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Performance Evaluation Team Report

MISSION 1206

DIRECTORATE OF SPECIAL PROJECTS
OFFICE OF THE SECRETARY OF THE AIR FORCE

BYE 15323-73

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PERFORMANCE EVALUATION TEAM

MISSION 1206

15 FEBRUARY 1974

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PUBLICATION REVIEW

This report has been reviewed and is approved.

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PERFORMANCE EVALUATION TEAM
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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 1206. Volume II is entitled, "Sensor Subsystem Post Flight Analysis Report," TCS 363515-73.

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

TABLE OF CONTENTS

SUMMARY

SECTION I

SUMMARY

1.1 INTRODUCTION

The sixth HEXAGON Satellite Vehicle (SV) was placed into the nominal 87.7 x 155.3 NM orbit by the Titan III D Booster on 13 July 1973. This was the second mission to carry the Mapping Camera Module and associated RV. Mission planning included a 45 day Mapping Camera mission, a 75 day Panoramic Camera mission, and 5 days of Solo operations. On the fourth day of the mission, the SV experienced a Primary Attitude Control System (PACS) anomaly which caused a yaw bias. Control was switched to the Redundant ACS (RACS) for the remainder of the mission. Except for 21 frames lost due to lack of a Stellar platen press operation, the Mapping Camera operated successfully throughout the mission with the film quality being rated as Very Good. All the Mapping Camera film, including 61 frames of IR, was exposed and transported into RV-5 which was aerially recovered on Rev 683. The Panoramic Camera operated throughout the mission, and its RVs were aerially recovered on Revs 310, 505, 926, and 1202. The overall image quality of the Panoramic Camera system was rated Good. All of the film was exposed and transported into the RVs, including 21,000' of SO-255 Color Film located in five separate segments on the Aft Camera and 500' of IR film on the Forward Camera. All Solo tests were successfully completed and the SV was deorbited on Rev 1471 (Day 92). A successful Vehicle Atmospheric Survivability Test (VAST) was performed to observe SV breakup characteristics.

MISSION OVERVIEW

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SECTION II

MISSION OVERVIEW

2.1 PREFLIGHT PLANNING

Mission 1206 was the second mission to carry the Mapping Camera Module, the associated Re-entry Vehicle (RV), and the Doppler Beacon.

A. Several actions were taken prior to launch to control problems encountered during previous missions and during factory testing: RCS Tanks 1, 3, and 4 were capped and the RCS Thrusters, both Primary and Redundant, were supplied directly from the Orbit Adjust (OA) Tank. The fuel in RCS Tank 2 was to be used as an emergency supply only, see Figure 2-1.

B. The ACS/RCS wiring was modified to permit cross-strapping without requiring turn off of the non-controlling ACS. The Primary ACS controlled the Primary RCS Thrusters at lift-off.

C. The RACS Inertial Reference Assembly (IRA) Torquer power supply was isolated from vehicle ground to prevent torquer shorts from inducing rate biases.

D. The following Block II hardware components were installed: (1) CUBIC Transponder (SGLS-2), (2) both PACS and RACS using ferrotic Inertial Reference Assemblies, and (3) 50 hour pyro batteries in the main Re-entry Vehicles (RVs 1-4) to provide a next day recovery capability after activation.

2.2 PREFLIGHT CONSTRAINTS

The Mission 1206 orbit was designed to:

A. Maintain solar (Beta) angle within +2° to -8° for the planned 75 days.

B. Have orbit adjusts occur on a two-day cycle with positive/negative OAs as needed to maintain argument of perigee between 120° and 140 degrees.

