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

Prepared and Submitted by the
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FOREWORD

This report describes the performance of the first HEXAGON Program Satellite Vehicle (SV-1). The vehicle was launched on 15 June 1971 and completed its primary mission with the recovery of RV number four on 16 July 1971. This report encompasses only these 31 days.

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ACRONYMS

ACS	Attitude Control System
BFE	Best Fit Ephemeris
BV	Booster Vehicle
CCC	Charge Current Controller
CV	Constant Velocity
DIU	Data Interface Unit
ECS	Extended Command System
ESD	Emergency Shut Down
FCEA	Flight Control Electronics Assembly
FOSR	Flexible Optical Solar Reflector
FST	Flight Support Team
HS	Horizon Sensor
HSA	Horizon Sensor Assembly
ICD	Interface Control Document
IRA	Inertial Reference Assembly
MCM	Mapping Camera Module
MCS	Minimal Command System
NSPC	Normal Stored Program Command
OA	Orbit Adjust
OAS	Orbit Adjust System
OB	Optical Bars
P	X-axis Magnetometer Output
PCM	Pulse Code Modulation
PDA	Positional Drive Assembly (Solar Array)
PDJB	Power Distribution J-Box
PDWN	Pitch Down
PGR	Pitch Gyro Rate
PIP	Predicted Impact Point
P/L	Payload
PMU	Programmable Memory Unit

PVA	Pitch Vehicle Attitude
Q	Y-axis Magnetometer Output
R	Z-axis Magnetometer Output
RCS	Reaction Control System
RGR	Roll Gyro Rate
RPS	Reserve Power System
RTS	Remote Tracking Station
RV	Reentry Vehicle
RVA	Roll Vehicle Attitude
SBAC	Satellite Basic Assembly Contractor
SCC	Subsystem Command and Control
SDV-3	Satellite Development Vehicle
SECO	Stage II Engine Cut Off
SGLS	Space Ground Link System
SOLO	Operations Beyond the Primary Mission
SPC	Stored Program Command
SPL	Sound Pressure Level
SRM	Solid Rocket Motor
STC	Satellite Test Center
SV	Satellite Vehicle
TM	Telemetry
TT&C	Telemetry, Tracking and Control
VCO	Voltage Controlled Oscillator
VSPC	Variable Stored Program Command
YGR	Yaw Gyro Rate
YVA	Yaw Vehicle Attitude

Section 1

SUMMARY OF GENERAL SYSTEM PERFORMANCE

1.1 SV SYSTEM PERFORMANCE

The first HEXAGON Program Satellite Vehicle was placed in its planned 100 x 165 nm orbit by a Titan IIID Booster Vehicle on 15 June 1971. Photographic operations commenced on the second day and continued until the 31st day, one day beyond the required 30 day primary mission life. The four RVs were separated from the SV with their film loads on Days 5, 11, 25 and 31. All RVs except the third were successfully recovered. The overall performance of the Satellite Vehicle was excellent and all HEXAGON mission objectives except the recovery of RV 3 were met. Following an extended SOLO operation period (which is not described in this report), the SV was successfully deboosted after 52 days in orbit. The overall SV performance for the ascent phase and each of the four mission segments is summarized as follows:

<u>Ascent</u>. Ascent events were all entirely nominal and proper stabilization of the SV allowed deployment of the Solar Arrays at the first opportunity on Rev 1. Apparent contamination of Aft Section thermal control surfaces during ascent caused an over-temperature condition in the battery module in Bay 12 which remained constant throughout the mission. The power system supported payload operations as planned in spite of the over-temperature batteries.

<u>Segment One</u>. By Rev 16, all Sensor Subsystem health checks had been completed and operational photography began on Rev 24. On Rev 82, RV 1 was successfully separated with a total film load of 40,000 feet. Damage to the main parachute and aerial retrieval target cone was observed which led to the decision to allow the RV to water impact. The RV was recovered from the water with no damage to the payload. Photographic image quality was considered to be acceptable for the forward-looking camera and good for the aft-looking camera.

Segment Two. Operational photography continued on Rev 88 using RV 2. On Rev 179, RV 2 was successfully separated with a total film load of 52,000 feet. Main parachute damage again occurred but aerial retrieval of the RV was successful. Image quality for this film load was rated good for both the forward- and aft-looking cameras representing an improvement over the RV 1 payload due to focus adjustments.

Segment Three. Operational photography continued on Rev 185 using RV 3. On Rev 405, RV 3 was successfully separated but was not sighted nor recovered by the aerial retrieval forces. Major damage to the main parachute apparently occurred during deployment. As a result of this malfunction, the entire film load of 54,000 feet was lost. A reduced film load was proposed for RV 4 to help insure proper recovery.

Segment Four. Following some difficulties with Emergency Shut Downs (ESDs), operational photography was resumed on Rev 470 using RV 4. The prolonged high temperature condition in the Bay 12 battery module resulted in the premature degradation of the pyro batteries which resulted in the separation of RV 4 on Rev 502, somewhat before even the reduced load of film was obtained. Separation and aerial retrieval of RV 4 was entirely normal and 26,000 feet of film was recovered. The photographic image quality from the forward-looking camera was good and was somewhat further improved over that recovered from RV 2. Image quality for the aft-looking camera was acceptable but was slightly degraded from that taken from RV 2 for reasons as yet unknown.

1.2 SUBSYSTEM PERFORMANCE

The performance of the SV Subsystems throughout the mission was generally excellent. All primary equipment functioned throughout the four segments and no backup equipment was required. Subsystem performance is summarized as follows:

Attitude Control System. The ACS meets performance requirements in all operating modes. No adjustments are necessary for the design mission.

Reaction Control System. Apparent early degradation of thruster pulse shape was observed but with no impact on control of the SV. The cause has not yet been determined but no changes are required for the design mission. Propellant capacity is adequate for the design mission.

Electrical Distribution and Power. The Main Power System meets requirements. The Reserve Power System, carried on this vehicle only, was not required. No adjustments are necessary for the design mission. Relocation of Bay 12 batteries to Bay 3 is necessary until the ascent contamination problem is eliminated. The pyro power system meets performance requirements with batteries in normal temperature range. Relocation of batteries to Bay 3 is necessary until the contamination problem is eliminated.

Orbit Adjust System. The OAS meets performance requirements. No adjustments are necessary for the design mission. Propellant capacity is adequate for the design mission.

Tracking, Telemetry, and Command. The TT&C system meets performance requirements and no adjustments are necessary for the design mission. Antenna pattern results in recommendation to restrict secure word block commanding to favorable station elevation angles. Extended Command System logic errors prohibit use of certain 11- and 12-bit commands. Impact of these constraints is minor. Instrumentation was adequate for SV control and diagnosis.

Lifeboat II. Health checks show performance meets requirements and no adjustments are necessary for the design mission. Battery capacity is adequate for tank heating but relocation to Bay 3 is necessary until the contamination problem is eliminated.

Structures and Mechanisms. All performance requirements were met and no adjustments are necessary for the design mission. Solution of the contamination problem may require new ejectable shields over the Aft Section thermal control surfaces.

Thermal Control System. All active and passive thermal control designs meet requirements except for the Bay 12 Aft Section over-temperature condition associated with the ascent contamination problem. A beta angle constraint is necessary until the contamination problem is eliminated but no changes to the basic thermal design are indicated.

A more detailed discussion of the performance of these subsystems is presented in subsequent portions of this report.

1.3 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 may be found.

Table 1-1

ANOMALIES

Rev	Description	Impact	Cross Reference
Ascent	HSA output transient	Primary roll and pitch output transients observed during SV/BV separation. Apparently caused by microphonics resulting from separation shock. Operation normal on orbit so no mission impact. Design changes on SV-2 are not indicated although SV-7 and up design will not be as susceptible to microphonics.	Paragraph 2.3.1
Ascent	Acoustic microphone	Microphone sensitivity to static pressure pulses at lift-off caused data degradation. Corrective high pass filters to be installed on SV-2 microphone amplifiers.	Paragraph 14.2
2	Hot Aft Section	Over-temperature condition on Bay 12 battery module resulting in degraded main power system capability and early pyro battery depletion. SV-2 to fly with battery module moved to Bay 3, beta angle restricted to near +20 deg, and contamination experiments installed in Bays 11 and 12 to identify problem solution. Appropriate solution planned to be implemented on SV-3.	Paragraphs 5.4, 5.5, 12.3, and 12.4
Throughout	Data drop-outs	SGLS antenna pattern holes excluded secure word loading at high station elevations. Operational restrictions are not severe and will be continued on future vehicles. No design changes indicated	Paragraph 4.2.2
82	RV 1 chute damage	Damaged chute sighted by retrieval forces. Water impact allowed with successful recovery. Modified parachute design to be retrofitted on SV-2.	Paragraph 8.3
179	RV 2 chute damage	Damaged chute sighted but successful aerial recovery implemented. SV-2 parachutes to be retrofitted.	Paragraph 8.3
314	Emergency shut down	Jam in fine film drive system. Normal ops resumed following constant velocity and engineering tests. No design changes indicated.	Paragraph 7.2.1

Table 1-1 (Continued)

Rev	Description	Impact	Cross Reference
402	Emergency shut down	Apparent temporary obstruction in coarse film path. Normal ops resumed following creep and constant velocity tests. No design changes indicated.	Paragraph 7.1.1
405	RV 3 chute failure	RV not sighted, nor recovered. Apparent premature disreef of main chute caused structural failure. SV-2 chutes to be retrofitted.	Paragraph 8.3
435, 459 460	RCS Thruster pulse shape distortion	Distortion similar to but not as severe as ground test experience occurred prematurely. Vehicle control entirely adequate and extra propellant usage not indicated. Cause and corrective action under investigation. No design changes indicated.	Paragraph 2.2.2
474, 476	RCS Thruster thrust level shift	Thrust level shift similar to ground test experience. Thrust remained within limits and showed a tendency to return toward normal conditions in a subsequent firing. In mono ops, roll rate exceeded fine mode rate limits. To be studied further. No design changes indicated.	Paragraph 2.2.2
445	Emergency shut down	Input drive capstan in fine film drive system stopped rotating. Cause is unknown. Normal ops resumed following mono ops during 5 revs and a recycle operation. No design changes indicated.	Paragraph 7.2.2
484	Pyro battery depletion	Pyro battery number 1 began rapid voltage decay earlier than anticipated. Review of battery duty cycle and temperature environment revealed degradation to be predictable. Reduced loading and cooler environment for SV-2 are planned.	Paragraph 5.5, and 12.4
492	Emergency shut down	ECS logic problem caused erroneous commands which caused ESD. SV-2 through SV-4 will restrict use of certain VSPCs. SV-5 will incorporate modified ECS.	Paragraph 4.3.1.2.3, 7.1.2 and 7.3

Section 2
ATTITUDE CONTROL

The SV-1 Attitude Control System performed as expected and met all specifications that could be measured. The summaries presented in the ACS section detail those requirements that could be verified from flight data.

2.1 ATTITUDE CONTROL SYSTEM

2.1.1 BV/SV Separation

BV/SV separation occurred at 545.2 sec vehicle time. Master clear OFF (which enables the pitch, roll and yaw integrators to accumulate angle), was at 513.4 sec and SECO (which terminates BV attitude control) occurred at 533.3 sec vehicle time. The maximum rate and attitude excursions attained by the SV following master clear OFF and the times in which the SV attitudes and rates came back within the specified limits following BV/SV separation are shown in Table 2-1.

Table 2-1
BV/SV SEPARATION

	From Master Clear Off to BV/SV Separation				Capture			
	Rate (deg/sec)		Attitude Excursion (deg)		Attitude		Rate	
					Angle	Settling Time	Rate	Settling Time
	Max Specified	Actual	Max Specified	Actual	Spec/ H/S Meas (deg)	Spec/ Meas (sec)	Spec/ Meas (deg/sec)	Spec/ Meas (sec)
Pitch	±.752	-.22	-22.85 to +9.63	+.94	±.70/ <±.30	1500/ 667	±.014/ +.010	1500/ 83
Roll	±.786	+.34	-7.50 to +10.94	+.75	±.70/ <±.30	1500/ 667	±.021/ +.020	1500/ 31
Yaw	±.752	+.19	-7.66 to +11.50	+2.1	±.64/ N/A	1500/ 667	±.014/ -.010	1500/ 630

2.1.2 Payload Operations

To evaluate the SV rate performance for the stereo payload (P/L) operations, one typical operation from each RV load was closely examined and the results are shown in Table 2-2. The rate data from several other P/L operations during each segment of the mission were scanned and the values shown are representative of those observed. In all cases the SV rates and integrator attitudes were held within their respective switching lines during the P/L operations following the startup transient. P/L operations were examined that used several combinations of scan angle and scan center positions with no apparent differences between them.

In mono operations, the roll rate stayed within the required limits for P/L operations following the film transport on command; however, the roll rate during the start and stop of the Optical Bars (OBs) exceeded the fine mode rate switching line of 0.0153 deg/sec. This was not expected since the level of control torque was thought to be more than the level of OB roll torque. This discrepancy is under study and SOLO experiments were carried out on Revs 629 and 645 to help resolve this question. See also discussion on RCS thrusters in paragraph 2.2.2.

