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Performance Evaluation Team

June 3 1972

MISSION 1203

DIRECTORATE OF SPECIAL PROJECTS

OFFICE OF THE SECRETARY OF THE AIR FORCE

BYE 15310-72

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PERFORMANCE EVALUATION TEAM

MISSION 1203

JAN 3 1978

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PERFORMANCE EVALUATION TEAM
REPORT NO. 1203/72

PUBLICATION REVIEW

This report has been reviewed and is approved.

Joe E. Sanders
JOE E. SANDERS
Major, USAF
Chairman, Performance Evaluation Team

PERFORMANCE EVALUATION TEAM
REPORT NO. 1203/72

FOREWORD

This report was prepared for and by direction of the Director of Special Projects, Office of the Secretary of the Air Force. The report is Volume I of the final mission report for HEXAGON Mission 1203. Volume II is entitled Sensor Subsystem Post Flight Analysis Report, TCS 354014-72.

The report was prepared by the SAFSP HEXAGON Performance Evaluation Team (PET) using reports and data provided by SAFSP, the Technical Advisor (TA) Staff, Post Flight Analysis (PFA) Team, and HEXAGON Satellite Vehicle Integrating Contractor (SVIC).

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AEROSPACE

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Editorial assistance and publication services were provided by the Air Force Special Projects Production Facility (AFSPPF). The PET wishes to commend Colonel William E. Callanan, Commander, and his most able staff for their support.

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SECTION I
SUMMARY

1.1 INTRODUCTION

The third HEXAGON mission was planned for 45 days in the primary phase followed by a 15 day Solo operation. The Satellite Vehicle (SV) was placed into the planned 96 x 137 NM orbit by the Titan III D Booster Vehicle (BV) at 1046 PDT, 7 July 1972. Photographic operations were performed on Days one through 58. Photographic operations were stereo during 1203-1 and 1203-2; primarily mono (Forward Camera) during 1203-3 because of a film edge fold in the Aft Camera Take-up (TU); and both stereo and mono (Aft Camera) for 1203-4, mono operations being required due to a film edge fold in the Forward Camera TU. The average ground resolved distance (GRD) for the mission was 4.1 feet. This result was obtained from a subjective evaluation of CORN tribar targets, regardless of weather conditions. The quality was significantly affected by haze/smoke and weather conditions existing at this time of year. The Re-entry Vehicles (RV) were deorbited and aerially recovered on Revs 132, 359, 586 and 927. Solo experiments and lifetime demonstration activities were conducted from Day 58 to Day 69 where the SV was deorbited on Rev 1104.

1.2 AEROSPACE VEHICLE (AV) SYSTEM PERFORMANCE

The Titan III D BV performed satisfactorily, injecting the SV into a nominal orbit. After recovery of RV-2, mission life was extended from 45 to 60 days; however active mission life was terminated on Day 58 due to degradation of the redundant Reaction Control System (RCS). Solo operations continued to Day 69. Loss of control during Solo resulted in SV tumbling and the decision to deboost the vehicle on Rev 1104. Stereo photography was used throughout mission segments one and two. All mission objectives were met. The SV was successfully deboosted on Rev 1104 under Lifeboat control.

1.3 SENSOR SUBSYSTEM PERFORMANCE

During Mission 1203 the Sensor Subsystem (SS) experienced disturbances in the film paths at extreme scans and high rewind velocities. Two over-tension Emergency Shutdowns (ESD) occurred during the mission; the first in the Aft Camera at the start of 1203-3 and the second during 1203-4 in the Forward Camera. Film edge folds in TU-3B and 4A were verified after capsule recovery. TU-4A builder roller jammed in the up position and after lowering the remainder of the segment was operated with zero rewind. Approximately 94,000' of film from the Forward Camera and 88,000' from the Aft Camera were recovered.

1.4 SATELLITE BASIC ASSEMBLY (SBA) PERFORMANCE

With the exception of the RCS, the performance of the SV subsystems throughout the mission was generally excellent; all other primary equipment functioned throughout the four mission segments requiring no additional backup equipment.

Mission Overview

SECTION II

MISSION OVERVIEW

2.1 PREFLIGHT PLANNING

The prime concern during preflight planning was how to manage an anticipated thruster problem. Data from previous flights and ground tests indicated that thruster valve leakage and subsequent degradation was caused by particulate deposits on the thruster valve seats. The particulates came from either contaminated fuel loaded into the vehicle prior to launch or from non-volatile residue (NVR) building up in the RCS tanks after the tanks were filled with propellant. Analysis indicated that the NVRs were caused by exposure of hydrazine to the rubber diaphragm in the RCS tanks and that this concentration of NVRs increased with exposure of the fuel to the diaphragm. Four basic preflight decisions were made to minimize the anticipated thruster problem:

A. Insure that the fuel loaded into the vehicle was as clean as possible.

B. Lift-off to be with the primary RCS tanks filled with hydrazine and with the secondary RCS tanks empty.

C. Minimize vehicle activity to delay the onset of thruster degradation.

D. Load propellants into secondary RCS tanks and transfer to the secondary RCS only after the primary RCS starts to degrade.

2.2 CONSTRAINTS

The major constraints applied to Mission 1203 were defined to provide an acceptable thermal environment in the presence of contamination and to minimize vehicle activity to delay the onset of thruster degradation. These constraints included:

A. Solar (Beta) angle to be within +34° to +26° for the 45 day prime mission phase.

B. Orbit adjust to occur on a 4 day cycle and to be positive only.

C. Perigee altitude to remain above 95NM.

D. Vehicle maneuver activity to be minimized.

Additional constraints were made to the camera system during on-orbit operation, see paragraph 4.1.

2.3 LAUNCH BASE

The Titan III D BV arrived at the SLC-4 East, VAFB launch site on 19 April 1972 and began its prelaunch readiness cycle. The SV was delivered to the launch pad on 21 June 1972. After mating the SV to the BV on Day R-13, the AV prelaunch checkout began. The checkout proceeded smoothly toward a planned launch date of 7 July 1972. Launch occurred at 1046 PDT at the opening of the launch window.

2.4 ASCENT

The BV performed nominally during ascent and injected the SV into the desired 96 x 137NM orbit with the following deviations in the planned orbit parameters.

Apogee Altitude (NM)	+ .068
Perigee Altitude (NM)	- .032
Period (second)	+ .189
Eccentricity	.000008

Additional experiments were conducted during flight to measure the contamination environment during launch and ascent. Analysis of the data from these experiments confirms that contamination occurs at solid rocket motor (SRM) staging.

2.5 ORBIT AND RECOVERY

2.5.1 1203-1 (Eight Days Duration)

After verification of SV stability on Rev 1, the solar array deployment was initiated. The left hand solar array was slow in erecting; however, complete deployment was verified at the POGO Rev 2 contact. Normal vehicle health checks were completed by Rev 4 and the first operational command message was generated and loaded on Rev 5. Payload operations began the first night.

The P989 Subsatellite was released on Rev 13 and achieved a nominal orbit. All camera operations throughout RV-1 demonstrated nominal characteristics with no anomalies or malfunctions experienced.

Aprx 27,400' of film per camera were exposed and stowed in RV-1. Overall quality was somewhat reduced by a non-optimum focus setting. Also the quality was affected to varying degrees throughout the mission by haze and specular reflections due to the sun angle.

RV-1 recovery on Rev 132 (Day 9) was nominal with the capsule air recovered and the major section of the heat shield retrieved from the water. The RV was loaded to 92.6% of capacity and the film load was balanced.

2.5.2 1203-2 (Fourteen Days Duration)

As a result of the 1203-1 PFA evaluation, SS focus was adjusted for maximum image resolution and the exposure requirements profiles were adjusted for optimum photographic information content. Operational photography progressed normally until Rev 314 when there was an indication of minor disturbances in the Aft Camera fine film path. Operations were continued with a manual limitation of 15 inches/second in the rewind velocity when going from a 120° to a 30° scan. Similar disturbances were reported on Revs 348 and 350 but no further action was taken before the recovery of RV-2 on Rev 359. Aprx 27,400' of film per camera were recovered. Both Take-ups experienced sheared core pins with the accompanying loose and snarled outer layers of film. Overall quality of the acquired photography was comparable to 1203-1. The focus adjustment on Rev 166 of +8 microns on the Forward Camera and -8 microns on the Aft was offset by other sensor system factors contributing to image smear degradation. Evaluation of the imagery placement on the film verified the Aft Camera mistracking characteristics beginning on Rev 314. This mistracking also apparently contributed to the "serpentine" film stack of the Aft Camera TU on 1203-2.

The first indication of a thruster problem occurred on Rev 175 when the temperature from Thruster 8 increased aprx 100°; however, thruster leakage was not significant until after the fifth orbit adjust (OA) on Rev 306.

A propellant transfer from the OA tank to RCS Tanks 1 and 2 was accomplished on Rev 331. Fifty pounds of propellant were transferred to dilute the contaminants in the RCS tanks and to determine if thruster performance would improve. The transfer appeared to have no effect upon the leakage rate. As of Rev 350 the use rate had increased from a nominal .26 lbs/rev to 1.4 lbs/rev.

Normal RV-2 separation, re-entry, and recovery were accomplished on Rev 359 (Day 23). The heatshield was retrieved. The RV was loaded to 92.8% at capacity and was balanced.

2.5.3 1203-3 (Fourteen Days Duration)

The Aft Camera fine film path disturbances continued into RV-3 operations. After an ESD on Rev 364, all stereo operations were limited to a rewind velocity of 15 inches/second. An additional constraint to exclude 30° or 120° scan angles was implemented on Rev 395. On Rev 399, Aft Camera operations were suspended for the balance of RV-3. This action was taken because on Rev 364 a film edge foldover on the Take-up doubled the rate at which the Take-up radius should have increased and a catastrophic failure appeared probable. The Forward Camera was then run in mono with the constraints removed and with both optical bars running to minimize torque. It was planned to load only 19,000' of film in RV-3 in order to maximize the supply of film for stereo operation into RV-4. The PFA Team reported that overall quality of the acquired photography was fair to good, with the Aft Camera noticeably better than the Forward. A performance trend existed wherein the photographic quality improved in the Aft and degraded in the Forward Camera as the mission progressed.

RCS-1 propellant use rates continued to increase and on Rev 363 Isolation Valve No. 2 was opened to connect the RCS to the Orbit Adjust System (OAS) tank. By Rev 385, the use rate of RCS-1 had increased to 1.4 lbs/rev and thruster temperatures were aprx 1000°F. Thruster pulse shape and performance remained nominal. By Rev 420, the RCS-1 use rate was aprx 2.4 lbs/rev and planning was started for a transfer to RCS-2. The orderly transfer to RCS-2 was made on Rev 436 with the Attitude Control System (ACS)/RCS configured ACS-1/RCS-2. It was planned to operate RCS-2 on Tanks 3 and 4 for approximately one day to establish use rate and then open Isolation Valve No. 3 and operate RCS-2 from the OAS tank. It was hoped that this mode of operation would delay NVR buildup by minimizing contamination from Tank 3 and 4 diaphragms. Use rate of RCS-2 was determined to be a nominal 3.5 lbs/day and OAS Isolation Valve No. 3 was opened on Rev 452.

To avoid propagating the film path disturbance by drawing affected film from RV-3 to RV-4, the normal Prep 1 sequence was modified to provide a minimum wrap on the Aft Camera Take-up. Prep 1 was executed over Vandenberg Tracking Station with the real time data microwaved to the Satellite Test Center (STC) for analysis. A requirement existed to analyze Prep 1 prior to initiating Prep 2. Timing was critical; therefore, a decision was made to proceed cautiously and delay the recovery of RV-3 for one day. Stereo photography was resumed on Rev 573.

RV-3 re-entry and aerial recovery was accomplished on Rev 586, with 16,600' of Forward and 3,300' of Aft material being recovered. The RV was loaded to 39% of capacity and was 58% unbalanced.

2.5.4 (Twenty-One Days Duration)

Stereo photography, which had started the day prior to RV-3 recovery, continued using 60° scan, 0° scan center and 5 ips rewind constraint. A stereo nested manual operation (MOP)/rewind evaluation test was conducted on Rev 600. The scan center constraint was removed on Rev 620 and the rewind constraint relaxed from 5 ips to 20 ips on Rev 622. As of Rev 669, scans of 30°, 60°, and 90° with scan centers of ± 15° and ± 30° and rewind velocities from 5 to 20 ips were accepted for sensor subsystem operation. The Forward Camera operated normally up to Rev 719 when it experienced a fold in the film similar to that on the Aft Camera in RV-3. Both cameras continued to operate, however, with the Aft Camera also being operated in mono to best utilize the film. RV-4 was recovered on Rev 927 with 22,636' on the Forward and 29,965' on the Aft Take-ups. The Forward Camera core pin sheared under retrieval loads. Overall quality of the acquired photography showed no change from that acquired during 1203-3. The Forward Camera continued to exhibit greater variability than the Aft with some instances of the Forward imagery being better than the Aft.

Selected Solo tests, that could be accomplished during mission operations, were started on Rev 640. OA tank heaters were turned on to evaluate propellant heat transfer, and selected high elevation passes were programmed for Space Ground Link System No. 2 (SGLS-2) to evaluate the antenna pattern starting with Rev 643/HULA. A tape recorder fast forward test was conducted by Rev 702.

RCS-2 propellant use rate increased from .3 lbs/rev on Rev 800 to aprx 1.5 lbs/rev on Rev 820. A pattern of increasing leakage was observed after Rev 801 when mono camera operations with one optical bar (OB) rotating interspersed with stereo operations. Thruster No. 8 started leaking on Rev 825, Thruster No. 3 on Rev 870, and Thruster No. 6 on Rev 905. RV-4 re-entry and aerial recovery occurred on Rev 927. The RV was loaded to 89% of capacity and was 24% unbalanced. After separation the SV was pitched back to a horizontal attitude and the Solo operational phase began.

2.6 SOLO TESTING

The SV-3 Solo phase started during the RV-4 mission phase for those experiments that could be conducted in parallel with mission photography. After RV-4 recovery on Rev 927, the planned Solo activity was started. The Solo experiment chronology is shown in Table 2-1. Solo test results are not available to date. After completion of the major subsystem and/or maneuver testing, a simulated mission phase was started. This phase operated the OBs (one or both) in a simulated profile to determine maximum mission life. The SV tumbled on Rev 1089 (ACS-1/RCS-2) and the decision was made to deboost early for a Pacific Ocean impact. Rev 1104 was selected for a Lifeboat deboost. A tumbling capture was loaded on Rev 1092 from ACS-1/RCS-1 to ACS-1/RCS-2 and was successful in recapturing stability. The SV remained stable on ACS-1/RCS-2 until Lifeboat was executed for deboost. Lifeboat control and OA performance was nominal and the SV impacted at the planned 15°N latitude on Rev 1104.