2.2.1 Panoramic Camera System Constraints

A. Rewind velocity limited to 5 inches/second.

B. No 30° scans at ±45° scan centers.

2.3 LAUNCH BASE

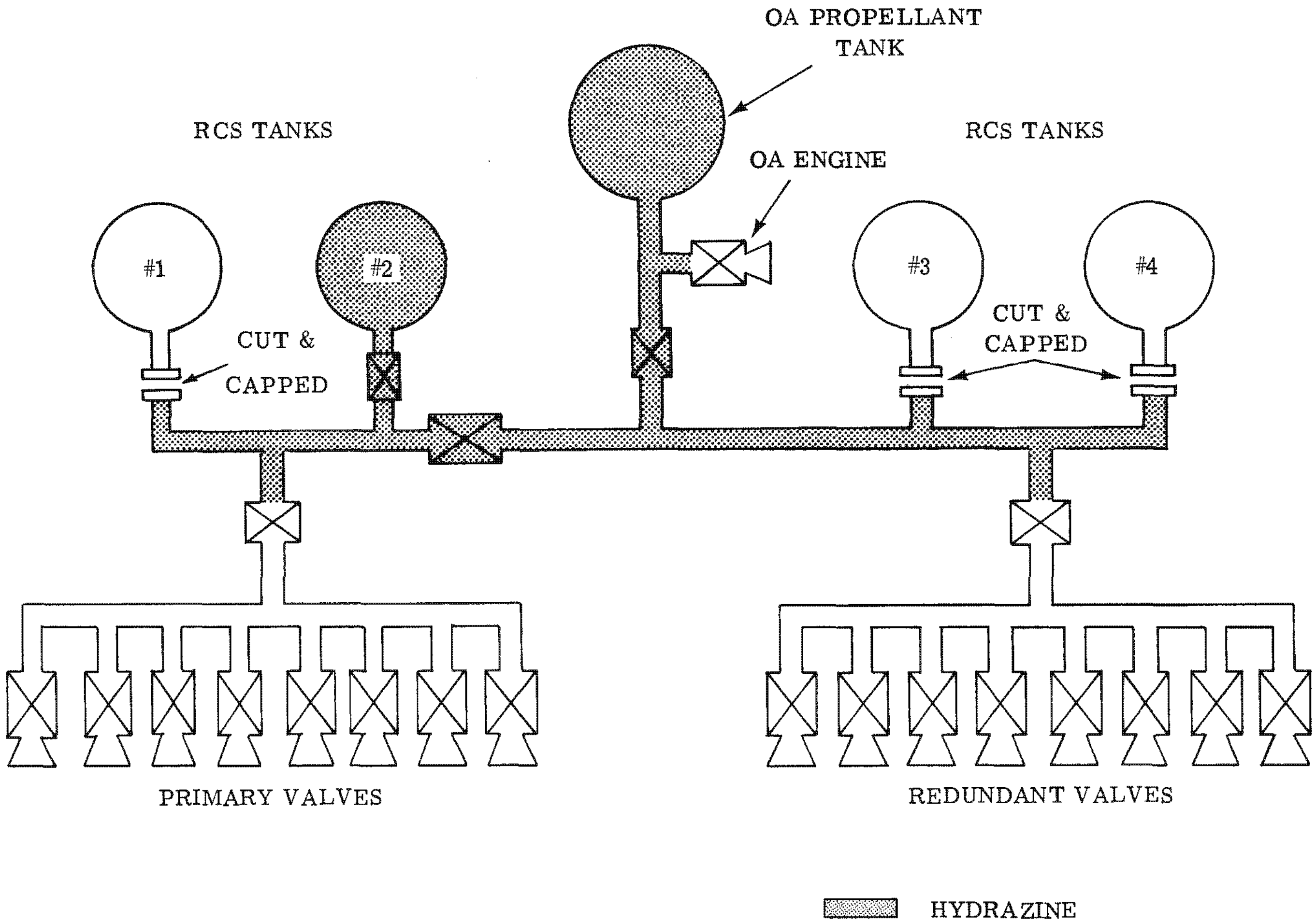
The Titan III D BV followed a normal prelaunch readiness cycle. The SV was delivered to the launch pad and mated to the BV without incident. The SV prelaunch activities were delayed one day by the replacement of the SGLS-1 Transponder. The vehicle was launched on 13 July 1973 at 1322 PDT near the opening of the launch window.

2.4 ASCENT

The BV successfully injected the SV into an 87.7 x 155.3 NM orbit. The achieved orbit was very close to nominal with the deviations shown as follows:

FIGURE 2-1

RCS/OA LIFT-OFF CONFIGURATION



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Apogee Altitude (NM)	-.25
Perigee Altitude (NM)	-.10
Period (second)	-.003
Eccentricity	-
Argument of Perigee (degrees)	.59

2.5 ORBIT AND RECOVERY

2.5.1 1206-1 (Twenty Days Duration)

Solar array deployment and subsystem health testing were completed as planned. Panoramic Camera mission operations were started with the Rev 5 command message and Stellar/Terrain (ST) operations on Rev 14 as scheduled. A yaw bias in ACS-1 developed on Rev 47 and control was transferred to ACS-2 on Rev 66. Increased torque on the Aft Camera optical bar was detected and camera sequences were modified to prevent a possible catastrophic failure by eliminating rewinds and nesting.

Approximately 28,700' of film per camera were exposed and stored in RV-1. Overall quality ranged from Very Good to Poor, with the majority rated as Good.

RV-1 was successfully re-entered and aerially recovered on Rev 310 (Day 21). The RV was loaded to 97.8% of capacity and the film load was balanced. No parachute or capsule damage was noted.

