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

Prepared and Submitted by the
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HANDLE VIA BYEMAN
CONTROL SYSTEM ONLY

FOREWORD

This report describes the performance of the second HEXAGON Program Satellite Vehicle (SV-2). The vehicle was launched on 20 January 1972 and completed its primary mission with the recovery of RV number four on 28 February 1972. This report encompasses these 40 days.

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ABBREVIATIONS

ACS	Attitude Control System
BV	Booster Vehicle
CCC	Charge Current Controller
CV	Constant Velocity
ECS	Extended Command System
EDAP	Electrical Distribution and Power
ESD	Emergency Shutdown
FCEA	Flight Control Electronics Assembly
FDU	Failure Detector Unit
FOSR	Flexible Optical Solar Reflector
FP	Film Path
FST	Flight Support Team
FT	Film Transport
FTFD	Field Test Force Director
GFE	Government Furnished Equipment
HS	Heat Shield
H/S	Horizon Sensor
HSA	Horizon Sensor Assembly
IRA	Inertial Reference Assembly
K	Kodi Tracking Station
LB-II	Lifeboat-II
MCLR	Master Clear Off
MCS	Minimal Command System
MMC	Martin Marietta Corporation
MOP	Manual Operation
MWC	Mid West Contractor
OA	Orbit Adjust
OAS	Orbit Adjust System

OB	Optical Bar
PCM	Pulse Code Modulation
PDA	Positional Drive Assembly
PDJB	Power Distribution Junction Box
PDS	Power Distribution Section
PDWN	Pitch Down
PGR	Pitch Gyro Rate
PMU	Programmable Memory Unit
PST	Pacific Standard Time
QCM	Quartz Crystal Microbalance
RC	Recovery Capsule
RCS	Reaction Control System
REA	Reaction Engine Assembly
REM	Reaction Engine Module
RTS	Remote Tracking Station
RV	Re-entry Vehicle
SBAC	Satellite Basic Assembly Contractor
SCC	Sequence Command and Control
SECO	Stage II Engine Cut-Off
SGLS	Space-Ground Link System
SPC	Stored Program Command
SRM	Solid Rocket Motor
SS	Sensor System
SSC	Sensor System Contractor
STC	Satellite Test Center
SU	Supply Unit
SV	Satellite Vehicle
TLM	Telemetry
TM	Telemetry
TT&C	Tracking, Telemetry and Command
TU	Take Up
TVC	Thrust Vector Control
VCO	Voltage Controlled Oscillator

Section 1
SUMMARY OF GENERAL SYSTEM PERFORMANCE

1.1 SV SYSTEM PERFORMANCE

Following a launch hold initiated by a low resistance in the Titan IIID Booster Vehicle pyro circuit and extended to 30 days by replacement of the BV thrust vector control valves, the Satellite Vehicle was injected into a nominal 86 by 188 nm orbit. Ascent events were all nominal and proper stabilization of the SV allowed deployment of the Solar Arrays on the first rev. The Subsatellite was properly ejected on Rev 14. The performance of the SV with respect to the primary mission objectives are summarized for each of the four mission segments as follows.

<u>Segment One</u>

Operational photography commenced following completion of Sensor System health checks. In spite of minor anomalies involving a take-up brake malfunction, a pneumatics system leak, and Optical Bar shutdowns during nested operations a full load of 28,000 feet of film on each side was exposed and transported into RV 1. RV 1 was successfully released and aerially retrieved on the 7th day. Several of the outer wraps of film were found to be torn, wrinkled and twisted due to sheared take-up core pins during recovery but the percentage of damaged film was small. Photographic image quality was considered to be fair for both the forward- and aft-looking cameras.

<u>Segment Two</u>

Operational photography continued using RV-2 and progressed normally, except for an isolated high tension ESD, until Rev 272 when a catastrophic break in the B-Side film strip occurred. No further usable photography was obtained on the B-Side. RV 2 was almost fully loaded with 27,500 feet on the A-side, and 27,700 feet on the B-Side. Release and aerial retrieval was successful on the 20th day. Image quality for this film load was rated as improved over Segment 1 with the aft-looking camera results being somewhat better than the forward-looking camera.

Segment 3

Monoscopic operation of Side A (forward-looking camera) continued using RV 3. 18,200 feet of film was loaded on the A-Side and RV-3 was successfully released and aerially retrieved on the 29th day. Image quality was not as good as Segment 2.

Segment 4

Monoscopic operation continued using RV 4 and 26,600 feet of film were loaded. Excessive REM valve leakage necessitated the release of RV 4 on the 40th day. Release and aerial recovery were successful. Image quality was comparable to that of Segment 3.

1.2 SUBSYSTEM PERFORMANCE

With the exception of the Reaction Control System, the performance of the SV Subsystems throughout the mission was generally excellent. Except for the RCS, all primary equipment functioned throughout the four mission segments and no backup equipment was required. Subsystem performance is summarized as follows:

Attitude Control System

The ACS met performance requirements in all operating modes.

Reaction Control System

Severe REM leakage and pulse degradation occurred on this flight resulting ultimately in the termination of the mission with no SOLO phase. Extensive task force activity is underway to isolate the cause(s). SV-3 operational constraints are being considered.

Electrical Distribution and Power

Due to the beta angle constraint and the relocation of the Bay 12 battery module to Bay 3, the EDAP system performed normally throughout the mission even though the ascent contamination of the aft section reoccurred as in SV-1.

Orbit Adjust System

As in SV-1 the OAS continues to perform flawlessly and meet all requirements.

Tracking, Telemetry, and Command

With the observance of the antenna pattern recommendations and the prohibition of certain 11 and 12 bit ECS commands, the TT&C System meets all requirements.

Lifeboat II

Health checks show performance requirements to be satisfied. The battery capacity was entirely adequate due to proper tank heater management. An actual Lifeboat II deboost was successfully performed.

Structures and Mechanisms

All performance requirements were again met including the proper ejection of the Bay 11 contamination experiment shields during ascent.

Thermal Control System

All active and passive thermal control designs performed within requirements. Evaluation of the ascent contamination using on-orbit thermal data was entirely successful.

A more detailed discussion of these subsystems is presented in subsequent sections 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

Day	Description	Impact	Cross Reference
1	SS Pneumatic System Leak	Low pressure shut-off valve on A-Side failed open. High pressure Iso valve was closed and mission completed with both FPs supplied from the B-Side of the system. Redundant latching relays on these valves to be implemented on SV-9.	Paragraph 7.6
1	TU Brake in RV-1 not actuating	Logic failure in SCC II confined to TU 1 only. Switched to SCC I to eliminate anomaly.	Paragraphs 7.1 and 7.3
2	Inadvertent OB shutdown during nested operations	Suspected electrical noise caused OB shutdown on two occasions. Nested ops resumed. Noise suppression fix is effective on SV-3 and up.	Paragraph 7.3
7	Outer film wraps on RV 1 loose and tangled, core pins sheared	Core locking pins sheared during recovery. Delays despooling operation but no design changes are indicated	Paragraph 8.1
7	Hole in RV 1 Aft Bulkhead	Hole caused by parachute swivel during deployment. Minor light fogging of film. Doubler added to aft bulkheads on SV-3 and up RVs	Paragraphs 8.1 and 8.3
19	Loss of B-Side tension	Apparently caused by breakage of B-Side film strip. Cause is unknown. Problem is currently under investigation.	Paragraph 7.2
19	RCS 1 REM leak	Primary REM valves began leaking. Switched to RCS 2. Cause currently under investigation.	Paragraph 2.2 and subparagraphs
23	One OA valve monitor failed	Failure shown to be a microswitch malfunction; valve operation was normal. No change indicated.	Paragraph 3.1

Table 1-1 (Cont.)

Day	Description	Impact	Cross Reference
25-29	RCS 2 REM leak	Redundant REM valves began leaking. Propellant usage rate acceptable for completion of mission.	Paragraph 2.2 and subparagraphs
29	SV tumbled during yaw for negative OA	Tumble caused by failure detector shutoff of RCS 2 due to thrust degradation of leaking REMs. SV captured with RCS 1 after three tumbling revs.	Paragraph 2.2 and subparagraphs
30	RCS 1 propellant usage increase	Usage up to 16 lb/rev (nominal is 0.4 lb/rev). Transfer to RCS 2 where usage is also higher than nominal but still acceptable for mission completion.	Paragraph 2.2 and subparagraphs
39	RCS 2 leak increases.	Leakage on RCS 2 increased to 8 lb/rev.	Paragraph 2.2 and subparagraphs
39	SV tumbled	Tumble capture with RCS 1 after 4 tumbling revs. RV 4 was recovered next day and LB-II deboost followed two revs later.	Paragraph 2.2 and subparagraphs

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Section 2
ATTITUDE CONTROL

2.1 ATTITUDE CONTROL SYSTEM

The SV-2 Attitude Control System (ACS) performed as expected and met all specifications that could be measured. The summaries presented in this section detail those requirements that could be verified from flight data. The performance of the control force equipment elements is reviewed in subsection 2.2.

2.1.1 BV/SV Separation

BV/SV separation was complete at approximately 539.2 seconds vehicle time. (Vehicle time starts 67 sec before lift-off.) Master clear off (MCLR), 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 527.2 sec 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.

2.1.2 Subsatellite/SV Separation

The significant Subsatellite/SV separation events of Rev 14.6 were as follows:

Event	Vehicle Time (sec)
Coarse Mode	76203.6
Neg Yaw Rate	76204.2
Stop Yaw Rate	76224.0
Separation	76293.4
Pos Yaw Rate	76309.2
Stop Yaw Rate	76329.0
Fine Mode	76359.0

Table 2-1

BV/SV SEPARATION

	Rate and Attitude at BV/SV Separation						Capture			
	Rate (deg/sec)		Attitude (deg)				Attitude		Rate	
			H/S at Sep		Λ(SECO-Sep)					
	Specified	Actual	Specified	Actual	Specified	Actual H/S/Int.	Specified(1) (deg)	Actual(2) (time in sec)	Specified(3) (deg/sec)	Actual(4) (time in sec)
Pitch	±0.752	-0.025	-22.85 to +9.63	+4.1	-0.49 to -4.03	+0.9/ +0.42(5)	±0.70	665	±0.014	109
Roll	±0.786	-0.269	-7.50 to +10.94	+3.1	+2.99 to +0.45	+1.74/ +0.60	±0.70	665 +520	±0.021	256
Yaw	±0.752	+0.175	-7.66 to +11.50	–	+4.48 to +0.66	–/ +2.16	±0.64	665 +520	±0.014	665

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

(2) Actual time required to achieve specified attitude (switched to fine mode plus settling time)

(3) Rate in deg/sec to be achieved in 1500 sec

(4) Actual time required to achieve specified rate

(5) Relative to the local horizontal

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The ACS parameters just prior to the instant of separation (76293.2 seconds vehicle time) were as follows:

Event	Actual	Specified
Pitch H/S	+0.28 deg	±1.0 deg
Roll H/S	-0.52 deg	±1.0 deg
Roll Integrator	-0.16 deg	
Yaw Integrator	+0.04 deg	
Pitch Integrator	+0.29 deg	
Roll Gyro Rate	+0.04 deg/sec	±0.1 deg/sec
Pitch Gyro Rate*	-0.05 deg/sec	±0.1 deg/sec
Yaw Gyro Rate	0 deg/sec	±0.1 deg/sec
Yaw Attitude (-14.0 deg desired)	-14.58 deg	14 ±1.0 deg

The yaw attitude was obtained by integrating the yaw gyro rate.

The maximum SV rates observed following the yaw separation impulse were:

Pitch Gyro Rate*	-0.094 deg/sec
Roll Gyro Rate	0.347 deg/sec
Yaw Gyro Rate	0.153 deg/sec

With the Subsatellite located on the vehicle port side along the -Z axis at 11.47 in., a positive roll rate such as shown above was expected.

2.1.3 Payload Operations

Three types of payload operations were used on SV-2 which presented distinctly different torque profiles to the vehicle. These were stereo payload operations, mono payload operations with one OB, and mono payload operations with two OBs. SV-2 gyro rate data observed during representative operations of the three types mentioned is shown in Table 2-2. In all cases the specification limits were met.

*Geocentric program rate of -0.0687 deg/sec was included.

Table 2-2

SV PERFORMANCE DURING P/L OPERATIONS

STEREO PAYLOAD OPERATION

SEG/ REV	PEAK RATES DURING START/STOP (DEG/SEC)			PEAK RATES DURING SS OPS (DEG/SEC)			SETTLING TIME (SEC)
	P*	R	Y	P*	R	Y	
	SPEC/ ACTUAL	SPEC/ ACTUAL	SPEC/ ACTUAL	SPEC/ ACTUAL	SPEC/ ACTUAL	SPEC/ ACTUAL	SPEC/ ACTUAL
2/176.4	NONE/+0.0023	NONE/-0.003	NONE/0.010	±0.014/0.0023	±0.021/-0.007	±0.014/0.010	0.2/0

MONO PAYLOAD OPS (WITH ONE OB)

3/314.4	NONE/-0.005	NONE/-0.042	NONE/-0.007	±0.014/-0.012	±0.021/0.011	±0.014/-0.003	6.6/0

MONO PAYLOAD OPS (WITH TWO OBs)

4/461.4	NONE/0.0077	NONE/0.006	NONE/-0.013	±0.014/-0.011	±0.021/-0.010	±0.014/0.001	6.6/0

*GEOCENTRIC RATE SUBTRACTED FROM INDICATED RATE

2.1.4 Recovery

The pitch-down maneuvers preceding the RV separations were all within specification and are summarized in Table 2-3, and the RV separation performance summary is shown in Table 2-4.