TABLE 2-1

SOLO TEST CHRONOLOGY

Load Rev/Sta	Test Description
629	TMECO Verification
640/POGO	OA Tank Heaters 1 & 2 On
643/HULA	SGLS-2 Antenna Patterns
682/COOK	OA Tank Heaters Off
702/POGO	Fast Forward Test No. 1
764/POGO	Continuous Record Test
785/BOSS	Mod Index - As scheduled until flight termination
824/GUAM	Continuous Record Test
927/KODI	RV-4 Recovery
930	Max Rewind
931/BOSS	Battery Efficiency
933/COOK	LSFS Calibration
934/COOK	Transfer Power to Switch Bus
939/BOSS	Execute MCS RV Enable SWRTC MCS Clock Rate (7 rev test)
945/POGO	Battery Efficiency - End Test
946/POGO	MCS Clock Rate - End Test Geo Rate Determination
947/POGO	Geo Rate Determination - End Test
948/POGO	Gyro Drift and Inverted Acquisition
951/KODI	Gyro Drift Rate - End Test [redacted] Coarse Mode Pitch Correction

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

TABLE 2-1 (CONT'D)

SOLO TEST CHRONOLOGY

Load Rev/Sta	Test Description
956	[redacted]
957/POGO	Yaw Reverse via Gyrocomp Fly Reverse
970/GUAM	Yaw Forward via Gyrocomp
972/POGO	HSA Inhibit during Roll
973	HSA Sun Inhibit during Yaw
975/KODI	RV-5 Simulated Recovery (Prep only)
976/POGO	RV-5 Simulated Recovery
976/KODI	RV-5 Simulated Recovery
976/HULA	RV-5 Simulated Recovery
980	[redacted]
988	ST Calibrate (APSA)
990/POGO	[redacted]
990/COOK	ACS-2 Health Check
991	Repeat ACS-2 Health Check
1004/BOSS	Geo Rate Off
1006/POGO	Geo Rate On
1008/POGO	Rev 1 Contingency Plan
1008/KODI	Rev 1 Contingency Plan
1009/POGO	Rev 1 Contingency Plan
1010/POGO	Rev 1 Contingency Plan
1011/POGO	Rev 1 Contingency Plan
1040/POGO	Recovery Abort Exercise
1041/POGO	Recovery Abort Exercise
1041/KODI	Recovery Abort Exercise
1041/HULA	Recovery Abort Exercise
1057/POGO	Rev 1 Contingency PCON-Rerun
1057/KODI	Rev 1 Contingency PCON-Rerun
1058/POGO	Rev 1 Contingency PCON-Rerun
1059/GUAM	Rev 1 Contingency PCON-Rerun
1060/POGO	Rev 1 Contingency PCON-Rerun

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

TABLE 2-1 (CONT'D)

SOLO TEST CHRONOLOGY

Load Rev/Sta	Test Description
1061	SGLS-1 with MIX 2 as scheduled
1072/COOK	B-Stow
1080/COOK	Creep Test with Disabled ESD
1086	[redacted] (b)(1) (b)(3)
1088/COOK	B-Stow

2.7 COMMAND LOAD SUMMARY

The software configuration used to support this mission was TUNITY MOD 1A and system software was Model 13.1C. A nominal two rev load cycle was used during the mission except for a two day test of the one rev load cycle. A total of 591 command messages were generated during the flight, of which 544 were loaded into the vehicle. The command system performed excellently throughout the flight; of some 165,000 separate commands loaded only four were rejected.

2.8 ANOMALY SUMMARY

Significant anomalies and malfunctions are listed chronologically in Table 2-2. The list includes a description of the anomaly, the mission consequences, and in some cases the changes indicated for subsequent vehicles. Detailed discussion of these anomalies can be found in this report.

TABLE 2-2

SUMMARY OF ANOMALIES

Day	Descriptions	Impact
1	Left solar array erection delayed.	No effect on mission. Delay duplicated in test. Erection release mechanism redesigned for SV-4 to eliminate possible interference between fittings.
1	Amp-hour unit reading erratic.	Output was not representative of actual power used. Normal operation from Rev 9 to 870. Problem under investigation. No change for SV-4.
19	RCS-1 REM leak.	Primary REM valves started to leak. Switched to RCS-2 on Day 27. Study of problem continues.
20	Disturbance in Aft Camera fine film path.	Restrict RWV to 15 ips when going from 120° to 30° scan. Failure analysis continuing on cause of tracking problems.

TABLE 2-2 (CONT'D)

SUMMARY OF ANOMALIES

Day	Descriptions	Impact
23	RV-2 retro truss separation delayed.	No impact on RV performance. MWC corrective action underway. No change for SV-4.
23	Both Forward and Aft outer wraps on RV-2 were loose and tangled. Core pins sheared.	Core-locking pins not designed for retrieval loads, shearing expected. No design change contemplated.
23	ESD on Aft Camera, tracking discrepancy at high RWV.	Restrict all stereo RWV to 15 ips. No 30° or 120° scan ops. Aft Take-up filled early. Forward mono operations only. Early drop of RV-3 to conserve film.
45	ESD on Forward Camera, tension in film path.	Cleared jam but fold in Forward Take-up caused intermittent use of Aft mono operations to use Aft film.
51	RCS-2 REM leak.	Vehicle control and fuel consumption satisfactory to complete mission. RCS-2 will be fed from OA tank only on SV-4 to eliminate NVR.
62	ACS-2 hard start.	ARM thermal design on SV-4 modified to allow dual IRA operation.
68	Tumble.	After 10 days Solo operations, leak sufficient to activate FDU. RCS-2 used to capture tumble.

Satellite Basic Assembly Subsystems

SECTION III

SATELLITE BASIC ASSEMBLY SUBSYSTEMS

3.1 ATTITUDE CONTROL SYSTEM (ACS)

The SV-3 ACS performed as expected during the primary mission and met all specifications that could be measured. The summaries presented in this section detail those requirements that could be verified from flight data.

3.1.1 Booster Vehicle/Satellite Vehicle (BV/SV) Separation

BV/SV separation was completed at approximately 539.4 seconds satellite vehicle time (SVT); SVT starts 67 seconds before lift-off. Master clear off (MCLR), which enables the pitch, roll, and yaw integrators to accumulate angle, was at 510.8 seconds and the Stage II engine shutoff (SECO), which terminates BV attitude control, occurred at 527.4 seconds SVT. The SV attitude changes from SECO to BV/ SV separation, and the attitude and rates as measured at BV/SV separation are shown in Table 3-1. This table also indicates the times in which the SV attitudes and rates came back within the specified limits following BV/SV separation.

TABLE 3-1

BOOSTER VEHICLE/SATELLITE VEHICLE (BV/SV) SEPARATION

	RATE AND ATTITUDE AT BV/SV SEPARATION						CAPTURE			
	RATE (degrees/second)		ATTITUDE (degrees) HS @ SEPARATION		ATTITUDE (degrees) Δ(SECO - SEPARATION)		ATTITUDE		RATE	
	Specified (deg/sec)	Actual (seconds)	Specified (degrees)	Actual (seconds)	Specified (degrees)	Actual HS/Integrator	Specified[1] (degrees)	Actual[2] (seconds)	Specified[3] (deg/sec)	Actual[4] (seconds)
Pitch	±0.752	-0.15	-21.7 to +13.0	+1.2	±3.5	-.16[5] -.37	±0.70	667.7	±0.014	120
Roll	±0.786	-0.26	±10.6	+1.2	±3.0	+1.06/ +1.025	±0.70	667.7 +520	±0.021	667.7
Yaw	±0.752	+0.175 +.084	-11.4 to +11.1	-	+4.5 to -3.5	-Unknown/ +1.46	±0.64	667.7 +520	±0.014	667.7

NOTES:
1 Attitude in degrees to be achieved in 1500 seconds.
2 Actual time required to achieve specified attitude (switch to fine mode + settling time).
3 Rate in degrees/second to be achieved in 1500 seconds.
4 Actual time required to achieve specified rate.
5 Relative to the local horizontal.

3.1.2 Subsatellite/SV Separation

The ACS parameters just prior to the instant of separation (70084.8 seconds SVT) were as indicated in Table 3-2.

TABLE 3-2

ATTITUDE CONTROL SYSTEM PARAMETERS AT SEPARATION

Event	Actual	Specified
Pitch H/S (degrees)	0.20	±1.0
Roll H/S (degrees)	-0.76	±1.0
Roll Integrator (degrees)	-0.14	
Yaw Integrator (degrees)	0.14	
Pitch Integrator (degrees)	0.23	
Roll Gyro Rate (degrees/second)	0.03	±0.1
Pitch Gyro Rate (degrees/second)	-0.04	±0.1
Yaw Gyro Rate (degrees/second)	0.01	±0.1
Yaw Attitude, -25° desired (degrees)	-25.23	-25±1.0

NOTES: 1. Geocentric program rate of -0.0687 degrees/second was included in the pitch gyro rate.
2. The yaw attitude was obtained by integrating the yaw gyro rate.
3. There are no established specifications for the roll, yaw, and pitch integrators.

The maximum SV rates observed following subsatellite separation impulse are listed in Table 3-3.

TABLE 3-3

MAXIMUM SV RATES AFTER SEPARATION

SV Rates	Rate (degrees/sec)
Pitch Gyro	-.04
Roll Gyro	±.31
Yaw Gyro	.16

3.1.3 Payload Operations

Stereo and mono operations with both OBs rotating and mono payload operations with one OB rotating were used on 1203. The vehicle rate and attitude specification limits were met in all cases during these operations.

3.1.4 Recovery

The pitch down maneuvers preceding the RV separations were all within specification and are summarized in Table 3-4. The RV separation performance summary is shown in Table 3-5.

TABLE 3-4

PITCH DOWN PERFORMANCE PRECEDING RECOVERY VEHICLE SEPARATION

RV/Rev	Pitch Down Angle: Desired ±3.0 Deg (degrees)	Pitch Down Angle: Actual PDWN (degrees)	Maneuvering Time to ≤ 0.1 Deg/Sec: Spec (seconds)	Maneuvering Time to ≤ 0.1 Deg/Sec: Actual (seconds)	Pitch Down Coast Rate: Command Rate (deg/sec)	Pitch Down Coast Rate: Coast Rate Expected (deg/sec)	Pitch Down Coast Rate: Coast Rate Actual (deg/sec)
1/132	-40.7	-39.9	150	84	-.705	-.75± .05	-0.71
2/359	-43.4	-43.0	150	86	-.705	-.75± .05	-0.72
3/586	-41.3	-41.5	150	78	-.705	-.75± .05	-0.72
4/927	-43.1	-42.8	150	83	-.705	-.75± .05	-0.73

TABLE 3-5

SUMMARY OF RE-ENTRY VEHICLE/SATELLITE VEHICLE SEPARATION PERFORMANCE

RV/Rev	Peak Pitch Rate (deg/sec)	Max Pitch Integrator Angle (degrees)	Induced Impulse By Rev (lbs/sec)	PDWN Prior to Sep (degrees)	Pitch Up Following RV Sep to Removal of Maneuver Command (degrees)	Pitch Inertia (After Sep) (slug-ft^2)	Pitch Thruster Moment Arm (feet)	Roll Angle: Spec (degrees)	Roll Angle: Meas. H/S (degrees)
1/132	1.94	12.0	117	-39.9	96.0[1]	100914	14.2	±1.0	-0.26
2/359	2.32	15.4	129	-43.0	43.1[2]	79269	12.9	±1.0	-0.04
3/586	2.16	11.7	117	-41.5	42.5[2]	64046	11.7	±1.0	-0.02
4/927	2.68	24.0	159	-42.8	51.1[2]	53671	10.9	±1.0	-0.04

NOTES: [1]To removal of maneuver command.
[2]To connection of H/S.

The pitch up maneuver following RV-1 was designed to produce the minimum contamination of the Aft-section. The pitch up maneuvers to the local horizontal following RV-2, 3, and 4, were for the purpose of conserving RCS propellants.

3.1.5 ACS-2 Hard Start

During the ACS-2 Health Check Experiment performed during Solo (Rev 991) one of the Redundant Attitude Control System (RACS) gyros failed to start. Although this anomaly occurred after the end of the primary mission, it has caused design and operational impact on SV-4 and all other subsequent vehicles.

3.1.5.1 Basic Problem Description

On Rev 991, 6 September 1972, Day 62, an attempt was made to transfer control to the RACS. The transfer was not completed because TM data showed that one of the RACS Inertial Reference Assembly (IRA)-1010 gyros would not start. Two subsequent attempts were also unsuccessful. This IRA was shutdown on Rev 1.3 and remained in this state until Rev 991 when the transfer was attempted.

Temperature data indicates that the pitch gyro was stalled; however, the roll gyro output was reportedly erratic. It is not known whether the pitch gyro was in fact the stalled component. The hard start gyro has constituted the one major failure source in the IRA. This problem should be corrected with the "Ferrotic" gyros which will be in the Block II Units. In addition, it is currently planned to have these new gyros installed in the RACS IRA of SV-5 and SV-6.

3.1.5.2 Approach for SV-4

Since this is the second of three flights to have had gyro restart failures, an intensive effort was started to modify the ARM thermal design to allow both IRAs (PACS and RACS) to be operated simultaneously throughout 1204. A design modification consisting of (1) adding heat conducting straps between the IRA mounting tray and the Bay 6 external doors, and (2) changing the Bay 7 external paint pattern from bare aluminum with black stripes to 100% white. Change 2 will help keep the Tracking, Telemetry, and Command (TT&C) module, particularly the tape recorders, within upper temperature limits. The effect of running both IRAs without heat straps is to increase gyro temperatures by about 30° F. With the heat strap modification, this increase should be no more than 15° F. With single IRA operation, gyro temperatures are expected to be 180° to 195° F. Therefore, with the heat straps in, dual IRA operation should produce gyro temperatures between 195° to 210° F. A temperature of above 205° F may be too high to allow continuous gyro operation; hence, there is a significant probability that the RACS may have to be shutoff in spite of the heat strap modification. In this case, the mission will continue in the single IRA mode as on the first three flight vehicles. The equilibrium temperature level for the gyros should be reached within the first three or four revs of flight. A curve of gyro heat-up versus time for dual IRA operation will be available to predict stabilized temperatures so that RACS can be turned off if necessary.

