 were used for inflight calibration. An additional 144 frames were cycled at the completion of the calibrate mode to deplete the stellar film supply. Of the total number of frames, 61 frames were SO-131 (false color) which were operated in the terrain camera. The terrain camera photography exceeded the predicted quality levels. Stellar photography also exceeded predicted results with the majority of frames recording approximately 100 stars and with many with up to 150 star images. There were no functional anomalies in either the stellar or terrain cameras for this mission. The changes on the terrain thermal door proved effective allowing unrestricted photography at all latitudes. Weather conditions were not as good as during the SV-5 mission; consequently, about 60 percent of the photography is cloud free as compared to 66 percent on SV-5. The effects of seasonal haze, associated with high solar attitudes, are detectable on many frames. Exposure levels for the majority of the photography are good. Based on SV-5 PFA, the exposure levels were decreased by one-half stop, but sand and high density areas were still approximately one-half stop overexposed and an exposure algorithm adjustment similar to that used on the SS is recommended. Visual edge matching (VEM) measurements indicated an average resolution of 57.4 lines per millimeter. This was the first mission to use SO-131 (false color) film in the terrain camera and this film produced exceptionally good photography with an estimated 50-75 foot ground resolution.

1.2 ANOMALY SUMMARY

Significant anomalies and malfunctions are listed chronologically in Table 1-1. The list includes a description of the anomaly, the mission consequences, the changes indicated for subsequent vehicles and a cross reference to the appropriate paragraphs where detailed discussions can be found.

Table 1-1
ANOMALIES

Day	Description	Impact	Cross Reference Paragraph
1	Battery 3 Heater Rapid Cyclic ON-OFF Operation Ceased on Rev 89	No mission impact. Attributed to creep of bimetal thermostat element at low temp change rate. Susceptible units screened out for SV-7 and up.	5.4
3	PACS Yaw Bias Developed on Rev 45	Some film quality degradation reported in PFA. Transfer to RACS on Rev 66. Attributed to torquer short. RACS unit and subsequent IRAs contain isolation fix which provides protection from torquer shorts.	2.1.5
5-6	REA 8 Abnormal Heating	No mission impact. Attributed to Non-NVR leak in valve. Estimated increase of 0.5 lb/day in RCS consumption.	2.2.1
13	Battery 2 Heater Exhibited Cyclic ON-OFF Behavior for Revs 211 and 212.	No mission impact. Similar to Battery 3 incident.	5.4
13	Optical Bar Drive Servo Torque Increased	SS restricted to one operation per rev of max 120 sec duration. BUFT- command used which eliminates nested Ops and rewind. Torque stabilized and restrictions lifted on Rev 362 (Day 23).	7.4
22	REA 8 Thrust Degradation	No mission impact. Flight data evaluation continuing.	2.2.3
42	REA 4 Thrust Degradation	No mission impact. Flight data evaluation continuing.	2.2.3
75	REA 7 Thrust Degradation	No mission impact. Flight data evaluation continuing.	2.2.3

Section 2
ATTITUDE CONTROL

2.1 ATTITUDE CONTROL SYSTEM (ACS)

The ACS performed as expected during the mission except for one anomaly – the PACS yaw gyro rate bias. The summaries in this section detail those requirements that could be verified from flight data. The performance of the Reaction Control System (RCS) equipment is reviewed in Subsection 2.2.

2.1.1 BV/SV Separation

BV/SV separation was completed at approximately 543.5 seconds vehicle time (vehicle time started 67.04 sec prior to liftoff). Master clear-off (MSTCLR), which enables the pitch, roll and yaw integrators to accumulate angle, was at 513.4 seconds and SECO, which terminates BV attitude control, occurred at 531.5 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 2-1. Also, the times in which the SV attitudes and rates came back within the specified limits following BV/SV separation (capture) are shown in Table 2-1.

Table 2-1
BV/SV-6 SEPARATION

	Rate and Attitude at BV/SV Separation						Capture			
	Rate (deg/sec)		Attitude (degrees)				Attitude		Rate	
			H/S at SEP		Δ(SECO to SEP)					
	Specified	Actual	Specified	Actual	Specified	Actual H/S/Int(5)	Specified (1) (deg)	Actual(2) (time in sec)	Specified (3) (deg/sec)	Actual(4) (time in sec)
Pitch	±.752	-.131	+13.0 to -21.7	+2.88	±3.5	+0.16/ +0.02	±0.70	(6)	±0.014	(6)
Roll	±.786	-.241	±10.6	+1.12	±3.5	+1.28/ +0.91	±0.70	(6)	±0.021	(6)
Yaw	±.752	+.087	+11.1 to -11.4	–	+4.5 to -3.5	–/ +1.65	±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 (663.3 sec after sep). The total 1183.3 sec is well within the spec of 1500 sec and no closer study was performed.

2.1.2 Payload Operations

A PACS yaw gyro rate bias began on Rev 45 and resulted in roll and yaw attitude offsets of varying magnitude until control was transferred to RACS on Rev 66. The roll attitudes as measured with the Horizon Sensor and the yaw attitudes as calculated with the relationship below are tabulated in Table 2-2 for each SS P/L operation during the subject period.

$$\psi_\epsilon = \frac{H_\phi}{\omega_o H_\psi} \omega_z + \psi_I \text{ deg}$$

where

ψ_ϵ = Yaw attitude, deg

H_ϕ = Roll H/S to Roll gain, 0.0055 sec^{-1}

H_ψ = Roll H/S to Yaw gain, 0.01667 sec^{-1}

ω_o = Orbital rate, 0.0012 rad/sec

ω_z = Yaw gyro rate as observed on controlling ACS, deg/sec

ψ_I = Yaw integrator output, deg

Table 2-2

P/L OPS DURING PERIOD OF YAW RATE BIAS

Rev	SS P/L Ops	Attitude (deg)			Rate (deg/sec)		
		Pitch H/S	Roll H/S	Yaw (1)	Pitch (2)	Roll	Yaw
48	37	0.0	0.22	1.4	0.0	-0.011	+0.007
48	38	+0.06	0.12	1.1	-0.002	-0.006	-0.005
48	39	+0.08	0.0	0.5	-0.002	-0.006	-0.006
54	40	+0.08	0.10	1.1	-0.002	-0.003	+0.007
55	41	+0.08	0.14	1.3	-0.001	+0.006	+0.007
56	42	+0.08	0.10	0.9	-0.002	-0.007	+0.007
56	43	-0.10	0.20	0.9	-0.003	-0.012	+0.007
58	44	+0.10	0.02	0.6	-0.003	+0.007	+0.007
58	45	+0.08	-0.02	0.3	-0.002	+0.005	+0.004
58	46	+0.08	0.02	0.7	-0.003	-0.006	+0.005
64	47	+0.08	-0.06	0.3	-0.002	+0.006	+0.007

(1) Yaw attitude is calculated from yaw rate bias.
(2) The value shown here is the deviation from the average orbital pitch rate of -0.068 deg/sec.

2.1.3 Mapping Camera Module (MCM) Operations

The SV behavior during the ST operations and the calibration maneuvers is discussed in this section. The ST-RV recovery is discussed in Section 2.1.4.

2.1.3.1 ST Operations. As discussed in Section 2.1.2, a PACS yaw gyro rate bias began on Rev 45 and resulted in roll and yaw attitude offsets of varying magnitude until control was transferred to RACS on Rev 66. Table 2-3 shows the roll and yaw attitudes observed during the ST operations for this period. The pitch attitude and all three rates were nominal. The yaw attitude is a calculated value based on the magnitude of the rate bias.

Table 2-3

ST OPS DURING PERIOD OF YAW RATE BIAS

Rev	ST+ (sec)	ST- (sec)	Attitude (deg)			Peak Rate (deg/sec)		
			Pitch	Roll	Yaw	Pitch	Roll	Yaw
58	308997.8	309056.6	+0.10	+0.02	+0.6	-0.070	-0.002	-0.001
58	309205.0	309312.6	+0.08	+0.04	+0.4	-0.072	-0.004	-0.006
58	309359.8	309459.0	+0.08	+0.02	+0.7	-0.072	+0.006	-0.008
59	314691.0	314873.2	+0.08	+0.04	+0.8	-0.071	-0.005	-0.001

2.1.3.2 MCM Calibration Maneuvers. The calibration maneuver on Rev 667 consisted of yawing the SV 180 deg, then pitching down -135 deg, followed by an inertial period for the calibration. Geocentric rate was then connected and disconnected two additional times to provide a total of three SV pitch attitudes for MCM calibrations. The two additional pitch attitudes were -141 and -147 deg. The SV was returned to nose forward flight by rolling the vehicle 180 deg and reconnecting geocentric rate at the appropriate time.

Since no attitude measuring capability existed during the sequence at angles greater than ±10 deg, the attitude performance may only be inferred by noting that the entire sequence was executed as planned. Also, the predicted pitch attitude at the final geocentric rate connect (196825.6 sec) was -0.4 deg and the actual was -2.0 deg as measured with the pitch H/S. This -1.6 deg pitch error at sequence completion was within the ±3.0 deg requirement of the initial pitch down maneuver.

The vehicle rates at the first frame of each calibration are shown below.

	Vehicle Time (sec)		Vehicle Rates at Frame 1 (deg/sec)		
	ST+	Frame 1	Pitch	Roll	Yaw
CAL 1	195527.0	195557.8	-0.001	+0.004	+0.001
CAL 2	195918.4	195944.6	-0.002	+0.002	+0.0
CAL 3	196308.4	196334.6	-0.004	-0.003	-0.001

2.1.4 Recovery

The pitch-down maneuvers preceding the four RVs and the ST-RV (RV-5) separations were all within specification and are summarized in Table 2-4. The RV separation performance summary is shown in Table 2-5.

The RV-5 recovery is performed with the SV yawed 180 deg and pitched down, with the release taking place along the SV X-axis. The vehicle rate and attitude parameters at RV-5 separation were as follows:

Pitch rate	+0.069 deg/sec
Roll rate	+0.001 deg/sec
Yaw rate	-0.003 deg/sec
Pitch attitude (PDWN)	-61.7 deg
Roll attitude (H/S)	+0.18 deg
Yaw attitude (Integrator)	-0.12 deg

Table 2-4

PITCH-DOWN PERFORMANCE PRECEDING RV SEPARATIONS

RV/ Rev	Pitch-Down Angle		Maneuvering Time to 0.1 deg/sec		Pitch-Down Coast Rate		
	Desired ±3.0 Deg	Actual (PDWN)	Allowable (sec)	Actual (sec)	Command Rate (deg/sec)	Coast Rate Expected (deg/sec)	Coast Rate Actual (PGR) (deg/sec)
1/196	-34.9	-35.2 (1)	150	77.2	-0.705	-.75 ±0.05	-0.70
2/505	-38.9	-38.1	150	82.2	-0.705	-.75 ±0.05	-0.71
3/926	-39.6	-38.8	150	86.2	-0.705	-.75 ±0.05	-0.71
4/1202	-37.5	-37.6 (2)	150	81.2	-0.705	-.75 ±0.05	-0.70
5/683	-63.3	-61.7	—	—	-0.705	-.75 ±0.05	-0.72

(1) The pitch gyro rate sampled and integrated by PDWN occurred at the point of switching from low rate mode to high rate mode. A 2.9 deg PDWN error resulted. The value shown has been corrected by that amount.

(2) Same as (1), only error was 4.1 deg.

Table 2-5

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 Separation (deg)	Pitch-Up Following RV Sep to Removal of Manvr Cmd (deg)	Pitch Inertia (After Sep) (slug-ft^2)	Pitch Thruster Moment Arm (ft)	Roll Angle	
								Spec (deg)	Meas H/S (deg)
1/310	1.56	11.2	143	-35.2	99.4	139158	16.7	±1.0	-0.04
2/505	1.34	7.0	128	-38.1	98.1	120410	15.9	±1.0	-0.06
3/926	1.45	9.7	131	-38.8	97.4	92380	14.6	±1.0	-0.08
4/1202	1.36	11.0	159	-37.6	36.0	84601	14.1	±1.0	-0.02

2.1.5 IRA Anomalies

Figure 2-1 is a graph of the PACS yaw rate bias observed from launch through Rev 1202. The bias was first observed on Rev 45 and on Rev 66 control was transferred to RACS cross-strapped to the primary reaction control system. After transfer the bias was monitored and remained in the range of 0 to -0.012 deg/sec until Rev 373 when the bias increased and the IRA began switching between high rate mode and low rate mode. Similar switching was again observed on Rev 379 after which the bias decreased to 0 to -0.005 deg/sec. On Rev 782 the gyro rate output switched to the high rate mode and remained at rates of -1.3 to -1.6 deg/sec which is beyond the limit of control for the rest of the mission.