Following RV 4 separation, a pitch-up of 49.3 deg to the local horizontal was commanded, rather than the usual 90 deg pitch-up. When the pitch-up command was removed, PDWN indicated a pitch-up angle of 58.6 deg. The overshoot results from the pitch integrator offset that still remains from the large separation rate. A 49.3 deg pitch-up maneuver is sufficiently short such that the large integrator attitude resulting from separation has not had time to go to zero. The estimated peak integrator angle of 26 deg would have required about 14.5 sec longer to zero out. The PDWN indicated at the time of maneuver completion, which is when the H/S are connected, was 51.6 deg. Connection of the H/S signal brought the SV back to a zero deg pitch attitude.

RV 3 release was performed with the redundant RCS Thrusters, therefore, REM thrust levels from chamber pressure data are not available.

2.1.5 Yaw Maneuvers

The Rev 208.3 and 209.1 yaw maneuvers associated with the negative OA of Rev 209.1 is typical of yaw maneuver performance on SV-2. Parameters associated with those maneuvers are shown in Table 2-5.

2.1.6 Failure Detector Operation

The failure detector was operated twice on SV-2. The first time was during a yaw-around maneuver in preparation for a negative OA burn. The sequence of events was as follows:

Table 2-3

PITCH DOWN PERFORMANCE PRECEDING RV SEPARATION

	Pitch Down Angle		Maneuvering Time to 0.1 (deg/sec)		Pitch Down Coast Rate		
RV/Rev	Desired ±3.0 deg	Actual (PDWN) (deg)	Spec (sec)	Actual (sec)	Command Rate (deg/sec)	Coast Rate Expected (deg/sec)	Coast Rate Actual – PGR (deg/sec)
1/98.3	-36.1	-36.1	150	72	-0.705	-0.75 ±0.05	-0.73
2/308.3	-40.3	-40.9	150	78	-0.705	-0.75 ±0.05	-0.73
3/453.2	-37.5	-36.7	150	73	-0.705	-0.75 ±0.05	-0.73
4/630.0	-40.7	-40.0	150	78	-0.705	-0.75 ±0.05	-0.73

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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 REM Thrust Level (2, 3) (lbf)	Pitch Down Prior to Sep (deg)	Pitch-up Following RV Sep to Removal of Maneuver Command (deg)	Pitch Inertia (After Sep) ($slug-ft^2$)	Pitch Thruster Moment Arm (ft)	Roll Angle	
									Spec (deg)	Meas. H/S (deg)
1/98.3	1.99	10.6	120.3	2/4.73 3/4.97	-36.1	100.1	101515	14.0	±1.0	+0.26
2/308.3	2.17	20.2	119.0	2/3.77 3/4.01	-40.9	99.9	78604	12.8	±1.0	+0.32
3/453.3	2.27	13.3	121.5	No Data (Red. RCS)	-36.7	98.5	63159	11.7	±1.0	+0.30
4/630.3	2.70	26.0	157.0	2/3.40 3/3.53	-40.0	58.6*	51852	11.2	±1.0	-0.28

*See discussion in paragraph 2.1.4.

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Table 2-5

YAW MANEUVER PERFORMANCE

	Yaw Angle (Actual not Observed	Valve/ Thrust	Maneuvering Time to Spec Rate		Yaw Coast Rate		
	Desired +1.0 deg	(lb_f)	Spec Rate/ Time (deg/sec/sec)	Actual Time (sec)	Command Rate (deg/sec)	Coast Rate Expected (deg/sec)	Actual Coast Rate (deg/sec)
Yaw Reverse Rev 208.3	-180	1 / 4.20 4 / 4.55 5 / 4.65 8 / 4.40	0.15/600	265	-0.705	-0.705 ±0.05	-0.71
Yaw Forward Rev 209.1	+180	1 / 4.20 4 / 4.55 5 / 4.65 8 / 4.40	0.014/1100	402	-0.705	-0.705 ±0.05	-0.72

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Relative Time (sec)	Event
0	Start yaw maneuver
10	Achieve coast rate (0.7 deg/sec)
30	Failure Detector enabled
85	Thruster 8 full on
124	Isolation Valve closes

The nominal time for the Failure Detector to close the Isolation Valve from the initiation of a failure is 37 sec. In this instance, the failure detector took 39 sec. No data is available for the second failure detector operation as it occurred out of station contact and the tape recorder was off.

2.1.7 Tumble and Captures

2.1.7.1 Rev 466 Tumble. On Rev 466 the SV tumbled during a yaw maneuver prior to a negative OA burn. The tumble was initiated by failure detector action caused by a long pulse requirement placed upon the number eight roll/yaw thruster. The most probable cause for the long pulse requirement was the increased aerodynamic torque (~9 ft lb peak) during the 180 deg yaw maneuver coupled with a low thrust capability of thruster eight.

The subsequent capture sequence was initiated on Rev 469.3K. The vehicle rates at the time of initiation (ACS 1 Execute) were:

Pitch – 0.20 deg/sec
Roll – 0.26 deg/sec
Yaw – 0.24 deg/sec

The rates were brought within the coarse mode rate switching lines in 527 sec of ACS 1 Execute in the pitch and roll axes. The yaw rate was observed to be within the switching limits between 1052.6 sec and 3639.0 sec after capture initiation. The roll search was commanded 120.2 sec after the initiation of the capture sequence.

The earth was in the field of view of both H/S heads in less than 243 sec after the start of roll search. The H/S outputs came within the H/S TM range in the times shown in Table 2-6. The remainder of the capture was as documented in the normal capture sequence of events. The capture is complete 520 sec after start of the Sequence 264 portion of the capture (switch to fine mode). Sequence 264 was initiated at 3932.6 sec vehicle time.

2.1.7.2 Rev 611 Tumble. The most probable cause of the tumble on Rev 611 was the high pulse rate of thruster number eight. This duty cycle most likely resulted from the inability of thruster eight to counteract the normal aerodynamic torque environment.

The capture sequence proceeded much like that on Rev 466. Its characteristics are summarized below and in Table 2-7.

	Pitch	Roll	Yaw
Initial Rates	-0.03 deg/sec	0.03 deg/sec	-1.08 deg/sec
Time to Capture (Coarse mode rates)	0 sec	4 sec	16 sec
Start Search (Relative to capture initiate)	120.2 sec	120.2 sec	120.2 sec
H/S Earth Capture (Relative to start search)	0 sec	0 sec	-

Table 2-6
REV 469 H/S CAPTURE CHARACTERISTICS

TM H/S Range	Time From Roll Search Initiate to Within H/S TM Limits	
	Pitch	Roll
Coarse ±10 deg	< 243 sec	< 243 sec
Fine ± 1 deg	270 sec	915 sec

Table 2-7
REV 614 H/S CAPTURE CHARACTERISTICS

TM H/S Range	Time From Roll Search Initiate to Within H/S TM Limits	
	Pitch	Roll
Coarse ±10 deg	0 sec	0 sec
Fine ±1 deg	0 sec	0 sec

2.2 REACTION CONTROL SYSTEM

2.2.1 Flight Summary

History of the RCS performance is shown in Fig. 2-1 and tabulated in Table 2-8.

Satisfactory attitude and rate control were provided by the RCS at all times except when the Failure Detector Unit (FDU) turned the system off and the vehicle tumbled (Revs 466 to 469 and 611 to 614).

In Table 2-8, the initial propellant usage rate of 0.3 lb/rev for the Primary RCS (RCS 1) compared closely with the pre-flight prediction as did the initial rate (Revs 324 to 403) of 0.4 lb/rev for the Secondary RCS (RCS 2)

2.2.2 Propellant Consumption

The RCS propellant consumption for the mission was 1108 lb as indicated in Fig. 2-2. This consumption required transfer of 808 pounds from the OAS to the RCS. This large consumption rate of 2 to 17 lb per rev as compared to the normal rate of 0.3 to 0.4 lb per rev was attributed to REM valve leakage and opposing thruster activity. The normal rate did occur on both the Primary and Secondary RCS prior to the development of the leakage.

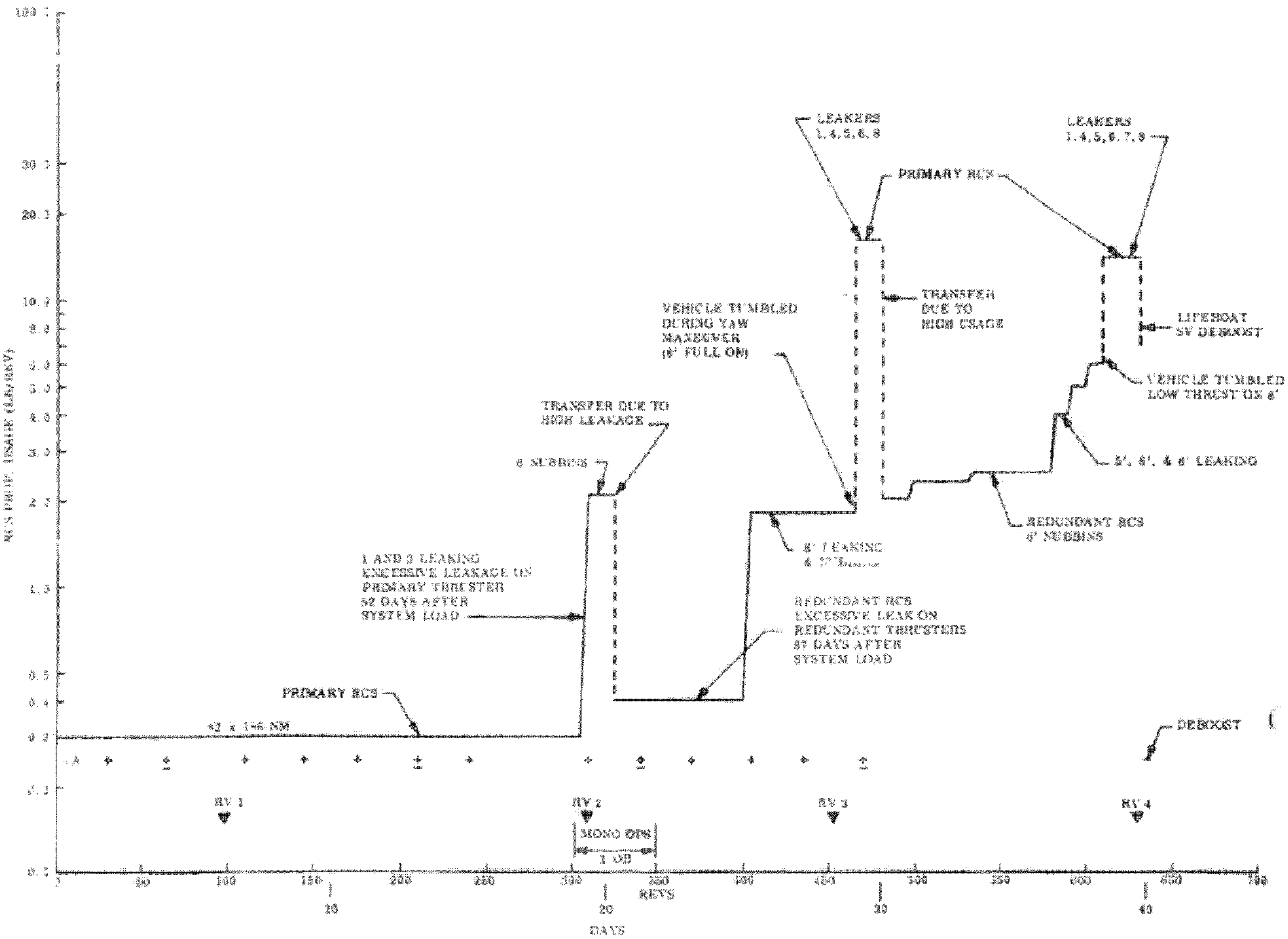

Fig. 2-1 RCS Usage Summary

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Table 2-8

FLIGHT SUMMARY OF REACTION CONTROL SYSTEM

Rev	Events	Average Propellant Usage (lb/rev)	Significant Events During Rev Interval						
			Yaw Maneuvers	OA Firings	RV Events	Pitch Maneuvers	Stereo Ops	Mono Ops	
								1 Bar	2 Bar
0-307		0.3	8	10	2	6	192		1
308	Thruster 1 Leaking								
311	Thruster 3 Leaking	2.1	Thruster 6 shows nubbins. Thrusters 3 and 6 over 1000°F						
324	RCS 1 to RCS 2		RCS 2 does not have temperature/pressure instrumentation						
↓		0.4	2	4				15	27
403			Excessive activity on Thruster 5 indicates Thruster 8 leaking						
↓		1.8	1	2	1	2			43
466	SV Tumbles		During yaw maneuver, failure detector unit shuts Isolation Valve 4, thus disabling RCS 2 after Thruster 8 steady state thrust for 30 sec.						
467	OA 17 Executed	0	SV tumbling so thrust not properly oriented – negative thrust only partially effective so perigee and period too large (see par. 3.1).						
469	RCS 2 to RCS 1		Tumbling capture sequence successful. All but Thruster 2 of RCS 1 remained over 1000°F at end of tumbling capture.						
↓		18							4
478	RCS 1 to RCS 2								
↓		2 5	2	2	1	2		1	22
611	SV Tumbles		FDU shut Isolation Valve 4. Prior data shows Thruster 8 further degraded.						
613	RCS 2 to RCS 1		Tumbling capture sequence successful						
↓		14			1	2			9
632	Lifeboat Capture and Deboost								