3.2 REACTION CONTROL SYSTEM (RCS)

3.2.1 Flight Summary

History of the RCS performance is portrayed graphically in Figure 3-1 and summarized in Table 3-6. Satisfactory vehicle attitude and rate control were provided by the RCS at all times during the 58 days of the active mission. The Failure Detector Unit (FDU) turned the system off and the vehicle tumbled from Revs 1089-1092 during the Solo mission.

3.2.2 Propellant Consumption

RCS propellant consumption for the mission was 1021 pounds, see Figure 3-2. Propellant was consumed only from RCS Tanks 1 and 2 until Day 22 when Isolation Valve-2 was opened to allow usage from the OAS tank as well. Normal propellant consumption varies from .2 to .4 pounds/rev.

3.2.3 Thruster Performance Degradation

Thrust characteristics for the primary RCS (RCS-1) were determined from the actual chamber pressure and temperature data. Thrust characteristics for the secondary RCS (RCS-2) were determined from the number of pulses and the pulse width data for the valve drivers. The first indication of thruster degradation was a sluggish pulse to pulse peak chamber pressure buildup observed on Rev 162. Figure 3-3 shows how REA-4 required seven pulses to reach 45 psi whereas REA-8, starting with the same chamber temperature, required only three. On Rev 227, REA-1 and REA-4 appear sluggish as compared to REA-5. However, no significant loss in performance of RCS-1 was detected before the transfer to RCS-2 on Rev 436.

When the transfer was made back to RCS-1 on Rev 990, a pulse shape tailoff was noted on REA-3 for Rev 991, see Figure 3-3. REAs 3, 4, 5, 6, and 8 were observed leaking. Vehicle control was maintained during this period when the RCS-1 was used; however, propellant consumption was 34 pounds/rev on Rev 990 and gradually reduced to 12 pounds/rev by Rev 999. The standby RCS was activated on Rev 436. Payload operations at this time consisted of mono operations with both OBs rotating. Identification of specific RCS-2 REA leakage is based primarily upon ACS data since REA bed temperature instrumentation does not exist on RCS-2. REA-8' started leaking on Rev 825, REA-3' on Rev 870, and REA-6' on Rev 905. RV-4 was separated on Rev 927 and the Solo mission was begun. During Solo, a series of experiments including yaw-arounds, pitch-downs, payload operations, etc., were conducted to test the capability of RCS-2. RCS-2 maintained control until the tumble on Rev 1089 when the FDU sensed REA-6' firing in a steady state mode for 27 seconds. Capture of the tumbling SV was successfully accomplished without difficulty using RCS-2, and vehicle stability was maintained through the start of the deboost sequence.

3.2.4 Corrective Action

The RCS propellant plan, which includes propellant cleanliness, tanking, and orbit utilization, implemented on SV-3 was successful in providing orbital life without a significant increase in fuel consumption for 22 days on RCS-1 and 24 days on RCS-2. However, the problem of REA valve leakage, caused by RCS tank diaphragm-generated non-volatile residues (NVRs), still exists. Action has been taken to

REACTION CONTROL SYSTEM USAGE SUMMARY

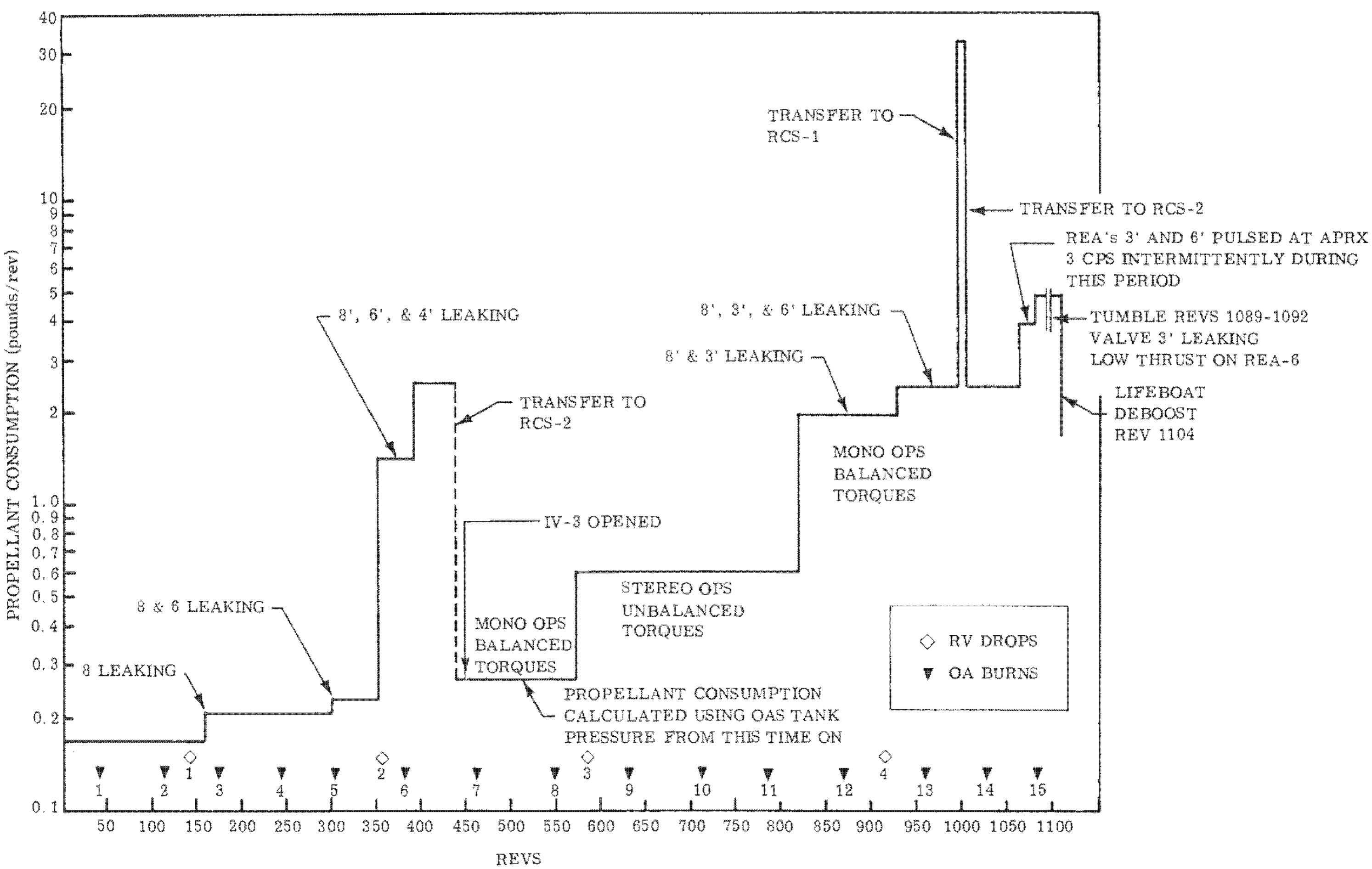


FIGURE 3-1

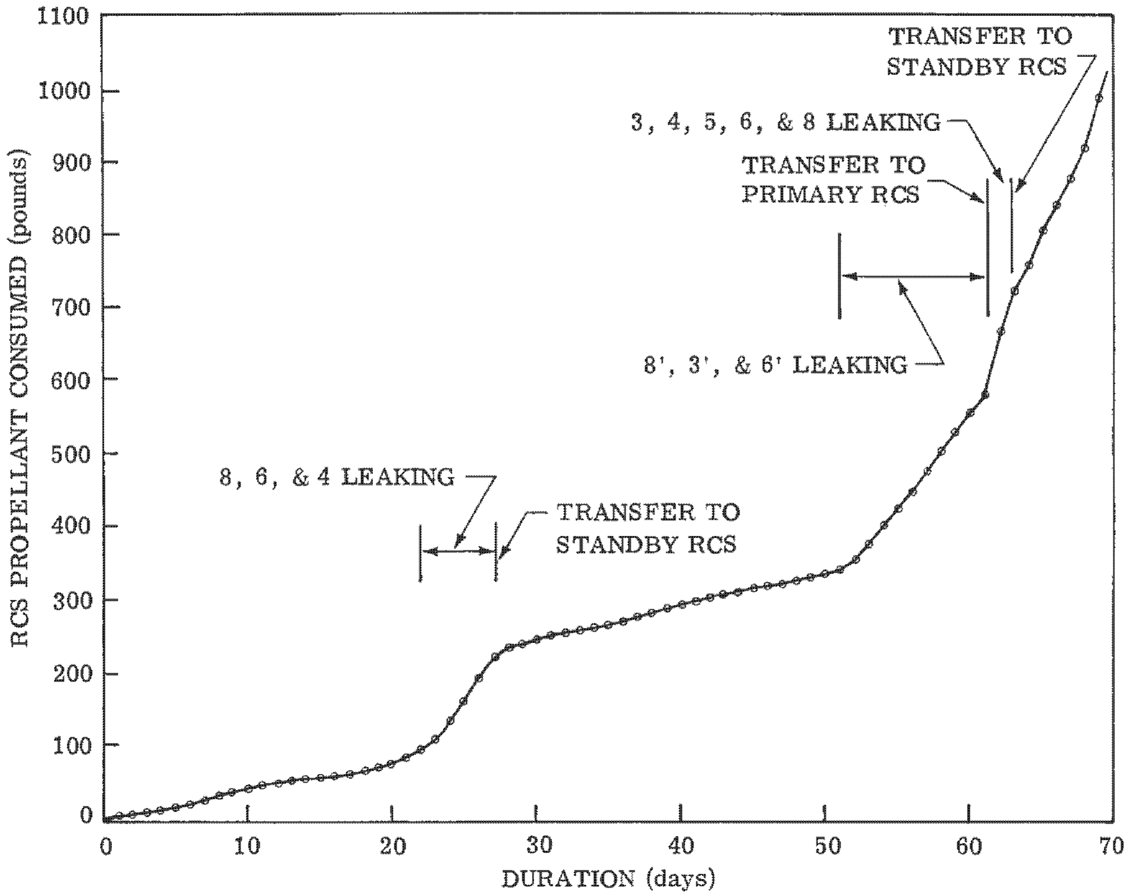
TABLE 3-6

FLIGHT SUMMARY OF REACTION CONTROL SYSTEM

Rev	Events	Average Propellant Usage (lb/rev)	OA Firings	RV Events	Pitch Maneuvers	Stereo Ops	Mono Ops 1 Bar	Mono Ops 2 Bar
0-174		0.17	2	1	2	147	-	-
175	REA-8 Leaking	0.22	REA-8 Temp Increased 100° to 460°.					
305	REA-6 Leaking	0.26	REA-6 Temp Increased to 800°.					
350	REA-4 Leaking		REA-4 Temp Increased to 900°.					
		1.40	3	1	2	104	-	-
395								
		2.50	1	-	-	22	-	-
428	Start Mono Ops		Mono Ops Utilizing Both OBs and One FT.					
		2.50	-	-	-			11
436	RCS-1 to RCS-2							
		0.27	2	-	-			116
574	Start Stereo Ops		Stereo Ops With Unbalanced Torques.					
		0.60	3	1	2	177	-	-
801	Start Mono Ops.		Mono Ops Utilizing One OB and One FT.					
		0.60	-	-	-	-	26	-
825	REA-8' Leaking		Increase Activity on Opposing REA and REM Mount Temp Rise. Veh Continuously Riding Pos Yaw Dead Band.					
		2.0	-	-	-	-	49	-
870	REA-3' Leaking		REA-3' Stopped Pulsing Although Reqd to Overcome Aero Torque.					
		2.0	1	-	-	-	16	-
905	REA-6' Leaking		REA-3' Started Pulsing at an Increased Rate. Veh Riding Pos Pitch Dead Band. Rem Mount Temp Increase.					
		2.5	1	1	2	-	9	-
990	RCS-2 to RCS-1	34 Decreasing to	An Immediate Increase in REA Temp Was Noted. REA-3, 4, 5, 6 & 8 are Leaking.					
998		12	-	-	-	-	-	-
999	RCS-1 to RCS-2							
		2.5	-	-	-	-	-	-
1060	REA-3' & 6' Leaking		It Was Noted that REA-3' Started Firing at Aprx 3 cps.					
		4.0	-	-	-	-	-	-
1089	Tumble		Immediately Prior to the Tumble, REA-3' Slowed its Pulse Rate And Then Stopped Pulsing. REA-6' Then Came on Steady State For 27 sec Causing the FDU to Close the Isolation Valves.					
		5.0	-	-	-	-	-	-
1092	RCS-2 → RCS-2		Tumbling Capture With RCS-2 Sequence Successful.					
		5.0						
1104	Lifeboat Deboost							

FIGURE 3-2

REACTION CONTROL SYSTEM PROPELLANT CONSUMPTION



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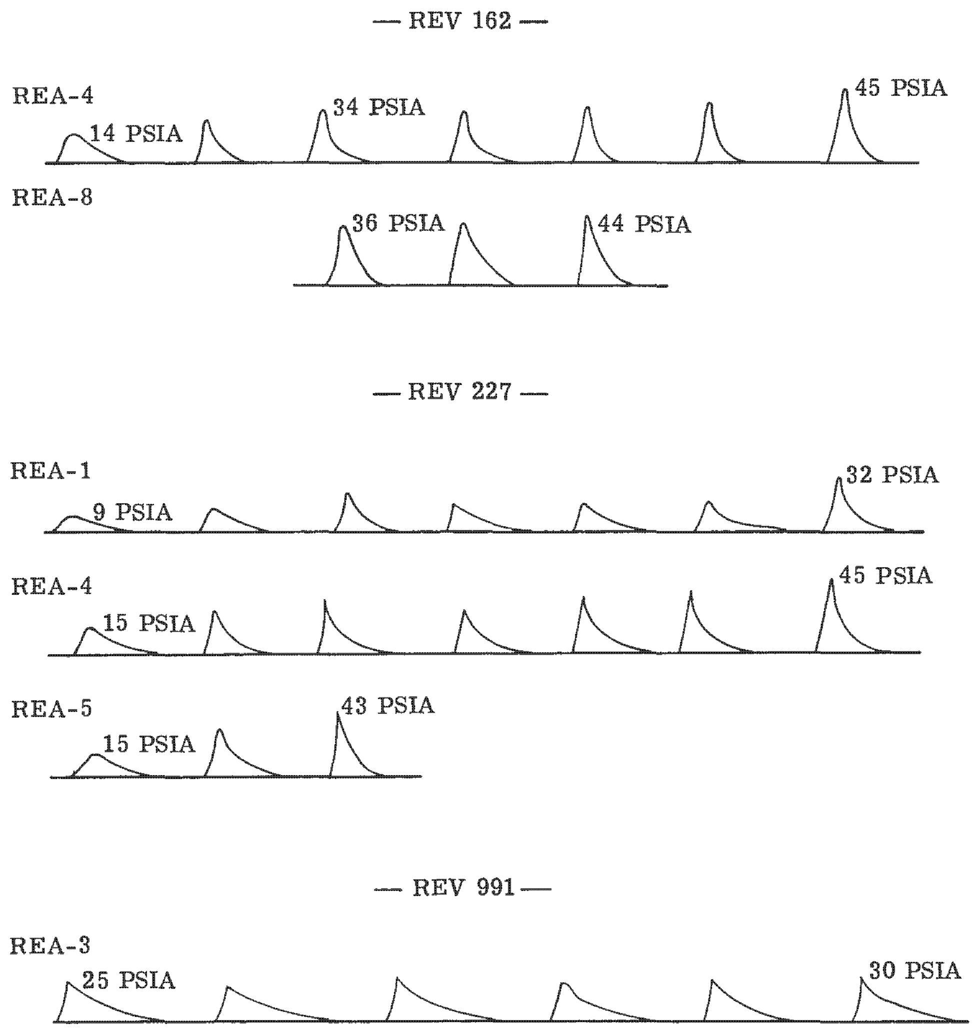
PRIMARY RCS PULSE SHAPE CHARACTERISTICS



NOTE: All pulse shape values are in pounds per square inch absolute (psia).