2.5.2 1206-2 (Eleven Days Duration)

As a result of the PFA evaluation on 1206-1, modifications to OOAA in-track and cross-track nominals and to the exposure parameters were made. Panoramic Camera mission photography continued without incident during the segment. The restrictions on rewind and nesting were removed on Rev 362 after the torque on the Aft Camera optical bar had decreased to a safe level. The overall photographic quality was rated Good to Poor with the majority rated as Fair. The lowering in quality is attributed to increased atmospheric haze. ACS-1 yaw bias remained in varying amounts during the segment. ACS-2 performance remained nominal. The orbit adjust (OA) plan was modified to a three-day cycle to save propellant and permit extending the mission to 90 days. Approximately 26,700' of film per camera, including 5,000' of color on the Aft Camera, were exposed and stored in RV-2. RV-2 was successfully re-entered and aerially recovered on Rev 505 (Day 32). The RV was loaded to 95.0% of capacity and 6.4% inbalanced. No parachute or capsule damage was noted.

2.5.3 1206-3 (Twenty-Six Days Duration)

Panoramic Camera mission photography continued without problem throughout this segment. The Aft Camera focal plane was changed for operation with color film as a result of PFA analysis of RV-2. Approximately 28,139' of black and white film were exposed by the Forward Camera, and 24,708' of film, including 10,000' of color in two segments, were exposed by the Aft Camera and stored in RV-3. The overall photographic quality was rated from Very Good to Poor with the majority rated as Good. The improvement in quality is attributed to the better atmosphere typical of the Fall season and to the fewer acquisitions at high obliquity. Degradation of thrust from Reaction Engine Assembly (REA) No. 4 was detected and mini-yaw maneuvers were conducted to permit measurement of thrust level. Performance of REA No. 4 remained satisfactory.

RV-3 recovery was planned for Rev 910 but was aborted on the recovery rev due to bad weather in the impact area. RV-3 was successfully re-entered and aerially recovered the next day on Rev 926. The RV was loaded to 96.4% of capacity and balanced. Two 3' to 6' tears in the parachute cone skirt were reported. No capsule damage was reported.

2.5.4 1206-4 (Seventeen Days Duration)

Panoramic Camera mission photography continued with only minor instrumentation problems throughout the segment. All available film for both cameras was expended. Approximately 25,935' of film, including 500' of IR were exposed by the Forward Camera and stored in RV-4; 22,214' of film, including 6,000' of color in two segments, were exposed by the Aft Camera and stored in RV-4. The overall black and white photographic quality was rated Very Good to Fair with the majority rated as Good. Again, it was felt that the better atmosphere was a major contributor to the improvement. The SO-255 Color Film quality ranged from Good to Poor.

The thrust level of REA Nos. 4 and 8 continued degrading but performance remained acceptable. RV-4 was successfully re-entered and aerially recovered on Rev 1202 (Day 75). The RV was loaded to 86.8% of capacity and unbalanced 5.9%. A large tear in the main parachute extended from the apex to the skirt. No capsule damage was reported.

2.5.5 1206-5 (Forty-Two Days Duration)

The Mapping Camera health test was executed normally on Rev 8 and photographic operations were started on Rev 14 as planned. The Doppler Beacon antenna was deployed properly and the beacon turned on prior to Rev 12 (Guam). Telemetry indicated intermittent operation of the Terrain Camera platen press on Rev 91. Subsequent testing suggested that the failure was a faulty telemetry switch. Operations were continued despite the problem. On Rev 137, the Stellar Camera platen press monitor became erratic. Switching to the redundant electronics resulted in no improvement.

K-value (Geomagnetic Radiation Index) reporting from Colorado and Alaska was in effect for the entire mapping mission to detect radiation conditions that might affect the Stellar film. No critical levels were detected during the mission nor was film fogging experienced. Operations were transferred to the IR film successfully on Rev 535 and the mapping mission completed on Rev 659.

A successful in-flight ST calibration with both the Terrain and Stellar Cameras photographing selected star fields was executed on Revs 666/667.

A total of 2,057 Terrain frames and 2,058 pairs of Stellar frames was exposed during the Mapping

Camera mission. The Stellar/Terrain RV was successfully re-entered and aerially recovered on Rev 683. No parachute or capsule damage was reported.

The quality of the acquired photography was Good with the average resolution slightly less than Mission 1205-5. Illumination geometry, weather, and the normal lens-to-lens variation are considered to be the primary reasons for the lower resolution.

The resolution of the IR film was lower than the normal Terrain film, however, the unique spectral characteristics provided added scene information.

2.6 SOLO TESTING

Non-interference Solo tests were started after completion of the mapping mission on Rev 683 and continued on a limited basis until 1206-4 recovery on Rev 1202 when formal Solo testing was started. The Solo test phase ended with the successful VAST deboost into Eniwetok lagoon on Rev 1471. A limited STC [redacted] The Solo experiment chronology is (b)(1)
shown in Table 2-1. All planned Solo testing was accomplished. (b)(3)

2.7 VEHICLE ATMOSPHERIC SURVIVABILITY TEST (VAST)

A VAST was conducted on Rev 1471 (Day 92). The purpose of this test was to observe the breakup and to attempt to impact surviving objects into Eniwetok lagoon for recovery. Data was obtained by TRAP and ARIA aircraft and the ARIS ship. Objects did land in the lagoon; however, none of the pieces were found in the subsequent water search. The search has been discontinued.