The yaw rate bias appears to be due to a high impedance short from the gyro torquer circuits to ground. This type of anomaly was previously seen in both IRAs on SV-5.

A miniyaw maneuver was performed on Rev 203 with the results shown in Figs. 2-2 and 2-3. The positive and negative rates achieved are sufficiently large that a variation in the yaw bias as a function of the yaw rate may be determined and, based on analysis previously performed, the expected rate bias variation with yaw input rate

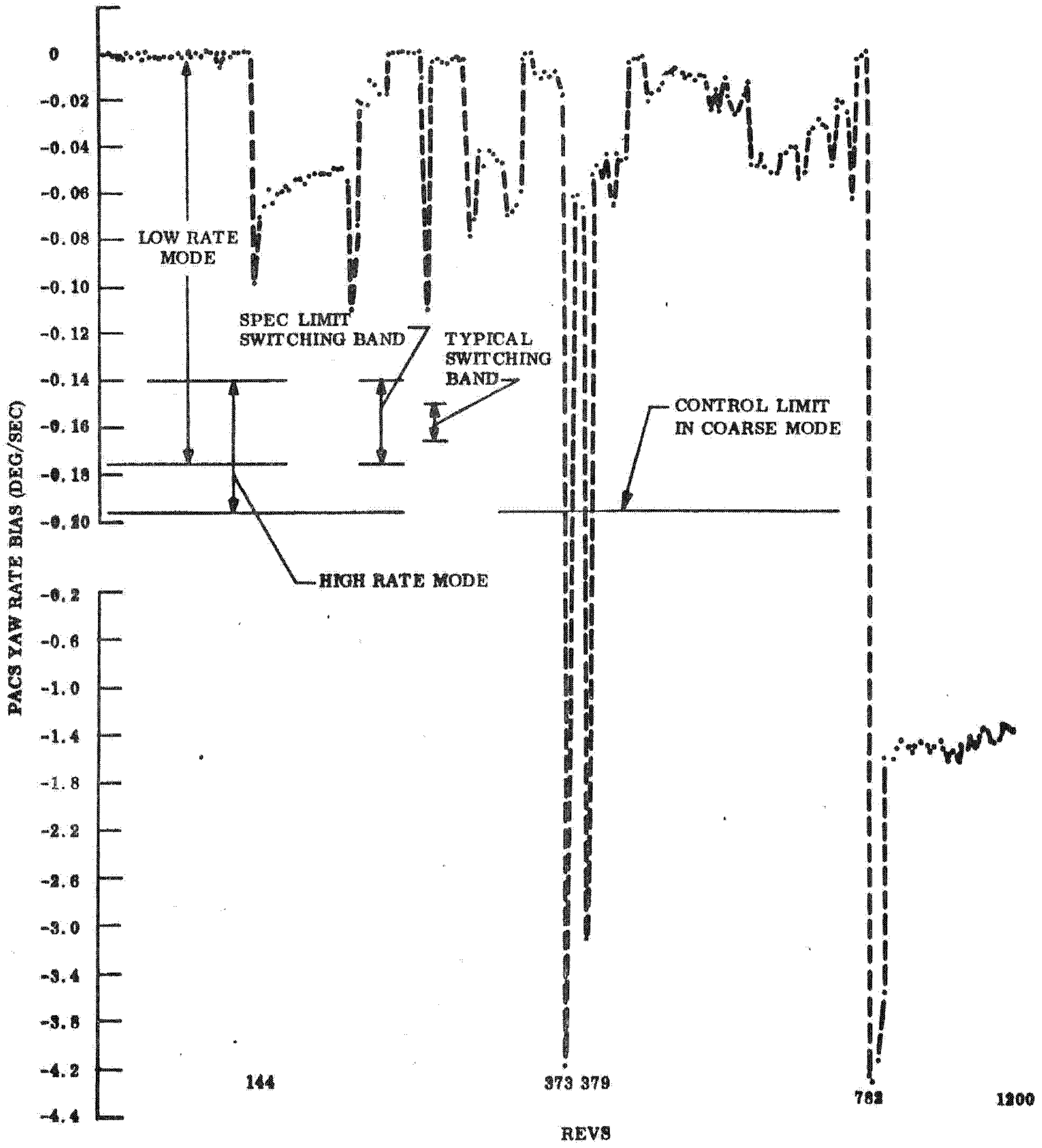

Fig. 2-1 PACS Yaw Rate Bias History

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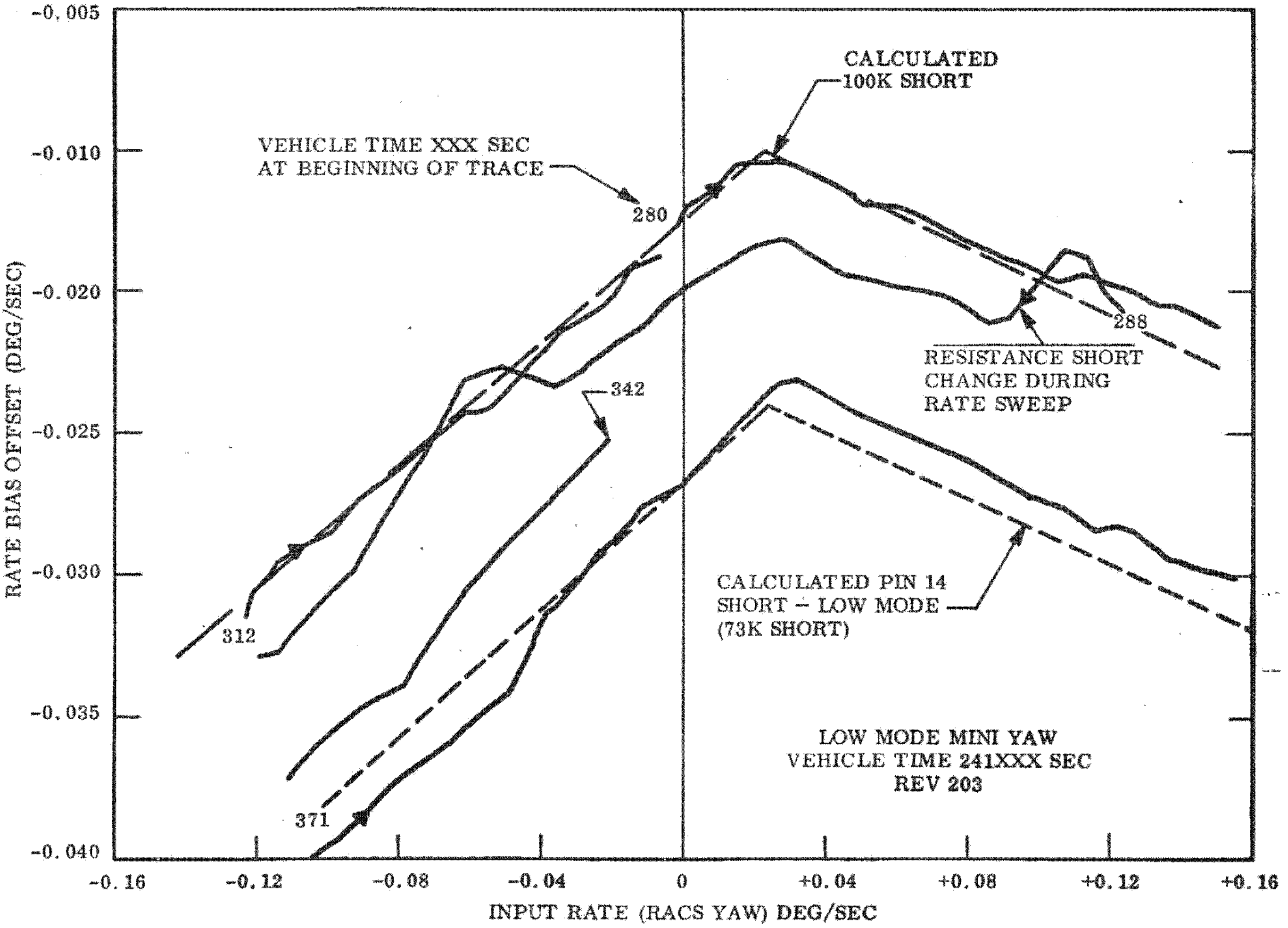

Fig. 2-2 PACS Yaw Rate Bias Offset From Miniyaw Test – Low Rate Mode

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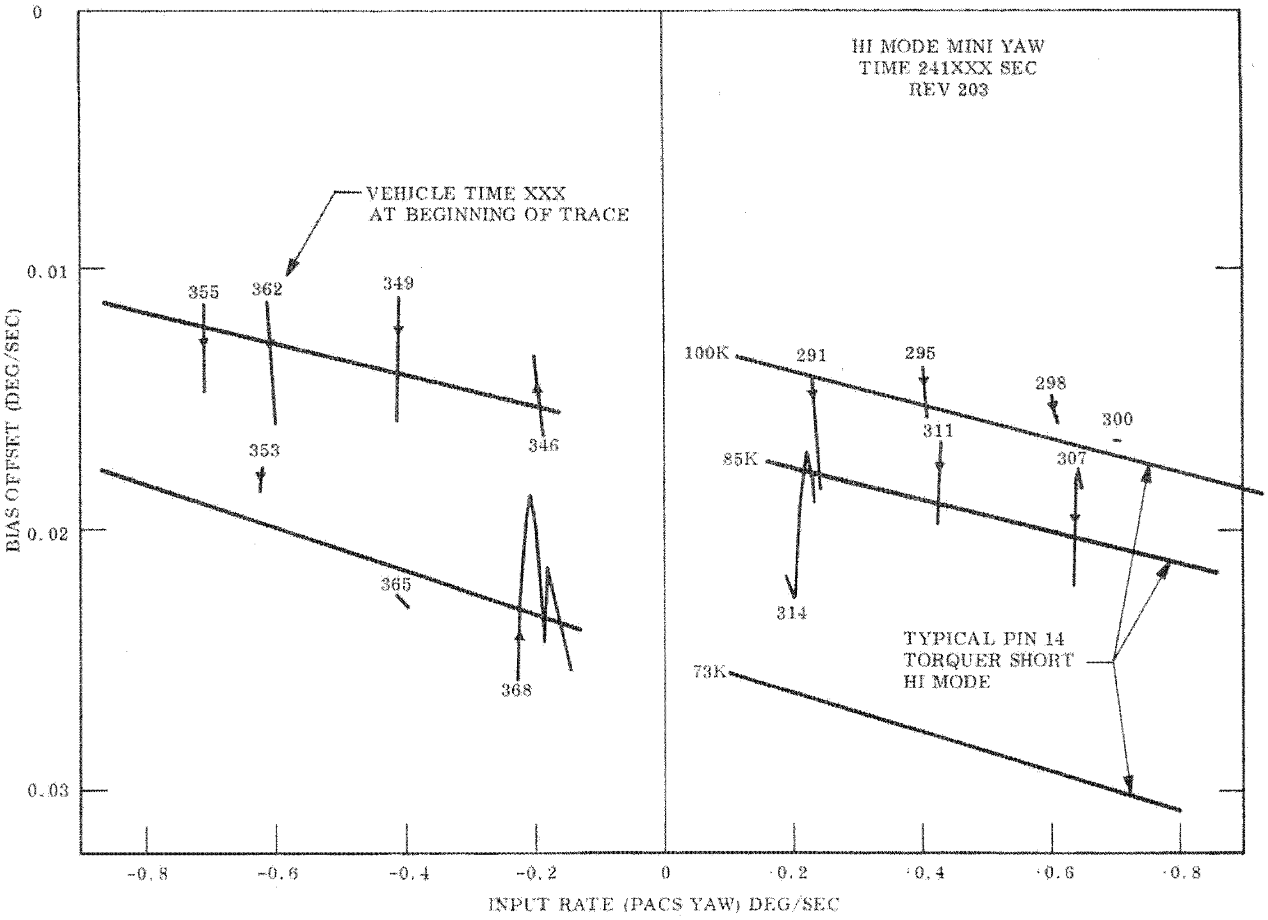


Fig. 2-3 PACS Yaw Rate Bias Offset From Miniyaw Test – High Rate Mode

for location and resistance of the short can be calculated. Figure 2-2 shows that the data when the rates are in the gyro low rate mode range correspond to a calculated short of 70 to 100k ohms between gyro pin 14 and the case. The exact location of the short in the circuit is not known.