2.1.3 Recovery

The pitch down maneuvers preceding the RV separations are summarized in Table 2-3. The pitchdown angle is read from the STC PDWN real-time data which is a software computed number – not a directly measured value. The maneuvering time is the time interval from the pitchdown rate command to the time the rate returns to a value of less than 0.1 deg/sec after removal of the command. Prior to the first RV separation, a pitchdown and pitchup test was run on Rev 66 which is included at the bottom of Table 2-3. No other data on a pitchup maneuver without the RV separation impulse was obtained during the basic mission.

The attitude channel maneuver rate command was -.705 deg/sec; however, the nominal expected coast rate is the summation of the rate channel maneuver rate command of 0.5 deg/sec plus the effective attitude channel saturation level of 0.5 deg divided by the rate to attitude gain ratio of 2.0 sec for an expected rate of $0.5 + 1/2 \times 0.5 = 0.75$ deg/sec.

Table 2-2

STEREO P/L OPERATIONS

Segment/Rev	Peak Rates During Start/Stop (deg/sec)			Peak Rates During Steady State Ops (deg/sec)			Settling Time (sec)
	Pitch*	Roll	Yaw	Pitch	Roll	Yaw	
	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.
1/74.3	None/-.001	None/ .009	None/-.007	±.014/-.001	±.021/-.005	±.014/-.001	0.2/0
2/155.4	None/-.003	None/-.006	None/ .009	±.014/-.001	±.021/-.006	±.014/ .009	0.2/0
3/381.3	None/-.001	None/ .004	None/-.010	±.014/-.001	±.021/-.006	±.014/-.001	0.2/0
4/477.4	None/-.006	None/ .008	None/ .011	±.014/-.001	±.021/-.002	±.014/-.001	0.2/0

MONO P/L OPERATIONS

Segment/Rev	Peak Rates During Start/Stop (deg/sec)			Peak Rates During Steady State Ops (deg/sec)			Settling Time (sec)	Roll Control Torque P/R Avail	P/L Roll Torque Required
	Pitch	Roll	Yaw	Pitch	Roll	Yaw			
	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.	Spec/Act.
4/476.3	None/-.012	None/ .047	None/ .007	±.014/ .002	±.021/ .008	±.014/-.007	6.6/0.0	>5.0/>7.0	<5.0/<6.0
4/474.4	None/-.012	None/ .026	None/ .008	±.014/-.012	±.021/ .010	±.014/ .007	6.6/0.0	>5.0/>7.0	<5.0/<6.0

*Geocentric Rate removed from pitch rate values.

Table 2-3

PITCH MANEUVER 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 Via PDWN (deg)	Spec (sec)	Actual (sec)	Command Rate (deg/sec)	Coast Rate Expected (deg/sec)	Coast Rate Actual (deg/sec)
1/82.2	-38.8	-38.3	150	76	-.705	-.75 ±.05	-.74
2/179.2	-44.1	-43.6	150	82	-.705	-.75 ±.05	-.74
3/405.2	-45.0	-44.8	150	83	-.705	-.75 ±.05	-.74
4/502.3	-42.0	-44.6	150	78	-.705	-.75 ±.05	-.74
Pitch down test Rev 66.3	-30.0	-29.7	150	60	-.705	-.75 ±.05	-.74
Pitch up test Rev 66.3	+30.0	+30.5	150	54	+.705	+.75 ±.05	+.73

Table 2-4

SUMMARY OF RV/SV SEPARATION PERFORMANCE

RV/Rev	Peak Pitch Rate (deg/sec)	Maximum Pitch Integrator Angle (deg)	Impulse Induced by RV (lb-sec)	Pitch Valve (2, 3) Thrust Level (lbf)	Pitch Down Prior to Sep (deg)	Pitch up Following RV Sep to Removal of Maneuver Command (deg)	Pitch Inertia (slug-ft^2)	Pitch Moment Arm (ft) (Thruster)	Roll Angle Spec (deg)	Roll Angle Meas H/S (deg)
1/82.3	2.01	13.4	126.5	4.82	-38.3	84.6 (1)	105121	15.3	±1.0	-.008
2/179.3	2.0 (2)	15.7 (2)	112 (2)	–	-43.6	90.2	82661	13.9	±1.0	+.04 (3)
3/405.3	2.35	21	128	3.67	-44.8	90.5	65990	12.8	±1.0	+.048
4/502.3	2.8	31.3	160	3.2	-44.6	93.4	55975	11.7	±1.0	+.08

(1) Complete data not available

(2) Estimates. Data not available for 17 sec after separation

(3) At POGO fade before separation

The RV/SV separation performance is summarized in Table 2-4.

2.1.4 Orbit Adjust

The disturbances resulting from the Orbit Adjust (OA) firings were within the predicted magnitudes and well within the dead band limits of the attitude control system and satisfied the settling time requirements of 20 sec.

The OA burn influence on the control system followed the predicted trends. The required propellant expenditures are shown in paragraph 2.2.1.

2.1.5 Deboost

The SV deboost sequence on Rev 839 was as follows:

	System Time (sec)	Veh. Time (sec)	ΔT (sec)
• Yaw around	60824.7	292128.4	
• OA On	66542.9	297846.6	1003.2 (OA On to OA Off)
• OA Off	67546.2	298849.8	194 (OA Off to Unable to maintain)
• Unable to maintain positive geocentric pitch rate of 0.0687 deg/sec	66740	299043.7	28 (Unable to maintain to Last data point)
• Last data point at COOK RTS	67768	299071.7	

SV attitude and rate control was lost at an altitude of about 56 nm.

The last rates and attitude observed were:

- Pitch H/S -0.32 deg
- Roll H/S +0.44 deg
- PGR -0.66 deg/sec
- RGR +0.030 deg/sec
- YGR +0.026 deg/sec
- PVA -0.44 deg
- RVA >+0.5 deg
- YVA +0.1 deg

With the aft end forward, the final motion observed was the aft end pitching up out of control.

2.1.6 Experimental Maneuvers

Yaw maneuver performance was evaluated prior to OA burns by performing a -180° yaw to a nose aft attitude and then a -180° yaw return to the nose forward attitude on Rev 240 and 241 with the results shown in Table 2-5. The maneuvering time is the time interval from the yaw rate command to the time the rate returns to a value of less than the specified rate after removal of the command. Subsequent yaw maneuvers preceding OA burns were performed satisfactorily.

Table 2-5
YAW MANEUVER PERFORMANCE

	Yaw Angle	Valve Thrust	Maneuvering Time to Spec Rate		Yaw Coast Rate		
		(Lbf)	Spec Rate/Time (deg/sec) (sec)	Actual Time (sec)	Cmd Rate (deg/sec)	Coast Rate Expected (deg/sec)	Actual Coast Rate (deg/sec)
Yaw Reverse Rev 240	-180	Valve 4&5 3.85	0.15/600	271	-0.705	-0.705 ±0.002	-0.705
Yaw Forward Rev 241	-180	—	0.014/1100	287	-0.705	-0.705 ±0.002	-0.705

Pitch maneuver performance was evaluated prior to RV separation on Rev 66 and this performance is included in Table 2-3.

2.2 REACTION CONTROL SYSTEM

2.2.1 Control Gas Usage

The RCS propellant consumed over the 31 days (502 Revs) was 134 ±10 lb as shown in Fig. 2-1. The flight measured consumption was computed from the RCS tank temperature and pressure telemetry data and has an uncertainty of ±10 lb at beginning and end of mission. Also shown in the figure is the pre-flight worst case prediction which was based on P/L ops per ICD and includes contingencies such as magnetic torques and leakage.

The control gas usage during the six OAS burns and deboost was as follows:

	Flight Measured (lb m)	Nominal Predicted (lb m)	2 Sigma Predicted (lb m)
6 OAS Burns	6.2	8.7	18.6
Deboost	10.7	9.8	19.4
Total	16.9	18.5	38.0

The results indicate that the OAS induced misalignment was nominal and the impulse prediction and selection of the thrust vector aim point were entirely adequate.

2.2.2 RCS Thruster Performance

Three RCS Thrusters showed some sluggishness in pulse shape tailoff at the end of the mission as shown in Fig. 2-2. The degree of tailoff change was minor and much less than observed during ground testing which is shown for comparison. The distortion of the pulse shape suggests some catalyst bed wear, particularly at low duty cycles. Vehicle control was not compromised and no change in propellant consumption could be detected. Pulses with tailoff sluggishness have the same total impulse as pulses with crisp shapes and thus no change in specific impulse is encountered. The small change in response and centroid is minor, not affecting vehicle control.

RCS performance appears to have been within specification limits during the mono ops in Rev 474 when the roll rate exceeded the expected value at the start and stop of the