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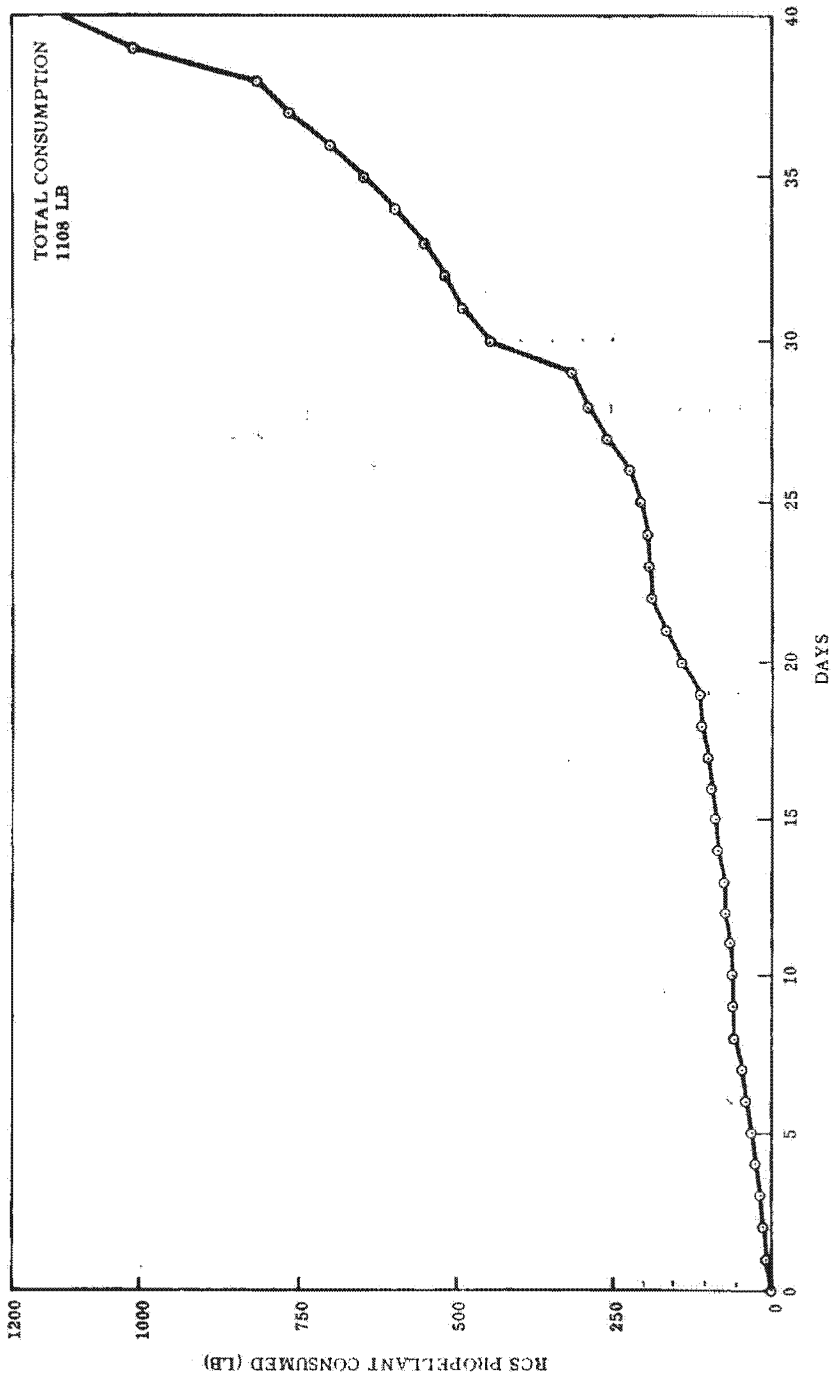

Fig. 2-2 RCS Propellant Consumption

High consumption was observed following high duty cycle activity (thruster chamber temperatures of greater than 1000°F, and thruster mount temperatures greater than 160°F as shown in Fig. 2-3). Early in the mission, when no valve leakage was present on any thruster, thrusters 3 and 7 chamber temperatures were higher than the other thruster temperatures, as shown in Fig. 2-3 for the first 165 revolutions. When valve leakage began, the temperature difference disappeared as indicated in Fig. 2-3. This relationship was noted in the post flight analysis for determining the onset of very large consumption.

The thruster mount temperatures are the only temperature indicators for the Secondary RCS. When these temperatures exceeded 160°F, excessive propellant consumption began on both the Primary RCS during Revs 309, 469 and 613 and the Secondary RCS during Revs 403 and 478.

2.2.3 Thruster Performance Degradations Resulting From Leaks

Thrust build-up delay was observed on the Primary RCS but it did not impact the mission. However, the same characteristic on the Secondary RCS resulted in vehicle tumble.

The thrust characteristics for the Primary RCS were determined from actual chamber pressure and temperature data. The thrust characteristics for the Secondary RCS were determined from the number of pulses and from the pulse width data derived from valve driver information.

Thrust build-up delay which was noted in steady-state firings, was preceded by impulse bit degradation which was observed during pulse mode duty cycles. These are illustrated in Fig. 2-4. The term "nubbins" has been introduced to indicate the "impulse bit degradation."

2.2.3.1 Primary RCS. Thrust build-up delay was observed to occur subsequent to large propellant consumption and high thruster temperatures as indicated on Fig. 2-3. Figure 2-5 illustrates "nubbins" first observed during Rev 322 on Thruster 6. Pulsing peak thrust was reduced to approximately 1 lb as compared to 2.7 lb for the

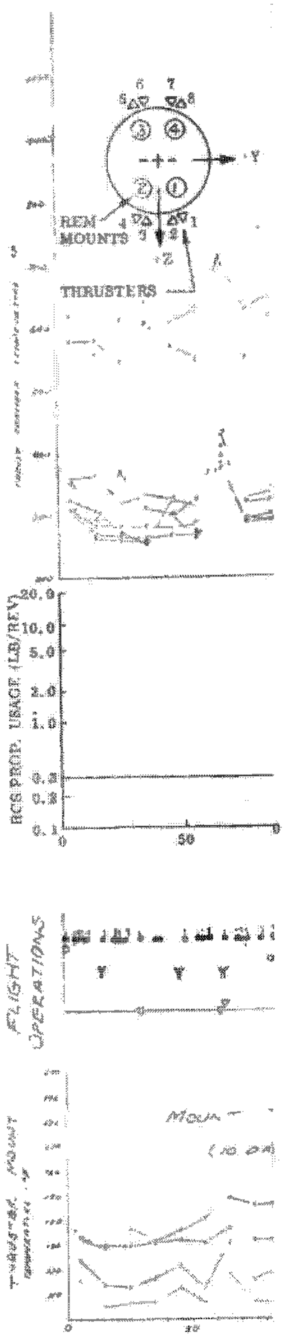

Fig. 2-3 History of RCS Performance

REV 630 THRUSTER NO. 6 – PRIMARY RCS

Pf = 143 PSIA

Tf 96°F

Tc 1100°F

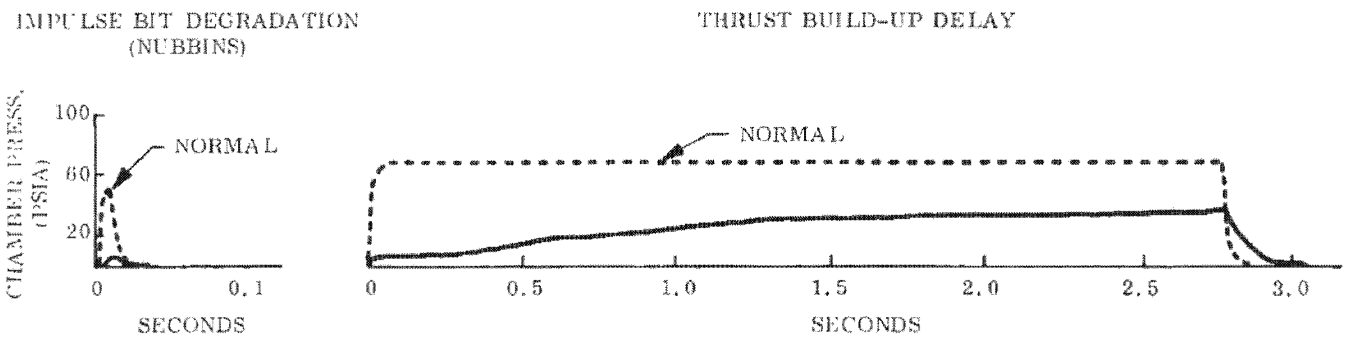

Fig. 2-4 Thrust Build-Up Delay/Impulse Bit Degradation (Nubbins)

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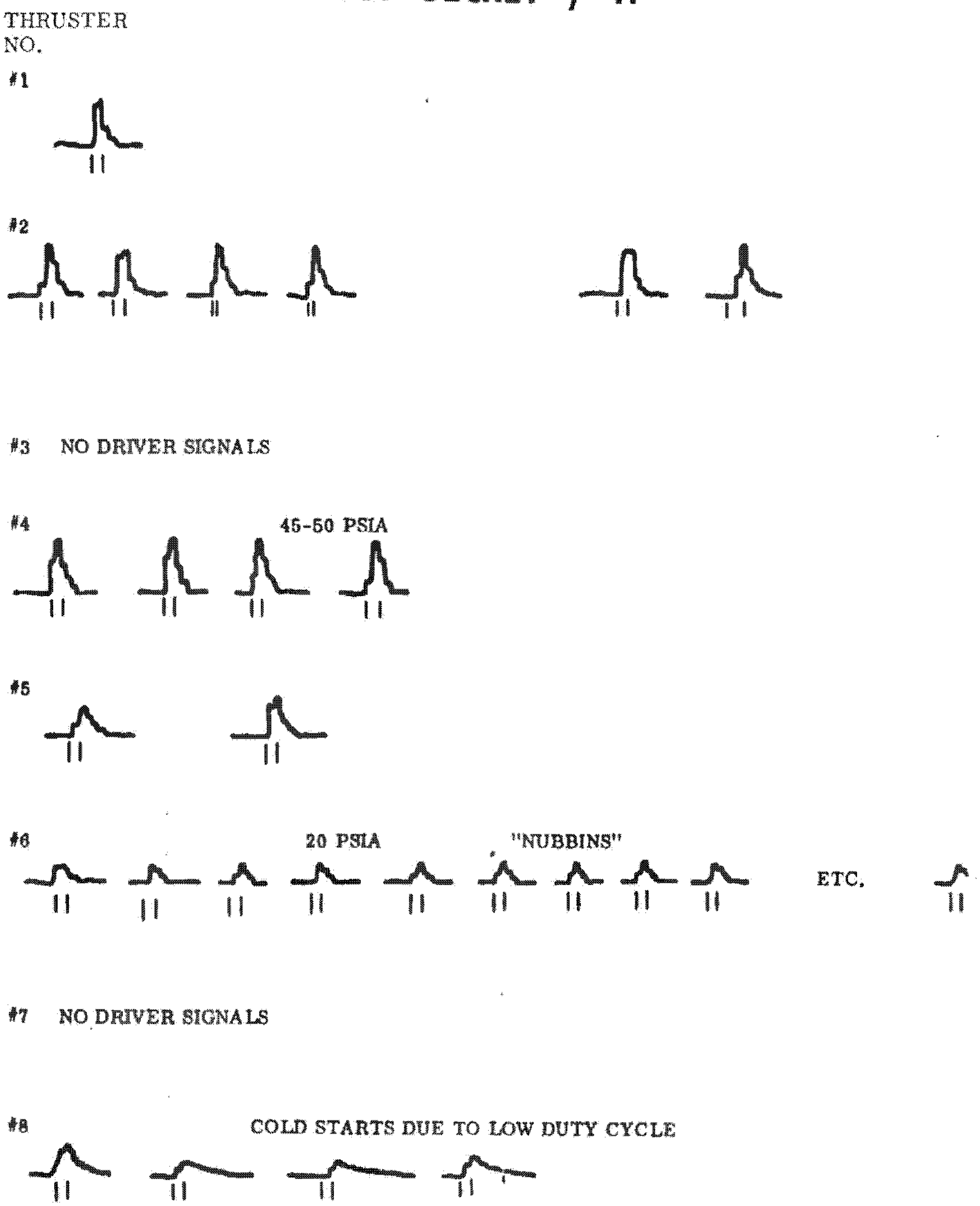


Fig. 2-5 Impulse Bit Degradation/Primary RCS (Rev 322)

other thrusters. The primary system was turned off at Rev 324. A test conducted on Rev 371 produced low leakage randomly on Thrusters 3, 8, 5 and 6 at the low temperature of 200°F instead of 1 and 3 which were leaking prior to Rev 324. RCS 1 was reactivated on Rev 469 to capture the vehicle from tumbling. The Thruster 6 thrust level had recovered to 3.2 lb as compared to 3.7 lb for the other thrusters. RCS 1 was turned off again at Rev 478, and control returned to RCS 2. RCS 1 was again reactivated on Rev 614 to again capture the vehicle from tumbling. Now the thrust had recovered to 2.2 lb compared to 2.8 lb for the others. The degradation of Thruster 6 on Rev 630 is shown in Fig. 2-4. It can be seen that in a pulsing mode, the nubbins produce very little thrust but when steady state operation is required the thrust builds up. RCS 1 on this rev controlled a pitch-down and post RV release sequence satisfactorily.

2.2.3.2 Secondary RCS. RCS 2 was first activated on Rev 324. Thruster 8 was detected as leaking on Rev 403. On Rev 435 during an OA, the thrust of 8 was noticeably degraded. On Rev 466, when the vehicle was yawed for the negative OA, the thrust of 8 had degraded enough to activate the FDU. It was calculated to have dropped to less than 0.2 lb.

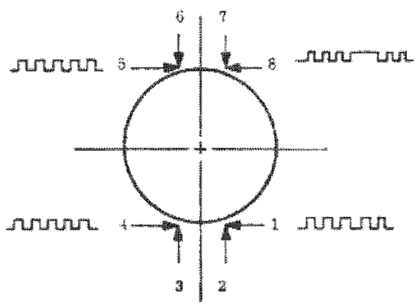
On Rev 478, RCS 2 was again used and worked essentially as well as it did on Rev 435. By avoiding maneuvers, the vehicle used RCS 2 from Rev 478 to 611. Typical performance during payload operation is shown in Fig. 2-6. It can be observed that Thruster 8 departed from a pulsing mode to a steady state type of operation suggesting that nubbins were encountered to the extent that not enough thrust was produced and an increase in duty cycle approaching steady state firing was required. The system further deteriorated in this interval and by Rev 611 could no longer control the vehicle even in the quiescent state; consequently, tumbling occurred.