Figure 2-3 presents the data when the vehicle rates were high enough to switch the gyro to the high rate mode. The data while not as definitive as the low rate mode data roughly indicates a torquer short of the same magnitude as the low rate mode data.

The mode switching on Revs 373 and 379 are indicative of a gyro torquer short with the resistance of the short decreased to 10 to 20k ohms. With such a short, the rate bias falls in the high rate-low rate mode switching region of the IRA and instability results. Figure 2-4 is a graph of rate bias versus resistance of a short showing the switching region.

The large increase in rate bias observed from Rev 782 on, is an indication that the resistance of the short further decreased to a value of approximately 600 ohms.

The RACS IRA 1018, which operated successfully for 91 days, had been retrofitted to alleviate the effects of gyro shorts from torquer to case. The retrofit isolated torquer circuits and their returns from signal or case ground and inserted a diode in the collector circuit of the torquer switching semiconductors to eliminate reversed offset currents. The PACS IRA1011 which exhibited the yaw bias was not retrofitted and did not contain the torquer isolation and blocking diode noted above.

The cause and mechanism of the torquer shorts are still being studied with the aim of eliminating them; in the meantime, all IRAs to be flown subsequent to SV-6 will incorporate the torquer isolation.

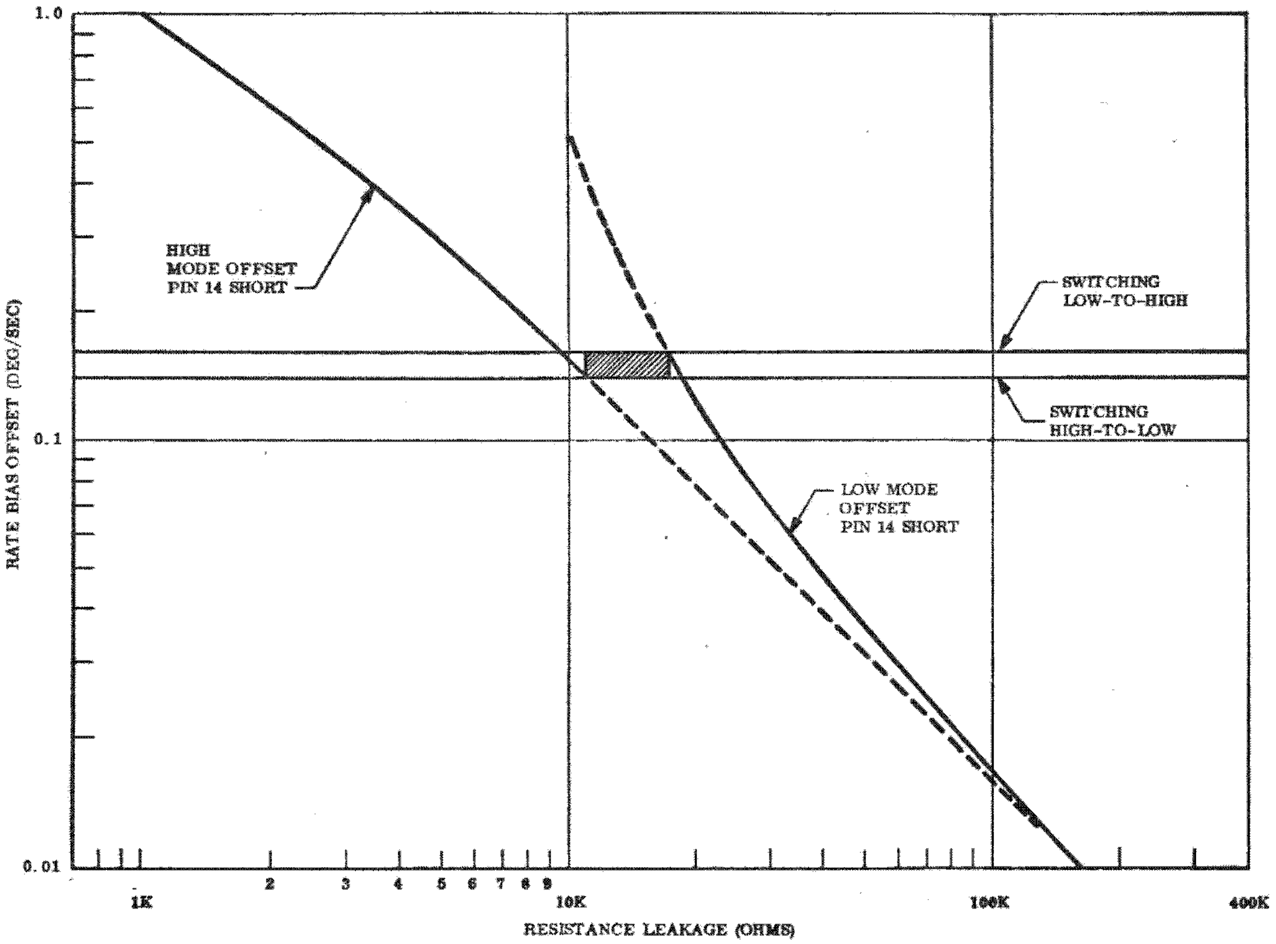


Fig. 2-4 Pin 14 Torquer Short Bias Offset

2.2 REACTION CONTROL SYSTEM (RCS)

2.2.1 Flight Summary

RCS flight history is shown in Fig. 2-5. The primary RCS was used for the entire active mission and provided satisfactory vehicle and rate control. An increase in the temperature of REA 8 on Rev 68 and a further increase after Rev 98 indicated that a leak was developing. This leak was attributed to seal damage such as a scratch or particle lodged on the lip of the poppet (not to an NVR buildup leak) since REA 8 did not display a continually increasing temperature with time, but in fact, showed a small temperature decrease as the feed pressure dropped. NVR buildup leaks on previous flights have shown a continually increasing temperature as the NVR deposits build-up on the poppet. NVR deposits were not expected since all control fuel was drawn from the main OA tank.

2.2.2 Propellant Consumption

RCS propellant consumption was entirely from the OAS tanks during the 75 day active mission and was computed to be 348 lb or 4.64 lb/day.

2.2.3 Thruster Performance

Thrust levels were determined using the individual REA chamber pressures. Figure 2-6 is a plot of the normalized thrust over the mission life. The dashed limits are the ±8 percent run to run tolerance allowed per specification. As can be seen REA 8 dropped out of limits at Rev 350, REA 4 around Rev 800 and REA 7 at approximately Rev 1200. REA 8 degraded to an actual thrust level of 1.93 lbf, REA 4 to 1.44 lbf and REA 7 to 2.42 lbf by the end of the active mission, Rev 1202. Due to the position on the vehicle occupied by REAs 4 and 8, this degradation could be tolerated and permitted tracking these thrusters throughout the active mission. Figure 2-7 shows the change in chamber pressure tail-off with life. Some lengthening is expected with life; however, times in excess of 100 ms are indicative of the starting of thrust degradation.