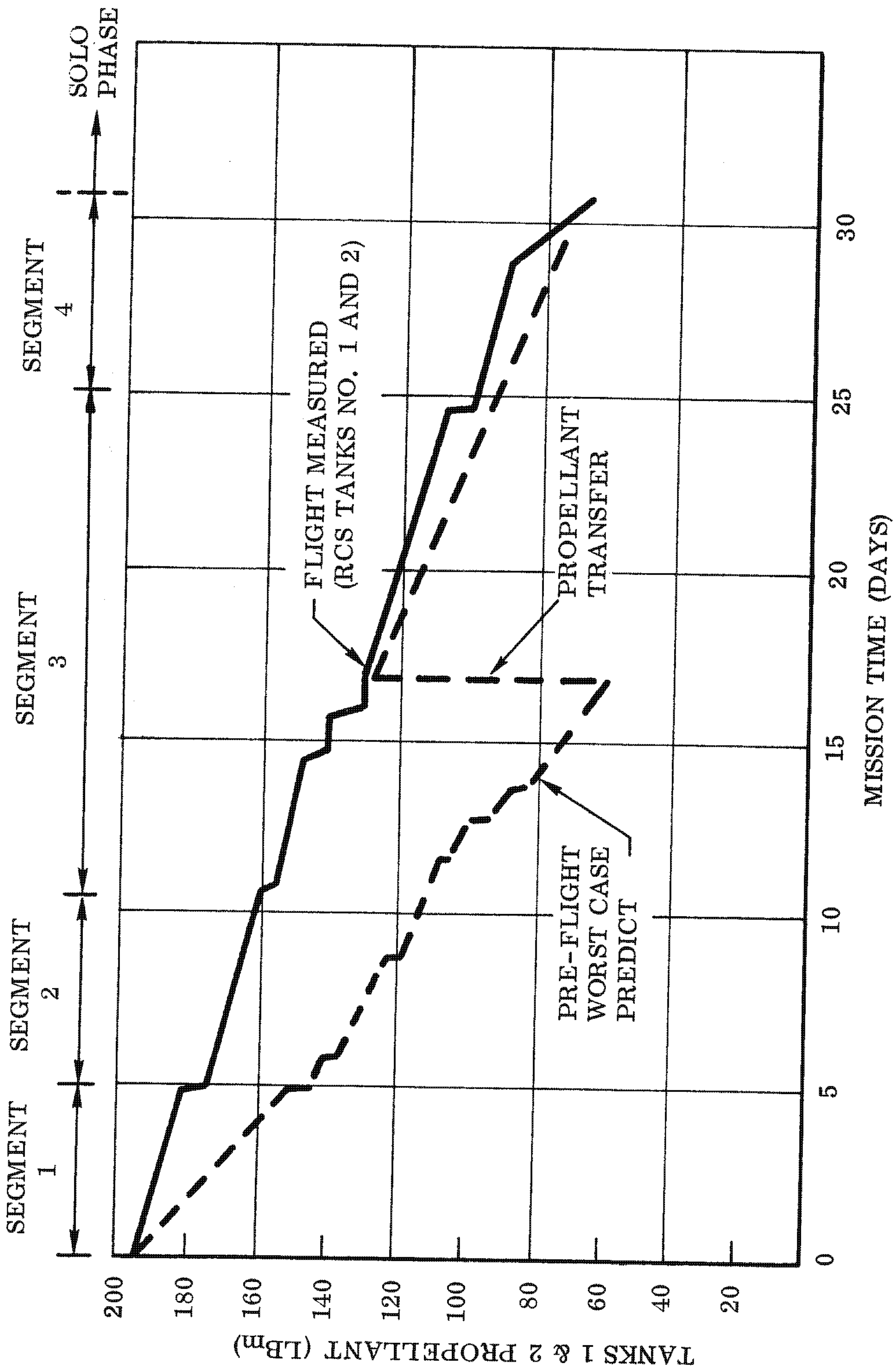

Fig. 2-1 RCS Propellant Consumption

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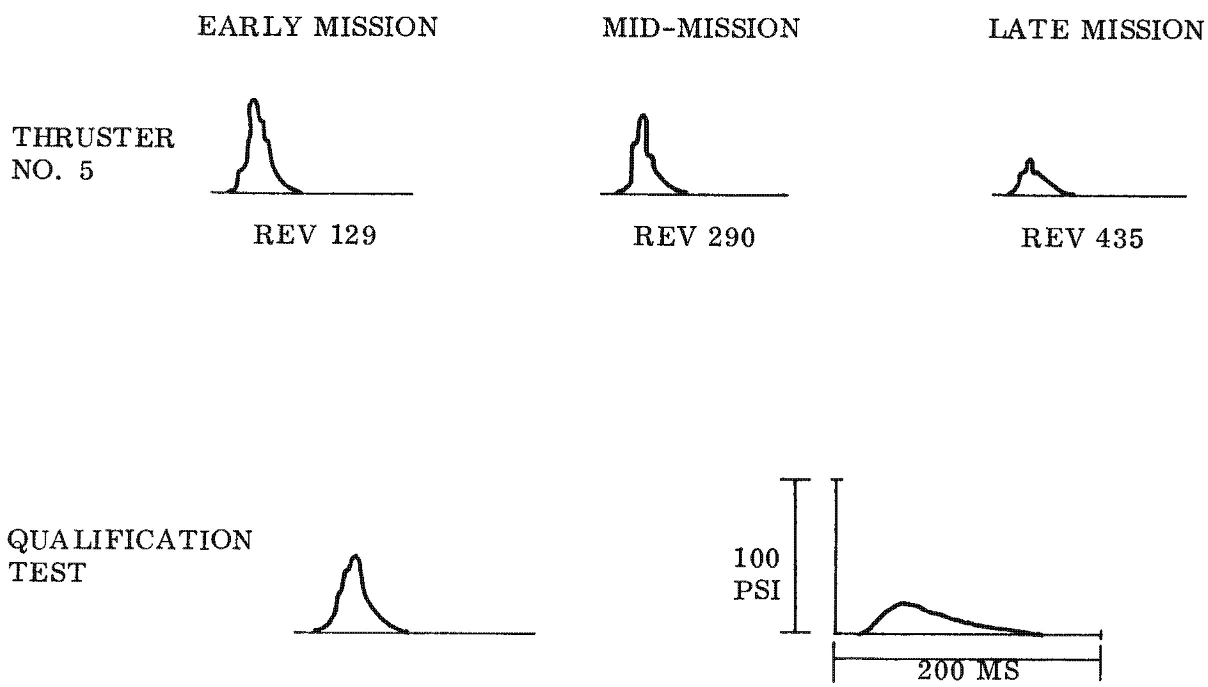


Fig. 2-2 RCS Thruster Performance

OBs as discussed in paragraph 2.1.2. RCS firings accurately reflect ACS driver commands and delay times between driver commands and thrust response appear to be normal in all cases.

OB START resulted in normal thrust levels (4.0 lb) for both Thrusters (No. 3 and 7). On OB STOP, where roll rates were again exceeded, the thrust level for Thruster No. 2 was 4.0 lb but Thruster No. 6 was 2.8 lb (minimum allowable: 2.5 lb). Although No. 6 Thruster was within minimum allowable limits, it appears to have shifted to a lower thrust level than the other three thrusters. Subsequent long firing operation of thruster No. 6, during RV-4 separation, showed an increase in its thrust to a level more closely approaching that of the other thrusters. Further evaluation of thrust level shift and OB-induced roll rates will be performed using the results from the SOLO experiments.

2.3 PROBLEMS

2.3.1 HSA Transient at Separation

A transient occurred on the primary horizon sensor outputs at separation which was not present on the redundant horizon sensor outputs. The roll output exhibited a +4.0 deg transient and the pitch output a +2.5 deg transient, both lasting approximately 5 sec. The probable causes investigated were (1) sun interference, (2) reflection off particles resulting from separation, and (3) microphonics resulting from separation shock. Sun interference was eliminated because the sun was overhead at the time of separation. Particle reflection was considered unlikely because the redundant horizon sensor did not exhibit transients. The most probable cause was considered to be microphonics because the horizon sensor is known to be susceptible to microphonics. This is not considered to be a flight problem since the horizon sensor is not connected until sometime after separation. Block II HSAs will not be as susceptible to microphonics due to redesign of the sensor head.

Section 3
ORBIT ADJUST

3.1 ORBIT CONTROL

The Orbit Adjust System was utilized six times during the primary mission for drag makeup and perigee location control. The OA firings were all normal and the engine performance was well within specifications. Pertinent performance factors are summarized in Table 3-1.

Table 3-1
OAS PERFORMANCE

OA Firing Number	Rev Number	Impulse Delivered (lb-sec)	Planned ΔV (ft/sec)	Achieved ΔV (ft/sec)	Percent Error in ΔV
1	127	9433	15.74	16.27	2.71
2	190	5457	9.98	10.24	2.58
3	254	33171	60.8	62.2	2.30
4	255	22669	-41.9	-42.7	1.91
5	336	2713	5.05	5.38	6.58
6	385	11877	22.11	22.29	0.81

3.2 DEBOOST

The deboost burn on Rev 839 was engine firing number 37. The performance of the Orbit Adjust System during the 1003 sec burn was nominal and indicated a healthy catalyst bed resistance. Delta velocity was 405 ft/sec and the SV impacted at 11 deg North and 127 deg West.

Section 4

TRACKING, TELEMETRY AND COMMAND

4.1 TRACKING

An evaluation of the tracking accuracy from best fit of tracking and computation of track through orbit adjusts is being prepared by the Field Test Force Director and will be available through that office.

4.2 TELEMETRY

4.2.1 General Performance

The general performance of the telemetry was excellent. No anomalies occurred with the system during the flight. The following list summarizes the approximate usage through Revolution 839:

	Side 1	Side 2
SGLS		
• Number of station contacts	896	116
• Operational time (min)	5,600	725
PCM		
• Operational Time (min)	17,957	25

• Mode	Operational Time (min)
A — Ascent	10
B — Orbit — Engineering	640
C — Orbit — Record	10,617
D — Orbit — Operational	6,722

Tape Recorder	No. 1	No. 2
• Number of Record Operations	3,380	14
• Number of Playback Operations	717	14
• Operational Time (min)	12,987	300

Instrumentation

Three temperature transducers were defective at launch. These were two shroud skin temperatures and one mid section temperature. The sound pressure transducer assemblies employed in the Ascent Telemetry System exhibited a slow recovery when the static pressure pulses at ignition and liftoff placed the transducer amplifier in or near saturating range. Changes will be implemented on SV-2 to eliminate this problem (see paragraph 14.2).

Ascent Telemetry System

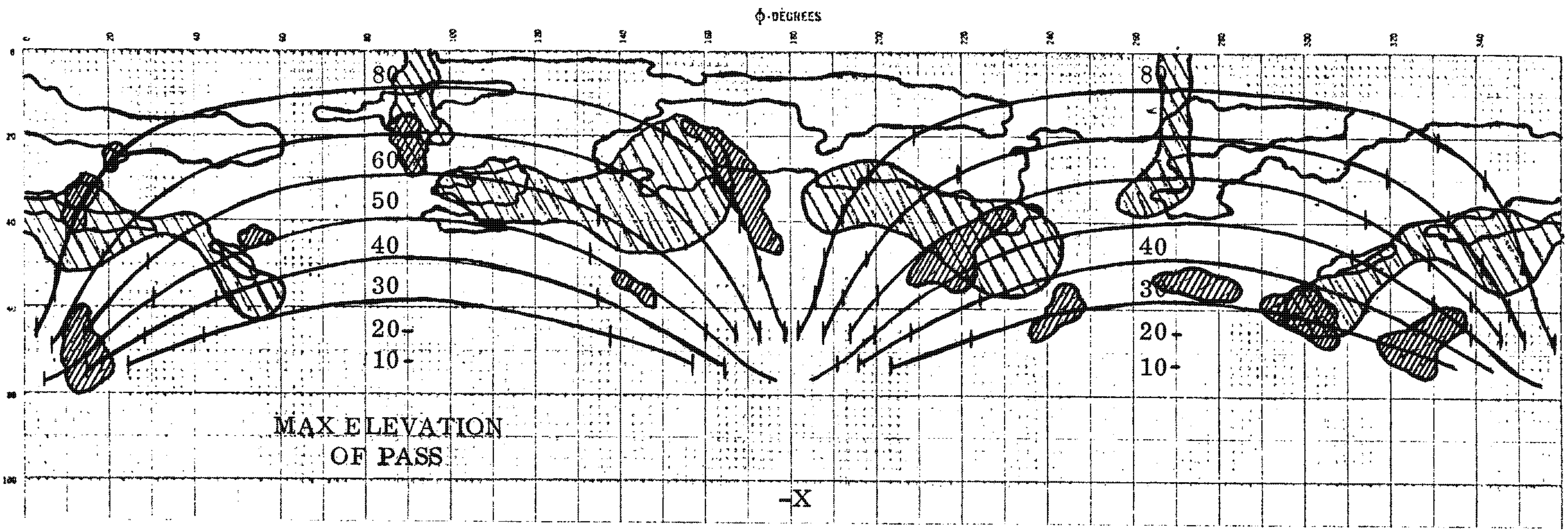
With the exception as described with the sound pressure transducers, all Ascent TM System data was highly acceptable. The operation, of course, was limited to the ascent phase of flight, and the ascent TM was operational in this phase for approximately ten minutes. The processing of the mid section FM data through the SGLS 1.7 MHz FM VCO also performed satisfactorily during the ascent phase of flight.

4.2.2 SGLS Antenna Requirements/Design Analysis

This analysis (LMSC-B215038A) was published 30 October 1970. In summary, the report provides an analysis of the SV SGLS 1 antenna pattern gain measurements versus worst case requirements (850 nm slant range at 5 deg elevation). The following list provides a summary of data:

Look Angle	Percentage Coverage
0 deg to 79.4 deg	Greater than 72 percent
30 deg to 79.4 deg	Grater than 86 percent

The report states that the requirements cannot be met in all directions at the downlink frequencies, but considering where these deficiencies occur, they were not considered significant.



<u>RIGHT SIDE</u>

S TO N (W OF STATION)

N TO S (E OF STATION)

<u>LEFT SIDE</u>

S TO N (E OF STATION)

N TO S (W OF STATION)

PATTERN HOLES (TEST) SGLS NO. 1

SGLS NO. 1 HOLES (SV-1)

SGLS NO. 2 HOLES (SV-1)

Fig. 4-1 Antenna Patterns

All Remote Tracking Stations experienced fluctuations during the mission. These fluctuations ranged from minor changes (5 dB) to complete drop-outs. The majority of fluctuations were identified and plotted. The observed SGLS 1 fluctuations are symmetrical (right/left side of SV) as shown in Fig. 4-1. Solar array positioning (during SOLO) to other locations resulted in no significant pattern changes. As a result of the SGLS 1 data obtained, a secure block loading constraint was recommended to Test Control. Also, predictions were made by the SBAC Flight Support Team (FST) and provided to Test Control for both block loading and tape recorder playback. These methods of avoiding the drop-outs were easily followed by Test Control with minimal impact and essentially no data loss. SGLS 2 was also used during the mission to obtain signal strength data. The data obtained indicates that the fluctuations are not symmetrical (i.e., left side different than right side). This data is also provided in Fig. 4-1.

Review of the SV hardware and the data obtained in flight indicates that the fluctuations are due to the SV antenna ground plane for both SGLS 1 and 2.

In summary, the original analysis published in 1970 defined holes in the pattern where drop-outs could be expected. After the fluctuations were identified and understood in flight, the system (Test Control, Test Advisor, FST, etc.) continued their functions knowing what the constraints were, and there was little or no impact to those tasks. For SV-2 and up, SBAC recommends that these same constraints be utilized and the FST continue to provide predictions as a normal function. No hardware changes are recommended.

4.3 COMMAND

4.3.1 GFE Command System

4.3.1.1 <u>Health</u>. The health of the Command System remained excellent throughout the entire operation. There were no equipment failures. None of the Command Systems were subject to out-of-specification temperatures or voltages. There were no power dropouts, relay driver overloads, or clock status errors experienced.

4.3.1.2 Extended Command System.

4.3.1.2.1 Command Modes. The ECS responded properly in all modes into which it was commanded. There were a total of 222 messages loaded in the ECS. This resulted in 135,226 SPCs being stored for readout from the PMUs. Of these 135,226 SPCs loaded, 77,429 were output by the PMUs for processing by the decoders. The remainder were erased out prior to time label matches. There were 16 ground station software anomalies on the initialize command following the selected read of the memory search upper bound at the end of an SPC load. These anomalies were caused by a timing problem in the RTS software. Correctors were incorporated into the RTS software on 21 July.

4.3.1.2.2 ECS Clock Operation. The accuracy of the ECS Clock was 2.32 parts in 10^7 (about 1 sec every 50 days). This corresponds to an average frequency offset of 0.237 Hz above the nominal frequency of 1.024×10^6 Hz. The frequency of the clock oscillators changed 0.066 Hz in 50 days. This results in a stability of 0.64 parts in 10^7 over a 50 day period. All of these values are well within system specification.