FIGURE 3-3

eliminate RCS Tanks 3 and 4 from the RCS-2 on 1204. This has been accomplished by cutting and capping the propellant lines to Tanks 3 and 4, thus leaving only the OAS tank to feed RCS-2. Therefore, the RCS-2 thrusters on SV-4 will not experience propellant with NVRs and should be less likely to leak. It should be noted, however, that the hard-seat valves which exist through SV-6 are much more susceptible to leakage than the soft-seat valves which will be on SV-7 and subsequent vehicles.

Recent ground tests simulating actual flight duty cycles on the RCS thrusters indicate a thruster catalyst bed degradation problem prior to 45 days of nominal usage. This problem has been masked by the valve leakage problems experienced on flights to date. Action is being taken to solve the bed degradation problem. Primary solutions being explored include the addition of heaters and a change in the hydrazine injection configuration. The latter constitutes a major redesign requiring retrofit. The effectiveness of any changes is unknown at this time. No changes are contemplated for SV-4 or SV-5.

3.3 ORBIT ADJUST SYSTEM (OAS)

3.3.1 Orbit Control

The OAS was utilized 12 times during the active 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. The OAS was successfully utilized three times during the Solo phase of the mission for drag makeup. See Table 3-8 for a summary of OAS performance.

3.3.2 Deboost

The final firing of the OA engine was for the Lifeboat II deboost on Rev 1104. The firing duration was 343.7 seconds to achieve a planned negative velocity increment of 150 feet/second.

3.4 LIFEBOAT II SYSTEM

3.4.1 Health Checks

The Lifeboat II data that was examined is summarized in Table 3-9. The magnetometer sensor data presented in Table 3-7 indicates equivalent attitude errors.

TABLE 3-7

MAGNETOMETER SENSOR DATA
(degrees)

Magnetometer	Attitude Error
Q	< .5
P	< .5
R	.7

The rates measured on the three Lifeboat II rate gyros were within .03 degrees/second of the rates measured on the ACS gyros.

TABLE 3-8

ORBITAL ADJUST SYSTEM PERFORMANCE

OA Firing No.	Rev Number	Impulse Delivered (lbs/sec)	Planned ΔV (feet/sec)	Achieved ΔV* (feet/sec)	Error ΔV (percent)
1	46	9900	16.18	16.24	.37
2	111	9555	15.45	15.73	1.78
3	176	11892	21.18	21.54	1.67
4	241	9616	17.20	17.33	.75
5	306	15929	28.52	28.82	1.04
6	387	12283	24.34	24.49	.61
7	468	19190	38.45	38.75	.77
8	549	12276	24.88	24.98	.40
9	629	13467	29.90	29.97	.23
10	712	16316	36.48	36.62	.38
11	793	13691	30.72	30.98	.84
12	874	18716	42.43	42.76	.77
13	955	14487	37.62	37.74	.32
14	1022	17996	46.10	47.14	2.25
15	1086	11291	30.59	30.98	1.26
Deboost	1104	54750	-150.00	-	-

*Determined from Best Fit Ephemeris data.

TABLE 3-9

LIFEBOAT II OPERATION

		Q Magnetometer (milligauss)		R Magnetometer (milligauss)		P Magnetometer (milligauss)		Y-Axis Gyro (degrees/second)	
Rev	Mode	Observed	Theoretical	Observed	Theoretical	Observed	Theoretical	Observed	Theoretical
18.3	S-N, DB	-20	-19.7	201	207	Not in use	-	-0.08	-0.068
	S-N, RV	-20	-18.4	Not in use	-	Negative Saturation	Negative Saturation		
	N-S, RV	-20	-18.2	Not in use	-	Negative Saturation	-		
132.3	N-S, RV	14	-	Not in use	-	Saturated and moves through null with pitch up		1.85	1.85
								1.70	1.73
586.3	N-S, RV	30.2	32	Not in use	-	204	203	-	-
927.3	N-S, RV	32	-	Not in use	-	Saturated and moves through null with pitch up		-	-
								X-Axis Gyro	
1104	-	-	-	-	-	-	-	0.40	0.41
								Z-Axis Gyro	
								1.09	1.08

3.4.2 Usage

The SV was successfully deboosted on Rev 1104 using Lifeboat II. The vehicle yawed around, pitched the nose up, and was stabilized in approximately 180 seconds after initiation of the deboost sequence at a SVT of 62272 seconds. The OA burn began 310 seconds after initiation and burned for 344 seconds. No significant perturbation was observed in either attitude or rate during the burn. The Lifeboat was reset 672 seconds after initiation. After an uncontrolled flight of 1102 seconds, Lifeboat was again activated to simulate a RV-5 drop at a SVT of 64047 seconds. At the time of execute initiation, very large attitude errors were observed together with X, Y, and Z rates of .48, .24, and -.32 degrees/second respectively. The vehicle again was stabilized in approximately 180 seconds. Tape recorder data was available until a SVT of 64433 seconds and showed no loss of control. However, the real time data starting at 64518 seconds indicated loss of control with large attitude errors and large X, Y, and Z rates. Control was not regained through the remainder of the operation. All data ceased at 64695 seconds. In summary, Lifeboat II parameters were within specification and no anomalies were noted.

3.5 ELECTRICAL DISTRIBUTION AND POWER SYSTEM (EDAP)

3.5.1 Solar Arrays

Solar Arrays were extended on Rev 1. Power output from each leg equaled or exceeded the specification value. Degradation for 60 days of flight was calculated from flight data to be 4.3%, which is within the specification of 5% for 30 days, even though high solar flare activity was encountered during flight mission. A left hand solar array erection anomaly is described in paragraph 3.9.

3.5.2 Main Bus Voltage

The main bus voltage varied from a low of 28.1 to a high of 31.8 volts. The acceptable range is 25.5 to 33 volts. Low voltage data was obtained just prior to sunrise with a bus load of 17±5 amps. High voltage data was gathered during the charge cycles.

3.5.3 Power Capability and Usage

Power usage ranged from 201 to 320 amp-hours/day. This is well below the 424 amp-hours/day capability. Excess capability was demonstrated by K2 charge relay cutoffs occuring on Rev 3 and essentially every rev thereafter except those with heavy payload operations.

All batteries operated in a desirable environment of 43° to 51°F, and performed normally throughout the mission.

Pyro Battery-1 stabilized at 48°F, thus minimizing self discharge to ~10% of launch capacity. Twenty 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. This left a cell degradation life of 67 days still available. Pyro Battery-2 followed the same pattern with the exception of being in the peroxide region until Day 44.

The Lifeboat battery operated normally in a 49°F environment throughout the mission. There were

155 amp-hours remaining from the initial capacity of 353 at the end of Mission 1203-4. Remaining cell degradation life was 67 days.

3.5.4 Amp-hour Meter Anomaly

The amp-hour unit operated improperly from launch through Rev 9. The output was not representative of the actual power used. The unit incremented and occasionally decremented in 10 or 15 amp-hour steps rather than 5 amp-hour steps. The unit returned to normal operation during Rev 9 and operated properly until Rev 780. From Rev 780 it started incrementing improperly, and continued in this condition until the end of the flight.

Failure analysis action has been directed to the supplier, Gulton Industries. The initial analysis indicates a resistor wired in series in the 18 volt power converter burned or shorted out allowing the voltage to rise to 24 volts. The short also forced the -5 volt output to increase to -6.6 volts creating faulty readings. The supplier will attempt to duplicate the failure in test to confirm the failure mechanism. No changes have been implemented in SV-4. There is no history of a failure of this kind in previous flights or ground tests. Because of the substantial power margin on SV-3, the malfunctioning of the amp-hour unit did not cause any operational difficulties.

3.6 TRACKING, TELEMETRY, AND COMMAND (TT&C) SYSTEMS

3.6.1 Tracking

The tracking accuracy for SV-3 was within the prescribed mission requirements.

3.6.2 Telemetry (TM)

TM system performance was satisfactory throughout the flight. A summary of usage through Rev 1104 is given in Table 3-10.

TABLE 3-10

SUMMARY OF TM USAGE THROUGH REV 1104

	Side 1	Side 2
Space Ground Link System (SGLS)		
Number of ON/OFF cycles	1,167	85
Operational Time (minutes)	7,185	572
Pulse Code Modulation (PCM)		
Total Operational Time (minutes)	19,391	286
Number of ON/OFF Cycles	7,690	92
Tape Recorder		
Number of ON/OFF cycles Record	6,523	7
Record Time (minutes)	11,756	164
Reproduce Time (minutes)	2,214	30
ON/OFF cycles Reproduce	853	7

3.6.3 Space Ground Link (SGLS) Performance

Down link signal strength fluctuations occurred. Dropout predictions were made by the Satellite Basic Assembly Contractor's (SBAC) Flight Support Team (FST) and were provided to the Government Test Control Team (TCT) 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, further experimentation with different station antenna polarizations (vertical, right hand, and 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.

The uplink operation error rate was well within specifications. The vehicle SGLS command equipment received approximately 9.5 million bits with only 4 anomalies being experienced.

3.6.4 Instrumentation

Instrumentation was successful during 1203, supporting all mission requirements. Table 3-11 lists the anomalous instrumentation which existed at lift-off.

TABLE 3-11

INSTRUMENTATION ANOMALIES AT LIFT-OFF

ID No.	Description	Status
A614	Bay 2 Internal Skin Temp 5	Reads Open
B052	Primary REA-2 Chamber Temp	Erratic & Unreliable

3.6.5 Command System

A summary of Command System usage through Rev 1104 is presented in Table 3-12.

TABLE 3-12

SUMMARY OF COMMAND SYSTEM USAGE THROUGH REV 1104

System	Total Operating Time (hours)
Extended Command System	1,656
Minimal Command System	25
Remote Decoder	6
Backup Decoder	25

The Extended Command System (ECS) responded satisfactorily in all command modes resulting in the loading of 120,896 Stored Program Commands (SPCs) in memory; of these, 79,477 were output by both programmable memory units (PMUs) for decoder processing. The remainder were erased prior to their time label matches. The accuracy of the ECS clock throughout the flight was determined to be .152 parts in 10^6. The clock oscillator frequency changed .072 Hz in 68 days.

The Minimal Command System (MCS) responded correctly to all commands. A clock test was performed during Solo operations, and the accuracy of the clock was .205 parts in 10^5.

Both sides of the Remote/Backup Decoder were utilized for each of the four recoveries. Performance of both sides was determined to be acceptable through analysis of TM data.

3.6.6 375 MHz Receiver

The 375 MHz Receiver was powered during the entire mission. It was used with no resultant anomalies during the MCS clock rate experiment.

3.6.7 Data Interface Unit (DIU)

The DIU performed satisfactorily throughout the flight. The operation counter accurately processed 13,860 counts on the Forward, and 12,841 counts on the Aft side.

3.7 THERMAL CONTROL

3.7.1 Forward and Mid-sections

The Forward and Mid-section structural temperature control is summarized in Table 3-13. The data indicates that the Forward and Mid-section thermal design provided good control of payload temperature levels. The results of the flight performance indicate that no design changes are required.

TABLE 3-13

FORWARD AND MID-SECTION TEMPERATURES FOLLOWING INITIAL TRANSIENT

(°F)

Parameter	Design Limits	SV-3 Actuals
$\bar{T}_{FWD}$	47/93	78/82
$\bar{T}_{TCA}$	48/92	72
$\bar{T}_{FWD} - \bar{T}_{TCA}$	< 20	6/10
$\bar{T}_{SU}$	49/91	74
$\bar{T}_{SU} - \bar{T}_{TCA}$	6/-4	2

NOTE: The following are definitions of these parameters:

1. $\bar{T}_{FWD}$ - Average radiation temperature of the Forward-section derived from the average bulkhead temperature.
2. $\bar{T}_{TCA}$ - Average radiation temperature of the Forward compartment structure in the Mid-section.
3. $\bar{T}_{SU}$ - Average radiation temperature of the Aft compartment structure in the Mid-section.

The Active Thermal Control System (ATCS) performed normally throughout the primary mission. $\overline{T}_{REF}$, which represents the average Mid-section film path temperature, varied between 69° and 73°F during the mission but was usually between 71° and 73°F.

The RV heater zones which are actively controlled relative to $\overline{T}_{REF}$ were generally within 1°F of $\overline{T}_{REF}$ indicating adequate performance of the ATCS.

3.7.2 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 33° at launch to 34° at deboost. A summary of critical temperatures is shown in Table 3-14.

The temperature level of the Aft-section was about 10°F above nominal predictions due to an external vehicle contamination problem which occurred during launch. This is considered to be the same contamination problem which occurred on 1201 and 1202. The contamination event was identified as the Solid Rocket Motor (SRM) staging from the special contamination experiments.

3.8 CONTAMINATION EXPERIMENTS

3.8.1 Description

Additional contamination experiments were flown on 1203 to measure two distinct contamination environments. The first group of experiments, installed on Bays 5 and 11 of the Aft-section, were designed to (1) measure the ascent contamination in terms of mass deposit at locations 180° apart, and (2) the effect of this mass deposit on the surface properties of white silicone paint and Flexible Optical Solar Reflector (FOSR), see Figure 3-4. Note that the blow-off shield was again used, as it was on SV-2, to isolate the effects of the ground lift-off cloud. Note also that the Quartz Crystal Microbalances (QCM) have a mass rate channel added for this flight to help interpret the readings of the mass channel. A proposed one bay model of a fiberglass cloth contamination shield was to be flown on Bay 12. However, this experiment was deleted after wind tunnel tests indicated mechanical deficiencies in the cloth shield design. The second set of experiments were installed on the Forward bulkhead at Station 1642 as shown in Figure 3-5. The devices were designed to (1) monitor the mass deposit produced by the RV spin motors, and (2) to assess the effect of this mass deposit on the surface properties of black and white silicone paints and aluminized Kapton. These are the thermal control surfaces to be used on the Mapping Camera Module (MCM) on SV-5 and subsequent vehicles.