2.2.4 Corrective Action

Action is underway with the following objectives:

- Determine and eliminate the cause(s) of leaks.
- Make the valves less susceptible to leak producing agents.
- Recommend mission parameters to reduce leak effects until problem solved.
- Assure thruster degradation is a result of leaking.

+OB (START)		REV
NO. 4	NO. 5	↓
17 PULSES 15 17	16 PULSES 16 16	491
17 21 20	16 15 15	500
16 32 18 20 19 18 19	17 34 18 17 18 16 18	507
19 20 24	13 18 23	539
17 25 19	13 22 18	540



-OB (STOP)	
NO. 1	NO. 8
15 PULSES 13 13	32 (3 SEC SS) 63 38
12 NA 10	68 NA 65 (4.5 SEC SS)
17 NA NA NA NA NA 11	35 NA NA NA NA NA 32 (0.6 SEC SS)
16 14 13	14 (0.5 SEC SS)* 64 53
9 - 13	30 (1.4 SEC SS)* - 38 (.7 & .6 SEC SS)

*THRUST IMBALANCE BETWEEN NOS. 1 AND 8 PRODUCE ROLL TO BRING ON NOS. 2 AND 6.

Fig. 2-6 RCS No. 2 Thruster Activity During Payload Operations

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Section 3
ORBIT ADJUST

3.1 ORBIT CONTROL

The Orbit Adjust System was utilized seventeen times during the mission for drag makeup, perigee location control and ground trace control. The OA firings were all normal and the engine performance was well within specifications. A single instance of incorrect quad valve position indication occurred on OA 13. This did not occur again and was attributed to a microswitch malfunction.

Attention is directed to OA 17. On this firing the RCS system was inoperative since the Failure Detector Unit had closed Isolation Valve 4 at 466 POGO and OA 17 occurred before reaching the next station pass. The loss in the velocity increment was due to the tumbling of the vehicle, not due to a malfunction of the OA. The +5.25 percent error in the positive OA 16 burn is slightly larger than the specified 5 percent; however, this value is based on the one rev Best Fit Ephemeris to the transfer orbit which is subject to error. The pairs of positive and negative burns (which are * in the table) are all subject to this error.

3.2 DEBOOST

The final firing of the OA engine was for the Lifeboat II deboost on Rev 632. The firing duration was 420 sec to achieve a planned negative velocity increment of 200 ft/sec (see par. 6.2 for additional comments). SV impact point (planned) was 35°N latitude, 169°E longitude.

Table 3-1
OAS PERFORMANCE

OA Firing NO.	Rev Number	Impulse Delivered (lb/sec)	Planned ΔV (ft/sec)	Achieved ΔV (ft/sec)	Percent Error in ΔV
1	30	+7775.0	+12.84	+13.35	+3.97
2	62	+24154.0	+39.10	+39.79	+1.75*
3	64	-14606.0	-23.57	-23.83	+1.10*
4	110	+17121.0	+30.17	+30.44	+0.90
5	143	+4886.0	+8.64	+8.73	+1.04
6	175	+10144.0	+17.91	+18.14	+1.28
7	207	+27640.0	+49.49	+49.59	+0.20*
8	209	-19870.0	-35.86	-35.89	+0.08*
9	239	+11184.0	+20.22	+20.31	+0.45
10	309	+5498.0	+10.98	+10.98	0
11	336	+33185.0	+65.96	+66.56	+0.91*
12	338	-11238.0	-22.25	-22.74	+2.20*
13	369	+5161.0	+10.53	+10.46	-0.66
14	402	+11452.0	+23.28	+23.33	+0.21
15	434	+9085.0	+18.43	+18.64	+1.14
16	465	+23173.0	+49.40	+51.99	+5.25*
17	467	-11228.0	-25.36	-11.11	-56.30*

Section 4

TRACKING, TELEMETRY AND COMMAND

4.1 TRACKING

4.1.1 Accuracy

An evaluation of tracking accuracy is being prepared by the FTFD and will be available through that office.

4.1.2 Ranging Anomaly

Some ranging signal dropout was experienced at remote sites other than COOK. An evaluation and subsequent report is currently in work by the responsible agency (PHILCO).

4.2 TELEMETRY

4.2.1 General Performance

Telemetry system performance was satisfactory throughout the flight. One specific exception to this is noted following the equipment usage summary.

4.2.1.1 Usage Summary Through Revolution 632.

	Side 1	Side 2
SGLS		
• Number of Station Contacts	775	2
• Operational Time (min)	4392	6
PCM		
• Total Operational Time (min)	12181	9
• Operational time by format (min)		
A = Ascent	10	
B = Orbit – Engineering	220	
C = Orbit – Record	7363	
D = Orbit – Operational	4597	

Tape Recorder	No. 1	No. 2
• Number of Record Operations	3939	117
• Number of Readout Operations	429	14
• Operational Time (min)	7149	214

4.2.2 Tape Recorder Anomaly

During payload operations on Rev 32, Tape Recorder 1 did not respond to a tape recorder OFF command that immediately followed a tape recorder ON command by 0.2 sec. Tape Recorder 2 exhibited the same lack of response on Rev 614. Subsequent evaluation revealed the recorder design prohibits recorder response to such close time ordered ON-OFF commanding. Consequently, flight software was modified to include flags designed to enhance detection of such commanding during the remainder of the flight. New hardware/software constraints were instituted to insure flag generation for all command messages in the event such anomalous commanding were to occur.

4.2.3 Down Link Signal Strength Fluctuations

All remote tracking stations experienced signal strength fluctuations during the flight. These were identified and plotted, and were found to range from minor fluctuations (5 dB) to complete dropouts. Dropout predictions were made by the SBAC flight support team (FST) and were provided to test control to insure acceptable signal strength levels for command loading and tape recorder playback. The methods for predicting dropouts resulted in excellent station pass planning with essentially no data loss. In addition, some experimentation with different station antenna polarizations (vertical; right hand circular) was conducted by those stations possessing that capability. The objective was to provide data for establishing values of possible gain differences between such polarizations. Data resulting from these experiments is being evaluated to determine if any gain can be attributed to polarization of the station antennas.

4.2.4 Instrumentation

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

ID No.	Description	Status
A013	REM Deflector Shield Temp 1	Erratic
A014	REM Deflector Shield Temp 2	Erratic
A015	REM Skin Temp 1	Open
A621	Bay 4 Int Skin Temp 3	Open
B001	Pri REA 1 Chamber Pressure	Erratic
P231	SU Shaft Side A Temperature	Failed

4.2.5 Ascent Telemetry

The Ascent FM/FM telemetry system performed satisfactorily during the entire ten minute ascent phase of flight. Recovery of data was deemed acceptable including the Mid Section FM data processing through the 1.7 MHz FM VCO of SGLS.

4.3 COMMAND

4.3.1 Uplink Operation

The vehicle SGLS command equipment was utilized to receive 292 messages with no anomalies being experienced. In loading a message at Rev 378 COOK, a reject was experienced by the ECS. Results from a special study indicate the probable cause of this reject was a bit change in the uplink data.

4.3.2 GFE Command System

4.3.2.1 Extended Command System. The ECS responded satisfactorily in all command modes resulting in the loading of 85,220 SPC's in memory; of these 85,220 SPC's loaded, 55,666 were output by both PMU's for decoder processing. The remainder were erased prior to their time label matches.

4.3.2.1.1 ECS Clock Operation. The accuracy of the clock throughout flight has been determined to be 0.214 parts in 10^6. The clock oscillator frequency changed 0.077 Hz in 38 days. This resulted in a stability of 0.75 parts in 10^7 over a 38 day period which is well within system specification.

4.3.2.1.2 Special Study. Early in flight, a six millisecond difference was observed between vehicle time history in TLM Format D and the corresponding microwave data from COOK. Subsequent investigation revealed the six millisecond bias was caused by a bad bit in the RTS prepass disks. A new prepass disk sent to the stations corrected the problem re-establishing zero bias.

4.3.2.2 Minimal Command Subsystem. The MCS responded correctly to all commanding. It was placed in the operate mode on Rev 18 for a health check and successfully processed 20 commands.

4.3.2.2.1 MCS Clock. The limited duration of the MCS did not permit clock accuracy or stability calculations to be performed.

4.3.2.3 Remote Decoder/Backup Decoder. Both sides of the Remote Decoder were utilized for each of the four recoveries. Performance of both sides was determined to be acceptable through analysis of telemetry data. Only one command was processed by the MCS backup decoder during the entire flight, that one executing during the Rev 18 MCS health check.

4.3.2.4 Command System Usage Summary Through Rev 632.

System	Total Operating Time (hours)
ECS	940.0
MCS	3.0
Remote Decoder	4.0
Backup Decoder	0.3

4.3.3 375 MHz Receiver

The 375 MHz Receiver was powered during the entire mission. Twenty commands were sent to the receiver during the Rev 18 MCS health check. All were processed satisfactorily by the receiver resulting in no anomalies.

4.3.4 Data Interface Unit

The data interface unit performed satisfactorily throughout the flight. The operation counter accurately processed 12,994 counts on Side A, and 7,190 counts on Side B.

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 from the initial output was too slight to be calculated and can be considered as 0 percent.

5.2 MAIN BUS VOLTAGE

The Main Bus voltage varied from a low of 26.7v to a high of 31.7v. The allowable range was 25.5v to 33v. Low voltage data was obtained during dark VAFB engineering passes with bus loads of 50 ±5 amps. High voltage data was gathered during the charge cycles.

5.3 POWER CAPABILITY AND USAGE

Power usage ranged from 210 to 328 amp-hours/day. This is well below the 424 amp-hours/day capability. Excess capability was demonstrated by K2 charge relay cutoffs occurring on Rev 3 and on essentially every rev thereafter except those with heavy payload operations.

5.4 TYPE 29 BATTERY PERFORMANCE

All batteries operated in a desirable environment (44 to 51°F) and performed normally throughout the mission.

5.5 PYRO BATTERY PERFORMANCE

Pyro Battery 1 stabilized at 51°F thus minimizing self discharge to ~10 percent. of launch capacity. Thirty-nine (39) days after launch, the battery left the peroxide operating region which indicated that a computed 3 amp-hours had been removed, leaving 10 amp-hours for continued use. Cell degradation life still available was 82 days. Pyro Battery 2 followed the same pattern with the exception of still being slightly in the peroxide region at the termination of flight.

5.6 LIFEBOAT BATTERY PERFORMANCE

The Lifeboat battery operated normally in a 52°F environment throughout the mission. 175 amp-hour remained at the end of the mission from an initial capacity of 340 amp-hours. Remaining cell degradation life was 82 days.

Section 6
LIFEBOAT II

6.1 HEALTH CHECKS

Lifeboat data was examined and is summarized in Table 6-1. The Q magnetometer sensor indicated a telemetry bias of 3.5 to 4.5 milligauss. After correcting for this bias, the Q magnetometer sensor equivalent attitude error was in error from the theoretical by 1.7 to 2.4 deg. The magnitude of this error is within expected values and would not create an out-of-specification attitude if under Lifeboat II control. The X and Z axes gyros could not be evaluated because of the small rates about these axes.

6.2 USAGE

The SV was successfully deboosted on Rev 632. Real-time POGO data verified the burn and the initiation of vehicle tumble; however, no Lifeboat II performance data was obtained since the deboost burn did not occur over a station.

Table 6-1

LIFEBOAT II OPERATION

Rev	Mode	Q Magnet. (milligauss)		R Magnet. (milligauss)		P Magnet. (milligauss)		Y Axis Gyro (deg/sec)	
		Observed	Theoretical	Observed	Theoretical	Observed	Theoretical	Observed	Theoretical
17.3	S-N, DB	-44	-33.8	Positive Saturated	Positive Saturated	Not in Use	–	-0.5	-0.068
	N-S, RV	-46	-36.9	Not in Use	–	Negative Saturated	Negative Saturated	-0.08	-0.068
98.3	N-S, RV	-41	-33.0	Not in Use	–	174	175	-0.06	-0.068
	N-S, DB	-32	-33.5	Positive Saturated	Positive Saturated	Not in Use	–	-0.06	-0.068
453.3	N-S, RV	-35	–	Not in Use	–	186	–	-0.05	-0.068
	N-S, DB	-23	–	Positive Saturated	–	Not in Use	–	-0.08	-0.068
631.3	N-S, RV	-23	–	Not in Use	–	Negative Saturated	Negative Saturated	-0.05	-0.068
	S-N, DB	-15	–	Positive Saturated	–	Not in Use	–	-0.05	-0.068

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Section 7
SENSOR SYSTEM

7.1 COARSE FILM PATH

Both coarse film paths exhibited proper operation during the mission when commanded with supply, loopers, steerers, and take-ups functioning normally with the following exceptions.

- Rev 15 — Take-up 1A Brake Anomaly. The Brake Verify signal indicated a malfunction during the Rev 16 MOP. Playback data from the Rev 15 MOP revealed the TU-1A Brake failed to engage at FT Stop. The brake anomaly was eliminated on Rev 22 by switching from SCC II to SCC I. The brake anomaly appears to be a failure of the brake releasing circuitry. A special test was run at the end of the mission on Rev 628 where the system was operated in SCC II. Take-up 4 brakes worked satisfactorily.
- Rev 144 ESD. Rev 145 POGO TLM noted that an ESD condition was present on the B Side. A constant velocity sequence had successfully executed prior to the ESD. After FT Start, the B Side experienced an ESD due to high tension. After the ESD, the tension decreased. A creep was run on Rev 149 and 150 and a constant velocity sequence on Rev 153 on the B Side, all satisfactorily. The B Side path was then returned to operational status.