4.3.1.2.3 ECS Logic Anomaly. An 11EV20640 VSPC scheduled for execution on Rev 492 at Vehicle Time of 118,459.8 sec did not perform its required function. Analysis revealed that the VSPC executed an NSPC EN02640 which is the Internal Decoder ON command. The decoder remained on for 214.6 sec until a TT&C OFF was commanded which is wired into the external decoder OFF.

A study of the decoder logic associated with these two unrelated commands revealed a logic design error existed. The logic equation for the EN02640 command is satisfied by the 11EV20640 bit pattern. The EN02640 is an internal command and the decoder inhibits the generation of a relay driver pulse. Since the 11EV20640 satisfied the EN02640 equation, relay driver pulses are inhibited. This produces a loss of 11EV20640 relay driver outputs. The design error also results in the loss of relay driver pulses for 15 other combinations of this 11 bit variable in Decoder A. In addition, 16 combinations of each of the 12 bit variables in Decoder A will not generate relay driver pulses. This brings the total number of commands in Decoder A that will not perform the required function to 48. A complete listing of these commands is provided in Table 4-1. This problem does not exist in Decoder B due to the difference in the Decoder Address Plug wiring.

Table 4-1
ILLEGAL VSPCs

11EV20640	12EV40640	12EV60640
11EV20641	12EV40641	12EV60641
11EV20642	12EV40642	12EV60642
11EV20643	12EV40643	12EV60643
11EV21640	12EV41640	12EV61640
11EV21641	12EV41641	12EV61641
11EV21642	12EV41642	12EV61642
11EV21643	12EV41643	12EV61643
11EV22640	12EV42640	12EV62640
11EV22641	12EV42641	12EV62641
11EV22642	12EV42642	12EV62642
11EV22643	12EV42643	12EV62643
11EV23640	12EV43640	12EV63640
11EV23641	12EV43641	12EV63641
11EV23642	12EV43642	12EV63642
11EV23643	12EV43643	12EV63643

Preliminary information from SP-7 indicates the Command Subsystem Contractor will incorporate a design change effective SV-5 and up. For SV-2 through SV-4 the following operational constraints are scheduled to be followed:

12EV4WXYZ (MCM Assigned):	Spare until SV-7
12 EV6WXYZ (TT&T Control):	Bit 33 assigned "0"
11EV2WXYZ (V_s):	16 film velocity speeds not available

4.3.1.3 Minimal Command Subsystem.

4.3.1.3.1 Command Modes. The MCS responded correctly to all commanding. The MCS was in the operate mode on Rev 20. The Rev 20 operation was for a health check. This test worked according to expectations.

4.3.1.3.2 MCS Clock Operation. The short duration of MCS operations did not permit clock frequency or stability calculations to be made.

4.3.1.4 Remote Decoder/Backup Decoder Command Modes. The Remote Decoder was used for each of the four recoveries. The performance of both sides was verified from telemetry to be proper in each case. No commands were issued from the Backup Decoder in this operation.

4.3.2 Uplink Operation

4.3.2.1 SGLS. The SGLS command link was used to transmit a total of 222 command messages. No anomalies were experienced with this link.

4.3.2.2 375 MHz Receiver. The 375 MHz Receiver was powered during the entire mission. Approximately 20 commands were processed by the Receiver with no anomalies.

4.3.3 Data Interface Unit

The Data Interface Unit performed flawlessly during its 406 operational cycles. No spurious request pulses were indicated by the operation counters and the predicted operation count equaled the DIU counter reading.

Section 5
ELECTRICAL DISTRIBUTION AND POWER

5.1 SOLAR ARRAYS

Solar Arrays were extended on Rev 1. Power output from each leg equaled or exceeded the specification value. Degradation for 31 days was ~2 percent of initial output. This is well within the 5 percent allocated for degradation over 30 days and 1 percent less than engineering predictions.

5.2 MAIN BUS VOLTAGE

Main Bus voltage varied from a low of 26.8V to a high of 31.6V. The allowable range was 25.5V to 33V. The low voltage data was obtained during dark VAFB engineering passes with bus loads of 45 to 50 amps. High voltage data was obtained during the charge cycles. Daily voltages are summarized in Table 5-1.

5.3 POWER CAPABILITY AND USAGE

Power usage ranged from 201 to 256 amp-hour/day which was well below the 280 amp hour/day capability based on 75 percent solar array output due to degraded Type 29 Battery performance (see paragraph 5.4). The quantity of excess amp-hours/day available are tabulated in Table 5-2.

5.4 TYPE 29 BATTERY PERFORMANCE

Batteries 3 and 4 operated at an undesirably high temperature (88-100^{O}F) during this flight. The battery thermal switches opened the K2 Solar Array circuits within 12 Revs from launch and K1 circuits in 13 Revs. With the K1s and K2s open the batteries were not being charged and therefore cooled, causing the K1 circuits to close by Rev 17.

Table 5-1

VOLTAGE CHART

Day	Maximum Voltage	Minimum Voltage*
1	30.9	28.0
2	30.0	27.6
3	30.0	27.5
4	30.0	27.4
5	30.2	27.8
6	30.2	27.4
7	30.0	27.1
8	30.4	27.4
9	30.3	27.3
10	30.1	27.3
11	30.2	27.2
12	30.0	27.1
13	30.2	26.8
14	30.4	27.5
15	30.5	27.7
16	30.6	27.3
17	30.0	27.8
18	30.8	27.4
19	30.4	27.2
20	29.9	27.5
21	30.3	27.7
22	30.1	27.6
23	30.3	27.3
24	30.3	27.6
25	30.3	27.7
26	31.4	28.0
27	31.2	27.8
28	31.1	27.7
29	31.6	28.6
30	31.2	27.6
31	31.5	27.4

*Minimum voltage obtained during dark engineering pass.

Table 5-2

POWER CHART

Day	Amp-Hour Used/Day	Amp-Hour Available/Day*	Amp-Hour Excess/Day
1	226	280	57
2	241	280	42
3	256	280	27
4	245	280	38
5	241	280	42
6	246	280	37
7	247	280	36
8	242	280	42
9	255	280	29
10	235	280	48
11	239	280	48
12	237	280	47
13	219	280	64
14	235	280	48
15	233	280	50
16	223	280	60
17	228	280	55
18	230	280	53
19	224	280	59
20	217	280	66
21	229	280	54
22	217	280	67
23	212	280	71
24	215	280	68
25	216	280	67
26	207	280	76
27	207	280	76
28	208	280	75
29	201	280	82
30	215	280	68
31	232	280	51
Total	**7078 ***7075	8680	1699

*6/8 Array **Calculated ***Amp-hour Meter

This heating and cooling cycle continued throughout the remainder of the mission and resulted in limiting the recharge of these batteries to about 35 amp-hr instead of the normal 40.5 amp-hr. The average Solar Array charge rate to these two batteries was therefore reduced by approximately 50 percent, thereby reducing the daily capability. On the other hand, higher temperatures prevailed for other equipment reducing or eliminating the power required for heaters. This offset the power generating loss and provided a positive margin. A detailed discussion of the Aft Section thermal anomaly that produced the over-temperature condition for these batteries is presented in paragraph 12.4.

Batteries 1 and 2 operated at 44 to 47°F throughout the mission and performed normally. Note that normal K2 opening for these batteries occurred only rarely since the fractional Solar Array output caused by the hot Batteries 3 and 4 was used to supply main bus requirements. This left insufficient charging current to drive Batteries 1 and 2 to K2 cutoff. However, as indicated in paragraph 5.3, the power capability of the system was entirely adequate to support the mission demands.

5.5 PYRO BATTERY PERFORMANCE

Pyro Battery number 1 voltage monitor began dropping on Rev 440 (27th day) indicating that the battery was approaching capacity depletion. The predicted life of both pyro batteries was 45 days minimum and was based on wet stand separator life being the limiting factor. The premature depletion of capacity was due to the self discharge rate being higher than allowed for at the 90-95°F temperatures experienced by the batteries (see paragraph 12.3). Under these conditions, self discharge would account for approximately 30 percent of the 8 amp-hr capacity at launch. Normally, self discharge would account for no greater than 10 percent of capacity if batteries had been in the temperature range of 45°F to 50°F. This was verified after the fact by a review of previous laboratory testing data and was further reinforced by Pyro Battery No. 2 following a similar degradation with a lighter load.

Corrective action follows two paths:

- Activate pyro batteries as close to launch as possible. Late activation will depend on the battery's ability to provide surge loads when in the peroxide regions. (This would increase capacity available for orbit use by 5 amp-hours if predischarge were to be deleted.)
- Command significant steady state loads to OFF when not required for data gathering during health checks and pyro operations. (This would increase capacity available for orbit use by 3.5 amp-hr.)

Section 6
LIFEBOAT II

6.1 HEALTH CHECKS

Rev 13. The Lifeboat II System was enabled for approximately 95 sec and executed for the last 35 sec of the 95 sec. From real-time data, proper phasing of the magnetometer outputs was verified. From post test data, the R and Q magnetometer outputs indicated agreement with expected outputs within 0.5 deg. The P sensor output was at TM saturation. Rate gyro evaluation showed the pitch gyro responding to orbital geocentric rate within 0.01 deg/sec of the primary ACS rate indication. Since vehicle rates were very low in yaw and roll, no quantitative comparison was possible. Proper thrust valve phasing in response to magnetometer outputs was verified during the execute period. Since the regulator valve was closed, the vehicle remained under the control of the primary ACS.

Rev 82. The System was enabled for 31 sec. There was no execute mode and reset occurred approximately 3 sec after RV separation. Approximate comparison of the P and Q magnetometer outputs from vehicle tape recorder playback data showed agreement within 2.5 deg with the expected outputs. The R sensor was TM saturated during the time the system was in the SV deboost mode. Rate gyros indicated approximately correct rates although the yaw and roll rates were again very low.

Revs 179, 405, and 502. The System was enabled for 31 sec in each case and reset occurred about 2 sec after each RV release. As of this writing, post test data from the tape recorder playback during these tests have not been processed for review so no results can be reported.

Despite the lack of data from the last three health checks, data from the first two verified that the Lifeboat II system performed satisfactorily in all modes (RV recovery, SV deboost, South-to-North and North-to-South).

6.2 USAGE

The Lifeboat II system was not used for active attitude control during the primary mission. Since the regulator valve was closed during the execute portion of the Rev 13 health check, no cold gas was expended.

Section 7

SENSOR SYSTEM

7.1 COARSE FILM PATH

Both coarse film paths operated properly during the mission with supply, looper, steerers, and takeups functioning normally for the most part. The exceptions were the B Side Emergency Shut Down (ESD) during the Prep 2 constant velocity on Rev 402, and the ESD on both sides due to Vx and Fs incompatibility on Rev 492.

7.1.1 Rev 402 ESD

Subsequent to the RV3 to RV4 cut and wrap sequence, a constant velocity (CV) test was performed causing an ESD condition on the B Side. Approximately 15 sec after film movement, the telemetry data indicated that the B Side coarse tensions decreased before the takeup summed error and integrated output indicated the takeup servo motor was exerting a much greater torque than normal. It was also noted that a ripple or chatter appeared and remained on the input drive, output drive, output coarse tensions takeup summed error and takeup tach. Except for the takeup signals, the other signals returned to their normal DC level. Following the issuance of the film transports OFF command, while the film was decelerating, the input and output tensions decreased causing the ESD condition. The takeup summed error went to its maximum value and the input and output drives exhibited a large error. At Rev 411 COOK a mini-creep was performed with the tensions returning to their normal level. At Rev 417 BOSS another mini-creep was performed indicating the system was responding normally. At Rev 419 COOK a CV Test was performed without a malfunction.

It appears there was an obstruction in the film path between the looper output and take-up. A SV-1 test anomaly exhibited signature similar to those of the flight anomaly. The cause of the test anomaly was a physical drag on the material caused by epoxy chips wedged between the material and idler roller in the takeup.

Examination of the processed film indicated no physical damage that would provide a clue to the exact location and cause of the ESD. The startup of the mini-creep that re-established proper tensions tends to confirm the conclusion reached from the telemetry data. It appears that the scuffing of the material by the output drive capstan, the embossing by the input drive capstan, and the 2 inch wide fog mark of the slit were all caused by the tension normalizing. During this period of time, the output capstan would be turning but little material would transport prior to the takeup pulling up the slack in the output looper, thereby causing the scuffing on the material. The film path back to the supply from the slit would be under tension and not moving initially causing the embossing. A metallic-like chip that has the appearance of a piece of scrap from manufacturing operation was discovered embossed into the base side of the film, 17 inches toward the takeup from the slit. The metal chip was metallurgically analyzed as aluminum with traces of zinc, copper, and magnesium. Until the source of the metal chip is identified, the location of the chip on the film is not necessarily meaningful.

7.1.2 Rev 492 ESD

On Rev 492 the A and B Sides ESD'd because of incompatible Vx and Vs inputs caused by the failure of the ECS command system to input the required Vs for the second operation of a three operation nested sequence. This caused the third operation to be missed because there was no camera power OFF command until the end of this operation. With the camera power ON command of the fourth operation, the ESD circuitry was reset and subsequent operation was normal. See paragraph 7.3 for more discussion.