The stationary calorimeter panel is used as a reference, while the movable panel is exposed to the RV spin motor plumes and then flipped up for comparison with the stationary panel.

3.8.2 Results

3.8.2.1 Aft-section

Ascent TM data showed that the blow-off cover came off properly between 9 and 10 seconds

TABLE 3-14

AFT-SECTION CRITICAL COMPONENT TEMPERATURES

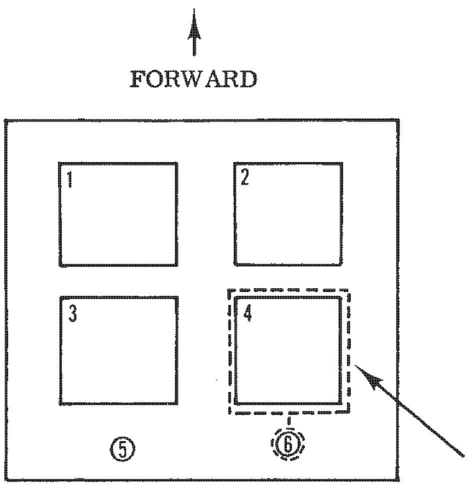
(°F)

Critical Component	Design Limits	SV-3 Actuals[1]
— EDAP —		
PDJB	-30/170	55/58
CCCs	-30/170	74/86
Batteries, Bay 3	35/70	44/47
Batteries, Bay 1	35/70	46/49
PDAs	-30/160	-[2]
Solar Arrays	-125/225	-68/145
— ACS —		
IRA	50/130	108/116
HSA Heads	0/130	62/86
FCEA	-30/160	99/106
— OAS —		
Tank	65/100	79/93
Quad Valve	35/200	109/111[3]
Catalyst Bed	-	123/151[3]
— T&T —		
Tape Recorders	20/130	87/105
Transmitters	-30/170	86/108
PCM Master	-30/170	96/115
PCM Remote, Bay 2	-30/170	48/58
PCM Remote, Bay 10	-30/170	101/110
— COMMAND —		
PMU-A	-40/145	102/106
PMU-B	-40/145	111/116
Clock	-40/153	113/116
MCS	-40/149	93/101
— RCS —		
Tanks	40/140	67/99
REM Valves	≥45	85/182
Plumbing, Bay 12	35/140	76/96

NOTES: [1] Stabilized orbital operation (most equipment 70° to 90°F at lift-off) does not include temperature excursions during engineering tests.
[2] Instrumentation deleted on SV-3.
[3] Data with OA engine not firing.

8003 AFT-SECTION CONTAMINATION EXPERIMENTS

— BAY 11 EXPERIMENTS —



1 - NOT USED.

2 - FOSR EXPOSED.

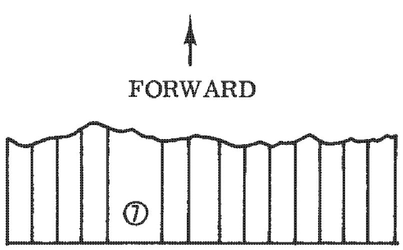
3 - WHITE SILICONE PAINT EXPOSED.

4 - WHITE SILICONE PAINT WITH PROTECTION THROUGH LIFT-OFF.

5 - QCM EXPOSED.

6 - QCM WITH PROTECTION THROUGH LIFT-OFF.

— BAY 5 EXPERIMENT —



7 - QCM EXPOSED.

FIGURE 3-4

PERFORMANCE EVALUATION TEAM
REPORT NO. 1203/72

STATION 1642 CONTAMINATION EXPERIMENTS

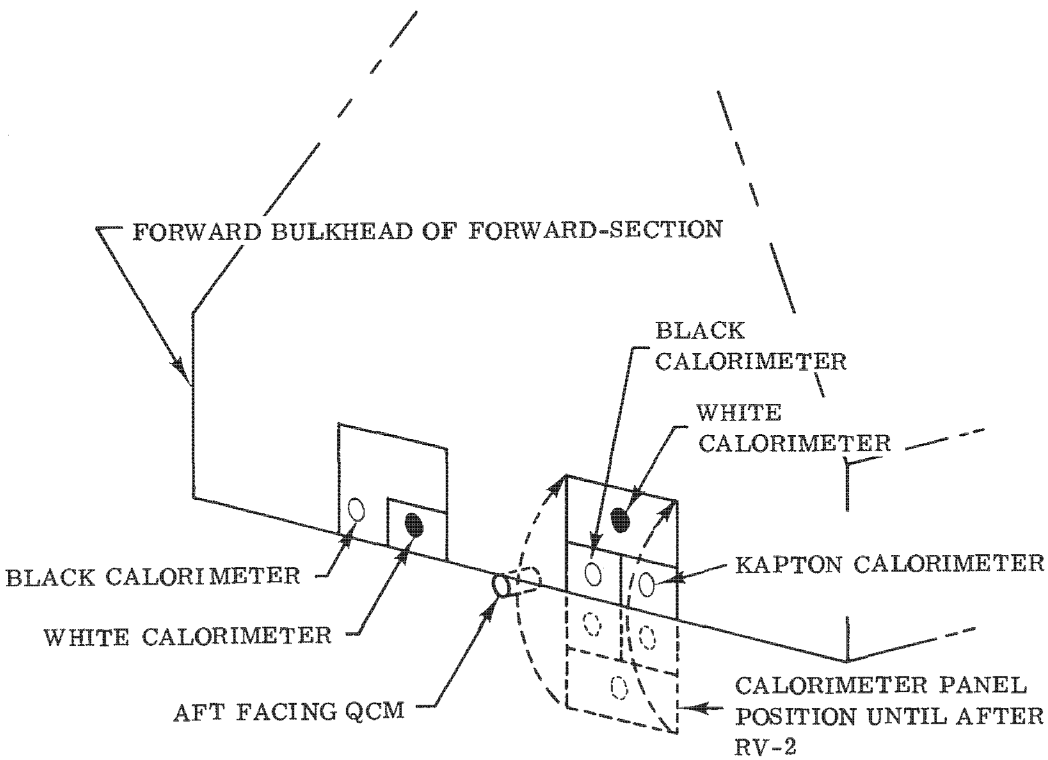


FIGURE 3-5

after lift-off. Orbital temperature data for the three calorimeters indicating the apparent solar absorptivity (α) is presented in Table 3-15.

TABLE 3-15

ORBITAL DATA INDICATIONS OF SOLAR ABSORPTIVITY

Orbital Condition	Calorimeter	Solar Absorptivity
Exposed Throughout Ascent	White Silicone	.42
	FOSR	.23
Exposed After Lift-off	White Silicone	.40

The nominal, uncontaminated α for white silicone and FOSR is .18 and .14, respectively.

The mass deposition measured during ascent by the three Aft-section QCM confirms SV-2 data which indicated SRM staging as the event producing the Aft-section contamination.

3.8.2.2 Station 1642

The spin-up event for the first RV caused negligible change in the mass deposition level measured by the Station 1642 QCM. Therefore, it was decided to wait until after RV-2 was released to flip the exposed calorimeter panel up to its readout position adjacent to the fixed reference calorimeter panel. The RV-2 spin-up produced a very slight increase in measured mass deposit and the calorimeter panel was flipped. After the exposed calorimeter panel was flipped up, the temperature cycling of the white and black calorimeters were compared directly with their counterparts on the fixed reference panel. Results of this experiment are given in Table 3-16.

TABLE 3-16

CALORIMETER TEMPERATURES

(°F)

Calorimeter	Maximum	Minimum	Orbit Average
Exposed White	13	-62	-23
Reference White	12	-59	-22
Exposed Black	163	-53	47
Reference Black	146	-59	41

3.8.3 Conclusions

3.8.3.1 Aft-section

The QCM protected from the lift-off cloud showed less deposit than the Bay 11 exposed QCM, but the Bay 5 exposed QCM showed even less deposition both at lift-off and at SRM staging. It may be concluded that the lift-off deposition does not appear to be uniform around the circumference of the Aft-section. Similarly, the deposition at SRM staging is not circumferentially uniform, but is more nearly so than the lift-off deposition. Although the nonuniformity of the measured deposition is academically interesting, the basic information provided by the Aft-section QCM confirms the conclusion reached on SV-2 that the SRM staging event causes significant contamination of the Aft-section surfaces. The calorimeter data agrees with the QCM data in that the white silicone sample protected from the lift-off cloud showed slightly less degradation than the white silicone sample exposed through ascent. As on SV-2, the FOSR sample suffered less degradation than the white silicone. This characteristic plus the inherent resistance of FOSR to ultraviolet degradation is sufficient justification to rapidly proceed to substitute FOSR for white silicone paint on future vehicles. It should be noted that deletion of the silver paint from the BV insulation pad had no appreciable effect on the SV contamination.

3.8.3.2 Station 1642

In view of the fact that very little mass deposit was recorded on the Station 1642 QCM during the spin-up of the first two RVs, it was expected that the exposed calorimeters would show very little degradation. The orbital temperature comparisons between the exposed and reference calorimeters verified this.

The conclusions from the Station 1642 experiment are that the MCM thermal control surfaces will not be appreciably degraded by the RV spin-up events, and that the present thermal design is adequate.

3.8.4 Action for Subsequent Vehicles

The MCM thermal design will not be significantly affected by the RV spin motor contamination; hence, no changes to the MCM paint pattern is indicated and no further experiments are planned.

The approach to a solution of the ascent contamination has been considerably affected by two factors. The first is the failure of the proposed fiberglass cloth Aft-section shield in wind tunnel testing. This failure indicated that a different shielding concept is required to accomplish the complete protection of the Aft-section surfaces during ascent. The second factor is that the relatively narrow beta range imposed on SV-2 and SV-3 would cause less mission impact for the next few flights provided the beta range could be shifted to bracket zero (noon launch). Feasibility studies show that the latter objective can be met in the presence of ascent contamination by relocating equipment away from the hot bays (11, 12, and 1). In particular, relocating the Type 29 Batteries to Bays 10 and 3 will allow a launch window around noon. In addition, the incorporation of FOSR in lieu of white silicone paint should allow an even wider launch window. Detailed thermal analysis of the battery installation into Bays 10 and 3, as well as FOSR implementation efforts, are in progress.

At this time, the plan for subsequent vehicles is as follows:

A. 1204

1. Fly the same as 1203 which includes batteries in Bays 1 and 3, and the beta angle restricted to approximately 25 to 35 degrees.

2. Fly FOSR on a standard corrugated Bay 12 door to verify proper orbital performance.

B. 1205 and 1206

1. Move batteries to Bays 10 and 3 and shift beta angle range to approximately 5 to -10 degrees.

2. Assuming successful demonstration of FOSR performance on SV-4, substitute FOSR for white silicone paint on most Aft-section external surfaces.

3.9 SOLAR ARRAY ERECTION ANOMALY

The erection and deployment time histories are shown in Figure 3-6 for the left (-Y) solar array and in Figure 3-7 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 required during the basic mission. Positioning to the standard positions of $\pm 18°$ and 0° were accomplished on both arrays during the Solo mission.

The times for deployment of the arrays were similar to those for SV-1 and SV-2. The times from the start to completion of erection were also similar; however, the left array delayed 1338 seconds before starting to erect as compared to the expected delay of 70 to 156 seconds. The delay was attributed to an interference in the erection release mechanism. The suspected interference was simulated in the laboratory and did prevent the mast from erecting; however, a small force was then sufficient to initiate the mast erection. The fitting has been redesigned to prevent a recurrence of this anomaly on subsequent SVs.

The right array has taken longer to deploy than the left array on SV-1 through SV-3. One possible explanation is that the sun heats the left array more quickly after sunrise for the beta angles flown by these vehicles, and the warmer array deploys in less time. The longer time, in itself, is not significant. Study of this phenomenon is continuing.