7.2 FINE FILM PATH

The fine film path on the forward camera functioned properly throughout the mission. The fine film path for the aft camera functioned properly until ESD on Rev 272. On Rev 272 a catastrophic failure of the film path prevented further photo operation with the aft camera (B Side).

The ESD occurred at completion of the last planned operation prior to the recovery of RV 2. the ESD was caused by either low tension or the looper at supply end of travel.

Since TU 2 was full it was decided to transfer to TU 3 to isolate TU 2 as the cause of the shutdown. A special sequence was generated to transfer to TU 3 independently of the double wrap sequence.

After the transfer to TU 3 was completed, three "B" Side mini-creeps were run. The data did not indicate any increase in tension. The microwave data from COOK was analyzed with the following conclusions:

- Since the TU 3 signals responded like a normal double wrap, material was being pulled out of TU 2.
- Since TU 3 was pulling against the brakes on TU 2 it did not appear that the take-up could gain on the amount the supply was delivering.
- The Steerer Sensors indicated 126 counts with no variation during transports from the response one would expect with no film movement through the steerers.
- The input and output drive diagnostics indicate the capstans were free wheeling, i.e., not transporting material.

Based upon the conclusions derived from the COOK data it was felt that the creeps were not accomplishing anything working against the brakes on TU 2. It was determined that 6 of the mini-creeps were sufficient to perform a double wrap (15 feet) on the B Side. Three additional mini-creeps were run.

Plans were developed to perform a Prep 1 on the A Side. The trim and seal (Prep 2) was completed to accomplish the constant velocity on the A Side. At this time, RV 2 was ready for recovery.

Additional creeps were also executed after the trim and seal in a further attempt at restoring the B Side film path. The data reinforced the belief that the B Side film path had separated. One more creep was run and then all hope of restoring the B Side path was abandoned.

At this time it was decided to convert the Sensor System to Mono A operations. The remainder of the mission was completed in Mono A. It was also verified that the creeps run after the trim and seal were sufficient to insure the separated tail of the B-Side film path was in TU-3.

7.3 COMMAND AND CONTROL

Sensor system performance with respect to the Command and Control Subsystem was nominal throughout the mission with two exceptions as noted below.

- Take-up 1A Brake Anomaly. SCC II was in use from lift-off through Rev 22 because of the Vs problem associated with the logic design error in the Extended Command System. SCC I was selected at Rev 22 because of a take-up brake "A" non-actuation which was isolated to a SCC II problem associated with TU-1 only. SCC II was selected and a CV test was run to further analyze the TU brake problem. (See Section 7.1 for a disussion of the take-up brake "A" problem.) SCC I usage required the software to be modified to set a malfunction flag in the command message whenever an illegal Vs (due to ECS design error) was selected. Upon recognition of such a flag, the message would be manually altered.

  No illegal Vs commands were commanded during the mission, so the above course of action was never required.

- Nested Operations Anomaly. On Rev 38, planned operation 33 did not functionally execute because the optical bars shut down at transport (FT) stop of the first operation of a nested pair. This same phenomena occurred on Rev 39, Planned Operation 36. The operations that failed to functionally execute were commanded through SCC I. After the nested operation that failed, several nested operations were commanded without repeating the failure. Since the problem did not reoccur in SCC I, no attempt was made to transfer to SCC II to try and circumvent the problem. Selection of nested operation was discretely controlled by inputs to target selection software to minimize loss of high priority operations during the mission.

The most likely cause of the premature OB shutdown is due to electrical noise generated by the seal door closing and the supply brake energizing at FT Stop being interpreted by the SCC as an "ESD" or "TU TOO FULL" signals. SV-3 experienced a similar type of failure during test. The problem has been corrected by adding suppression diodes across the seal door close and supply brake on relay lines into the SCC. Effectivity is SV-3 and up.

7.4 OPTICAL BAR PERFORMANCE

The optical bars ran slightly fast on orbit, as they did during ground test. However, since this deviation was known and approved during ground testing, the effects on the system were compensated for during chamber tests by "F" and "P" knob adjustments.

On Rev 192, Operation 139, insufficient time was allowed for the optical bars to stow. As a result, the bars were out of phase for the remaining operations in the message load (Op 140, 4 frames, and Op 141, 9 frames). The bars were stowed on Rev 198 before executing any additional operations. On Op 245, Rev 393, the OB's did not stow. Stow sequences were executed on Rev 402. Ten operations were executed prior to stowing.

A modification was made to the software to assure that adequate time was provided for OB stow before camera power was turned off.

7.5 INSTRUMENTATION

P231 (supply motor housing temperature adjacent to Encoder "A") was found to be inoperative during ground testing. P969 and P970 (builder roller down verify "A" and "B") were disconnected during ground tests. The sensor system was acceptable for flight with these deficiencies. All other instrumentation performed properly throughout the flight.

7.6 PNEUMATICS

Prior to the first station contact a sequence was performed to activate the pneumatics system. At the first tracking station contact it was noted that the A Side tank pressure and temperature was decreasing indicating a leak in the system. The path pressure was observed to be at 0.97 psia indicating the low pressure shut off valve had failed open.

A command sequence was initiated to close the "A" high pressure isolation valve on Rev 2. When the high pressure isolation valve was closed the nitrogen supply had depleted from 34.1 lb to 30.3 lb. Failure of the low pressure valve to close was durther verified during camera operation by observing the increased pressure on the "A" regulator instrumentation monitor. The command to close the low pressure valve was verified to be executing at the command decoder.

Limitation in the instrumentation does not permit isolation of the malfunction to a single point between the command inputs to the PDS and the low pressure shut off valve. The most probable cause of the open shut off valve was a failure of the latching relay in the PDS. Models P-9 and subsequent will have redundant latching relays in the PDS to prevent these types of failures.

The pneumatics system exhibited the capability to perform satisfactorily from one tank periodically balanced with the opposite tank.

Section 8
RE-ENTRY VEHICLES

8.1 SUMMARY

The recovery statistics are shown in Table 8-1 and Fig. 8-1. Performance of the RV Subsystem is summarized in Table 8-2. Data indicate that all RV events (on-orbit, re-entry and recovery) occurred as planned and the RV flights followed the predicted trajectories.

On RV 1 a puncture in the Recovery Capsule (RC) bulkhead resulted in minor exposure of the payload. RV 4 also had a small puncture in the bulkhead but protective wraps on the payload stack prevented exposure of the payload. Fracture of core pins at aerial retrieval of RV's 1 and 4 resulted in disheveled payload stacks. Operation of the payload sensor system on Side A only resulted in unbalanced payloads on RV's 3 and 4. The preflight constraint of "60 percent unbalanced payload on the first significantly unbalanced flight" was imposed on RV 3. Satisfactory performance of RV 3 resulted in removal of this constraint on RV 4 which performed satisfactorily with an unbalance exceeding 90 percent.

All subsystems performed satisfactorily except that the high frequency transmitter output on RV 1 was intermittent. This malfunction had no effect on the RV flight and all TM data was obtained.

8.2 RE-ENTRY 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.

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Table 8-1

RV RECOVERY SUMMARY

	Flight 1	Flight 2	Flight 3	Flight 4
RV Serial No.	12	11	10	9
Recovery Rev No.	98	308	453	630
Recovery Date (1972)	26 January	8 February	17 February	28 February
Payload Weight, (lb) (A;B)	A = 219.0 B = 221.5	A = 216.2 B = 220.3	A = 142.2 B = 0.6	A = 208.7 B = 0.0
Unbalance Percent	0.9	0.5	66.4	92.3
SV Orbit (h_p x h_a/ωp)*	83.3 x 184.9/131.3	84.0 x 179.2/118.6	85.3 x 190.3/121.6	87.0 x 151.2/97.4
SV Pitch Angle (deg)	-40.3	-36.5	-37.5	-40.7
Nominal PIP Latitude	18.0 N	26.5 N	25.0 N	18.5 N
Impact Location Error (BFE vs. Test Report TWX)				
Overshoot (nm)	16.5	19.8	9.6	13.6
Crosstrack (nm)	3.1E	5.6E	6.6E	15.3E
Recovery (Aerial)				
Altitude (ft)	12,000	9,300	13,500	10,500
Parachute Condition	Minor Damage	No Damage	No Damage	No Damage
Retrieval Pass	1	2	1	2
RC/Payload Condition	Minor Exposure of Payload; Hole in RC Bulkhead	Good	Good	Payload Good, but Small Hole in RC Bulkhead

*h_p = Altitude of Perigee (nm), h_a = Altitude of Apogee (nm), ωp = Arg of Perigee (deg)

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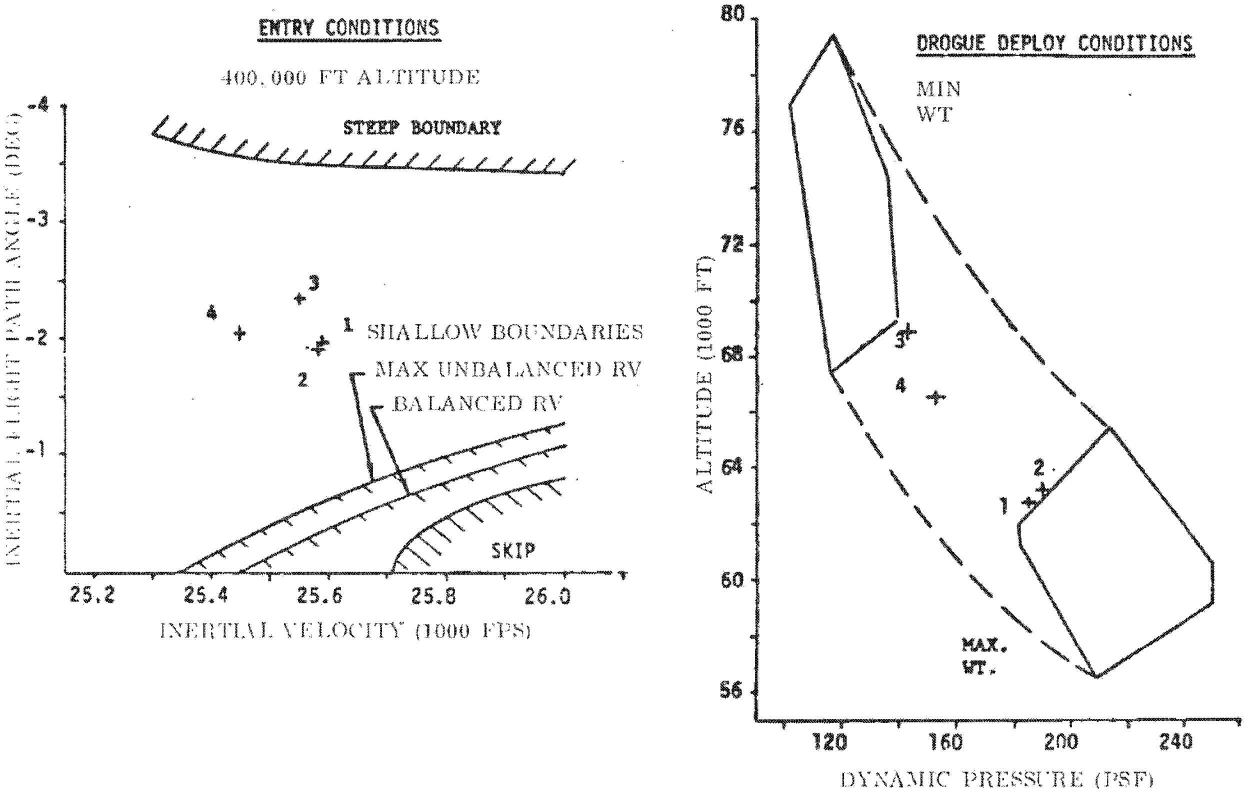

Fig. 8-1 SV-2 Re-entry Parameter Comparisons

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Table 8-2

RV SUBSYSTEM PERFORMANCE SUMMARY

RV Subsystem/Function	Performance Assessment
On-Orbit Thermal Protection	Normal • T_{PL} Container = $T_{ref}{}^{+0^{o}F}_{-6.6^{o}F}$ • Power Usage (Watts/RV) Maximum = 17.1 (First Day in Orbit) Stabilized = 9.0 Allowable = 20.0
Trim and Seal	Normal
Electrical Power & Distribution	Normal • All Batteries Activated • All Voltages > 25.5 Volts
Sequential Subsystem	Normal • Primary and redundant systems in each RV were verified to have functioned properly by telemetered data and factory test.
Pyro Subsystems	Normal • All primary and redundant pyrotechnics in each RV were verified by factory inspection to have functioned properly, although a short section of HS pyro line had prematurely burned due to gap in base thermal protection on Flight 1.
Spin Stabilization	Normal
Retro Motor	Normal
Tracking, Telemetry, Instrumentation	• Intermittent operation of high freq transmitter on Flight 1 — All TM data was obtained.
Heat Shield	Adequate Thermal Protection of Payload • Recovered HS shows excessive recession at random points. • Recovered HS's show separation of base ring ablator at bondline at localized points
Base Thermal Protection	Adequate Thermal Protection of Payload • Hot boundary layer gas leakage under pyro covers causing overheating of HS pyro lines and local bondline separation of HS base ring ablator.
Structure	• Parachute swivel punctured RC bulkhead— induced by parachute extraction dynamics
Recovery System	Drogue Performance Normal Main Parachute Performance Normal on Flights 2, 3 and 4. • Minor damage on Flight 1

Stability margins during the retrograde and exoatmospheric coast phase were high for each flight. Onboard data show body transverse rates less than 5 deg/sec for the unbalanced payload conditions. These rates are well within the predicted values. The spin and residual spin rates were also as predicted during this phase.