7.2 FINE FILM PATH

Both fine film paths functioned properly throughout the mission with the exception of fine film drive jams on the B Side causing an ESD on Rev's 314 and 445.

7.2.1 Rev 314 ESD B Side

There was an ESD at brake release of the fifth operation; telemetry data indicated a jam in the fine film drive system. A constant velocity run was made on Rev 322 in real-time during the COOK pass. After the ESD the tension in the system had normalized and the looper had repositioned, therefore, the ESD circuitry was reset with the camera power ON command. The constant velocity run was proper so a six frame engineering sequence was run in real-time on the Rev 323 COOK pass. This sequence was performed satisfactorily and subsequently normal payload operations were resumed. Inspection of the film was not possible since this ESD occurred while operating in Takeup 3.

7.2.2 Rev 445 ESD B Side

On Rev 445 there was an ESD at brake release of the fourth operation. Telemetry data indicated film not being driven properly through the fine film drive system causing the looper to be driven to the stop on the takeup side which generated the ESD.

An abbreviated mini-creep was run in real-time on the Rev 452 COOK pass. The data from this run indicated that, although a small amount of film moved through the fine film drive, the Input Drive Capstan was not rotating.

In an attempt to free the suspected jam in the input drive several sequences were programmed. On the Rev 459 COOK pass, the Optical Bars were run to cycle the platen but this had no effect and the looper remained at the takeup side limit switch. Four more abbreviated mini-creeps were run on Revs 465 and 466 on the POGO and BOSS passes and these also did not alleviate the ESD condition.

On the Rev 468 COOK pass a 20 inch/sec constant velocity was programmed for a 5.4 sec duration which transported film through the fine drive system but did not free the drive capstan.

On Rev 472 a monoscopic B side run was undertaken and this data indicated that the looper moved from the ESD position and tensions had normalized at the beginning of this run.

On the Rev 476 COOK pass a stereo engineering sequence was run which showed the B Side Input Drive Capstan driving properly. Normal stereo payload operations were resumed on Rev 477.

Detailed analysis of the processed film indicated no signs of physical damage on the material. There were no tears, foldovers, dimpling, scuffing, embossing or scratching to indicate a mistracking or hangup that would cause an ESD due to the film web itself. At the beginning of the ESD operation, some plus density marking was observed indicating the twister was oscillating and the material not moving. There was approximately 26 ft of extremely faint plus density streaks (that matched the input drive capstan lands and grooves) that could only be observed by grazing light. This started at the beginning of the second of the 4 mini-creeps and continued through the first 165 ft of the mono B operation. Measurements made on the processed film confirm the telemetry data. On the operation that ESD'd, material only moved 5 inches past the slit tending to confirm that the output looper was driven to the stop. The lack of plus density banding or physical damage on the material for the first of the 4 mini-creeps could be due to a lower tension as the supply fed out 31 inches of film on the operation that shut the system down. As the mini-creeps were run, more film was transported past the slit than was supplied, possible increasing the tension but not sufficient to do more than pressure expose the emulsion. No changes to the system are indicated.

7.3 COMMAND AND CONTROL

Sensor system performance with respect to the command and control subsystem was nominal with one exception that caused an emergency shutdown during Rev 492. During this operation the system was commanded to a 120 deg scan angle configuration from a 60 deg scan angle. Due to a logic design error in the Extended Command System the Vs command necessary for the 120 deg scan angle was decoded incorrectly as a Decoder A ON command, and the coarse film speed was not changed from the previous operation. The resultant incompatibility between the coarse and fine film speeds was too large for looper compensation, and the shutdown occurred when the looper was driven against the stops.

In their present configuration, the Decoders will not allow the commands listed in Table 4-1 to be executed. This list is comprised of the long Variable Stored Program Commands which use Decoder A and end in the octal characters 640, 641, 642, and 643. Of these commands, those beginning with 11EV21, 11EV22, 11EV23, and 11EV24 are not presently mechanized. The Command Subsystem Contractor has indicated that those in the list beginning with 12EV6 are not configured as logical command sequences and are not used as a result. The remaining commands are 11EV20640, 11EV20641, 11EV20642, and 11EV20643, which correspond to command coarse film speeds of 53.5190 ips, 53.6475 ips, 53.7760 ips, and 53.9045 ips respectively. In the event a redesign to the command system cannot be implemented prior to future missions, these commands must be avoided.

The illegal Vs commands noted above will, at present, be sent only during an operation which required a scan angle of 120 deg and a Vx/h of 0.0417 rad/sec. In a mission utilizing the design orbit, the 0.0417 rad/sec Vx/h value will not be encountered. If the mission did require one of the illegal commands, the software could be made to set a malfunction flag in the command message to identify the problem. Upon recognition of such a flag, the message could be manually altered in either of two ways. One way would be to switch to SCC 2 which would not exhibit the Vs problem because Decoder B would be used to execute the commands. The other way would be to change the Vs command to a legal value as close as possible to the correct value. The new value would, at most, be two steps away from the correct value. Such a variation would not degrade photography and would not cause a system shutdown. Additional discussion of the ECS logic anomaly is presented in paragraph 4.3.1.2.3.

7.4 OPTICAL BAR ASSEMBLY

Both Optical Bar assemblies performed properly through the mission. The only point of significance noted during the operation of the OBs was the slightly higher torque required from the OB servo motors at higher film chute pressures. This did not affect performance in any way and also was observed in prolonged runs during ground test prior to flight.

7.5 INSTRUMENTATION

All instrumentation points operated correctly throughout the flight except P552 (Metering Rod 3B Drive End Temperature) which provided erratic readings. Other temperature monitors in the vicinity supplied adequate data for thermodynamic analysis of the system. The instrumentation system provided ample data for evaluation of normal sensor system operation. Additional data was needed to adequately analyze the ESD which occurred at Rev 445. For this situation, addition of input and output drive capstan tachometers and summed errors to Telemetry Format C would have presented a more complete record of events leading to the shutdown.

Section 8

REENTRY VEHICLES

8.1 SUMMARY

The four RV flights were made after on-orbit times of 5, 11, 25, and 31 days. Flights 1, 2 and 4 were successful; the payload was transported undamaged. Aerial recovery was made of Flights 2 and 4. Flight 1 was recovered by the Surface Recovery Unit, because the recovery parachute did not present an acceptable target for aerial retrieval. Flight 3 was not sighted nor recovered. It is concluded that the main parachute was damaged extensively, and that the Flight 3 capsule impacted the water at a velocity in excess of 400 fps, at a location very near the predicted impact point (PIP).

Data indicate that all on-orbit, separation, reentry and recovery events occurred as planned and the flights followed predicted trajectories. All subsystems performed satisfactorily and met the entry requirements from this 100 x 165 nm (nominal) orbit, with the exception of the main parachute.

8.2 REENTRY VEHICLE PERFORMANCE

The following performance statements apply to all four RVs. The Satellite Vehicle provided a satisfactory pitch angle for each RV separation. All other SV/RV interface functions were satisfactory. All RV on-orbit functions were normal and occurred on time. A summary of the performance of the four reentry vehicles is given in Table 8-1. The payload weights in Table 8-1 are measured weights for the recovered capsules. The payload was essentially balanced for each flight. The impact locations reported by the recovery TWX message, and not corrected for wind drift, were very close to the predicted impact point determined by computer program at the Satellite Test Center.

Table 8-1
SV-1 RV RECOVERY SUMMARY

	Flight 1	Flight 2	Flight 3	Flight 4
RV Serial No.	8	7	5	6
Recovery Rev No.	82	179	405	502
Recovery Data (1971)	20 June	26 June	10 July	16 July
Payload Weight (lb)	319.0	418.0	419.5*	204.1
Unbalance (percent)	1.2	1.5	0.22	2.3
SV Pitch Angle (deg)	-39	-44	-45	-42
Nominal PIP Latitude	17.5 N	25.0 N	25.0 N	27.0 N
Impact Location Error (BFE vs Test Report TWX)				
Overshoot (nm)	8.4	10.8	6.6	2.4
Crosstrack (nm)	3.6 W	7.2 W	13.8 E	9.0 W
Recovery	Water	Aerial	None	Aerial
Altitude (ft)	0	9400	–	12000
Parachute Condition	Severe Damage No Target Cone	Severe Damage	Failure	No Damage
RV/Payload Condition	Good	Good	Not Recovered	Good

*Value taken from on-orbit telemetry

Stability margins during the retrograde and exoatmospheric coast phase were high for each flight. Data obtained from onboard instrumentation show body transverse rates were less than 5 deg/sec which is within the 1σ calculated values for balanced payload conditions. However, the data also show that the spin rate and residual spin rate were lower than predicted.

The entry (400,000 ft altitude) velocity and flight path angle for each flight are shown in Fig. 8-1 compared to envelopes of possible entry conditions for which the reentry vehicles was designed to be compatible. During the early period of the entry phase, the residual roll rate, which had been nearly constant during the exoatmospheric coast phase, began to decrease. After approximately 110 sec the roll direction reversed. This reversal was typical for all four flights and had no measurable effect on the capability of the RVs to enter successfully. Angle of attack was less than the predicted values throughout the significant heating portion of the entry, due to roll reversal and associated phenomena. Velocity and altitude time histories apparently correlated well with predicted normal values as evidenced by the accuracy of the impact.

Figure 8-1 also shows the altitude and dynamic pressure for each flight at the time of drogue parachute deployment with respect to the design envelope. Flight instrumentation data show that drogue performance as a decelerator was essentially as predicted. For example, the maximum dynamic pressure at drogue release and main parachute deployment was 58.7 psf observed on Flight 2, and the predicted value for this flight was 60.2 psf.

Flight 4 performed nominally throughout entry and retrieval. Flights 1, 2 and 4 were sighted while descending on the main parachute. Each was reported to have a descent rate satisfactory for aerial retrieval in spite of the damage to the main parachute. Flights 2 and 4 were retrieved in the air. Flight 1 survived water impact with no damage nor leakage. Flight 3 entry was normal until main parachute deployment. Telemetry data shows that abnormally high axial 'g' levels were induced during the initial, reefed-open stage of the main parachute. It is concluded that the parachute was extensively damaged and that Flight 3 capsule impacted the water at a velocity in excess of 400 fps.

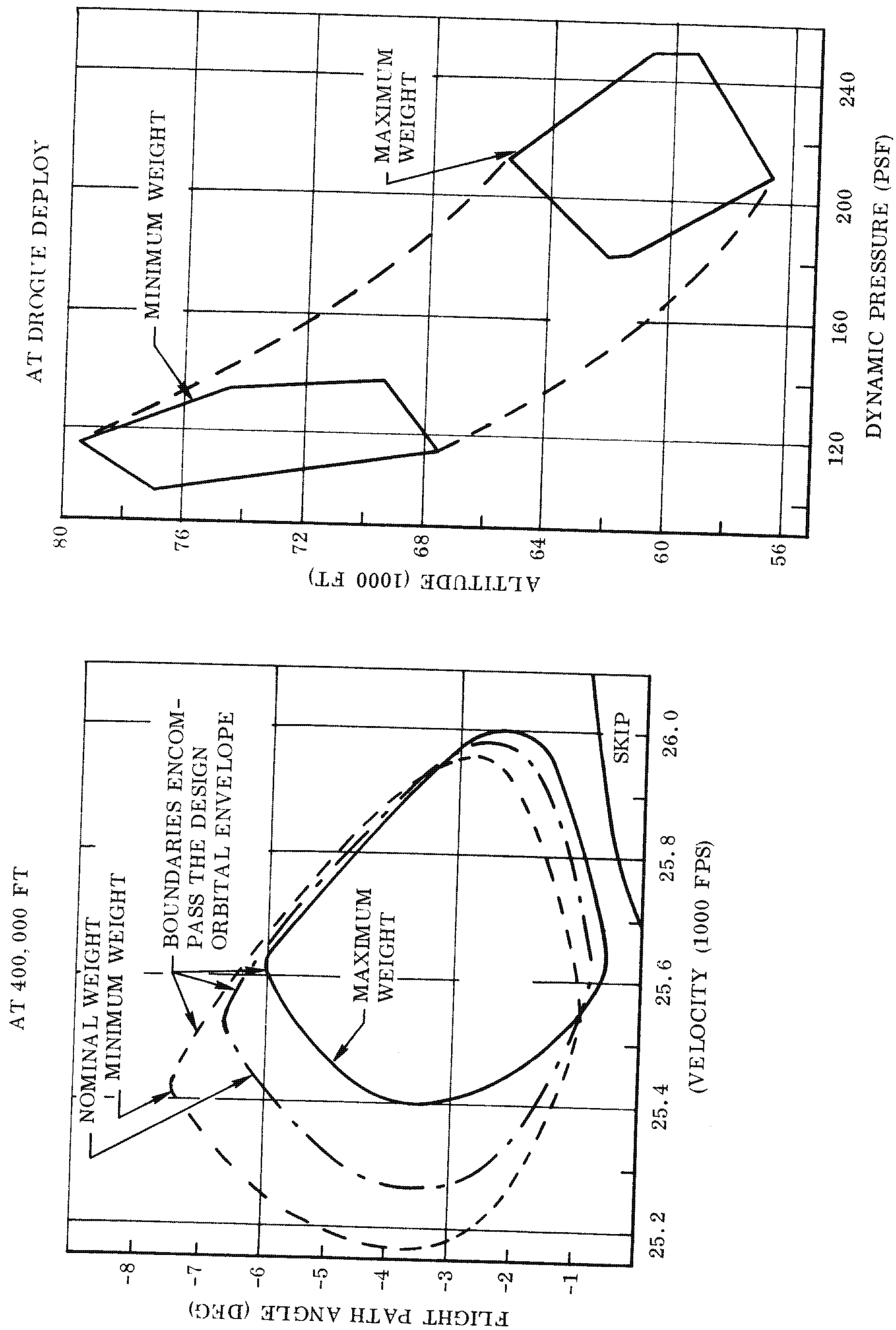


Fig. 8-1 Reentry Parameter Comparison

8.3 REENTRY VEHICLE SUBSYSTEM PERFORMANCE

The performance of the Reentry Vehicle subsystems is summarized in Table 8-2. Review of the flight data and post flight inspection and test of the recovered vehicles show five areas of anomalous conditions as follows:

a. Major damage in main parachute
b. Heat shield bond line temperatures higher than predicted
c. Spin and residual spin rate lower than predicted
d. Spin reversal during the early period of atmospheric entry
e. Base heat protection door not closed to latched position