LEFT HAND SOLAR ARRAY ERECTION AND DEPLOYMENT TIME HISTORIES

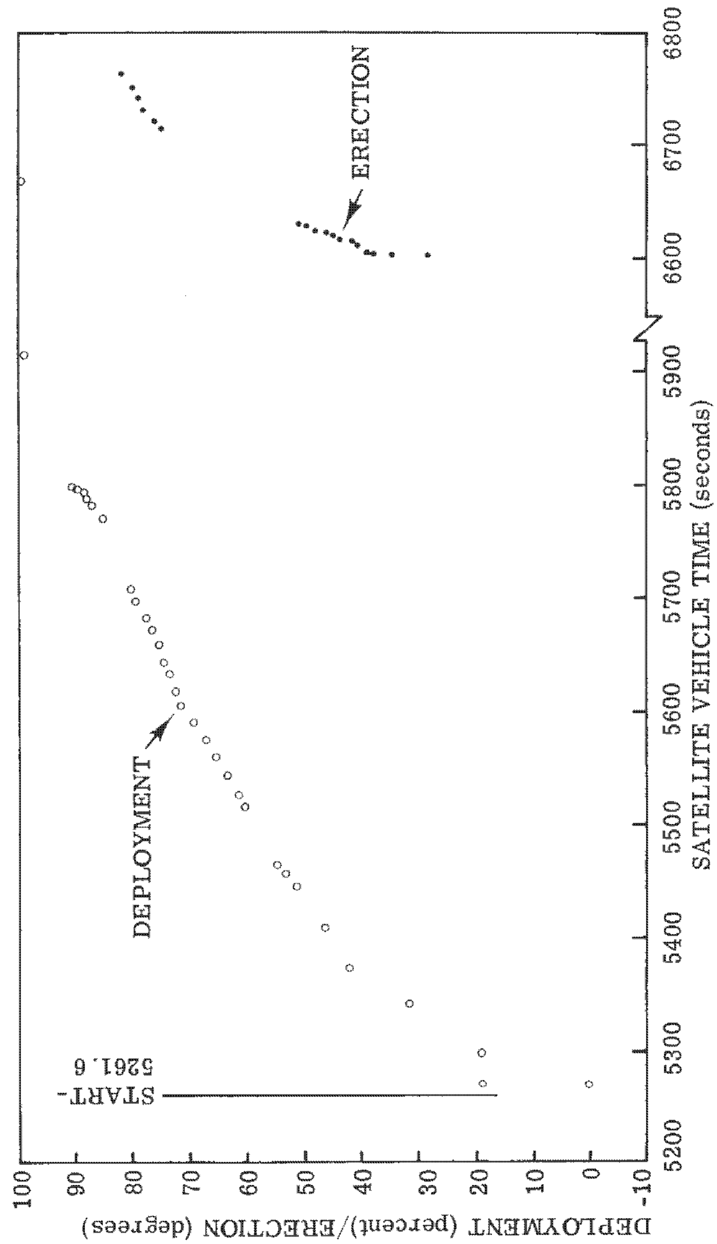


FIGURE 3-6

RIGHT HAND SOLAR ARRAY ERECTION AND DEPLOYMENT TIME HISTORIES

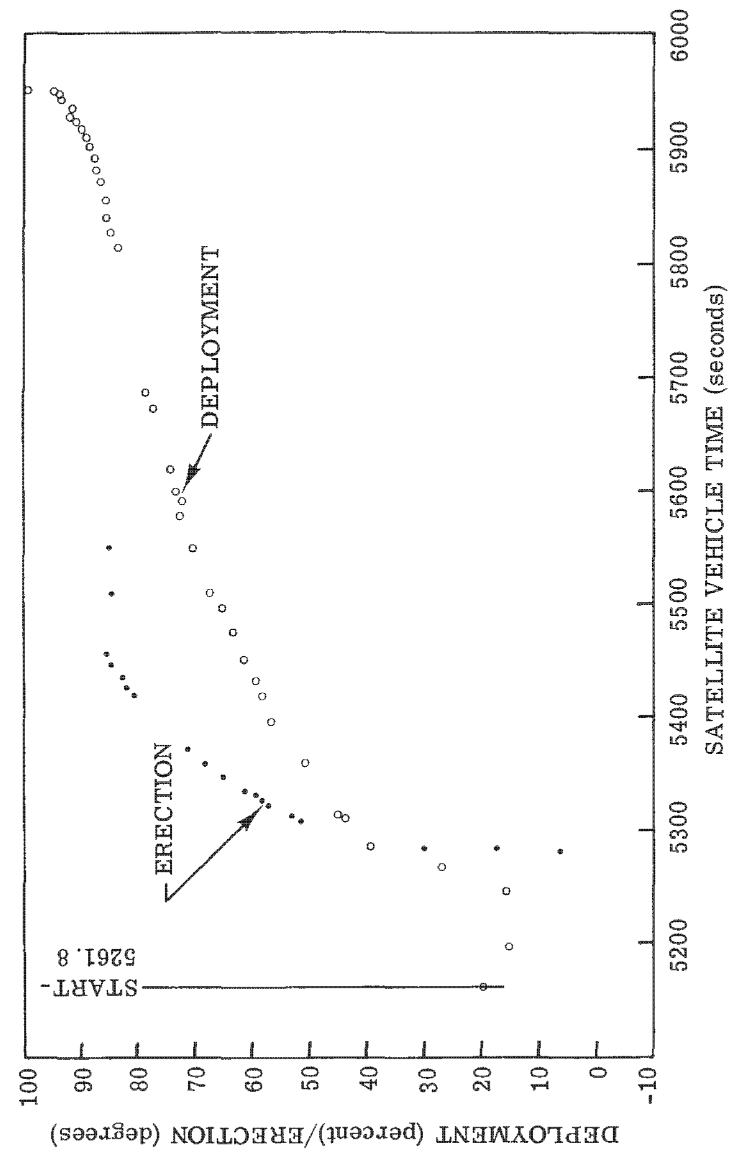


FIGURE 3-7

Payloads

IV

SECTION IV

PAYLOADS

4.1 SENSOR SUBSYSTEM

4.1.1 Camera Operations and Performance

Mission 1203, the third flight of the HEXAGON system, is classified as a qualified success. While the general camera performance was acceptable, there were two significant operational problems that affected the overall performance. The first problem was the occurrence of a fold in the Aft Camera film after Op 320 at the initiation of rewind. This problem caused stereo operations on Mission Segment 1203-3 to be discontinued after Op 340. Since the Aft Camera fold was being generated in the 1203-3 Take-up, Aft Camera operations were resumed on 1203-4, which resulted in no further folding on this camera.

The second problem was another film fold which occurred on the Forward Camera during Op 563. This fold initiated during rewind. As this fold occurred during 1203-4, stereo operations were not ceased until the Take-up was nearly full.

Mission 1203 provided poorer overall image quality than previous missions. The altitude of 1203 was approximately 15 percent higher than 1202, while virtually the same percentage of photography was acquired at high scan angles from both missions. The relatively high altitude, time of year, haze levels, early launch time, and specular reflection conditions, in combination with the large percentage of area covered at high scan angles are considered to be the major causes of this comparatively poorer overall quality.

Table 4-1 represents the percentage of United States Intelligence Board (USIB) targets against which 90% clear photographic coverage has been obtained from Missions 1201-1203 to satisfy three month surveillance of target clusters, six month area search, and twelve month area search.

TABLE 4-1

RESPONSE TO USIB REQUIREMENTS

Area	3 Months	6 Months	12 Months
China	69	75	95
Eastern Europe	69	92	95
Mongolia	100	92	95
North Korea	92	99	N/A
North Vietnam	100	95	N/A
Mid East	96	98	N/A
USSR	97	89	83

4.1.2 Constraint/Event History

As a result of the film fold anomalies, a number of constraints were levied on camera operations and engineering tests. These constraints were established to determine sensor health status, minimize the potential for failure propagation, and maximize the exposed film return. The SS constraint/event history is summarized in Table 4-2.

TABLE 4-2

SENSOR SUBSYSTEM CONSTRAINT/EVENT HISTORY

Rev	Constraint/Event	Reason
346	Limited Max Rewind to 15 ips for 120° - 30° Scan Combinations	Disturbances Noted in Film Path (120° Scan Followed by 30° are most severe).
364	ESD, Aft Camera	Continued Disturbances Following Large Rewind.
371	Constant Velocity Test	Clear Film Path of Material at ESD.
372	Constrain Rewind to 15 ips	Eliminate Tracking Disturbance After Large Rewind.
395	Constrain Scans to 60° and 90° Only	Eliminate Most Severe Potential For Mistracking.
411	Suspend Operations	Investigate Potential Aft Foldover.
428	Mono Forward Ops Only, Constrain Rewind to 55 ips at All Scan Angles, No Negative Centers	Avoid Possible Failure Running Aft Material While Folded.
455-552	Creep Aft Camera Once Per Day	Keep New Film in Path to Avoid Excessive Wear in Anyone Spot and Preclude the Film From Taking a Set.
567/570	Prep 1A (Modified)/Prep 2	Preparations for Recovery of RV-3.
573	Resume Stereo Ops in RV-4, but Constrain 5 ips Only at 60° Scans and 0° Center	Conservative Restart With Most Favorable Conditions (No Folds Apparent, Ops Normal).
600	Stereo MOP To Evaluate 20 ips Rewind Constraint	No Disturbance Noted.
620	Keep Constraint Removed	Open Ops to 60° Scans at Any Center.
622	Raised Max Rewind to 20 ips	
625	Stereo MOP to Evaluate 90° Scan	Successful.
634	Stereo MOP to Evaluate 35 ips Constraint	Successful.
639	Modified Constraints to 60° and 90° Scans Only, All Centers, and 35 ips Max Rewind	Conservative Systematic Relaxation of Operating Modes.
649	Stereo MOP to Evaluate 52 ips Rewind	Disturbance Noted.
655	Constrained Rewind to 5 ips Only	Conservative " Safe" Condition While Re-evaluating Ops at Higher Rewinds.

TABLE 4-2 (CONT'D)

SENSOR SUBSYSTEM CONSTRAINT/EVENT HISTORY

Rev	Constraint/Event	Reason
671	Reset Max Rewind to 20 ips. Added 30° Scans at All Centers Except ±45°	Small Disturbances Also Found at 35 ips. Evaluation Indicated 30° Scans Acceptable; but No 120° or ±45° Centers.
719	ESD, Forward Camera	Major Disturbances During Rewind.
728	Creep Tests, Forward Camera	Re-establish Film Path Integrity.
730	Constant Velocity, Forward Camera	Clear Path of Disturbed Material.
731	Stereo Confidence MOP	Verify Proper Performance.
734	Reduced Rewind to 5 ips Only, Eliminated 90° Scans	Eliminate Modes That Have Most Disturbance Potential.
740	Constrain Stereo Ops to Minimum Length of 20 Frames, Nominal	Clear Path Between Start-Stop Transients.
801	Normal Ops Modified to Aft Mono With Stereo by Exception	Fold In Forward Material Apparent by accelerated Radius Buildup. Aft Mono Required to Maximize Use of Aft Material.
852	Forward Builder Roller Did Not Restore After Rewind	Possible Bind in Normal Rewind Raise/Lower.
860	Creep Tests, Forward Camera	Verify Operation Capability.
861	Forward Camera, MOP	Restore Builder Roller.
866	Implement Shutdown by Buft for Stereo Ops Only.	Eliminate Rewinds When Forward Camera runs.
	Eliminated Pneumatics to Forward Camera During Mono Aft Ops	Save Gas.

4.1.3 Camera Data

The camera data for 1203 is summarized in Table 4-3.

TABLE 4-3

CAMERA STATISTICS

Parameter	Forward Camera	Aft Camera
Camera Designation	A	B
Film	1414	1414
Focal Length (inches)	59.973	59.978
Equivalent Filter Type	W-12	W-2E
Initial Focus Setting* (μ)	84	118
Supply Footage (feet)	103,170	107,728
Supply Spool No.	1951	1941

TABLE 4-3 (CONT'D)

CAMERA STATISTICS

Parameter	Forward Camera	Aft Camera
Supply Film Weight (lbs)	810.9	843.8
Optical Set Nos.	016	022
Initial Pneumatics (lbs)	17.05	17.05
Remaining Pneumatics (lbs)	1.8	1.1

*Focus was changed once on both cameras.

4.1.4 Focus

As was the case with the first segment of Missions 1201 and 1202, 1203-1 was flown slightly out-of-focus. Immediate post flight analysis at BRIDGEHEAD of the thru focus engineering runs from 1203-1 resulted in a decision to change focus +8 microns on the Forward Camera and -8 microns on the Aft. The PI suitability ratings indicated that a greater percentage of the targets from 1203-2 were rated good after the focus changes.

VEM and line focus data was obtained on 1203-2. The Aft Camera data from these analyses indicated that the in-flight focus adjustment was correct. However, the VEM data for the Forward Camera indicated that focus needed to be adjusted by -4 to -8 microns, while the line focus data showed that the initial flight setting was correct. In any event, the VEM data indicated that there was no significant difference in overall quality between the two focus positions.

The LSFS on Mission 1203 agreed with the final settings, indicating that a -8 micron adjustment was necessary on the Forward Camera and a +8 micron adjustment on the Aft Camera.

Mission 1203 was the first of the HEXAGON missions for which flight focus was initially set to within the established ± 8 micron budget. However, investigations are continuing on improving the preflight focus settings. The A-2 collimation chamber has been modified to provide for focus data at any field position by tilting the vehicle. In addition, the A-2 collimators are being modified to allow for absolute determination of their effective focus.

4.1.5 Photographic Image Quality

The photographic performance of both Mission 1203 cameras was acceptable. The Forward Camera performance analysis was based on major axis profile analysis and the results were as expected and essentially to specification. A similar evaluation of the Aft Camera performance concluded that it was of lower quality than the Forward. The results also indicated that the Aft Camera was lower in quality than that predicted during preflight testing.

The Forward Camera data clearly shows losses in resolution at the beginning of scan (-60 to -40 degrees). The performance of the Aft Camera was even more anomalous. Preflight testing led to the prediction that the 0° field major axis profiles of the Aft Camera would be essentially constant. However, the measured performance indicates a decreasing level of camera resolution with increasing scan angle from the center of scan. This observation is true for the 60° and 120° scan sectors measured. This problem is manifest with the acquisitions measured at all scan centers with 60° scan sectors. These problems were not expected, nor can they currently be explained. Additional analysis is under way in an attempt to pinpoint the cause of this resolution degradation.

Analysis of the combined VEM data indicates that the mean area weighted 2:1 contrast ground resolved distance for Mission 1203 was: 3.0 feet between ± 30° of scan; 6.6 feet for acquisitions beyond 30° of scan; and 8.6 feet for acquisitions beyond 45° of scan. Based on the 2:1 contrast VEM data the Grand Area Weighted Average Resolution for Mission 1203 was 5.1 feet. For the average intelligence targets, the Grand Area Weighted Average Resolution is estimated to have been 6.9 feet. This compares with similar estimates of 5.1 feet and 5.0 feet for 1202 and 1201 respectively.

4.1.6 Exposure

Overall, the analysis of this mission showed fewer exposure anomalies than the two previous missions. A reduced exposure time (two-slit bias) was included in the initial exposure recommendation on the basis of the exposure analysis made for Mission 1201. This reduction in exposure had an adverse effect on the shadow detail for this mission, and the two-slit bias was removed beginning with Op 182. Mission 1203 was the first mission to include an exposure correction for desert areas. Analysis of the imagery of these areas confirmed the desirability of this correction.

A special investigation was performed on images affected by specular reflections that resulted in "bloomed" imagery. Another investigation was made on scene radiance with a sand surround. The results of this investigation substantiated the exposure changes implemented in 1203.

4.1.7 Coarse Film Path Tracking Anomalies

The ESDs experienced on the Forward and Aft Cameras while operating into TU-3 and TU-4 are understood. Information available from flight diagnostics and observations on the recovered Take-ups was adequate to reconstruct the sequence of events after a fold had been generated. During rewind, the film that had spilled to one side of the Take-up was displaced laterally until it contacted the edge of the roller support structure, climbed the support, and folded over upon itself. This fold was carried back over other rollers toward the Supply during the remainder of the rewind. On the next forward operation the fold was captured at some roller in a stable situation so that it continued in further operations.

Tracking tests on several test beds have led to tentative conclusions regarding builder roller misalignments and film thickness variations in an effort to determine the limits of these parameters as they relate to film spillage on the TU. Actions have been initiated to limit the causal factors and increase the confidence in flight vehicles starting with 1205. The operations of 1204 have been constrained to avoid difficulties similar to those which caused the tracking failure on 1203.