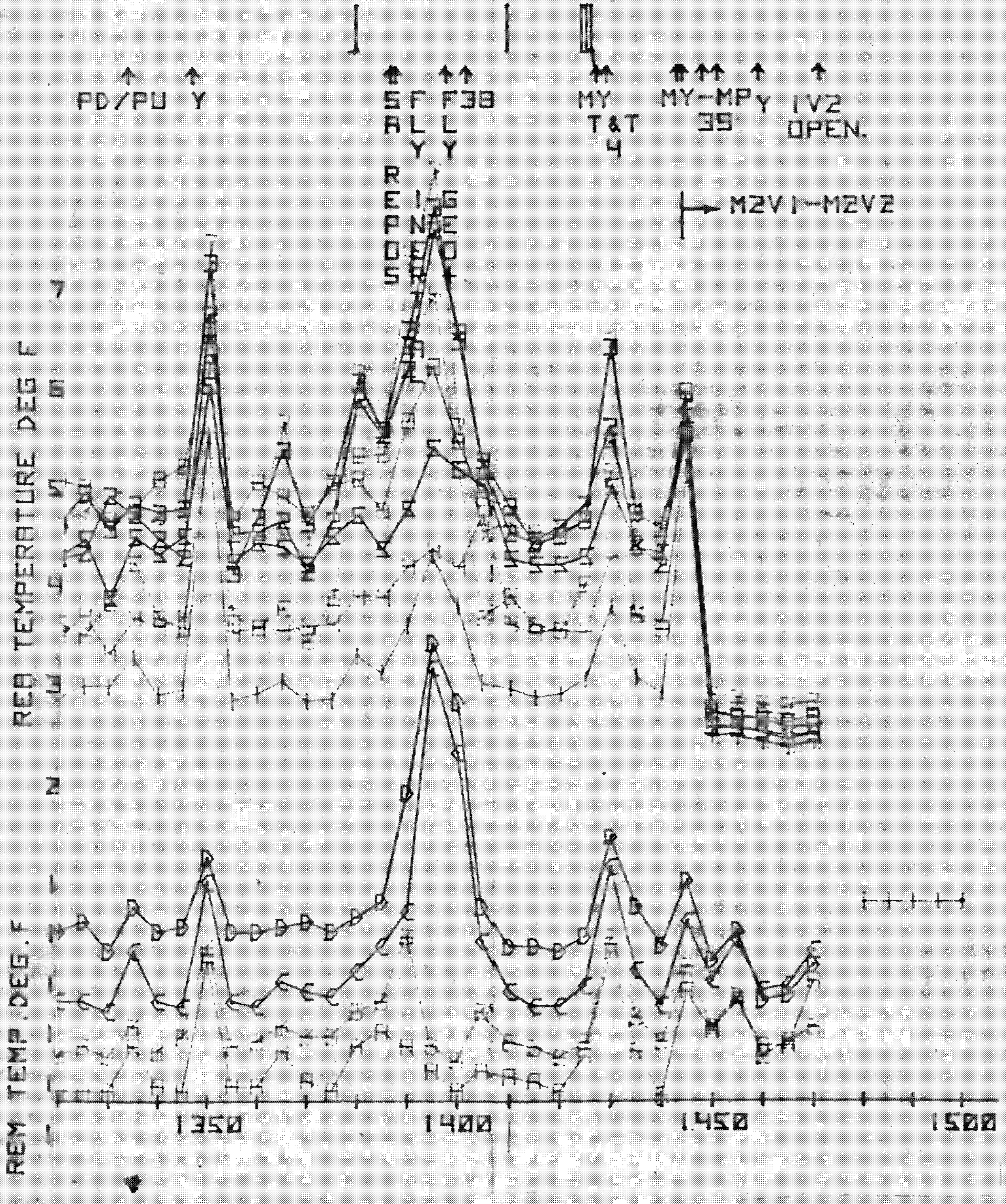


Fig. 2-5 RCS Flight History

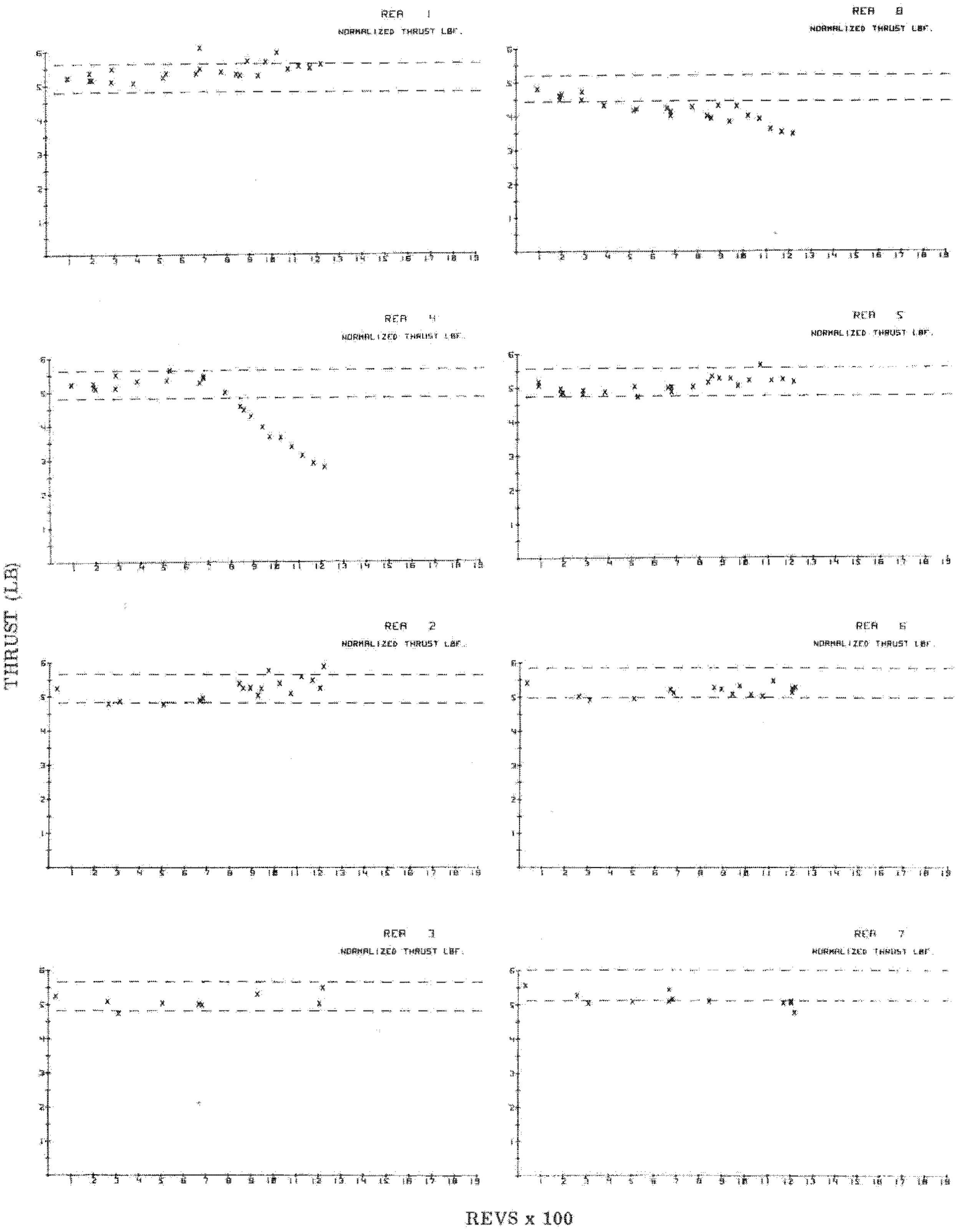


Fig. 2-6 Normalized Thrust History

NOTE: TAIL-OFF TIME IS THE TIME INTERVAL FROM THE VALVE OFF COMMAND TO THE POINT WHERE THE REA CHAMBER PRESSURE FALLS TO 10 PERCENT OF THE MAXIMUM ON THAT PULSE

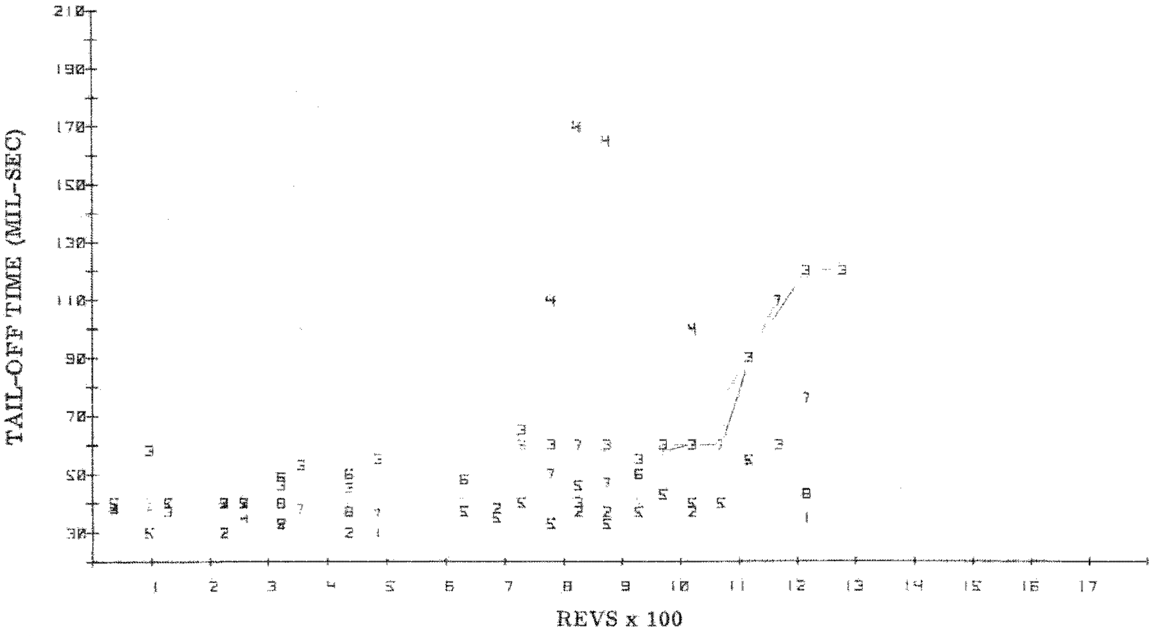


Fig. 2-7 Tail-Off Times for RCS 1 (U)

Section 3
ORBIT ADJUST

3.1 ORBIT CONTROL

The Orbit Adjust System (OAS) was utilized 34 times during the basic mission and 5 times during the SOLO phase. Engine performance and the engine nozzle temperature indicated slightly higher than normal values; however, engine performance predictability was well within the specified accuracy of 5 percent as can be seen in Table 3-1.

After OA 29 the catalyst bed pressure drop showed a decaying trend similar to that observed on SV-5, SV-4 and SV-3. As on SV-5, the deboost firing was broken into a series of short burns to avoid any possibility of engine washout.

3.2 DEBOOST

The deboost firing consisted of five pulses (200, 200, 200, 200 and 206.2 seconds) with an off-time of five seconds between pulses. Total firing duration was 1006.2 seconds to achieve a planned negative velocity increment of 420 ft/sec. To optimize impulse accuracy for the Vehicle Atmospheric Survivability Test (VAST) experiment associated with the deboost, adjustments for engine performance biases due to low catalyst bed pressure drop and engine family variations were included in the performance predictions.

Table 3-1

OAS PERFORMANCE

OA Firing No.	Rev No.	Impulse Delivered (lbf-sec)	Planned ΔV (ft/sec)	Achieved ΔV (ft/sec)	Percent Error ΔV
1	30	4249	6.58	6.51	-1.00
2	62	8313	12.87	12.76	-0.86
3	94	15359	23.83	23.65	-0.76
4	96	8218	-12.96	-12.71	-1.93
5	127	5965	9.22	9.22	0
6	159	7935	12.42	12.30	-0.97
7	192	15943	24.70	24.77	+0.28
8	194	7672	-12.03	-11.97	-0.50
9	224	6921	10.73	10.78	+0.47
10	257	8573	13.32	13.41	+0.67
11	289	15472	24.26	24.27	+0.04
12	291	6147	-9.60	-9.66	+0.62
13	321	6728	11.35	11.47	+1.05
14	354	7478	12.77	12.77	0
15	386	19029	32.42	32.64	+0.68
16	388	10997	-18.77	-18.93	+0.85
17	435	11098	18.93	19.16	+1.22
18	485	10887	18.73	18.86	+0.69
19	532	21773	37.42	37.86	+1.17
20	534	11678	-20.02	-20.39	+1.85

Table 3-1 (Continued)

OA Firing No.	Rev No.	Impulse Delivered (lbf-sec)	Planned ΔV (ft/sec)	Achieved ΔV (ft/sec)	Percent Error ΔV
21	581	8993	17.15	17.19	+0.23
22	630	11954	22.73	22.90	+0.75
23	685	14202	27.04	27.34	+1.10
24	727	10356	20.44	20.51	+0.34
25	776	23133	45.67	46.04	+0.80
26	778	8775	-17.80	-17.54	-1.46
27	824	8463	16.85	16.97	+0.71
28	873	16007	32.01	32.21	+0.62
29	928	13552	27.25	27.41	+0.59
30	970	9364	20.76	21.05	+1.40
31	1019	10886	24.41	24.58	+0.69
32	1068	11406	25.55	25.56	+0.04
33	1116	8877	20.23	20.22	-0.05
34	1167	17032	38.54	38.93	+1.00
35	1214	3608	9.37	9.28	-0.96
36	1216	5481	14.09	14.12	+0.21
37	1278	21578	55.16	55.95	+1.38
38	1400	6965	18.04	18.15	+0.61
39	1448	3221	8.32	8.44	+1.43
Deboost	1471		-420	*	

*Ephemeris data not available; however, reentry tracking during VAST was highly successful.

Section 4
TRACKING, TELEMETRY AND COMMAND (TT&C)

4.1 TRACKING

SGLS 2 was turned on for the COOK pass on Rev 600 for the planned daily performance check. Due to the sequence of events at acquisition, both ranging data and command capability was lost throughout the pass.

The turn-on sequence of events was as follows:

(1) The transponder was turned on 7 seconds prior to starting up-link "S" pulses

(2) The transponder was in the non-coherent mode at turn-on and went coherent as soon as uplink modulation (S pulses) was established.

(3) Transponder telemetry data (Loop Stress and Command Signal Presence) indicated that the transponder went coherent with command signal presence indication (S pulses present) and the receiver frequency was offset approximately – 52 KHz from nominal.

The above sequence of events and telemetry data imply that the vehicle receiver phase lock loop was still sweeping in search of the uplink carrier when uplink modulation was established. Under these conditions the receiver will phase lock to the first uplink it sees as it is sweeping through its range. The data suggests that the receiver locked on a subcarrier approximately 52 KHz from the carrier. Nominal receiver sweep time is 12 seconds.

The turn-on sequence was revised to insure that the vehicle receiver is in the coherent mode (i.e., that the receiver has phase-locked to the unmodulated uplink carrier) prior to establishing uplink modulation. Subsequent station passes were normal when operation was in accordance with this constraint.

4.2 TELEMETRY

4.2.1 Anomalous P-Monitor Data

Numerous Mid Section Payload P-Monitors exhibited erroneous data (zero TMV) during portions of Rev 1126 P and 1131 G. Also, Tape Recorder playback of Rev 1130 payload operations showed that the same monitors were bad for a portion of that operation. In all three cases, the data was initially bad and then became good at some later time. The data was all associated with a payload power source that comes on coincident with the I+ command. The data did not become good until as much as 5 minutes after the I+ command.

SBAC data on the same slices of Remote Unit No. 4 was good during times when the payload P-monitors were bad. Specifically, good SBAC data included DIU temperature monitors and mid section AXXX (structure) temperature monitors.

Diagnostic playbacks of main bus voltages and currents and structure current showed no abnormal activity during periods of bad payload data or at the times when the data went from bad to good. There is no known single failure in the remote unit which would account for the anomalous data.

It was therefore concluded that SBAC equipment operated properly and that the cause of the anomalous data is within the mid section payload.

4.2.2 General Performance

Telemetry system performance was satisfactory throughout the flight. Out of a total of 1323 active station contacts through Rev 1201, PCM Side 1 was utilized on 1320 station contacts and SGLS Side 1 was utilized on 1222 station contacts. PCM Side 2 was utilized on Rev 9 KODI and Revs 18 POGO and 18 HULA with normal performance. SGLS Side 2 (a Cubic transponder) was operated periodically throughout the flight for a total of 101 station contacts to observe the performance of the new transponder to be flown on Block II vehicles (Reference SOLO Report for SV-5 on anomaly involving the Cubic transponder, Side 2, on that flight). In addition, operation of the PCM system during tape recording and operation of the Tape Recorders (T/R #1 and T/R #2) was normal throughout the flight.

4.2.3 Instrumentation

The following comprises the list of anomalous instrumentation existing at liftoff:

A439	A known erratic temperature monitor that was dispositioned to use as is
P222	A known erratic temperature monitor that has been dispositioned to use as is.

4.3 COMMAND

The vehicle SGLS command equipment was utilized to receive approximately 14.5 million bits with no vehicle problem indications.

4.3.1 GFE Command System

4.3.1.1 Extended Command System. The ECS responded satisfactorily in all command modes resulting in the loading of 185,713 SPCs in memory. Of these 185,713 SPCs loaded, 94,896 were output by both PMUs for decoder processing. The remainder were erased prior to their time label matches.