For the four flights, only the main parachute demonstrated performance which compromised mission success and resulted in the loss of the recovery capsule on Flight 3. The other four anomalous conditions did not compromise the performance of these four flights. However, they are exceptions to the design and performance criteria established to ensure compatibility with entries from the most critical true anomalies for orbits up to 70 x 404 nm and for unbalanced payload conditions.

The RV contractor has initiated analysis and test effort to resolve causes for these anomalous conditions and to determine needed changes.

~~TOP SECRET / H~~ BIF003W/2-065766-71

Table 8-2

RV SUBSYSTEM PERFORMANCE SUMMARY

RV Subsystem/Function	Performance Assessment
On-Orbit Thermal Protection	Normal • $T_{P/L}$ Container = $T_{REF} {}^{+0^oF}_{-5^oF}$ • Power Usage (Watts/RV) Max = 12.6 (first day in orbit) Stabilized = 3.5 Allowable = 20.0
Trim and Seal	Normal
Electrical Power and Distribution	Normal • All Batteries Activated • All Voltages 25.5 volts
Sequential Subsystem	Normal • Both redundant systems of recovered RVs (Flights 1, 2 & 4) were verified to have functioned properly by telemetered data and factory test. • Flight 3 event sequencing verified to have functioned properly by telemetered data.
Pyro Subsystems	Normal • All primary and redundant pyrotechnics in each recovered vehicle (Flights 1, 2 & 4) were verified by factory inspection to have functioned properly.
Spin Stabilization	• Spin motor function – normal • Spin rate during retro 0.5 rad/sec below nominal • Spin residual rate 0.6 rad/sec below nominal
Retro Motor	Normal
Tracking, Telemetry, Instrumentation	Normal

Table 8-2 (Continued)

RV Subsystem/Function	Performance Assessment
Heat Shield	• Bondline temperatures higher than predicted • Adequate protection Flights 1 through 4 • Recovered HS from Flight 2 shows more recession than predicted
Base Thermal Protection	• Adequate thermal protection — No evidence of backside temperature in excess of 100°F • One door did not latch on Flights 1 and 4 • Hinge cover door missing on Flight 2
Structure	Normal
Recovery System	• Drogue performance normal • Main parachute anomalies Flight 1 — major canopy and target cone damage Flight 2 — major canopy damage with moderate target cone damage Flight 3 — major damage — capsule not recovered Flight 4 — no damage in canopy nor target cone

Section 9

Section 10

SUBSATELLITE

There were no Subsatellites flown on SV-1.

Section 11

STELLAR TERRAIN SUBSYSTEM

There was no Stellar Terrain Subsystem flown on SV-1.

Section 12

THERMAL CONTROL

12.1 FORWARD AND MID SECTION

The Forward and Mid Section structural temperature control is summarized in Table 12-1. The data indicates that the Forward and Mid Section thermal designs are adequate and no changes are forthcoming as a result of SV-1 experience.

12.2 ACTIVE THERMAL CONTROL

The Active Thermal Control System performed normally throughout the primary mission. The redundant system was not used. T_{REF}, which represents an average Mid Section film path temperature, varied between 67 and 71^{o}F during the mission. The RV control zone temperatures tracked T_{REF} within 1^{o}F throughout the mission. Heater power usage was normal verifying that the RV thermal design is adequate.

12.3 AFT SECTION

Acceptable Aft Section temperature control was achieved with all equipment within design temperature limits except for an over-temperature condition for the Bay 12 Battery Module. The orbital beta angle for this vehicle was +20 deg and nearly constant for the entire 31 day mission. A summary of critical component temperatures is shown in Table 12-2. The Battery Charge Control System protected the Bay 12 Batteries from extreme over-temperatures and allowed for acceptable electrical system performance throughout the mission.

The temperature level of the Aft Section was approximately 15^{o}F above predictions. Temperatures of areas of the skin which received direct solar energy impingement had orbit average temperatures as much as 55^{o}F above predictions. The cause for this anomaly is believed to be contamination of the external thermal control surfaces of the Aft Section occuring during the ascent events (see paragraph 12.4). The net result of this contamination was an increase in solar absorptivity of the white paint and bare aluminum external thermal control surfaces. Areas of the skin which receive direct solar energy impingement thus had temperatures hotter than expected.

Table 12-1
FORWARD AND MID SECTION THERMAL TEMPERATURES

Parameter	Design Limits (°F)	SV-1 Actuals (°F)
T_{FWD}	47/93	72/77
$T_{FWD} - T_3$	≤6	4/6
$\|T_{FWD} - T_{TCA}\|$	≤20	5/7
T_{TCA}	49/91	67/70
T_{SU}	47/93	71/74
$T_{SU} - T_{TCA}$	-4/5	4

where

T_{FWD} = Orbit average temperature of the active RV bays derived from an average of the bulkhead temperatures for each bay.

T_3 = Orbit average temperature of the upper pylon structure in the active bays.

T_{TCA} = Orbit average temperature of the forward compartment of the mid section derived from an average of several internal structural temperatures.

T_{SU} = Orbit average temperature of the aft supply compartment of the mid section derived from an average of several internal structural temperatures.

Table 12-2

SV-1 AFT SECTION CRITICAL COMPONENT TEMPERATURES

Critical Component	Design Limits (°F)	SV-1 Actuals** (°F)
EDAP		
PDJB	-30/170	67/70
CCCs	-30/170	85/97
RPS Bay 3	30/110	58/68
RPS Bay 5	30/110	75/82
Batteries Bay 12	35/70	88/100
Batteries Bay 1	35/70	44/47
PDAs	-30/160	70/95
Solar Arrays	-125/225	-74/150
ACS		
IRA	60/130	109/111
HSA Heads	0/130	66/80
FCEA	-30/160	103/106
OAS		
Tank	70/100	92/96
Quad Valve	35/200	114/118*
Catalyst Bed	—	129/134*
T&T		
Tape Recorders	20/130	88/102
Transmitters	-30/170	88/115
PCM Master	-30/170	96/122
PCM Remote Bay 2	-30/170	61/69
PCM Remote Bay 10	-30/170	104/110

*Data with OA engine not firing.
**Stabilized orbital operation (most equipment 70 to 90°F at lift-off).

Table 12-2 (Continued)

Critical Component	Design Limits (°F)	SV-1 Actuals** (°F)
COMMAND		
PMU A	-40/145	101/103
PMU B	-40/145	109/111
Clock	-40/153	111/113
MCS	-40/149	95/99
RCS		
Tanks	40/140	77/98
REM Valves	≥45	100/158
Plumbing Bay 12	35/140	91/98

**Stabilized orbital operation (most equipment 70 to 90°F at lift-off).

The thermal design of the Aft Section is such that most equipment near these hot skins are also thermally coupled to the colder areas of the Aft Section, and therefore these equipment were not significantly hotter than predictions. However, the active temperature control scheme of the Bay 12 Battery Module is such that the batteries are directly coupled to the skin. The Bay 12 skin temperatures running 55°F hot tended to make the batteries run nearly 55°F hot. The problem was further aggravated by reduced battery electrical efficiencies at the higher temperatures which also increase battery temperatures.

Built into the electrical charge system design are relays which remove electrical charge from the batteries if certain temperatures are exceeded. This design worked well and resulted in removing all charge from the batteries at approximately 98°F. Shortly after this event occurred the batteries would begin to cool and would continue to cool until the charge was again applied at a lower temperature level. This scheme resulted in Bay 12 Battery temperatures which cycled between 88°F and 100°F, and allowed for acceptable electrical performance. (See additional discussion in paragraph 5.4).

Without the presence of contamination the Battery Module skins will have temperatures sufficiently cold to achieve battery temperatures in the desired range of 35 to 70°F. Once the contamination source is identified and a design fix made to prevent the contamination, acceptable battery temperatures will be achieved.

12.4 AFT SECTION TEMPERATURE CONTROL ANOMALY

12.4.1 Causes

The possible causes for the anomalous Aft Section temperature levels which caused the Type 29 Batteries in Bay 12 (Batteries 3 and 4) to run hotter than their limits were evaluated in detail. The candidate causes were:

- Item 1 Unexpected behavior of corrugated Aft Section surfaces in direct sunlight (effective solar absorptivity higher than predicted).
- Item 2 Improper application or preflight damage to Aft Section thermal control surfaces.
- Item 3 Basic thermal design error that was not detected during thermal-vacuum acceptance testing.
- Item 4 Contamination of external Aft Section surfaces by ascent events.

Item 1 was investigated by conducting a special test of actual corrugated Aft Section panels in a simulated solar flux (parallel light) environment. The results of this test confirmed the validity of the basic design values used for the effective solar absorptivity of the corrugated panels.

Investigation of Item 2 included a review of (1) the actual solar absorptivity and emissivity measurements made in Building 156 before SV-1 ship; (2) all Q/A checks, (3) cleaning processes, and (4) white paint batch data. These reviews failed to reveal any evidence of improper application or pre-flight damage of Aft Section thermal control surfaces.

A complete review of the Aft Section thermal math model and the results of the SDV-3 and SV-1 thermal vacuum tests was made to investigate Item 3. The result of this review was that the thermal math model and confirmation thereof by the thermal-vacuum tests is valid.

Contamination of Aft Section surfaces during ascent is the apparent cause of the anomalous Aft Section temperature levels. Ascent events that could contribute to contamination include the liftoff ground cloud, SRM staging, Stage I/II separation, RV separation, Stage II retro, and Shroud separation. Although it is impossible to distinguish between these possible sources, review of available ascent temperature data, review of movies of SV-1 and other vehicles during lift-off and ascent, discussions with other program offices, and review of prior analyses of these contamination sources has resulted in the conclusion that most of the contamination occurred during liftoff and/or SRM staging. Accordingly, a plan of action as described below was formulated for SV-2, leading to a positive fix on SV-3.

12.4.2 Action for SV-2

Observing that all Aft Section components other than the Bay 12 Batteries remained within their respective temperature limits, SV-2 will be flown at or near the same beta angle as SV-1 (+20 deg). To protect the Bay 12 Batteries from overheating again, the entire Bay 12 Battery Module will be relocated to Bay 3 which will be vacant on SV-2 due to deletion of the Reserve Power System. Minor changes to the Bay 3 thermal design will be made to provide the proper environment for the Battery Module, thus insuring that all four Type 29's will run within limits on SV-2.

Having insured proper temperature control of all Aft Section equipment by flying the same beta angle as SV-1 and relocating the Bay 12 Batteries to Bay 3, the following objectives pertaining to the source of the contamination and the evaluation of possible fixes will be addressed on SV-2:

1. Distinguish source – liftoff cloud
2. Distinguish source – SRM staging
3. Evaluate degradation of present thermal control surfaces (white silicone, bare aluminum, black Kemacryl).
4. Assess smoth skin over corrugations as a possible fix.
5. Assess FOSR as a substitute for white paint (FOSR stands for Flexible Optical Solar Reflector and is aluminum foil with a thin layer of teflon).
6. Assess Z-93 as a substitute for white paint (Z-93 is an inorganic, ceramic-based white paint).
7. Evaluate nature of liftoff cloud contaminants.