Figure 8-1 shows the entry conditions to be well within previously established entry boundaries. The residual roll rate was nearly constant during the exoatmospheric coast phase, decreased during the early period of the entry phase and after 120 sec reversed. This reversal has been typical for all four RV's of this mission and for all four RV's of SV-1. The roll reversal had no significant effect on the capability of the RV's to enter successfully. Angle of attack was low throughout the significant heating portion of all four entries due to roll reversal and associated phenomena. The small range dispersions indicate the predicted entry trajectory was followed. Roll reversal and the unbalanced payloads resulted in the development of lunar mode* flight characteristics approximately 175 sec after atmospheric entry of RV 3 and 4. Lunar mode prevailed at the time of maximum heating and maximum dynamic pressure for these flights.

Figure 8-1 also shows conditions at time of drogue chute deployment. Data indicates drogue performance was as predicted.

The main parachutes have had extensive modifications since SV-1. No significant damage occurred on RV's 2, 3 and 4 and only minor damage that did not impair performance occurred on RV 1. The parachute on RV 2 was reported unstable requiring a second pass for retrieval. On RV 4 the target cone was reported to by lying on the canopy during the first pass; the cone was erect and retrieval was made on the second pass.

*Lunar mode flight denotes RV entry where one point of the heat shield assumes the most forward position and the RV rotates or oscillates about this point.

8.3 RE-ENTRY VEHICLE SUBSYSTEM PERFORMANCE

Review of the Re-entry Vehicle subsystems indicates the following six anomalous conditions which exceed MWC design and performance criteria:

- Small puncture in RC pressure bulkhead caused by parachute swivel.
- Damage to the main parachute.
- Intermittent operation of the high frequency transmitter.
- Uneven ablator erosion of the heat shield.
- Hot Boundary Layer gas leakage under pyro thermal covers.
- Roll reversal during the early period of atmospheric entry.

Only the puncture in the RC bulkhead compromised mission success. MWC has initiated analysis and test effort to resolve causes for these anomalous conditions and to determine needed changes. Current status of this effort is as follows:

- Increasing thickness of the bulkhead in the region of the main parachute swivel in its packed position.
- Continuing test and evaluation of newly designed main parachute for future flights.
- Investigating vendor technique of assembling the isolator section of the high frequency transmitter.
- Increasing heat shield ablator thickness for all future flights.
- Shielding pyro line and improving seal of pyro thermal cover.
- Continuing effort to determine cause of roll reversal.

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

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Section 10

SUBSATELLITE

10.1 SUBSATELLITE PERFORMANCE SUMMARY

A 435 lb Subsatellite System integrated on the -Y side of the SV Forward Section pylon was transported into orbit. The prelaunch pad load contained a contingency pre-programmed command sequence for the Subsatellite erection and separation to be used in the event that the nominal Rev 14 sequence could not be performed.

The prelaunch pad load provided for separation to occur at 30 deg south descending over Rev 7.6. The nominal plan to erase the prelaunch pad load on Rev 5 BOSS was accomplished.

A SV command load containing the Subsatellite erection and separation sequence was accomplished on Rev 12 GUAM, with the actual erection and separation times based on the latest tracking data available prior to generation of the new command load.

Separation occurred on Rev 14.6 descending at 24.0 deg south, with erection occurring 450 sec prior to separation. A 14.0 deg yaw left maneuver by the Satellite Vehicle was in effect at the time of separation (see Section 2.1.2).

From lift-off through Rev 14, the Satellite Vehicle telemetry was monitored to determine the Subsatellite status prior to and during erection and separation.

After separation had occurred, one final status check from the Satellite Vehicle telemetry, along with the playback of the tape recorder separation sequence, completed the real-time support. The final orbit achieved by the Subsatellite was nominal.

10.2 SUBSATELLITE TEMPERATURE ANOMALY

Prior to separation from the Satellite Vehicle the Subsatellite battery temperature was monitored and analyzed. The initial battery temperature rate of increase of approximately $4^{\circ}F$ per rev was faster than anticipated from pre-flight predictions, and the maximum measured level of $91^{\circ}F$ was higher than the maximum 70 to $75^{\circ}F$ estimated for an initial beta angle of +24 deg. The Subsatellite component temperature cool-down rate, immediately after separation, agreed very well with pre-flight transient predictions. The Subsatellite orbiting battery temperature data of $51^{\circ}F$ to $62^{\circ}F$ correlates well with the pre-flight prediction of $55^{\circ}F$ for an orbit average temperature.

The most significant contributions to the higher than expected temperatures were as follows:

- A linear interpolation of computer-calculated temperatures for beta angles of 0 and 60 deg.
- The presence of some free molecular heating which was not included in computer model.
- Conduction of energy from the erector/ejector assembly.
- A slightly warmer thermal control surface on the Subsatellite as compared to the computer model approximation.

Section 11
STELLAR-TERRAIN SUBSYSTEM

There was no Stellar-Terrain Subsystem flown on SV-2.

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 Forward and Mid Section thermal designs provide good control of payload temperature levels. No design changes are forth coming as a result of flight performance.

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 the average Mid Section film path temperature varied between 72°F and 80°F during the mission but was usually above 78°F.

The RV heater zones which are actively controlled relative to T_{REF} were generally within 1°F of T_{REF} indicating adequate performance of the Active Thermal Control System.

12.3 AFT SECTION

Acceptable Aft Section temperature control was achieved with all equipment within design temperature limits. The orbital beta angle for this vehicle ranged from 29.9 deg at launch to 27.5 deg at deboost. A summary of critical temperatures is shown in Table 12-2.

The temperature level of the Aft Section was 10 to 15°F above nominal predictions due to an external vehicle contamination problem which occurred during launch. This is considered to be the same contamination problem as occurred on SV-1. The contamination event was identified as SRM staging from the special contamination experiments (see paragraph 12.4).

Table 12-1

FORWARD AND MID SECTION TEMPERATURES FOLLOWING INITIAL TRANSIENT

Parameter	Design Limits (°F)	SV-2 Actuals
T_{FWD}	47/93	83/86
$\overline{T}_{TCA}$	49/91	78/80
$\lvert T_{FWD} - \overline{T}_{TCA}\rvert$	<20	3/6
$\overline{T}_{SU}$	47/93	80/82
$\overline{T}_{SU} - \overline{T}_{TCA}$	6/-4	2

Definitions:

T_{FWD} — Average radiation temperature of the Forward Section derived from the average bulkhead temperature

$\overline{T}_{TCA}$ — Average radiation temperature of the forward compartment structure in the Mid Section

$\overline{T}_{SU}$ — Average radiation temperature of the aft compartment structure in the Mid Section

Table 12-2

SV-2 AFT SECTION CRITICAL COMPONENT TEMPERATURES

Critical Component	Design Limits (°F)	SV-2 Actuals(2) (°F)
EDAP		
PDJB	-30/170	64/68
CCC's	-30/170	56/96
Batteries, Bay 3	35/70	45/52
Batteries, Bay 1	35/70	42/47
PDA's	-30/160	(3)
Solar Arrays	-125/225	-80/156
ACS		
IRA	50/130	112/113
HSA Heads	0/130	66/88
FCEA	-30/160	(3)
OAS		
Tank	65/100	69/94
Quad Valve	35/200	118/122(1)
Catalyst Bed	—	140/158(1)
T&T		
Tape Recorders	20/130	92/112
Transmitters	-30/170	92/121
PCM Master	-30/170	102/133
PCM Remote, Bay 2	-30/170	56/73
PCM Remote, Bay 10	-30/170	106/120
COMMAND		
PMU A	-40/145	104/108
PMU B	-40/145	117/118
Clock	-40/153	117/120
MCS	-40/149	102/104
RCS		
Tanks	40/140	64/100
REM Valves	≥45	102/202
Plumbing, Bay 12	35/140	75/110

(1) Data with OA engine not firing
(2) Stabilized orbital operation (most equipment 70 to 90°F at lift-off)
(3) Instrumentation deleted on SV-2

12.4 CONTAMINATION EXPERIMENTS

12.4.1 Description

As described in the SV-1 Flight Test Engineering Analysis Report, a series of experiments were flown on SV-2 in order to satisfy the following objectives:

- Distinguish source – liftoff cloud.
- Distinguish source – SRM staging.
- Evaluate degradation of present thermal control surfaces (white silicone, bare aluminum, black Kemacryl).
- Assess smooth skin over corrugations as a possible fix.
- 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).
- Assess Z-93 as a substitute for white paint (Z-93 is an inorganic, ceramic-based white paint).
- Evaluate nature of liftoff cloud contaminants.
- Evalute effectivity of fiberglass cloth as a contamination shield.

The Aft Section Bay 11 and 12 equipment doors were modified as shown in Fig. 12-1 to meet these objectives. The "QCM's" are Quartz Crystal Microbalances which are small electronic devices that measure mass deposit directly. The sensing surface is a crystal with a sticky, vacuum-stable coating, mounted nearly flush with the vehicle skin. In addition, umbilical arm contamination sample boxes were installed as shown in Fig. 12-2.

12.4.2 Results

Ascent telemetry data showed that the blow-off and lanyard pull-off shields operated correctly. Orbital temperature data for the various white calorimeters indicated the following apparent solar absorptivities (α):

Exposed Throughout Ascent	α
White Silicone Calorimeter	0.52
Z-93 Calorimeter	0.40
Corrugated White Silicone Panel (Bay 12)	0.52
Smooth White Silicone Panel (Bay 12)	0.52
Smooth FOSR Panel (Bay 12)	0.42

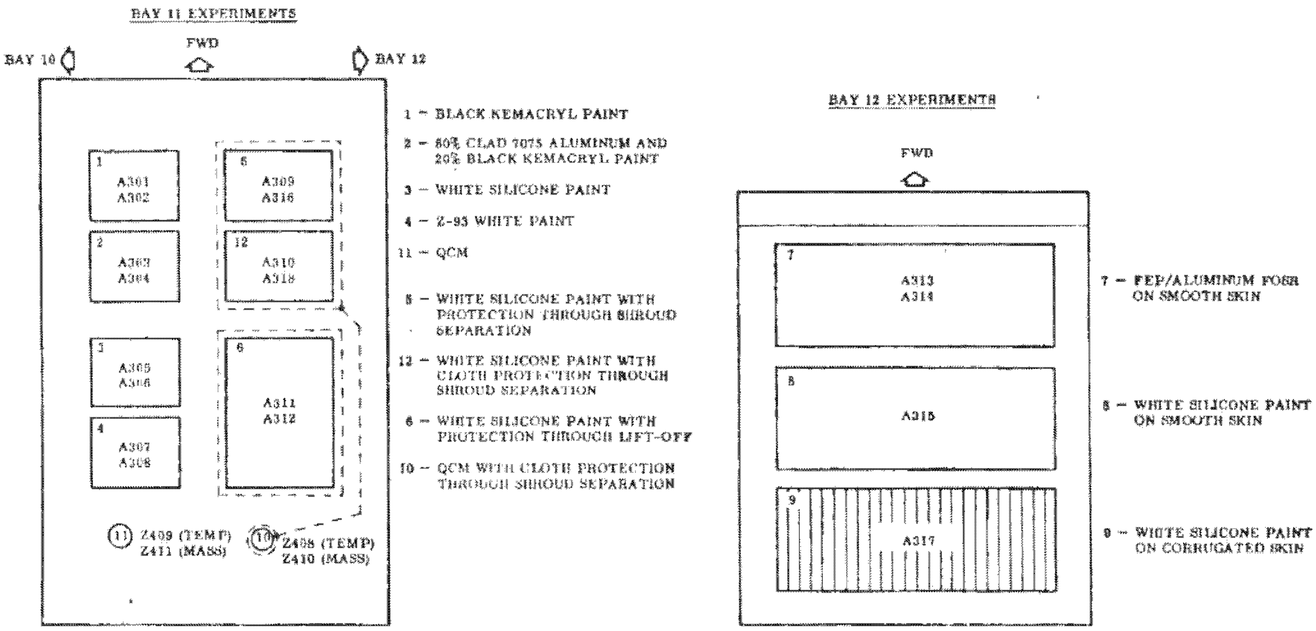

Fig. 12-1 SV-2 Flight Experiments

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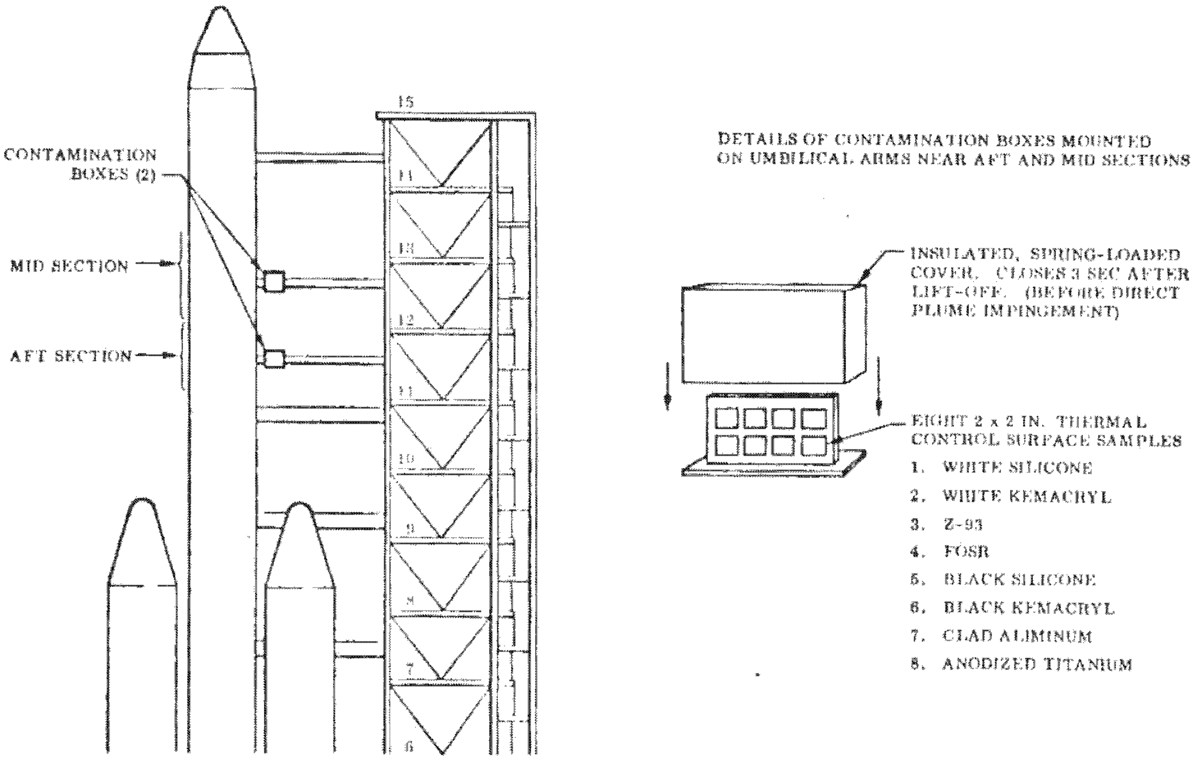

Fig. 12-2 Umbilical Arm Contamination Sample Boxes

Exposed After Lift-Off	α
White Silicone Calorimeter	0.46
Exposed After Shroud Separation	
White Silicone Calorimeter	0.18
White Silicone Calorimeter Covered with Fiberglass cloth	0.18

The nominal, uncontaminated α for white silicone is 0.18. The emissivity (ϵ) of all the white paint samples was essentially unchanged. Both the α and ϵ of the exposed bare aluminum sample changed from nominal values of $\alpha = 0.29$ and $\epsilon = 0.03$, to $\alpha = 0.38$ and $\epsilon = 0.12$.