In loading the 185,713 SPCs there were no command rejects except as follows:

Rev 113 POGO	Commanding difficulties because of an RTS problem
Rev 600 COOK	Command capability lost throughout pass due to RTS procedural error as noted in paragraph 4.1.
Rev 910 POGO	When the emergency VBE message for Event 3 was used on this Rev, a delay in VBE'ing both PMUs occurred when the initial commands conflicted with SPC readouts, which have priority.

None of these rejects are attributable to the ECS.

4.3.1.1.1 ECS Clock Operation. The accuracy and stability of the ECS clock, as computed for each flight segment, are listed in the following table.

ECS CLOCK PERFORMANCE

	Accuracy	Stability, Average 6-Hour Period
Segment 1	1.43 parts in 10^7	6.02 parts in 10^{10}
Segment 2	1.43 parts in 10^7	6.02 parts in 10^{10}
Segment 3	2.05 parts in 10^7	3.63 parts in 10^{10}
Segment 4	2.34 parts in 10^7	2.64 parts in 10^{10}

4.3.1.2 Minimal Command Subsystem. The MCS responded correctly to all commands.

4.3.1.3 Remote Decoder/Backup Decoder. Both sides of the Remote Decoder were used for each of the five recoveries. Performance of both sides was determined to be acceptable through analysis of telemetry data.

4.3.1.4 Command System Usage Summary Through Rev 1201.

System	Total Operating Time (Hours)
ECS	1804.0
MCS	5.0
Remote Decoder	2.0
Backup Decoder	0.05

4.3.2 375 MHz Receiver

The 375 MHz Receiver was powered during the entire mission with no anomalies.

4.3.3 Data Interface Unit

The Data Interface Unit performed satisfactorily throughout the flight.

Section 5

ELECTRICAL DISTRIBUTION AND POWER (EDAP)

5.1 SOLAR ARRAYS

Solar Arrays were extended on Rev 1. Power Output from each leg exceeded the specification value. Degradation from the initial output to the end of the fourth segment was 5.2 percent. The solar array degraded 3.5 percent during the first 30 days which is within the predicted degradation of 3 to 5 percent. Total degradation after the RV-5 drop was 4.6 percent.

The degradation associated with the RV-5 drop was not isolated by before and after flight data as it was on SV-5. However, the 1.1 percent increase in degradation that occurred from 30 days to after the ST-RV drop on the 43rd day is considerably less than the 1.6 percent increase on SV-5 that occurred over the two day interval that included the ST-RV drop. This indicates the ST-RV drop produced considerably less contamination of the Solar Arrays on SV-6 than it did on SV-5.

5.2 MAIN BUS VOLTAGE

The main buss boltage varied from a low of 27.1 volts to a high of 31.6 volts. The allowable range was 25.5 volts to 33.0 volts. Low voltage data was obtained with a buss load greater than 50 amps. High voltage was observed prior to K2 cutoffs on charge cycles.

5.3 POWER CAPABILITY AND USAGE

Power usage ranged from 320 to 390 amp-hours/day. Average usage over the mission was 339 amp-hours/day which was below the average available capacity of 379 amp-hours/day.

5.4 TYPE 29 BATTERY PERFORMANCE

All Type 29 batteries operated in a desirable environment (44 to 50°F) throughout the mission. Two battery heaters cycled abnormally during the flight. On Rev 7 the heater on Battery 3 began a 10 sec ON and a 4 sec OFF cycling that continued until Rev 89 when the heater resumed a normal operation. On Revs 211 and 212 Battery 2 exhibited a similar short ON/OFF cyclic operation. In both cases the batteries were maintained in the desirable temperature range of 44 to 50°F. The cyclic behavior is attributed to the action of a bimetallic disc within the thermostat which moves toward a concave position before snapping to that position as it cools. This motion releases pressure on the switch contact, increasing resistance and resulting in heating of the disc causing it to turn off again. Worst consequence of a complete failure would be a continual ON position raising the battery temperature to 65°F which would be tolerable. A solid state device is scheduled to replace this item on Block III. In the interim, additional testing has been introduced to screen out switches that might incorporate discs that would give this cyclic performance. No other action is contemplated.

5.5 PYRO BATTERY PERFORMANCE

Pyro battery performance is summarized in Table 5-1.

Table 5-1
PYRO BATTERY PERFORMANCE

	Pyro Battery 1	Pyro Battery 2
Stabilized Temperature	50°F	49°F
Left Peroxide Region	9 days	22 days
Liftoff Capacity	10.6 amp-hours	10.2 amp-hours
Based on 75 Day Mission		
Used During Mission	2.6 amp-hours	2.6 amp-hours
Remaining Capacity	8.0 amp-hours	7.6 amp-hours
Remaining Cell Degradation Life	52 days	48 days

5.6 LIFEBOAT BATTERY PERFORMANCE

The Lifeboat battery operated normally in a 52°F environment throughout the mission. A total of 133 amp-hours remained at the end of the mission from an initial 353 amp-hours at launch. Remaining cell degradation life was 52 days.

Section 6

LIFEBOAT II

6.1 BAY 10 BATTERY INDUCED ERRORS

As on SV-5, two Type 29 batteries were installed in Bay 10 adjacent to the Lifeboat magnetometers in Bay 9. To establish the magnitude of the battery induced magnetometer errors, a calibration test was run on Rev 51 with the following results:

- Telemetry bias on both P and Q magnetometers was 0 to 1.5 milligauss; therefore, no correction is required for T/M bias
- Permanent magnetism produces an error of approximately ±1 milligauss on the P and R magnetometers and a -3 milligauss error on the Q magnetometer.
- Induced magnetism errors are similar to those on SV-5 and are the largest error source, depending on magnetic field magnitude and direction. Error ranges are

  Q +2 to -6 milligauss
  P +6 to -5 milligauss
  R +4 to -5 milligauss
- Based on the errors encountered, it was concluded the Lifeboat system would operate within specified attitudes if it were used.

Additional data confirming the Lifeboat ability to meet attitude specification was obtained during RV-1 and also RV-4 when the P and Q magnetometer outputs were compared with computed values from DGMAP. The results imply less than a 0.5 deg error in pitch and yaw, well within the allocated error of 2.5 deg.

No deboost simulation was performed; however, data obtained during the Yaw Attitude Determination Tests (see Section 6.2) can be used to derive the magnitude of the errors that would be encountered in deboost and these were 0.8 to 1.4 deg in yaw and 0.6 deg in pitch, well within the allocated error values of 1.7 degrees.

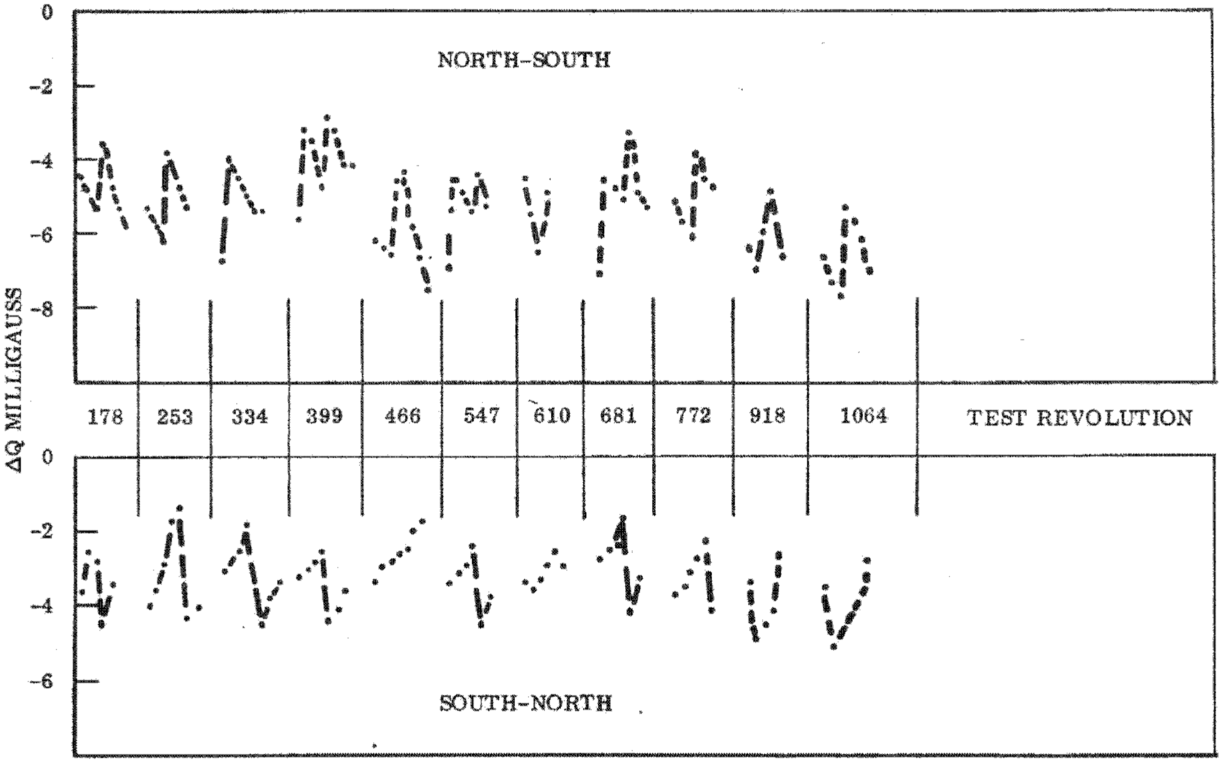
6.2 Yaw Attitude Determination

Periodic yaw attitude determination tests were performed during the flight as a backup in the event of ACS malfunctions.

These tests were performed at near equatorial locations with the vehicle orbit path north to south and then south to north. The data was taken at approximately the same latitudes and longitudes for each test sequence, minimizing variations due to changes in the magnetic field.

This data is shown in Figure 6-1. During these tests yaw attitude was approximately zero degrees. Since a 1 degree yaw error would result in a 6 milligauss change in the ΔQ magnetometer from DGMAP, it can be seen that such an error would be difficult to detect without the establishment of the magnetometer distortion error while ACS control is normal.

However with the magnetometer baseline (no yaw attitude error) it is then possible to detect the existence of yaw attitude errors in excess of 1 deg.



ΔQ IS DIFFERENCE BETWEEN MAGNETOMETER READING AND PREDICTED READING (DGMAP)

Fig. 6-1 Yaw Attitude Determination Tests

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Section 7

SENSOR SYSTEM

7.1 COARSE FILM PATH

Both coarse film paths (supply, loopers, steerers, articulators and takeups) exhibited nominal operation throughout the mission. The same 5 ips maximum rewind velocity and scan-angle restrictions as imposed on preceding flights to preclude mistracking were adhered to throughout this mission also.

7.2 FINE FILM PATH

Both fine film paths performed nominally throughout the entire mission.

7.3 COMMAND AND CONTROL

The command and control subsystem functioned normally through the mission in both stereo and mono modes. The OOAA nominals and focus of the aft looking camera were adjusted to optimum values as determined by PFA for the color film used in this camera. No compensating adjustments were made during the brief period of SV attitude error early in Segment one.

7.4 OPTICAL BAR PERFORMANCE

The optical bar photographic performance was nominal throughout the mission. Post-flight analysis showed that different best focus positions were required for the black-and-white film and the color film used in the aft looking camera. The necessary adjustments were made as described in Paragraph 7.3. Mechanical performance of the forward looking camera optical bar was nominal throughout the mission, but the aft-looking camera optical bar drive servo torque began increasing above nominal levels early in Segment one. To avoid a potentially catastrophic failure, operations were restricted to one operation per rev with a maximum duration of 120 seconds. By the beginning of Segment two, the torque had stabilized at a safe level and the above operational restrictions were lifted on Rev 362. Operation for the remainder of the mission was nominal except for the higher but still safe torque level.

7.5 INSTRUMENTATION

No major anomalies or malfunctions occurred during the mission. However, on a few occasions in Segment four, the SS temperature and pressure monitors indicated zero TM volts several seconds after being commanded ON (via the Sensor Subsystem Instrumentation Power On Command). In all cases nominal signals eventually appeared and no operations were affected.

7.6 PNEUMATICS

Pneumatics subsystem performance was nominal throughout the mission. During SOLO the pneumatics system was run to depletion and the average use rate was determined at 0.0215 lb N_2/minute of pneumatics operation.