In order to accomplish these objectives on SV-2 the following experiments will be performed:

1. Bay 11

   The existing Bay 11 Door will be replaced with a modified Bay 6 door. The Bay 6 door will not have a Horizon Sensor Fairing and the four Horizon Sensor Head holes will be used for calorimeters having white silicone, black Kemacryl, bare aluminum and Z-93 surfaces. One of the four calorimeter panels will be protected through the lift-off cloud event, a second panel will be protected through the SRM staging event, and the remaining two panels will be exposed throughout ascent. The layout of this experimental Bay 11 door is shown in Fig. 12-1. Orbital temperature data from these calorimeter panels are expected to satisfy objectives 1, 2, 3 and 6 as stated above.

2. Bay 12

   The existing Bay 12 door will be covered with a dummy corrugated door mounted on thermal stand-offs. This dummy door will be segmented into three different configurations: (1) dummy corrugations painted white silicone (like original Bay 12 door); (2) dummy corrugations covered with a smooth skin which is painted white silicone; and (3) dummy corrugations covered with a smooth skin which is finished with FOSR. This experimental Bay 12 door is shown in Fig. 12-1. Thermocouple data from each of these three sections on orbit is expected to satisfy objectives 3, 4 and 5.

3. Umbilical Contamination Samples

   Three boxes containing eight thermal control surface samples will be mounted on the umbilical arms near the SV aft and mid sections. The boxes will be closed shortly after SRM ignition so that the samples are exposed to the lift-off cloud but are subsequently protected from direct SRM exhaust impingement. The layout for these boxes is shown in Fig. 12-2. Surface property data pre- and post-launch should satisfy objective 7.

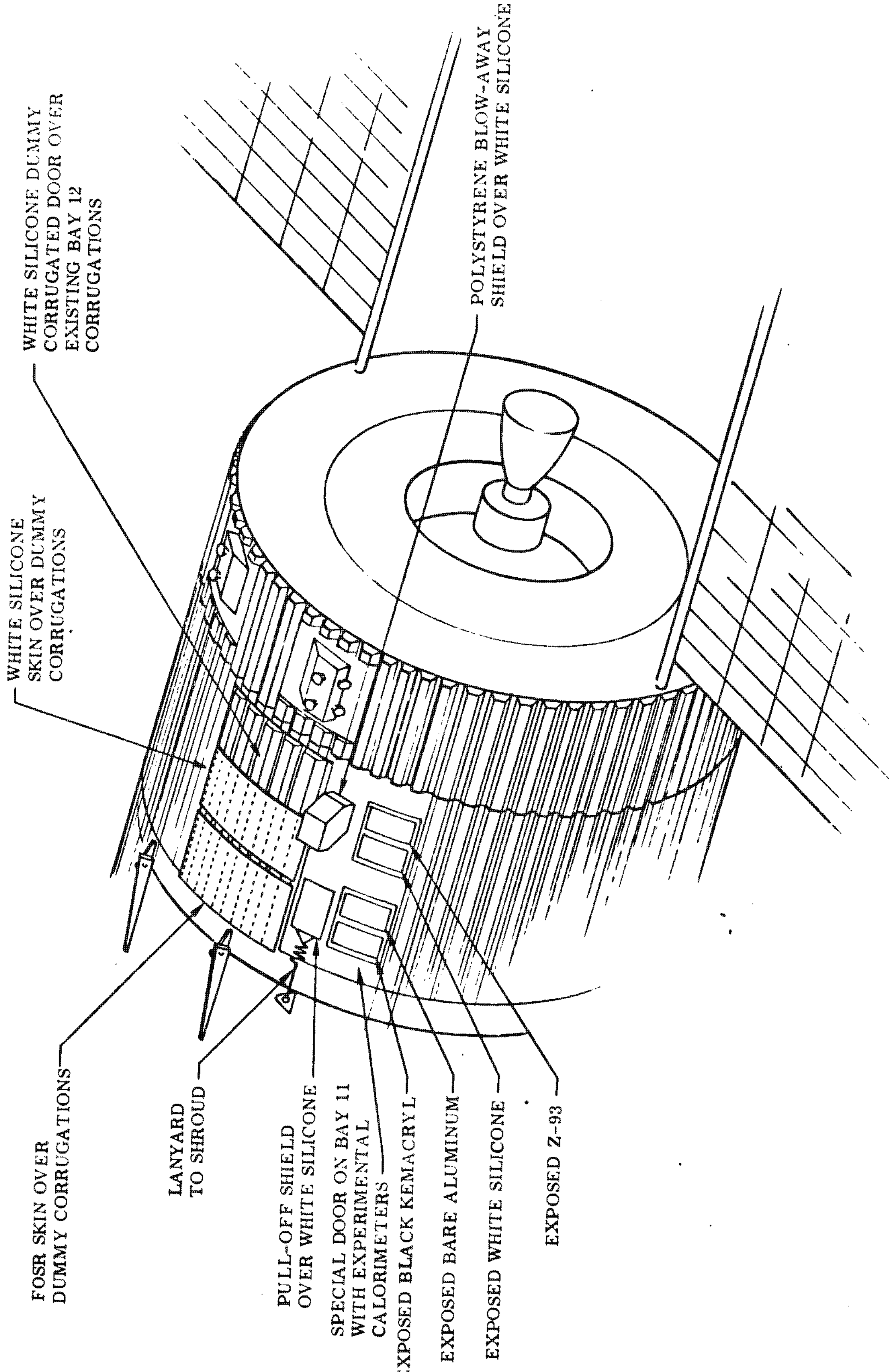


Fig. 12-1 SV-2 Contamination Experiments

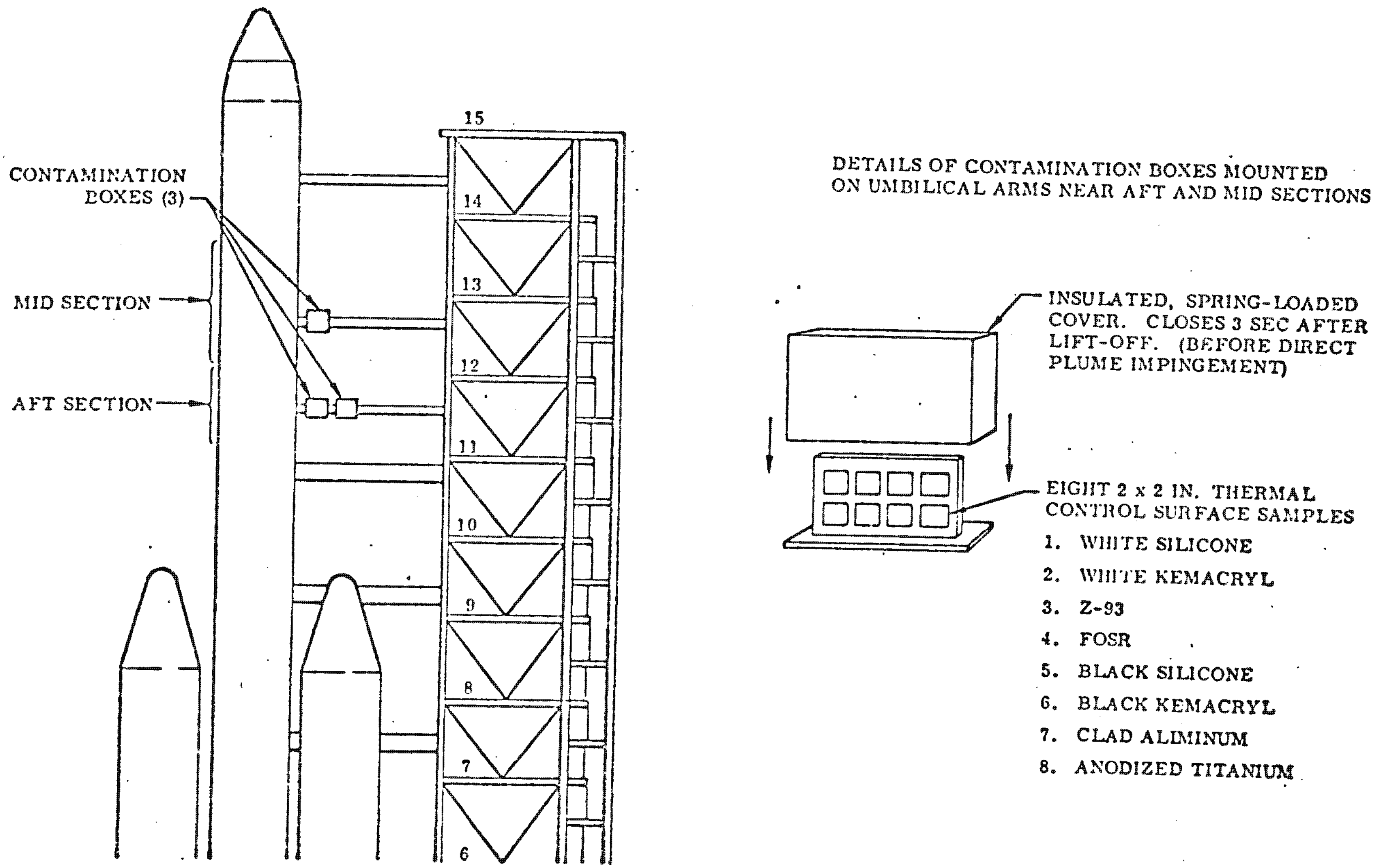


Fig. 12-2 Umbilical Arm Contamination Sample Boxes

12.4.3 Action for SV-3

Based on the data obtained from the experiments described above for SV-2, a positive fix will be implemented on SV-3. These fixes range from a simple blow-away shield for liftoff cloud protection, through using FOSR or Z-93 as a white silicone paint substitute, through application of a smooth skin over the Aft Section corrugated surfaces, to the installation of a protective Shroud which is ejected after the SRM staging event. Lead time requirements dictate that the SRM staging shield preliminary design and the study of application techniques for Z-93 be started before SV-2 is flown.

Section 13
MASS PROPERTIES

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

Table 13-1

MASS PROPERTIES

Event	Weight (lb)	SV Sta (in.)	$\overline{Y}$ (in.)	$\overline{Z}$ (in.)	I_x (slug-ft^2)	I_y (slug-ft^2)	I_z (slug-ft^2)	I_{xy} (slug-ft^2)	I_{xz} (slug-ft^2)	I_{yz} (slug-ft^2)
Separation from Stage II	20627	2016.9	1.59	4.21	5004.4	134820.1	134156.1	-966.9	2026.3	68.7
Solar Array Extended	20627	2017.4	1.59	4.21	6160.0	135773.7	136210.0	-963.6	2035.2	-153.2
Before RV 1	20608	2011.4	1.61	4.60	6146.7	142505.0	142942.2	-1022.3	2424.8	-160.0
After RV 1	19177	2036.4	1.74	3.68	5950.9	105121.6	105687.3	-838.5	1067.4	-153.2
Before RV 2	19112	2028.5	1.77	4.26	5943.9	112016.3	112572.1	-911.6	1550.7	-161.9
After RV 2	17601	2053.1	1.92	3.15	5734.1	82661.2	83359.0	-729.9	229.3	-153.7
Before RV 3	17210	2043.6	2.04	3.94	5714.5	86564.1	87250.4	-841.8	581.1	-172.4
After RV 3	15682	2066.7	2.24	2.63	5497.4	65990.6	66824.8	-664.6	-574.5	-162.4
Before RV 4	15649	2063.5	2.30	3.04	5492.2	67541.0	68365.7	-708.6	-422.8	-172.6
After RV 4	14346	2081.0	2.50	1.86	5299.3	56047.6	56999.5	-572.0	-1192.1	-163.3
Begin Deboost	12844	2069.5	2.56	1.68	5202.4	52478.6	53472.8	-584.0	-1124.7	-198.8
End of Deboost	12111	2062.3	2.70	1.75	5190.3	50119.3	51115.3	-628.1	-1146.1	-201.4

Section 14

STRUCTURES AND DYNAMICS

14.1 ASCENT ACCELERATION

The axial accelerations were measured at Station 1642 and 2180 and are shown in Fig. 14-1 along with the design and static test levels for the complete ascent.

The significant dynamic acceleration levels (measured on the SV forward bulkhead at Station 1642) are presented in Table 14-1.

Table 14-1

PYLON RESPONSES
(Station 1642)

Event	Axis	Level g's Zero to Peak	Frequency (Hz)
Lift Off	Z	0.75	4.0
SRM Burn	Y, Z	0.5	4.0, 4.0
SRM Burn out	Z	0.5	16.0
SRM Separation	X, Z	0.5	20.0, 11.0
Stage I (POGO)	X	0.4	19.0
Stage I Shutdown (STG II IC)	X	1.0	19.6
	Y	0.4	20.0
	Z	0.8	20.0

The accelerations measured during Stage 0 flight indicate no excessive dynamic loadings on the SV. Stage II shutdown resulted in very low dynamic accelerations such that no particular fundamental mode excitation could be identified from the accelerometer traces.