None of the samples in the umbilical arm boxes showed any significant change in properties except the bare aluminum. These samples exhibited changes in α and ϵ of up to 0.11 and 0.24, respectively. The mass deposition measured during ascent by the exposed and protected Quartz Crystal Microbalances are shown in Fig. 12-3.

12.4.3 Conclusions

The overall conclusions derived from the experiments are as follows:

- The SRM staging event causes unacceptable contamination.
- The liftoff cloud causes minor contamination.
- SV/BV separation (and Stage II retro) causes no contamination.
- Fiberglass cloth appears to effectively prevent contamination.
- Z-93 and FOSR both showed somewhat less degradation than white silicone but still not acceptable.
- Smooth skin degradation is the same as the corrugations.

The sources of contamination during the SRM staging event are the aluminum oxide particles expelled by the SRM staging motors, and finely divided silver particles from the silver paint on the BV insulator pad that is burned off by the SRM staging motor exhausts.

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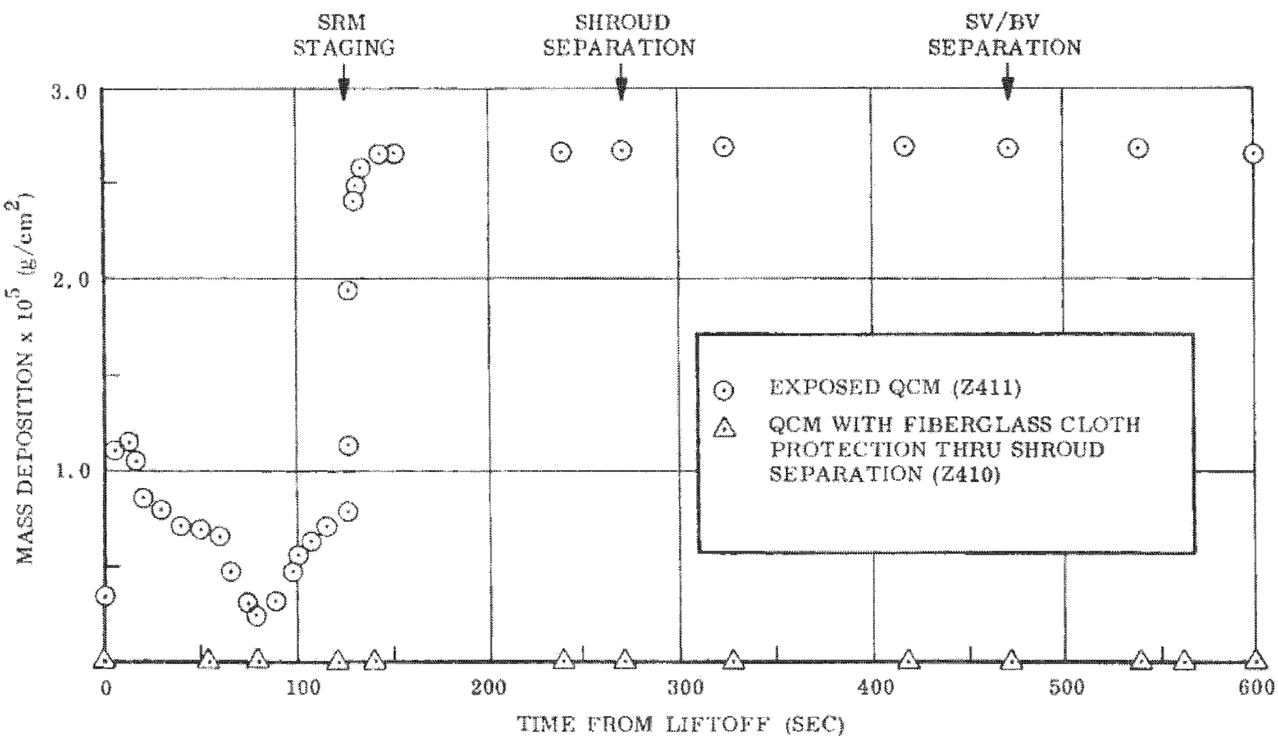

Fig. 12-3 SV-2 QCM Data

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12.4.4 Action for Subsequent Vehicles

In view of the above results, the following actions are planned for subsequent vehicles.

<u>SV-3</u>

1. Restrict the beta angle
2. BV contractor to remove the silver paint from the BV insulator pads
3. Fly additional experiments in Bays 11 and 12 to further evaluate the nature of the contamination and the performance of the fiberglass shield material.

Concurrent to the above efforts:

<u>SV-4</u>

1. Move Bay 12 battery module to Bay 3
2. Restrict the beta angle
3. Develop and fly a fiberglass contamination shield through shroud separation.
4. Fly sufficient instrumentation to evaluate shield.

<u>SV-5 and Up</u>

1. Fly contamination shield
2. Remove beta angle constraint

Section 13
MASS PROPERTIES

The history of the SV mass properties throughout the flight are tabulated in Table 13.1.

Table 13-1

SV-2 ACTUAL ON-ORBIT MASS PROPERTIES

Description	Weight (lb)	Inches			Slug-ft^2					
		$\overline{X}$	$\overline{Y}$	$\overline{Z}$	I_x	I_y	I_z	I_{xy}	I_{yz}	I_{xz}
Launch Weight	23264	1990.5	0.06	3.18	7018.5	169104.5	169028.7	-1306.5	1403.1	73.3
After Injection	20268	2005.7	0.09	3.68	4884.9	134377.8	134224.1	-1285.4	1718.6	72.7
Solar Arrays Ext.	20268	2006.2	0.09	3.68	6040.5	135378.5	136325.4	-1285.2	1726.3	-149.2
After Subsat.Eject.	19888	2009.0	0.90	4.01	5857.4	132224.4	133050.8	-602.4	2005.3	-208.1
Before RV 1	19646	1999.5	0.96	4.63	5830.6	139565.6	140395.8	-677.4	2472.9	-218.8
After RV 1	18097	2027.1	1.04	3.53	5620.5	101514.9	102490.0	-565.6	965.0	-214.3
Before RV 2	17611	2014.4	1.17	4.41	5576.3	105961.6	106944.2	-683.7	1318.7	-235.4
After RV 2	16070	2040.6	1.28	3.16	5363.3	78603.8	79733.2	-567.1	20.1	-229.9
Before RV 3	15649	2034.5	1.25	3.01	5346.8	78378.2	79505.2	-583.9	360.8	-263.2
After RV 3	14414	2054.0	1.40	1.92	5162.6	63158.8	64406.7	-466.6	-473.2	-255.4
Before RV 4	13557	2042.7	1.53	2.67	5132.6	61230.5	62478.2	-555.0	-465.0	-270.0
After RV 4	12245	2061.0	1.77	1.21	4932.6	51852.2	53233.7	-434.5	-1194.4	-258.6
End Deboost	11923	2057.6	1.81	1.25	4929.8	50724.4	52105.8	-450.3	-1205.3	-258.8

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Section 14
STRUCTURES AND DYNAMICS

14.1 PRE-LAUNCH WINDS ALOFT LOADS ANALYSIS

Table 14-1 presents a chronological tabulation of the winds aloft computer runs for SV-2. The R-17 runs are program checks made with theoretical wind profiles.

During the December launch period, MMC's Thrust Vector Control fluid usage constraint parameters were exceeded three times during wind runs. During the January launch period, no violations occurred. In addition to the two parameters shown, the SV structural loads, the SRM side force and the vehicle response in terms of αq were checked and found to be within constraints.

14.2 ASCENT ACCELERATION

Axial accelerations measured at Station 1642 and 2180 are shown in Fig. 14-1. together with design and test values. The severe loading event, Stage 1 Shutdown, for both SV-2 and SV-1 and design values is presented in Table 14-2. As can be seen, the values for SV-1 and SV-2 are similar and are both significantly lower than predictions. The response levels in the first three longitudinal modes are shown in Table 14-3.

14.3 ASCENT ACOUSTIC AND VIBRATION ENVIRONMENT

The acoustic and vibration measurements are shown in Table 14-4. These measurements were taken in the same vehicle locations as on SV-1. The amplifier saturation which occurred on SV-1 was corrected by the high pass filters installed on SV-2. Measurement 961 was slightly clipped at lift-off for a very short time, but not enough to interfere with the analysis of the data. Sensor 961 gave the same flight reading as on SV-1, which again is significantly lower than the original value anticipated, but which is attributed to the very local and transient nature of the external shock. In general, the acoustic levels were higher than those of the first flight and the vibration levels were about the same.

Table 14-1

SUMMARY OF WINDS LOADS ANALYSIS

Date	STC Run		Balloon Release Time (Zulu)	TVC Dump Voltage = 0			TVC Fluid Usage for Control (% Allow.)	Remarks
	T-HR	PST		SRM No.	Time From SRM Ignition (sec)	Total Time (sec)		
6 Dec 71	R-17	0830	(3)	1	49.0 - 54.0	5.0	109.0	(1), (4), (5), (7)
20 Dec 71	T-24	1215	1440	-	0	0	63.5	(1)
21 Dec 71	T-85	0220	0620	-	0	0	75.0	
	T-3.0	0748	1223	1	11.0 - 11.4	0.4	[101.0]	(2), (4), (7)
				1	50.0 - 59.0	9.0		(6), (7)
22 Dec 71	T-24	1100	1135	1	11.0 - 11.2	0.2	[122.0]	(1), (4), (7)
				1	21.0 - 32.4	11.4		
				2	11.2 - 32.0	20.8		
23 Dec 71	T-24	1100	1115	1	27.0 - 30.2	3.2	[130.0]	(1), (4), (7)
				1	46.8 - 53.0	6.2		(6), (7)
6 Jan 72	R-17	1100	(3)	1	49.0 - 54.0	5.0	114.0	(1), (4), (5), (7)
18 Jan 72	T-24	1025	1100	-	0	0	34.0	(1)
19 Jan 72	T-8.5	0320	0640	-	0	0	51.5	
19 Jan 72	T-3.0	0800	1234	-	0	0	59.5	
19 Jan 72	T-1.0	0930	1534	-	0	0	63.5	(2)
20 Jan 72	T-8.5	0400	0634	-	0	0	70.5	
20 Jan 72	T-3.0	0830	1234	-	0	0	53.5	
20 Jan 72	T-1.0	0930	1534	-	0	0	52.5	

Notes:
(1) The data were verified as correct by Martin Marietta Corporation (MMC)
(2) Used also as T-24 Hr run for next day
(3) MMC Met Note 2 wind profile was used. The profile is used as a backwind from a quartering direction.
(4) TVC fluid usage for control constraint was exceeded. 100 percent of allowable is a Go condition.
(5) TVC side force constraint was exceeded. 100 percent of allowable is Go condition.
(6) TVC dump voltage off constraint exceeded. 5.6 sec off between 29 and 75 sec after SRM ignition is the allowable.
(7) AF (SP-7) was informed of constraint violation.

[xxx.x] Denotes constraint exceeded.