4.1.8 Fine Film Path Tracking Anomalies

The Aft Camera fine film path exhibited tracking disturbances throughout the mission. The film wander in some instances was so significant that it precluded the imaging of the SVT word and scan angle marks on that edge of the film. There were also instances of edge rubbing, but no major damage or deformation of the film was noted. These fine film path disturbances do not appear to be related to the coarse film path anomalies; however, the cause is not understood at this time. The missing scan angle marks resulted in difficulty in accomplishing mensuration requirements.

4.1.9 Command and Control

Sensor subsystem performance was nominal with respect to command and control throughout the mission. All ESDs experienced were attributed to the previously discussed film path anomalies. All instrumentation was operational throughout the mission.

4.1.10 On-Orbit Performance Assessments

The PFA Team convened at the processing site (BRIDGEHEAD) after recovery of each re-entry vehicle to evaluate performance of the camera system from the imagery and telemetry. During the course of the PFA activities on RV-1, actions were taken to improve photographic quality. These actions are summarized in Table 4-4.

TABLE 4-4

ACTIONS TAKEN TO IMPROVE IMAGE QUALITY

A. Forward Camera

Rev 166, the focus position was retreated by 8 microns to a new platen position of 92 microns.

B. Aft Camera

Rev 166, the focus position was advanced by 8 microns to a new platen position of 110 microns.

C. Both Cameras

Rev 184, the two-slit bias reduction in exposure time was removed.

D. Photographic Processing

1203-3 and 1203-4, a modified dual gamma process was used on the product from both cameras. The purpose was to improve the highlight detail.

4.1.11 Exploitation Suitability

The overall PI suitability of the imagery from 1203 was fair and not as good as 1201 or 1202. From a photointerpreter's point of view the factors which had an inhibiting influence on interpretation of the imagery were:

A. Loss of shadow detail during 1203-1.

B. Blooming of the highlights on 1203-1 and 1203-2.

C. Mono operations on the majority of 1203-3.

D. The smaller scale photography of 1203 as compared to 1202.

E. The haze and specular reflection characteristics of summer missions.

Mission 1203 demonstrates the beneficial interpretability effects to be gained when the entire acquisition/processing/reproduction process is monitored and changed as necessary throughout the mission operation. This is apparent in correlating the PI suitability ratings of each bucket with the changes in camera operation and processing techniques, see paragraph 6. 1. The effects of the focus adjustment and increased exposure on 1203-2, and the improvement in highlight detail utilizing the modified dual gamma process on 1203-3 are apparent.

The MIPs for the mission ranged from 127 on 1203-1 Aft to 143 on 1203-4 Aft.

A mean of the MIPs for each mission indicates that 1203 is the lowest to date (1201 - 137, 1202 - 150, and 1203 - 135). It should be understood that the MIP value is intended to be indicative of the best photography acquired by the camera system within each mission segment, and is not intended to be representative of the mission's overall image quality.

There is no doubt that scale, obliquity, and haze on high scan angle imagery affect interpretation. High scan angle photography does not generally fulfill the PI's target requirements, nor is it as useful as imagery acquired near nadir. NPIC uses it primarily for search purposes, but has also obtained some intelligence from individual targets when no other coverage is available.

4.1.12 Processing and Reproduction

Defilming operations were slowed by tangled, creased, and damaged film on the Take-ups in all four buckets. Over 95% of the frames in the first three buckets were completely and accurately titled by the Optical Titling System. The percentages were much lower on 1203-4 (87.0% Forward and 83.4% Aft) because of the extensive occurrence of high edge fog and damaged film which hampered framemark detection.

The standard dual gamma process was used on 1203-1 and 1203-2. However, this process was modified for the last two segments to aid in compensating for the poor highlight detail that was evident in 1203-1 and 1203-2. This change resulted in less blooming and improved highlight detail.

Other aspects of original negative processing, breakdown/compositing, and reproduction were accomplished without incident. The duplication requirements on 1203-4 were satisfied by BRIDGEHEAD rather than the usual division of work between BRIDGEHEAD and AFSPPF.

NPIC analysis showed that there is no significant difference between the BRIDGEHEAD and AFSPPF second generation duplicate positive copies in terms of resolution, granularity, or tone reproduction

4.2 SURVIVABILITY SYSTEM

[redacted]

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

4.3 SUBSATELLITE

A Subsatellite System weighing 445 lbs was mounted on the left (-Y) side of the SV Forward and successfully carried into orbit. The separation sequence was loaded on Rev 12. After a yaw left maneuver of 25° by the SV the subsatellite was separated on Rev 13.5 at 0° latitude on the descending node. All subsatellite separation events were within desired tolerances and a nominal orbit was achieved by the subsatellite. The real time reset command to remove power from the interface was executed on Rev 14 during the POGO pass.

4.4 STELLAR TERRAIN SUBSYSTEM

There was no Stellar Terrain Subsystem flown on 1203.

Reentry Vehicles

SECTION V

RE-ENTRY VEHICLE SUMMARY

5.1 SUMMARY

As a result of the parachute damage which occurred on 1201, "quick fix" changes were made to the parachutes for 1202. A more permanent fix to the parachute, consisting primarily of heavier cloth material, was incorporated into all SV-3 RVs prior to flight. Deployment altitude was kept at 40,000 feet until additional flight experience is obtained. The improved parachute design resulted in a satisfactory performance, and all four re-entry vehicles were successfully recovered aerially.

Increased ablator thickness was incorporated into the heat shields beginning with this flight due to the greater than anticipated erosion noted on the heat shields recovered from SV-1 and SV-2. Portions of the heat shields from all four segments of 1203 were recovered, and no problems were noted.

Heat protection was added to the heat shield pyro lines to provide additional protection during re-entry. No problems were experienced on this mission.

Two RVs from SV-2 had punctures in the Aft bulkhead in the area of the parachute swivel. Doubler plates were added in this area to all vehicles effective with SV-3. No problems were experienced on this flight.

All RV on-orbit functions were normal and all SV/RV interface functions were nominal. All RV subsystems performed satisfactorily with the exception of a delayed retro truss separation on RV-2. This malfunction had no detrimental effect on the re-entry. See paragraph 5.3 for further details. A summary of the performance of the four mission segments is given in Table 5-1. The last RV was recovered after 58 days in orbit, a record for satellite photo reconnaissance vehicles.

TABLE 5-1

1203 RV RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
RV Serial No.	16	15	14	13
Recovery Rev No.	132	359	586	927
Recovery Date	15 July 72	29 July 72	12 August 72	2 September 72
Payload Weight (lbs)				
Forward	216.2	215.0	155.5	179.9
Aft	218.1	217.0	26.7	228.7

TABLE 5-1 (CONT'D)

1203 RV RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
Nominal PIP Latitude	23.4 N	25.9 N	19.0 N	16.9 N
Impact Location Error				
In-Track (NM)	8.1 S	20.0 S	1.65 S	8.1 S
Cross-Track (NM)	1.9 W	2.2 E	.9 E	1.0 W
Recovery				
Altitude (feet)	12,700	10,500	12,300	11,700
Parachute Condition	No Damage	Minor Damage	No Damage	No Damage
Retrieval Pass	1	2	1	1
Payload Cond	Good	Good	Good	Good

NOTE: Impact location error is the Best Fit Ephemeris versus Test Report TWX.

The Aft Camera malfunctioned during RV-3 operation and was not operated during a portion of the mission. This resulted in a 58.2% unbalance at time of re-entry. The Aft Camera malfunction was corrected at the time of transfer to RV-4. The Forward Camera malfunctioned late in the mission, resulting in an 18.5% unbalance at time of separation. No problems were encountered with re-entry. The camera system malfunctions are discussed in paragraph 4.1

The core pins in the Forward and Aft Take-ups of RV-2 and the Forward Take-up of RV-4 were sheared, which resulted in the outer few layers of film despooling into the recovery capsule. The core pins were designed to prevent the Take-ups from rotating during retro thrust and re-entry. To date, the pins have sheared before the aerial recovery loads exceed the capability of the Beryllium Take-up shaft or the Take-up encoder. The data on recovery loads indicates that the design specifications on the core pin were probably exceeded, and that the core pin performed as designed. Analysis is continuing.

5.2 RE-ENTRY VEHICLE DYNAMICS

Roll-reversal during re-entry of all four RVs of this mission was similar to that encountered on SV-1 and SV-2. The phenomenon is not understood, but does not appear detrimental. The thermal blanket was removed from RV-1 prior to flight to further investigate this phenomenon. The only effect was to delay the roll-reversal to a 20,000 foot lower altitude. All other roll-reversal associated behavior remained unchanged. Analysis of this phenomenon is continuing.

5.3 RETRO TRUSS

Post flight review and analysis of the RV-2 telemetry and on-board tape recorder data revealed that the retro truss did not separate at the normal jettison time of approximately 175 seconds. Analysis indicated that all command and pyro functions did occur at programmed times. Pitch, yaw, and roll data showed differences beginning at this time from other SV-3 data and from previous SV-1 and SV-2 data. Mathematical reconstruction of RV performance with a retro truss attached shows excellent correlation with the actual flight data. A second "glitch" occurs in the data trace corresponding to an altitude of approximately 323,000 feet (346 seconds after separation). At this point the pitch, yaw, and roll acceleration began to return to values normally seen on the other flights, and to values predicted for performance with the retro truss off. The delayed truss separation is attributed to minor interference of the separating elements. The Midwest Contractor (MWC) has initiated corrective action to preclude a recurrence. The delayed truss separation had no subsequent effect on the recovery.

5.4 IMPACT PREDICTION ACCURACY

Figure 5-1 is a plot of actual versus the predicted impact point for the first twelve recovery vehicles (Missions 1201, 1202, and 1203).

RECOVERY VEHICLE IMPACT AREAS

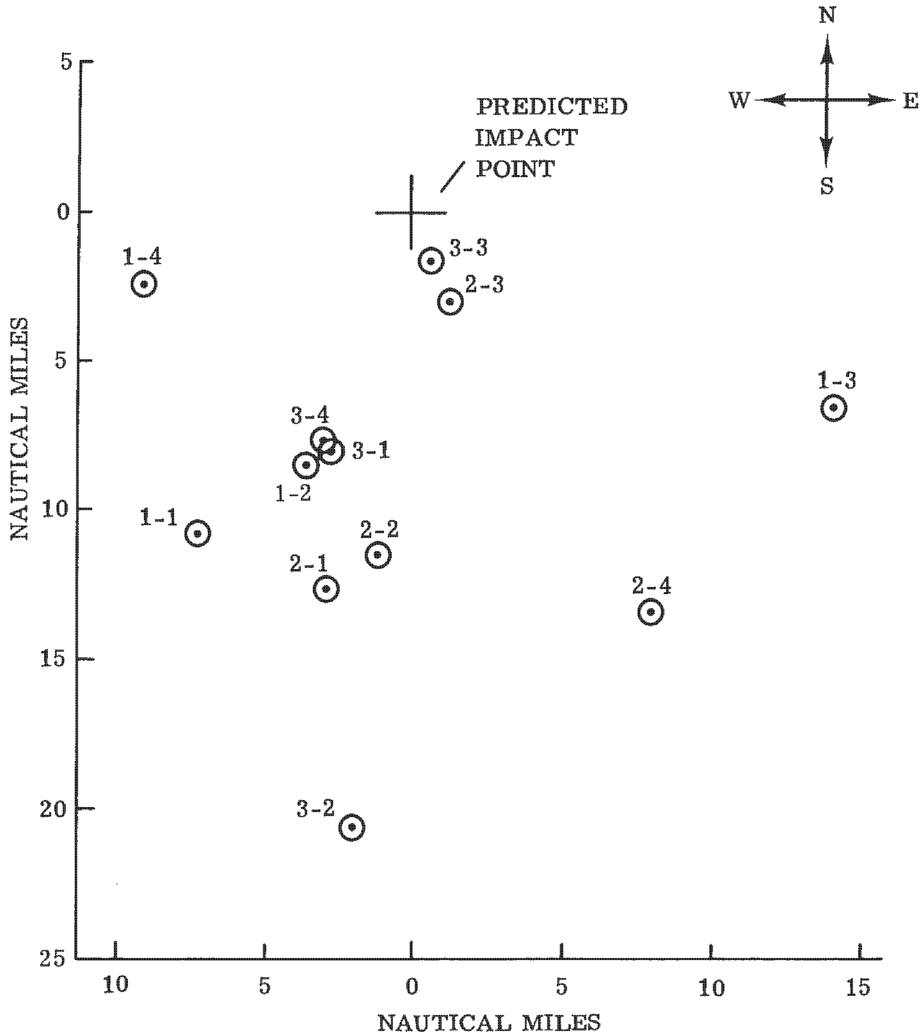


FIGURE 5-1

Operational Support

VI

SECTION VI

OPERATIONAL SUPPORT

6.1 SOFTWARE

The software configuration used to support Mission 1203 was 'TUNITY MOD 1A (updated FOC) with STAGEN, TELPRO, and TWURT modules providing greater flexibility. AOES/System II configuration was MODEL 13.1C. A nominal two per rev load cycle was used during the mission, except for a successful two day test of the one per rev load cycle. A total of 591 command messages were generated of which 544 were loaded into the vehicle. Six 'TUNITY software problems which were considered flight critical were corrected during the mission. The flight critical Software Problem Reports (SPRs) are summarized below.

6.1.1 SPR M1A-3089 ('TINCO)

The Mission Performance Report (MPR) was unable to process an operation which had a DIU frame counter recycle in the midst of an operation with a Vx/h update near this recycle. The LMODE Program was used on 1201 and 1202 to strip the frame counter and time data from the Bird Buffer Retrieval Tape (BBRT). After comparing this data with the 'TFRTFIX output to insure that times were identical, the DIU count was changed to eliminate the recycle. These data cards were then used to process the rev that contained the recycle. A new program modification to 'TINCO was delivered to correct the problem prior to the next recycle.

6.1.2 SPR M1A-3090 ('TFIELD)

The daily operating constraints displayed by 'TBALL were being affected by running it in the ACC mode. The extra camera-on time for reset rewind was not being carried forward when the 'TLITAB was rewritten in the ACC mode. The 'TBALL time totals are used to determine if the operating constraints are being violated. Although the inaccuracy introduced by the error was small, it was determined to be flight critical and 'TFIELD was modified to prevent the rewriting of the 'TLITAB in the ACC mode.

6.1.3 SPR M1A-3095 ('TOREP)

The Rev 94 MPR output contained 16 frames for each OB and, at the end of the OB-B printout (Frame 016), Frame 016 for OB-A was printed again. This problem was flight critical because the data could not be used in this format. A change was made to 'TOREP correcting the problem, and it was incorporated on the flight Aux Master Tape.