Section 8
RECOVERY VEHICLES

8.1 SUMMARY

The recovery statistics are shown in Table 8-1 and Fig. 8-1. Performance of the RV subsystems is summarized in Table 8-2. Data indicate that all RV events (on-orbit, reentry and recovery) occurred as planned (except for the premature activation of the flashing recovery light during "reel-in" on all flights except RV-2) and the RV flights followed the predicted trajectories. In addition to premature activation of the flashing light, two minor anomalies occurred. On RV-4, the Recovery Light cover lanyard failed at its attach point to the drogue lazy leg. The cover was removed from the light but the cover and lanyard were not extracted from the vehicle. Also on RV-4 a heat-shield SMDC (Shielded Mild Detonating Cord) line separated from its connector with no adverse effects.

All payloads were recovered in good condition. Loose outer wraps on the payload takeup units are due to rotation of the payload after aerial retrieval induces shearing of the corepins. Loads exceeding the corepin strength were anticipated. Strengthened corepins are scheduled for SV-11.

8.2 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 8-1 shows the entry conditions to be well within previously established entry boundaries and that the conditions at time of drogue chute deployment were within the design envelope.

Table 8-1
RV RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
RV Serial No.	26	27	25	28
Recovery Rev No.	310	505	926	1202
Recovery Date (1973)	1 August	13 August	8 September	25 September
Payload Weight (lb) (A;B) (Measured wt from Recovered RV)	A = 233.8 B = 234.2	A = 212.0 B = 227.0	A = 224.0 B = 225.0	A = 206.4 B = 193.6
Unbalance Percent	0.2	6.5	0.4	5.5
SV Orbit (h_p x h_a/ω_p)*	87.92 x 151.14/ 135.62	88.22 x 155.07/ 128.37	87.48 x 145.87/ 131.20	89.04 x 152.20/ 124.45
SV Pitch Angle (deg)	-35.2	-38.1	-38.8	-37.6
Nominal PIP Latitude	27.00°N	21.00°N	26.00°N	25.50°N
Impact Location Error (EPPD vs. Teapot Eval)				
Overshoot (nm)	5.73	9.74	4.66	3.06
Crosstrack (nm)	1.02E	5.33W	2.22W	0.07W
Recovery (Aerial)				
Altitude (ft)	8700	9800	13,500	14,000
Parachute Condition	No Damage	No Damage	Moderate Damage**	Moderate Damage**
Retrieval Pass	2	2	1	1
RC/Payload Condition	Good	Good	Good	Good

*h_p = Altitude of Perigee (nm), h_a = Altitude of Apogee (nm), ω_p = Argument of Perigee (deg)

**Damage had no effect on recovery capability or chute performance

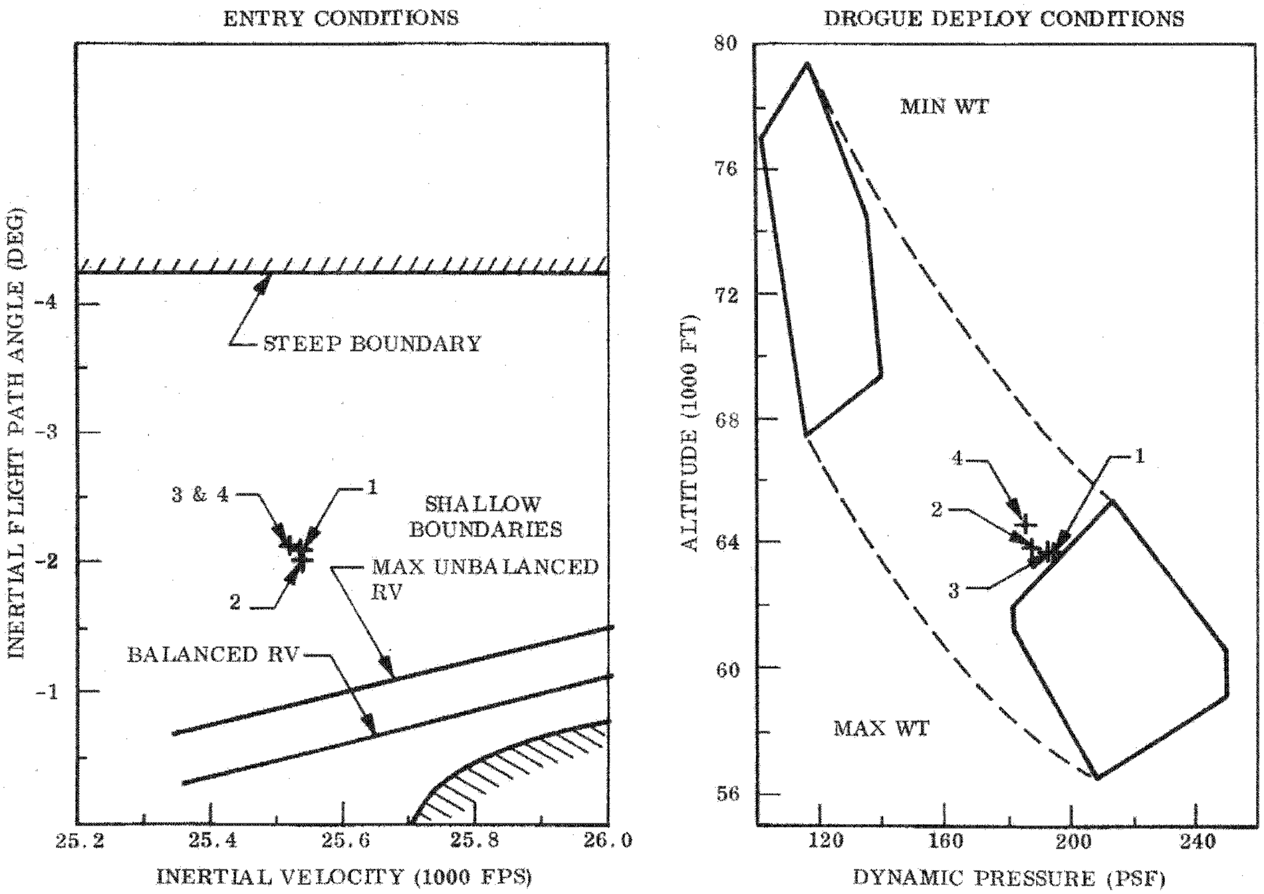

Fig. 8-1 SV-6 Reentry Parameter Comparisons

Table 8-2

RV SUBSYSTEM PERFORMANCE SUMMARY

RV Subsystem/Function	Performance Assessment
On-Orbit Thermal Protection	Normal ● T_{PL} Container = $T_{REF}{}^{+0^{\circ}F}_{-5.6^{\circ}F}$ ● Power Usage - Watts (Avg of 4 RVs) Maximum = 17.6 (first day in orbit) Stabilized = 8.6 (fifth day in orbit) Allowable = 20
Trim and Seal	Normal
Electrical Power & Distribution	Normal ● All batteries activated ● All voltages were at least 25 volts open circuit voltage
Structure	Normal ● Recovery light cover was removed from light but cover and lanyard were not extracted from vehicle.
Pyro Subsystem	Normal ● All primary and redundant pyrotechnics in each RV were verified by post flight inspection to have functioned properly. The heat shield separation SMDC line separated from the connector block on RV-4
Spin Stabilization	Normal
Retro Motor	Normal
Tracking, Telemetry, Instrumentation	Normal
Heat Shield	Normal
Base Thermal Protection	Normal
Sequential	Normal ● On RV-1, -3 and -4, while in tow the water sensor switch was inadvertently shorted by a piece of graphite cloth from the parachute cover causing the RV recovery light, used as a recovery aid, to be energized. The aircraft recovery crew reported that the light was flashing during "reel-in" of the RV
Recovery	Normal

8.3 REENTRY VEHICLE SUBSYSTEM PERFORMANCE

8.3.1 Sequential Subsystem

During aerial recovery of RVs 1, 3 and 4, the water recovery sequence was activated during tow. This anomaly was first reported on RV-3 of SV-5 and its cause is attributed to strands of graphite cloth from the parachute thermal cover shorting the water sensor switches. A protective vent cap has been added to the water sensor effective on SV-7.

8.3.2 Structure

PFA of RV-4 revealed the lanyard (which removes the cover from the recovery light during drogue parachute release) had failed at its attach point to the drogue lazy leg. Even though failure occurred; cover removal from the light was accomplished. Since this was concluded to be a random type failure and the main purpose of the lanyard was achieved, no changes will be made in the present design. On SV-11 and up, a new parachute design will be incorporated which eliminates those features of the lanyard which contributed to this anomaly.

8.3.3 Pyro Subsystem

During heat shield separation on RV-4, an SMDC line separated from the brass connector block. Fracture of all heat shield attach bolts and nominal heat shield separation were achieved. Following a similar occurrence on the RV/SBA separation SMDC lines during the pyro shock tests for APSA run on the SDV-3 (Satellite Development Vehicle No. 3) in early 1972, the aluminum ferrule nut design on all SMDC separation systems were replaced with stainless steel ferrule nuts to provide a 50 percent increase in strength between the brass connector block and SMDC line connection. This change will be incorporated on SV-9026 and up. Additional clamps were added to hold the SMDC lines on the RV/SBA interface after the SDV-3 tests.

(b)(1)
(b)(3)

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Section 10

SUBSATELLITE

There was no subsatellite flown on SV-6.

Section 11

STELLAR TERRAIN (ST) SUBSYSTEM

11.1 ST PERFORMANCE

The operation and performance of the second ST camera system flown on SV-6 is considered excellent. No functional anomalies were encountered.

11.2 ST-RV (RV-5) RECOVERY

The ST-RV was successfully recovered on Rev 683. Recovery statistics are shown in Table 11-1. All RV systems performed normally. The SV provided a satisfactory pitch angle after 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. 11-1. The miss distance between the PIP and EPPD was calculated to be 15.22 nm short and 3.57 nm East of the ground track. The offset of the pick-up point and the EPPD is attributed to wind. The capsule was recovered at 12,800 ft on the first pass with no damage to the chute or capsule.

Table 11-1

ST-RV (RV-5) RECOVERY SUMMARY

Recovery Rev	683
Date	24 August 1973
Payload Weight (100%)	69.33 lb
SV Recovery Orbit	
Perigee (nm)/Apogee (nm)/Perigee ~~Angle~~ ARGUMENT (deg)	87.7/147.0/126.7
SV Pitch Angle (after yaw around)(deg)	-64.4

	PIP	EPPD	Air Snatch
Latitude	22° 27.6'	22° 42'	23° 00'
Longitude	163° 54.6'	163° 48'	163° 45'
Altitude			12,800 ft

11.3 DOPPLER BEACON SYSTEM (DBS)

The DBS satisfactorily performed all mission objectives. The antenna was deployed as commanded and there were no anomalies.