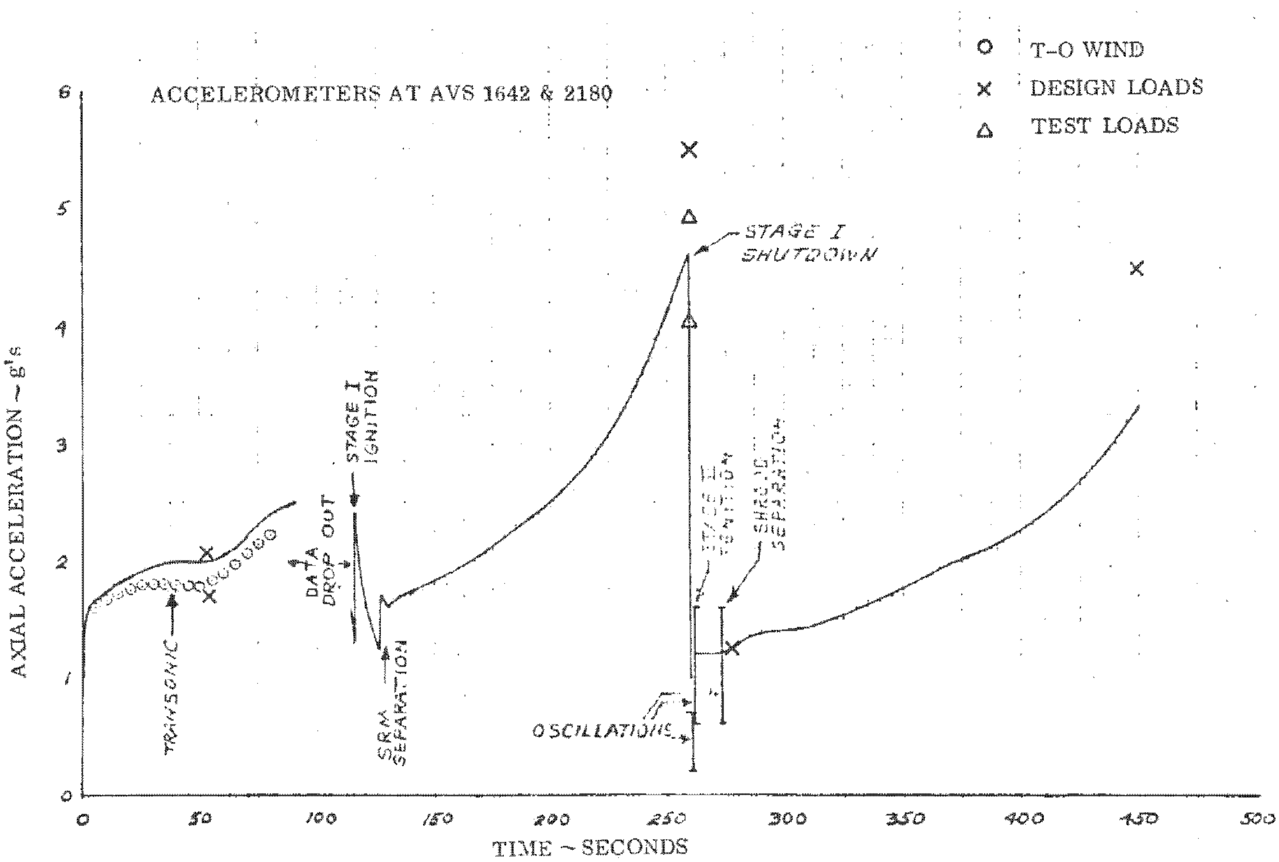

Fig. 14-1 Axial Acceleration History

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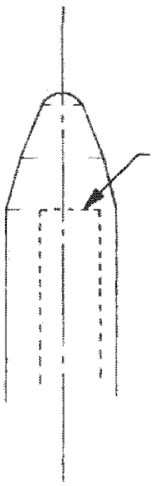
Table 14-2

ACCELEROMETER MEASUREMENTS

(Stage I Shutdown)
Station 1642



Axis		Acceleration (g's)		
		SV-2	SV-1	Design*
X	Peak Compression	+4.8	+4.5	+5.5
	Peak Tension	-0.2	-0.2	-3.0
	Max Oscillatory Component	±0.6		±3.0
Y		±0.15	±0.2	±0.33
Z		±0.75	±0.8	±3.0

*Based on 27 Transients Criteria

Table 14-3

ACCELEROMETER MEASUREMENTS BAND PASS ANALYSIS RESULTS
(Stage I-Shutdown) — SV-1/SV-2

Frequency Range (Hz)	Frequency (Hz)	Axis	Acceleration at Sta. 1642 (g's)		Mode Description
			SV-2	SV-1	
16 - 18	17	X	±0.6	±0.31	1st Longitudinal
		Y	±0.08	±0.1	
		Z	±0.42	±0.2	
18-23	20.4	X	±0.6	±0.6	2nd Longitudinal
		Y	±0.07	±0.1	
		Z	±0.5	±0.35	
23-30	29	Z	±0.11	±0.1	3rd (Booster Tank Mode)

14.4 SOLAR ARRAY

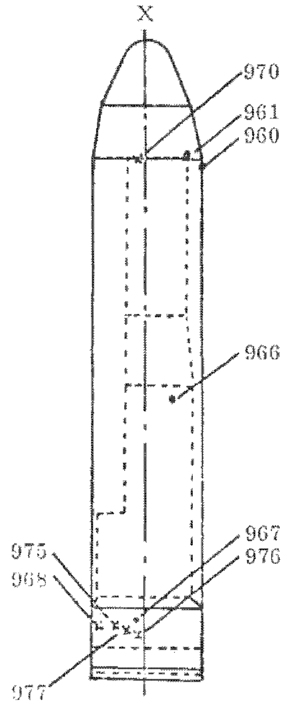
The erection and deployment time histories are shown in Fig. 14-2 for the left (-Y) Solar Array and in Fig. 14-3 for the Right (+Y) Solar Array. Since the arrays were deployed and erected in the proper position for the flight beta angle, no positioning was necessary and none was performed. In general, the arrays deployed more slowly than on SV-1, whereas the erection times were almost the same.

Table 14-5 is included to compare the flight values with the last two ground tests on the arrays before flight. The erection times vary by ±50 percent from the ground tests. The deployment times for the left array increased by +50 percent and for the right array between +80 to +300 percent (closer definition is not possible since no flight data is available for this interval). Data will continue to be collected to better explain why the right array lags the left array.

Table 14-4

SUMMARY OF LIFT-OFF, FLIGHT, AND TEST DATA (U)

MEASUREMENT LOCATIONS



● Microphones

x Vibration Pick-ups

	Lift-Off Max/Nom	Ascent Max/Nom	Test**
Microphones			
960 Fwd Ext	154.5/146 dB*	149/146 dB*	159/151.5 dB*
961 Fwd Int	143.5/139	121	143
966 Mid Int	136/131	117	134.5
967 Aft Int	135/132	126	139
Vibration Pick-ups			
970 Fwd Bulkhead	4.6/2.5 G_{rms}	0.5 G_{rms}	8.0 G_{rms}
968 PCM Module	0.46/0.3	0.3/0.2	0.5
975 T&T Module	0.8/0.5	0.8/0.5	1.0
976 Arm Module	0.7/0.42	0.35	1.2
977 LB Module	1.6/1.2	1.2/1.0	2.1

*Surface Pressure

**Values measured during SV-2 Acoustic Acceptance Test

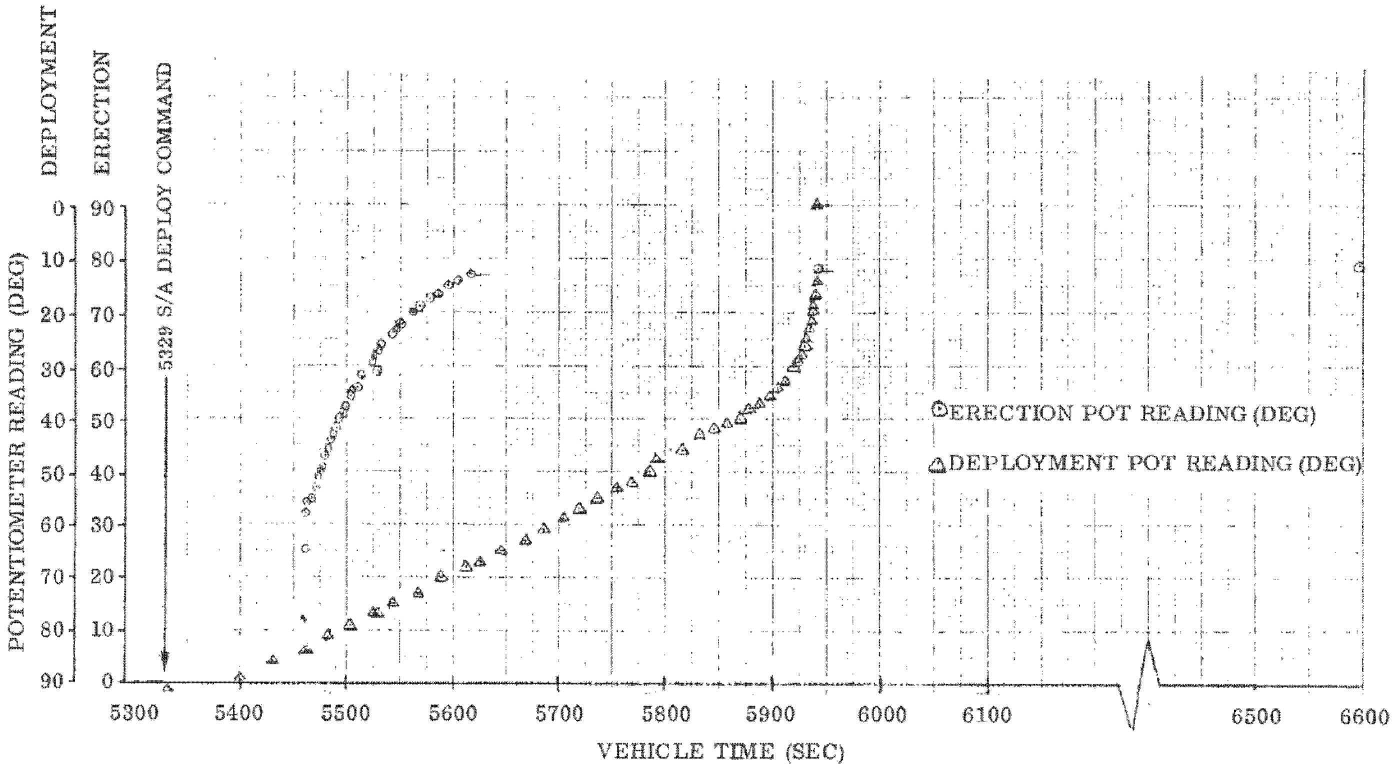


Fig. 14-2 Left Hand Solar Array Erection and Deployment Time Histories

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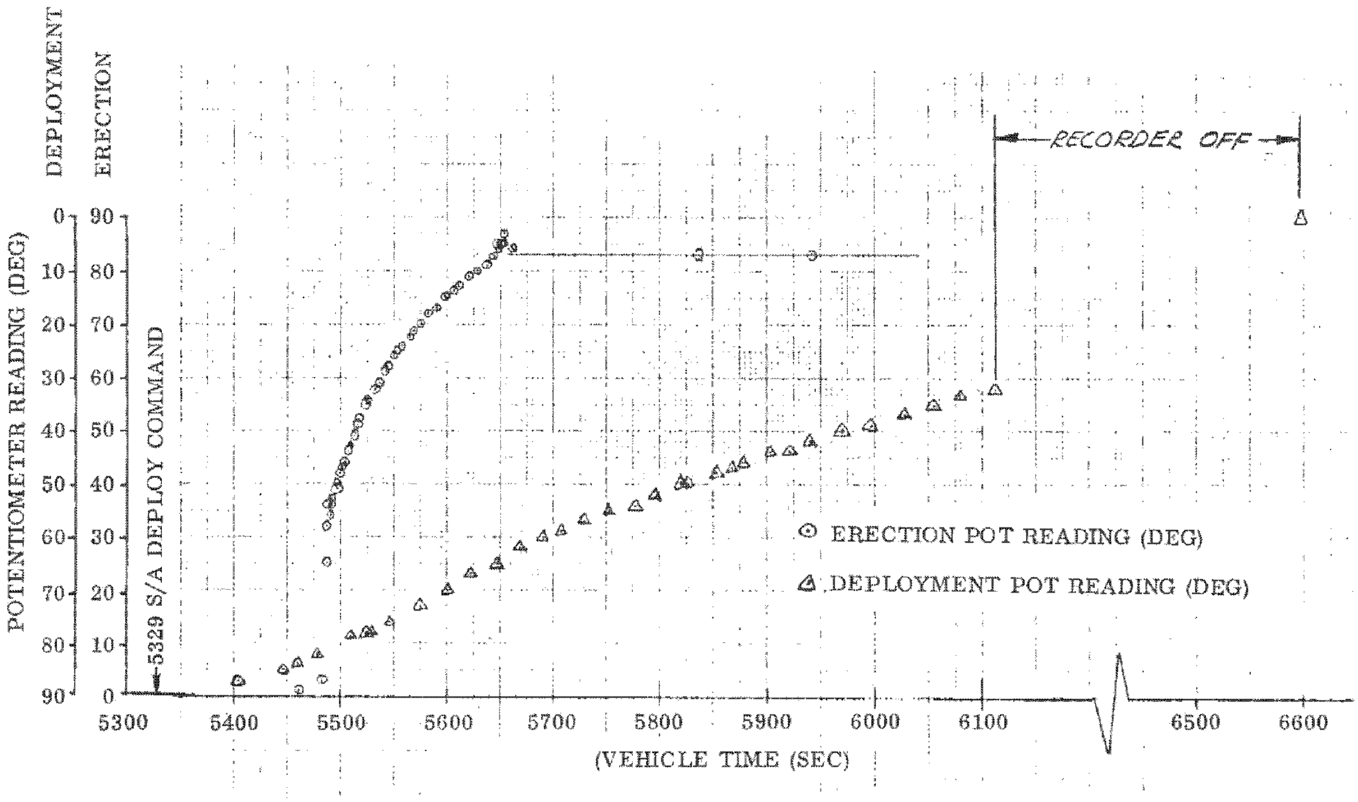

Fig. 14-3 Right Hand Solar Array Erection and Deployment Time Histories

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Table 14-5

SV-2 TIMES FOR SOLAR ARRAY DEPLOYMENT AND ERECTION

	Left Array			Right Array		
	Ground Test 1	Ground Test 2	Flight	Ground Test 1	Ground Test 2	Flight
Temperature	Room Ambient	Room Ambient	Not Available	Room Ambient	Room Ambient	Not Available
Times in Seconds						
Deploy Command to:						
-Start of Erection	104	99	131	99	105	151
-End of Erection	301	293	288	222	225	326
Erection Time	197	194	157	123	120	175
Deployment Time	401	395	611	333	425	790-1268

Section 15
SOFTWARE

There were no software problems which impacted flight objectives.

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