6.1.4 SPR M1A-3096 ('TBALL)

As a result of an improper procedure in generating Message 680, an error was identified in 'TBALL which was caused by using the wrong penalty factor when an SE SELECT span was run in conjunction with an SE ACC span. The routine 'TCATCH was not applying the 'COPLOS penalty to the first rev of the SE SELECT span; instead, it was using 'COPWST, which caused a different selection. The problem was determined to be flight critical because optimum selection wasn't being accomplished whenever SE ACC was used in conjunction with SE SELECT. A change was made to 'TCATCH correcting the problem, and it was incorporated on the flight Aux Master Tape.

6.1.5 SPR M1A-3101 ('TOREP)

On Rev 125, the MPR output inserted data between Aft Frames 012 and 013. This data was information from Forward Frame 012 which had been previously reported. This problem was determined to be flight critical since the user was unable to process the MPR transmission. The solution was to initialize an index pointer which was being incorrectly set during ascending operations. This change was incorporated on the flight Aux Master Tape.

Although this problem appears to be very similar to SPR M1A-3095, it involved a new set of circumstances and both modifications are required.

6.1.6 SPR M1A-3110 ('TOREP)

The transmission tape output from the MPR contained meaningless data between two revs of valid data. No data was missing from the transmission tape and the System Output (SO) Tape and printer output were correct. A proper transmission tape was made from the SO Tape. The problem was determined to be flight critical and a change was made to 'TOREP correcting the problem. This change was incorporated on the flight Aux Master Tape.

6.2 SATELLITE CONTROL FACILITY (SCF)

The performance of the Satellite Control Facility (SCF) in support of the third HEXAGON mission was commendable. Equipment and operational problems were encountered but were solved without impact on the mission. Command message generation and transmissions as well as down link TM reception and processing were satisfactory to support the operation. SV-4 validation was conducted in parallel with mission operations during 1203-4 and Solo TM mode generation. Additionally, a one week exercise using 'TUNITY MOD 1B and MODEL 13.1E was conducted to evaluate SV-4 software.

6.2.1 Command Message Generation

The two per rev load cycle was employed using a base station pass (SP) message and an add-on [redacted] message every two revs in order to use the latest weather data. There were 591 (b)(1) (b)(3)
command messages generated for the operation, of which 8% were rejected. The message rejections were caused by violation of hardware constraints, changes in payload selections, non-standard commanding in response to anomalies, and from the complexity of the Solo experiments. The message generation, checking, altering, and transmission cycle supported Mission 1203 satisfactorily.

Appendix A – References

Appendix B – Glossary

APPENDIX A

REFERENCES

1. HEXAGON Program Preliminary Post Flight Report Flight No. 3. Technical advisory report, BIF-107W-17033-72, 27 September 1972. (~~S~~/H)

2. Flight Test Engineering Analysis Report for the HEXAGON Program Satellite Vehicle No. 3 LMSC Integrating Contractor. (~~TS~~/H)

3. Satellite Control Facility Operations Evaluation, October 1972. (~~S~~/H)

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APPENDIX B

GLOSSARY OF TERMS

ACC Mode	Software Option that Finds Areas of Intelligence Value for a Rev Span.
ACS	Attitude Control System.
AFSPPF	Air Force Special Projects Production Facility.
Aft	Aft-looking Camera, Camera B.
AIM	Aerial Image Modulation.
ANOVA	Analysis of Variance.
AOB	Air Order of Battle.
AOES/System II	General Purpose Satellite Flight Support Software at STC.
aprx	Approximately.
ARM	Attitude Reference Module.
AS	Aft-section.
ASE	Articulator Summed Error.
ATCS	Active Thermal Control System.
AUGIE	Acronym for Data Compression Technique Used for RTS to STC Data Transmission.
Aux Master	Auxiliary Master Tape. Contains HEXAGON Flight Support Software at STC.
AV	Aerospace Vehicle.
BBRT	Bird Buffer Retrieval Tape. Records at STC From Transmissions From RTS.
BFE	Best Fit Ephemeris.
BPI	Band of Peak Information.
BRIDGEHEAD/BH	Primary Film Processing and Immediate Post Flight Evaluation Facility.
BV	Booster Vehicle.
C-	Camera Power-off Command.
C+	Camera Power-on Command.
CCC	Charge Current Controller.
CEI	Contract End Item.
CG	Center of Gravity.
Chamber A	Photographic Vacuum Test Chamber Located at East Coast SSC Facility.
Chamber A-2	Photographic Vacuum Test Chamber Located at West Coast Facility.
c/mm	Cycles Per Millimeter.
COMIREX	USIB Committee on Imagery Requirements and Exploitation.
CORN	Controlled Range Network.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

CORREL	On-orbit Adjust Assembly Calibration Test Program.
cps	Cycles Per Second.
CRYSPER	On-orbit Performance Prediction Program Combining Target Acquisition, Atmospheric, Illumination, and Camera Performance Models.
CV	Constant Velocity.
CW	Continuous Wave.
DCSE	Drive Capstan Summed Error.
DFC	Defenses/Security.
DIM	Dynamic Image Motion.
DIU	Data Interface Unit.
D log E Curve	Sensitometric Response of Film to Light. Plot or Density to Log of Exposure.
DMAAC	Defense Mapping Agency Aerospace Center.
DMATC	Defense Mapping Agency Topographic Center.
DN	Duplicate Negative.
DP	Duplicate Positive.
DRAP	Pulse Code Modulation TM Data Retrieval and Analysis Program.
ECS	Extended Command System.
EDAP	Electrical Distribution and Power.
EEI	Essential Elements of Information.
ELC	Electronic.
EM	Electromechanical.
EMI	Electromagnetic Interference.
EOD	Electro-Optical Department.
ESD	Emergency Shutdown.
ESO	Emergency Shutdown Override.
EXSUBCOM	Exploitation Subcommittee of COMIREX.
EXTRFPLS	Focal Plane Position Transducer and LSFS Reading Extractor Program.
FAFNIR	Program that Locates CORN Deployed Targets and Edge Catalog Targets.
FAK	Forward Assembly Kit.
FBS	Film to Bar Synchronization.
FCEA	Flight Control Electronics Assembly.
FDU	Failure Detection Unit.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

FFL	Flange Focal Length.
FIDAP	Flash Image Displacement Analysis Program.
FOCMO	Thru Focus Motion Plot and Line Indicated Focus Program.
Forward/Fwd	Forward-looking Camera, Camera A.
FOSR	Flexible Optical Solar Reflector.
FP	Focal Plane.
FPA	Flight Profile Addendum.
FP-A	Focal Plane - Forward Camera.
FP-B	Focal Plane - Aft Camera.
FPP	Focal Plane Position.
fps	Feet Per Second.
FS	Forward-section.
FST	Flight Support Team.
FT	Film Transport.
FTF	Field Test Force.
FTFD	Field Test Force Director.
g	Gravity.
GMT/Z	Greenwich Mean Time.
GOB	Ground Order of Battle.
GRD	Ground Resolved Distance.
HBT	Horizontal Baseline Test.
HFLIP	Data Strip and Print Program.
HOPE	HEXAGON Operational Performance Estimated Report. Summarizes Key Performance Related TM Data for Mission Engineering Operations.
HS	Horizon Sensor.
HSA	Horizon Sensor Assembly.
HWT	Hardwire Tester.
Hz	Cycles Per Second (Hertz).
IAS	Imagery Analysis Service.
ICD	Interface Control Document.
ID	Input Drive Capstan.
IMC	Image Motion Compensation.
IOR	Interop Runout.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

ips	Inch(es) Per Second.
IR	Infrared.
IRA	Inertial Reference Assembly.
LBS	Lifeboat System.
LMODE	Off-Line Program That Extracts Camera Data From BBRT for MPR Generation.
LSFS	Lateral Separation Focus Sensor.
MAA	Mission Analysis Area.
MACFACT	Mission Accomplishment Factor Program. Used to Process Key Performance Related Electromechanical Data.
MC	Metering Capstan.
MCLR	Master Clear Off.
MCM	Mapping Camera Module.
MCRECON	TM Cross-Track Smear Estimate Program. Processes the Metering Capstan Summed Error Signal to Produce an Estimate of Film Motion and Absolute Smear Levels.
MCS	Minimal Command System.
MCSE	Metering Capstan Summed Error.
MES	Mission Evaluation Score.
MFA	Measurement Filter Assembly.
MI	Measure of Interpretability Rating Technique.
MIP	Mission Information Potential.
MIPOLPER	Program which Combines the Optical Transfer Function Program with the Performance Prediction Program.
MIS	Missile.
MMTF	Monochromatic Modulation Transfer Function.
MOD	Modification.
MONO	Monoscopic Operation.
MOP	Manual Operation.
MPR	Mission Performance Report.
MS	Mid-section.
MTF	Modulation Transfer Function.
MTF/AIM	Modulation Transfer Function/Aerial Image Modulation Intersection Point.
MWC	Midwest Contractor.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

NBS	National Bureau of Standards.
NCVU	Negative Constant Velocity Unit.
NEC	Northeast Contractor.
NISC	Naval Intelligence Support Center.
NM	Nautical Miles.
NOB	Naval Order of Battle.
NPIC	National Photographic Interpretation Center.
NSPC	Normal Stored Program Command.
NVR	Non-volatile Residue.
OA	Orbit Adjust.
OAK	NPIC Publication That Lists First Phase Exploitation Results.
OAS	Orbit Adjust System.
OB	Optical Bar or Order of Battle.
OD	Output Drive Capstan.
ON	Original Negative.
OP/Op	Camera System Operation.
OPD	Optical Path Differences.
OTD	Optical Technology Division.
OTF	Optical Transfer Function.
O^2A^2/OOAA	On-orbit Adjust Assembly.
P	X-axis Magnetometer Output.
PACS	Primary Attitude Control System.
PAS	Performance Assessment.
PBF	Plane of Best Focus.
PCA	Point of Closest Approach.
PCM	Pulse Code Modulation.
PDA	Positional Drive Assembly (Solar Array).
PDJB	Power Distribution J-Box.
PDS	Pneumatics Distribution System.
PDWN	Pitch Down.
PERFORM	Camera Resolution Performance Prediction Program.
PERSAP	TM Resolution Performance Prediction Program. Estimates Metering Capstan Telemetry and Measured Optical Performance.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

PFA	Post Flight Analysis.
PFALINES	Post Flight Analysis Line Program. Computes 2:1 Resolution Performance and Estimates Image Motion Amplitudes.
PGR	Pitch Gyro Rate.
PI	Photointerpreter.
PIP	Predicted Impact Point.
P/L	Payload.
PME	Photo Mode Summed Error.
P-mode	Photographic Mode.
PMTF	Polychromatic Modulation Transfer Function.
PMU	Programmable Memory Unit.
PN NEG (-)	Pneumatics-off.
PN PLUS (+)	Pneumatics-on.
PN/PNU	Pneumatics.
ppm	Pulse Per Minute.
PRF	Pulse Repetition Frequency.
PSD	Power Spectral Density.
psi	Pounds Per Square Inch.
psia	Pounds Per Square Inch Absolute.
PVA	Pitch Vehicle Attitude.
PW	Pulse Width.
Q	Y-axis Magnetometer Output.
QCM	Quartz Crystal Microbalances.
R	Z-axis Magnetometer Output.
RACS	Redundant Attitude Control System.
rad/sec	Radians Per Second.
RCS	Reaction Control System.
REA	Reaction Engine Assembly (Thruster).
REM	Reaction Engine Module.
REV	Orbital Revolution.
RGR	Roll Gyro Rate.
RMS	Root Mean Square.

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APPENDIX B (CONT'D)

GLOSSARY OF TERMS

RPS	Reserve Power System.
RTS	Remote Tracking Station.
RV	Re-entry Recovery Vehicle.
RVA	Roll Vehicle Attitude.
RVTS	Re-entry Vehicle Test Station.
RWC	Rewind Constant.
RWV	Rewind Velocity.
SAL	Scan Angle Length.
SALT	Strategic Arms Limitation Talks Image Quality Rating Technique.
SBA	Satellite Basic Assembly.
SBAC	Satellite Basic Assembly Contractor.
SBAMS	Satellite Basic Assembly Mid-section.
SC	Scan Center.
SCC	Subsystem Command and Control.
SCF	Satellite Control Facility.
SDV-3	Satellite Development Vehicle.
SECO	Stage II Engine Shutoff.
[redacted]	
SE Select	Software Option Which Selects Optimum Camera Op Sequence for a Rev Span.
Seq	Sequence.
SETS	System Engineering Technical Support.
SGLS	Space Ground Link System.
SLC-4E	Space Launch Complex-4 East.
SO Tape	System Output Tape at STC.
SOC	Satellite Operation Center.
SOF	Start of Frame.
Solo	System Engineering Test after Fourth RV Separation.
SPC	Stored Program Command.
SPEC	Specification.
SPL	Sound Pressure Level.
SPR	Software Problem Report.
SRM	Solid Rocket Motor.

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

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

SS	Sensor Subsystem.
SSC	Sensor Subsystem Contractor.
SSTC	Sensor Subsystem Test Console.
STC	Satellite Test Center.
SU	Supply Unit.
SURVEY	Quick-look Time and Data Characteristics Program.
SV	Satellite Vehicle.
SVACS	Satellite Vehicle Attitude Control System.
SVIC	Satellite Vehicle Integrating Contractor.
SVT	Satellite Vehicle Time.
SWT	Slit Width Tests.
SYNCER	FIDAP Subroutine for Determining Film Synchronization Error.
TCA	Two-Camera Assembly.
TCS	Thermal Control System.
TCT	Test Control Team.
TM	Telemetry.
TMOTION	Estimate of Image Smear Program for Laboratory Tests.
TOBACC	Time for OB Velocity Command.
TTC	Tracking, Telemetry, and Command.
TU	Take-up Unit.
TUA	Take-up Assembly.
TUNITY	Operations Program for Camera System Commands.
TVC	Thrust Vector Control.
USIB	United States Intelligence Board.
UTB	Ultra Thin Base Film.
VAFB	Vandenberg Air Force Base.
VBE	Variable Block Erase.
VBT	Vertical Baseline Test.
VCO	Voltage Control Oscillator.
VDP	Vehicle Disturbance Program.
VEM	Visual Edge Match.
VIS	Vertical Integration Stand.

APPENDIX B (CONT'D)

GLOSSARY OF TERMS

Vs	Coarse Film Path Velocity.
VSPC	Variable Stored Program Command.
Vx/h	Orbital Angular Rate, In-track.
Vy/h	Orbital Angular Rate, Cross-track.
WCFO	West Coast Field Office.
WCPO	West Coast Project Office.
YGR	Yaw Gyro Rate.
YVA	Yaw Vehicle Attitude.