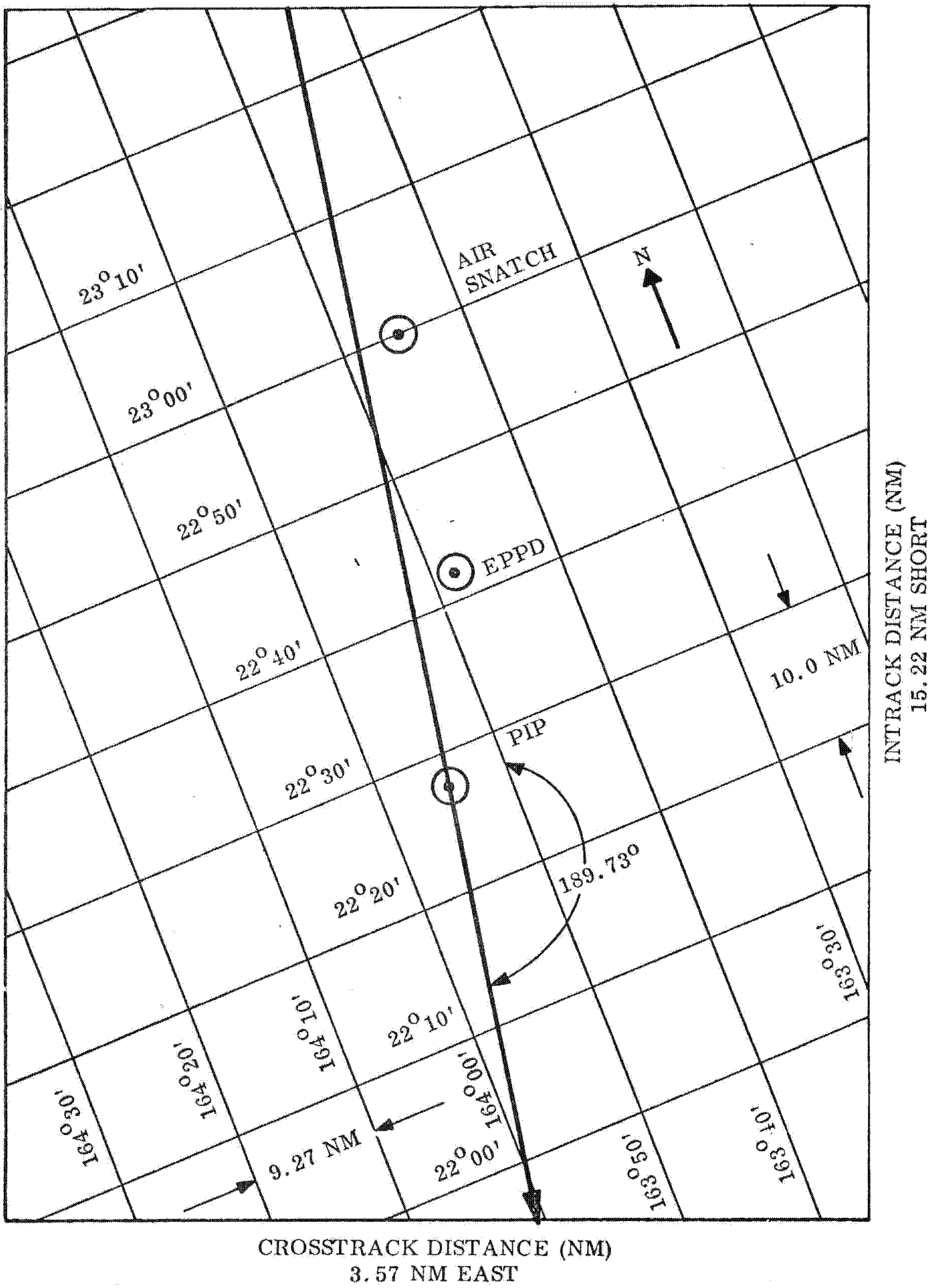

Fig. 11-1 ST-RV Recovery Locations

Section 12
THERMAL CONTROL

12.1 FORWARD AND MID SECTIONS

The Forward and Mid Section structural temperature control is summarized in Table 12-1. The data indicates that the thermal design of these sections provided the required orbital temperature control. No design changes are forthcoming as a result of SV-6 flight performance.

Table 12-1
THERMAL DATA SUMMARY

Vehicle Section	Parameter	Design Limits (°F)	SV-6 Actuals
Mid Section	$\overline{T}_{tca}$	49/91	65
	$\overline{T}_{su}$	47/93	66
	$\overline{T}_{su} - \overline{T}_{tca}$	5/-4	1
Forward Section	T_{fwd}	47/93	64/69
	$T_{fwd} - \overline{T}_{tca}$	±20	-1/4
MCM	T_{enc}	32/69	50
	$\overline{T}_{tu}$	30/85	46
	DBS Panel	32/90	58

Definitions:

$\overline{T}_{tca}$	Orbit average radiation temperature of the Forward compartment structure in the Mid Section
$\overline{T}_{su}$	Orbit average radiation temperature of the aft compartment structure in the Mid Section
T_{fwd}	Orbit average radiation temperature of the Forward Section derived from the average temperature of the bulkhead
T_{enc}	Orbit average temperature of the MCM enclosure
$\overline{T}_{tu}$	The satellite recovery vehicle average take-up temperature

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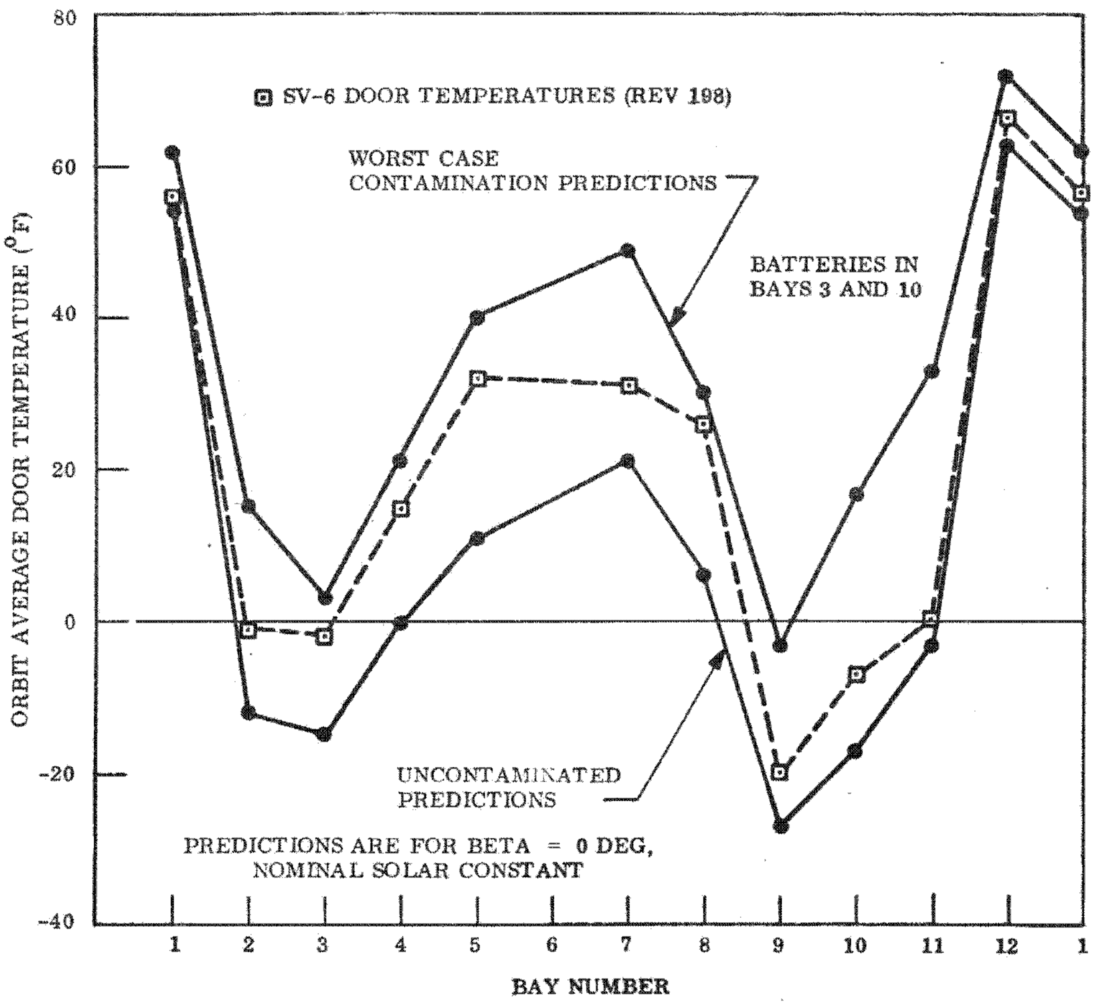

Fig. 12-1 SV-6 Equipment Door Temperatures

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12.2 ACTIVE THERMAL CONTROL (ATC)

T_{ref} for the forward section film path ATC remained relatively constant throughout the primary mission. The RV heater zones which are actively controlled relative to T_{ref} were generally within 1 deg of T_{ref}.

12.3 AFT SECTION

Acceptable aft section temperature control was maintained throughout the flight. All equipment temperatures remained within design limits as shown in Table 12-2.

The SV-6 Aft Section was configured as follows:

- Type 29 batteries were located in Equipment Section (ES) bays 10 and 3. This was first done on SV-5.
- Battery bay doors as well as bays 11 and 2 doors were covered with Flexible Optical Solar Reflector (FOSR), replacing white silicone paint. This was first done on SV-5.
- Heat straps were installed in the Attitude Reference Module (ARM) and the ES bay 7 door was painted white in order to provide capability for dual ACS operation. This was first done on SV-4.
- A Block II IRA and Horizon Sensor were flown in the ARM.

Flight data indicates that battery and IRA temperatures were satisfactory, and that the battery bay and ARM designs performed as predicted.

Equipment and structural temperatures indicated contamination degradation to external vehicle thermal control surfaces similar to that of all other flights. The amount of degradation was within the bounds of preflight analysis as indicated by Fig. 12-1, which compares actual Equipment Section door temperatures with predictions for an orbit angle (Beta) of 0 deg. Solar absorptance (α_s) for the degraded FOSR was estimated to be 0.27 to 0.41 less than the $\alpha_s = 0.50$ assumed for the worst case.

Table 12-2

SV-6 AFT SECTION CRITICAL COMPONENT TEMPERATURES

Critical Component	Design Limits (°F)	SV-6 Actuals (°F)(2)
EDAP		
PDJB	--30/170	74/76
CCCs	-30/170	82/89
Batteries, Bay 3	35/70	43/50
Batteries, Bay 10	35/70	44/53
PDAs	-30/160	50/77
Solar Array Panels	-125/225	-68/146
ACS		
IRA	50/130	97/110
HSA Heads	0/130	76/82
Gyros	50/200	150/173
OAS		
Tank	65/100	74/84
Quad Valve	35/200	83/158(1)
Catalyst Bed	---	116/160(1)
T&T		
Tape Recorders	20/130	70/91
Transmitters	-30/170	71/91
PCM Master	-30/170	68/88
PCM Remote, B2	-30/170	68/80
PCM Remote, B10	-30/170	63/75
Command		
PMU A	-40/145	76/79
PMU B	-40/145	85/88
Clock	-40/153	88/97
MCS	-40/149	50/65
RCS		
Tanks	40/140	69/86
Plumbing, Bay 12	35/140	75/88

(1) OA not firing
(2) Steady-state

Section 13

MASS PROPERTIES

The history of the SV mass properties throughout the flight are tabulated in Table 13-1.

Table 13-1

Description	Weight (lb)	Center of Gravity (inches)			Moment of Inertia (slug-ft^2)			Product of Inertia (slug-ft^2)		
		$\overline{X}$	$\overline{Y}$	$\overline{Z}$	I_x	I_y	I_z	I_{xy}	I_{xz}	I_{yz}
Prelaunch Weight	23983	1972.5	0.12	3.47	6895	198106	197880	-72	806	43
Separation From Stage 2	21002	1983.9	0.15	3.99	4753	166949	166651	-58	1081	43
Arrays Deployed 0°	21002	1984.4	0.15	3.99	5926	167984	168919	-57	1089	29
Prior to Drop 1	20433	1970.4	0.16	4.61	5916	170613	171548	-67	1529	29
After Drop 1	18883	1994.5	0.17	3.55	5704	139158	140241	-53	145	29
Prior to Drop 2	18551	1983.2	0.17	4.19	5708	141559	142626	-54	552	29
After Drop 2	17025	2004.8	0.18	3.00	5495	120410	121626	-45	-600	30
After Drop 5	16630	2014.0	0.19	3.65	5400	107187	108489	-36	332	26
Prior to Drop 3	15924	1999.1	0.20	4.49	5412	106226	107504	-45	604	26
After Drop 3	14386	2019.7	0.22	3.10	5198	92380	93807	-34	-323	27
Prior to Drop 4	13996	2009.3	0.23	3.88	5222	91593	92985	-45	-125	26
After Drop 4	12514	2025.6	0.26	2.30	5010	84601	86142	-34	-786	27

Section 14
STRUCTURE AND DYNAMICS

14.1 PRELAUNCH WINDS ALOFT LOADS ANALYSIS

Table 14-1 presents a chronological tabulation of the winds aloft computer runs for SV-6. The results are plotted on Fig. 14-1.

The loads and control analysis computer simulations leading to launch were accomplished without violating any of the established vehicle constraints and resulted in repeated Go for Launch recommendations. An R-17 day preliminary winds loads data check run was accomplished on 22 June 1973. These data checked the Martin Marietta Corporation (MMC) independently generated data well within all specified limits. MMC verified the SBAC data results as being acceptable by letter (MMC 73-Y-31198) dated 28 June 1973.

14.2 SOLAR ARRAY

The erection and deployment time history for the left (-Y) solar array is shown in Fig. 14-2 and for the right (+Y) solar array in Fig. 14-3. The arrays were deployed at the first station pass, INDI, and were fully deployed and erected by the next station, POGO where they were repositioned from +18 to 0 deg for the maximum output at the flight beta angle of -1.9 deg.

14.3 SHROUD SEPARATION

The shroud separation data is presently interpreted as indicating a faster separation than predicted which is similar to the experience on previous flights. Temperature sensors have been rearranged on SV-7 to examine thermal gradients across the frames as a possible contributor to this pnenomenon. Also special calibration tests and higher rates of data will be used to better define the initial separation motion on SV-7.