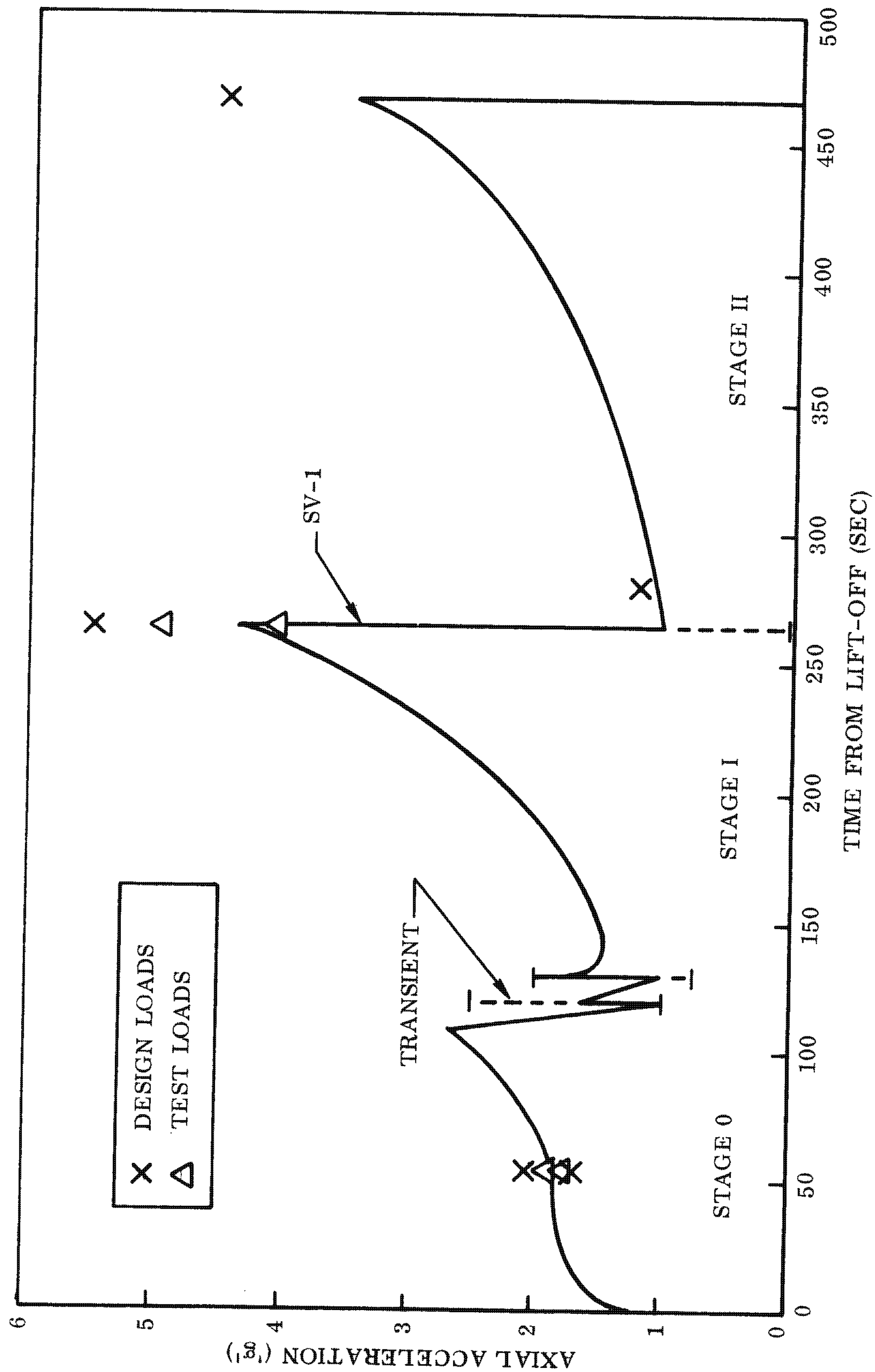


Fig. 14-1 Axial Acceleration History

Of particular interest on any Titan flight is the Stage I shutdown event and the fundamental longitudinal mode excitation phenomena. Stage I shutdown is the most severe structural dynamic loading event for loads on local structure and payload masses.

The maximum dynamic acceleration levels measured on the SV structure (at Station 1642) are presented in Table 14-2 along with the predicted levels for that location. The predictions are based on the set of 27 depletion shutdown transients used as a design criteria for this event.

Table 14-2

STAGE I SHUTDOWN DYNAMIC ACCELERATIONS
FLIGHT VERSUS PREDICTED

Direction	Location	Flight g's	Predicted g's
Axial -X	1642	±1.0	±3.0
Lateral -Y	1642	±0.4	±1.0
Vertical -Z	1642	±0.8	±2.5

As can be seen from Table 14-2, the measured response levels are significantly lower than the predictions. In order to compare the principal response frequencies, the accelerations measured due to Stage I shutdown were processed to obtain the response in various frequency ranges. The response levels and frequencies in three frequency ranges are shown in Table 14-3. The first three longitudinal modes of the vehicle are identified along with the predicted frequencies.

The fundamental longitudinal mode response, which can occur anytime during Stage I flight, reached its highest level shortly before Stage I burnout. The maximum level measured was 0.4 g's (zero to peak) at station 1642 which was well below the design level of 1.0 g's at the same location.

Table 14-3

BAND PASS ANALYSIS RESULTS
(Stage I Shutdown Transients)

Frequency Range	Axis	Frequency (Hz)	Acceleration (g's)	Mode	Predicted Frequency (Hz)
16-18	X Y Z	17.0 17.0 17.0	±0.31 ±0.1 ±0.2	1st Longitudinal	16.9
18-23	X Y Z	20.4 20.4 20.4	±0.6 ±0.1 ±0.35	2nd Longitudinal	20.6
23-30	Z	29.0	±0.1	3rd (Booster Tank Mode)	28.5

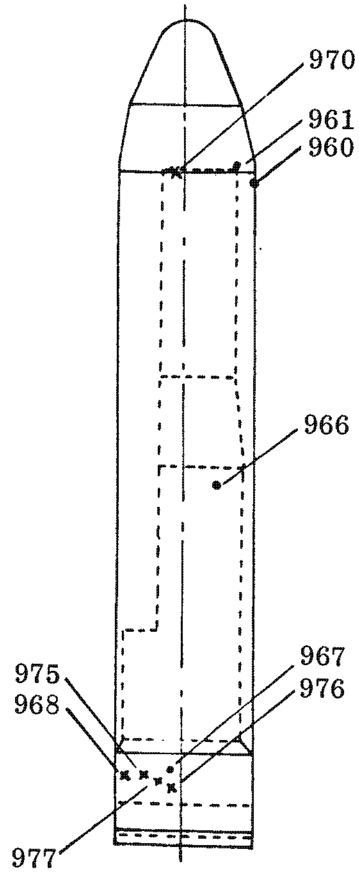
In conclusion, the low frequency accelerometer measurements indicated no loads problems during ascent flight. The severe loading event, Stage I shutdown, resulted in response levels lower than expected.

14.2 ASCENT ACOUSTIC AND VIBRATION ENVIRONMENT

The acoustic and vibration measurements are shown in Fig. 14-2. Excellent data quality from all nine channels were transmitted except for a data drift problem on the microphones at lift off. Most severe drifting occurred on measurements 961 and 967; these channels drifted beyond their band edges and the data was lost for a short time. The drift was due to microphone sensitivity to static pressure pulses at ignition and lift off. Corrective high pass filters are being installed on the SV-2 microphone amplifiers.

A tabulation of maximum overall sound pressure levels and G_{rms} values are also presented in Fig. 14-2. The flight reading of 120 dB for sensor 961 is significantly lower than anticipated which is attributed to the very local and transient nature of the external shock. In general, the flight data show that test levels are not exceeded except for

MEASUREMENT LOCATIONS



• MICROPHONES
× VIBRATION PICK-UPS

	LIFT OFF	MAX FLIGHT	ACCEPTANCE TEST LEVELS
MICROPHONES			
960 FWD EXT	154 dB	151 dB	159/151.5 dB
961 FWD INT	144	120	145
966 MID INT	134.5	119	136
967 AFT INT	134.5	125	139.5
VIBRATION PICK-UPS			
970 FWD BULKHEAD	6.0 G_{RMS}	0.6 G_{RMS}	12.2 G_{RMS}
968 PCM MODULE	0.75	0.5	- (1)
975 T&T MODULE	1.0	0.8	1.3
976 ARM MODULE	1.6	0.4	2.0
977 LB MODULE	1.4	1.0	2.7

(1) NO TEST DATA

Fig. 14-2 Summary of Maximum Overall SPL and G_{RMS} Values certain frequency bands. The test procedures are being reviewed with respect to this flight data; however, no changes in test specifications or procedures are indicated at this time.

14.3 SOLAR ARRAY

The history of the solar array erection and deployment are shown in Fig. 14-3. Since the arrays were deployed and erected in the proper position for this flight's beta angle, no positioning was necessary and none was performed.

Data exists to describe completely the erection of the left solar array and it was completed 230 sec after deployment was commanded. Only partial data is available for the other motions; however, data for the final portion of the deployment of the right array permits probable histories for all the motions to be sketched in on Fig. 14-3. It is estimated that the right solar array erected in 320 sec. The time for the right deployment was 650 sec and the time for the left deployment is estimated at 510 sec. Temperatures of the left and right erection dampers were 63 and 65°F respectively. The right array also took longer to erect and deploy during ground tests.

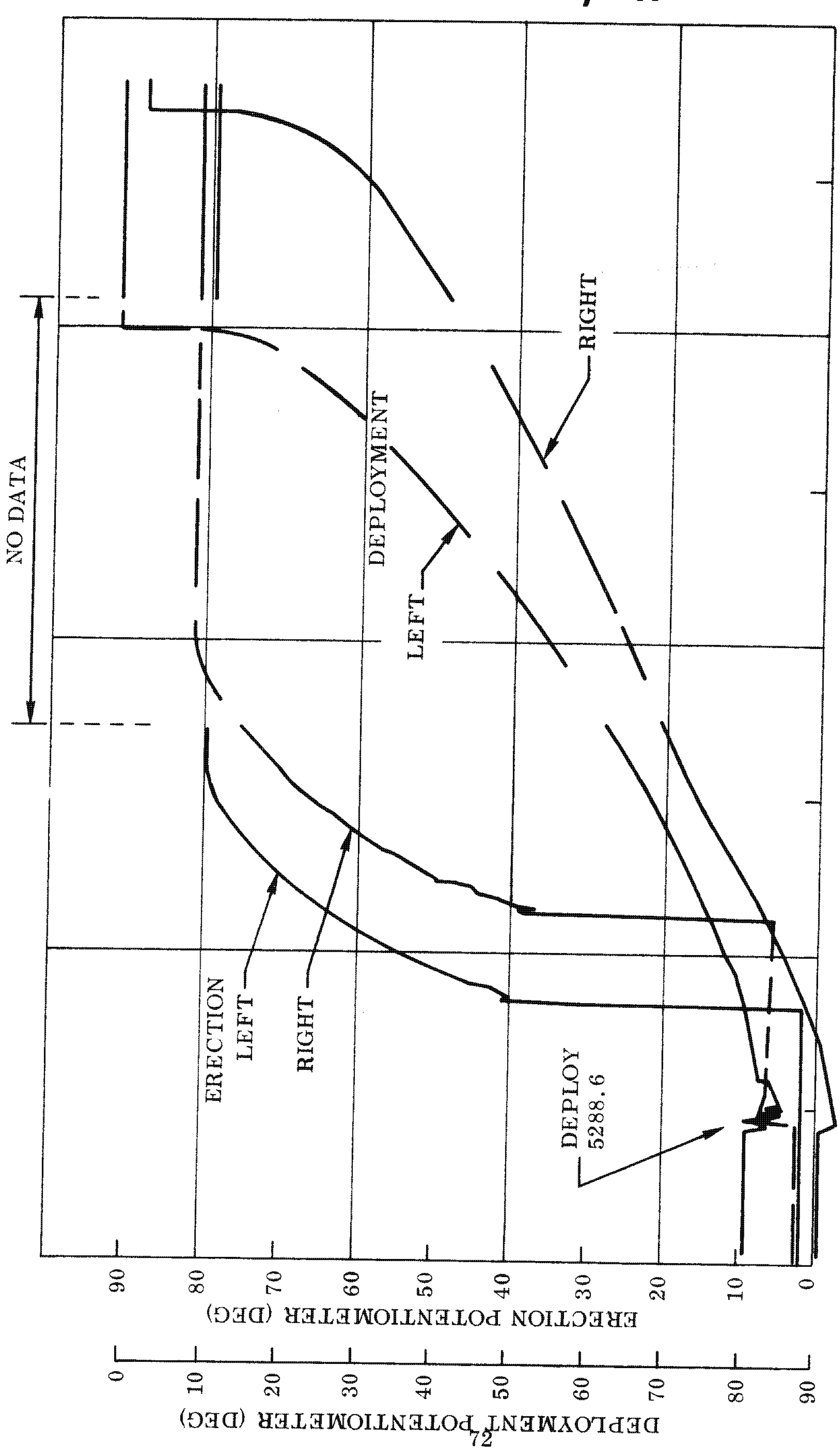


Fig. 14-3 Solar Array Erection and Deployment

Section 15
SOFTWARE

There were no software problems which impacted flight objectives.