Table 14-1

WINDS ALOFT ANALYSIS SUMMARY

	Balloon Release Time				
	T-30	T-12	T-6	T-3	T-0
	3800 Run at STC Time				
	T-24	T-8.5	T-3	T-1	---
<u>SV Structural Loads</u>					
Bending Mom (% Limit Load)	57.06	56.74	55.61	51.63	56.61
Critical SV Station	1902	1902	1902	1902	1902
Elapsed Time (seconds)	51.45	59.20	55.01	53.70	52.40
Altitude (feet)	28,000	36,998	31,989	30,488	29,001
<u>SRM Side Force</u>					
% Allowable	37.82	37.11	37.17	37.17	37.59
SRM No.	1	2	2	2	1
Pitch or Yaw	Pitch	Pitch	Pitch	Pitch	Pitch
<u>TVC Usage for Control</u>					
% Allowable Expended	56.2	55.7	53.0	48.4	60.4
SRM No.	1	1	1	1	1
Expended (pounds)	1294.25	1283.48	1222.38	1118.00	1391.20
<u>Vehicle Response</u>					
Maximum $\bar{\alpha}q$ (% allowable)	24.25	26.91	27.71	30.61	29.22
Maximum $\bar{\alpha}q$ (deg-psf)	1003.	1148.	1178.	983.	982.
Elapsed Time (seconds)	51.45	26.91	27.71	37.3	35.3
Altitude (feet)	28,000	31,948	31,556	14,553	13,002

~~TOP SECRET~~ / H

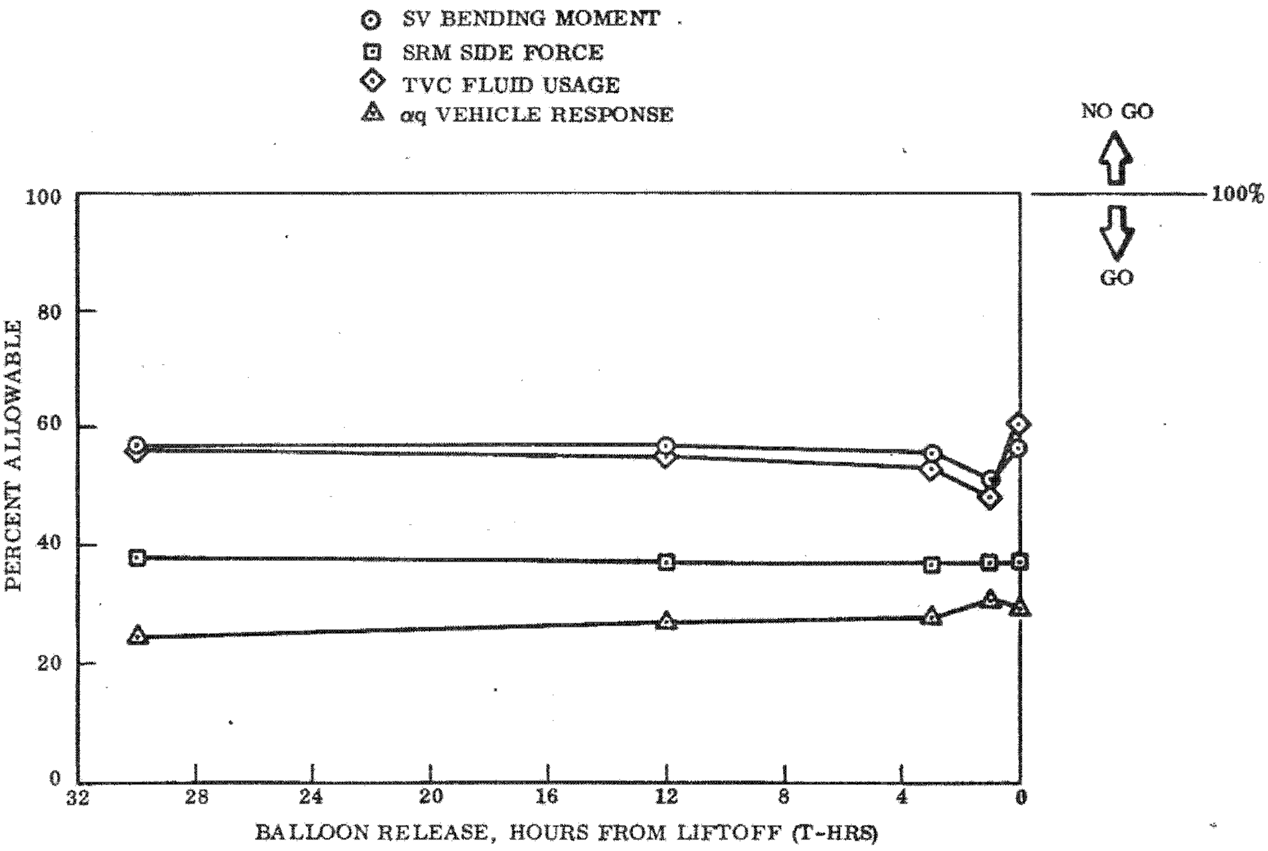

Fig. 14-1 Critical Launch Parameter Summary

~~TOP SECRET~~ / H

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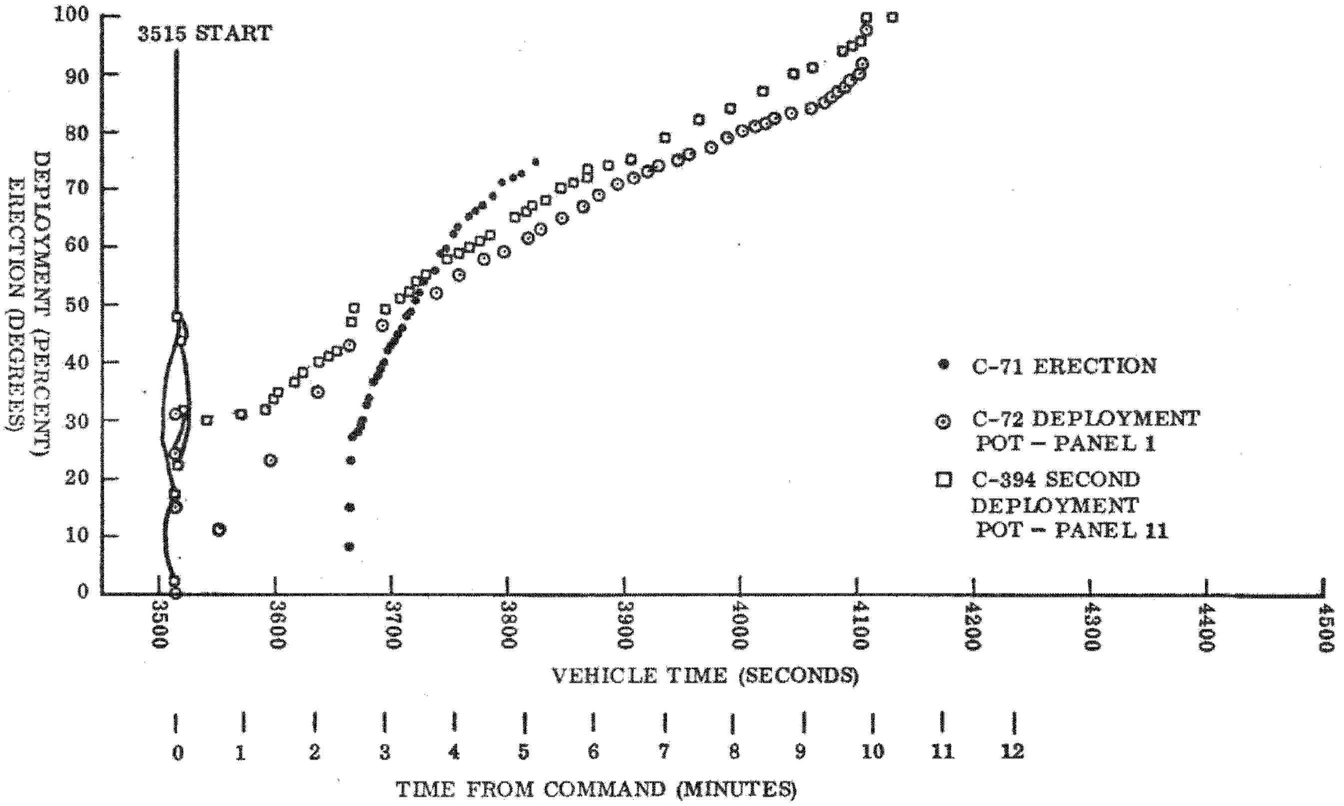

Fig. 14-2 Left-Hand Solar Array Erection and Deployment Time Histories

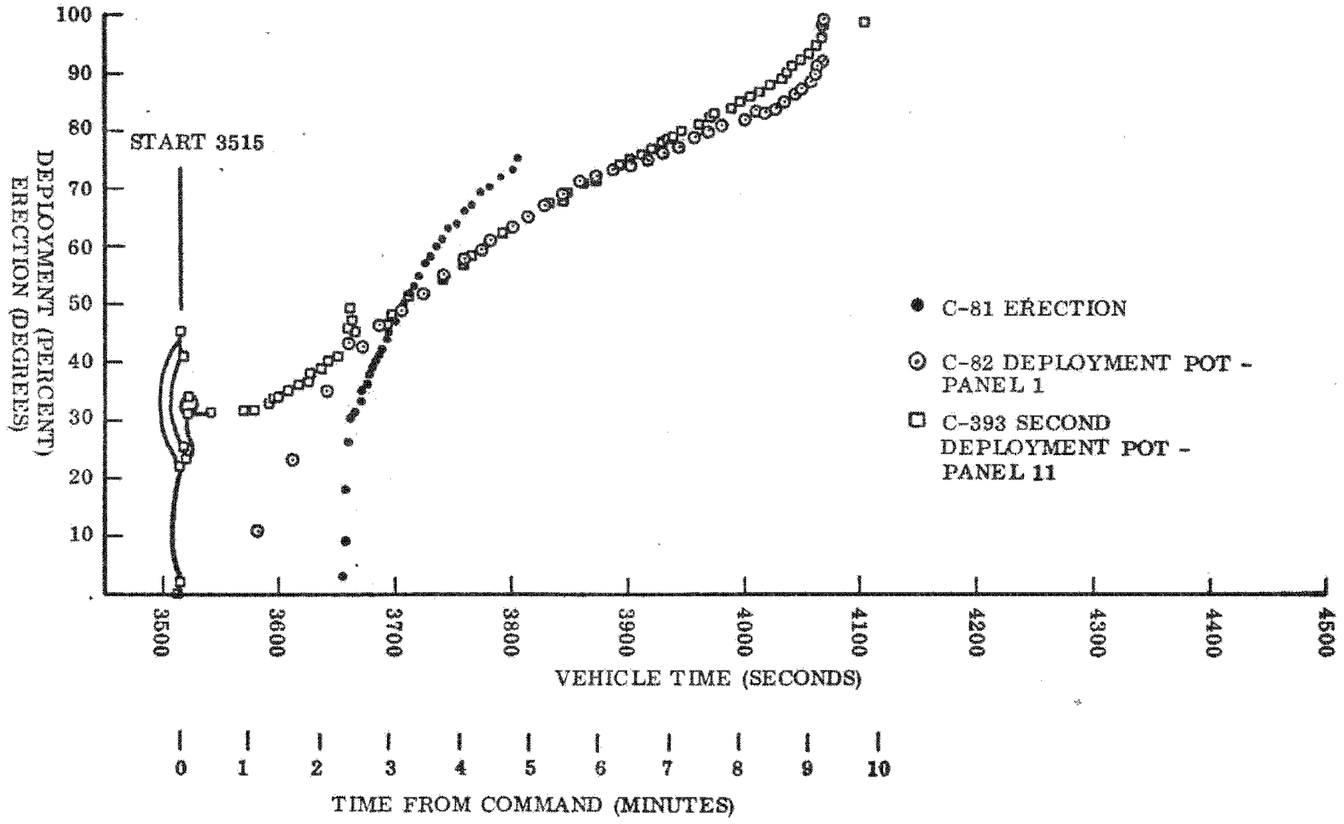

Fig. 14-3 Right-Hand Solar Array Erection and Deployment Time Histories

Section 15

SOFTWARE

There were no software problems which impacted flight objectives.