2.8 COMMAND LOAD SUMMARY

The software configuration used to support this mission was 'TUNITY MOD 2. The system software was MOD 13.1F. A nominal one rev load cycle for the payload revs was used throughout the mission. During the flight, a total of 1051 command messages were generated; 867 of these were loaded into the vehicle.

2.9 ANOMALY SUMMARY

Significant anomalies are listed chronologically in Table 2-2. The list includes a brief description of the anomaly and its effect on the mission. A more detailed discussion is provided in Section IV of this report.

TABLE 2-1

SOLO TEST CHRONOLOGY

Rev or Span	Test Description
Mission Segment 1206-3	
743	OPS-2(o) DBS Redundant Oscillator
745	OPS-2(p, q, r, s) ST Redundant Equipment
747	OPS-2(n) DBS Redundant Heater
760	ST-1 Evaluate Emergency Shutter Open DPS Off
777	ST-3 Verify Stellar Shutter Inhibit
858	ST-5 Verify Terrain Thermal Shutter Reset
926	RV-3 Recovery
Mission Segment 1206-4	
956-957	ST-5 Verify Terrain Thermal Shutter Reset
1132-1194	T&T-2 SGLS-2 PRN Modulation Test
1136-1138	ACS-2 Horizon Sensor Mapping
1154-1170	OPS-2(1) Redundant TCEA Test
1202	RV-4 Recovery. Full Solo Start.
Solo Test Operations	
1204-End	T&T-3 SGLS-2 Life Test
1204	OPS-2(m) SCC-1 Verification
1205	SS-3 OB Phase Lock Minus Test
1205	OPS-2(b) PCM 2, TPS 2, APS 2 Test
1209-1242	ACS-1A Ferrotic Gyro Start Test
1217	Yaw-Mini RCS-1 Evaluation
1222-1226	SS-1 SS Pneumatics Depletion
1222-1226	SS-2 OB Thermal Gradient
1244-1259	ACS-1B Ferrotic Gyro Start Test
1246-1250	SS-2 OB Thermal Gradient
1254-1258	SS-2 OB Thermal Gradient
1265-1403	T&T-1 Signal Strength Evaluation
1270	OPS-2(d) Backup Timer Test
1271-End	ACS-1C Ferrotic Gyro Start Test

TABLE 2-1 (CONT'D)

Rev or Span	Test Description	
Solo Test Operations (cont'd)		
1274-1284	RCS-1S Degraded Thruster Evaluation	
1281	Yaw-Mini RCS-1 Evaluation	
1285-1286	RCS-1B Degraded Thruster Evaluation	
1288-1393	RCS-1A Degraded Thruster Evaluation	
1291-1306	EDAP-1 Inertial Flight Characteristics	
1300	ST-6 ST Thermal Response - Extended Calibration	
1313-1315	OPS-4 MCS Recovery Message Test	
1317	[redacted]	(b)(1)
1330-1332	OPS-5 Recovery PCON Message Test	(b)(3)
1336	[redacted]	
1346	ST-3 Verify Stellar Shutter Inhibit	
1347	ST-2 Verify Stellar Capping Shutter	
1347	ST-4 Three Millisecond Exposure Test	
1347	ST-7 ST Data Quality - PCM 2	
1379	Yaw-Mini RCS-1 Evaluation	
1380-1393	EDAP-2 Inertial Flight Characteristics	
1423	DBS "ON" VAST Tracking	
1425	[redacted]	(b)(1)
1427	Yaw-Mini RCS-1 Evaluation	(b)(3)
1429	T&T-4 Signal Strength during Roll	
1441	[redacted]	
1443	Transfer to RCS-2	
1443	RCS-3 Thruster Performance - High Pressure	
1443	Yaw-Mini RCS Evaluation	
1444	PD-Mini RCS Evaluation	
1451	Fly Reverse - Pre-VAST	
1459	OPS-6 ST Operation after Extended OFF	
1464-1467	Solar Array Positioning	
1467	OPS-2(e) Aft Switch Bus to Lifeboat Battery	
1471	VAST-3 Vehicle Atmospheric Survivability Test	

TABLE 2-2

SUMMARY OF ANOMALIES

Day	Description	Impact
3	Primary ACS yaw bias was detected on Rev 47.	Control was transferred to the Redundant ACS on Rev 66.
3	Higher temperature on REA No. 8.	Indicated slight propellant leak. No effect on performance.
6	Terrain Camera Platen Press Monitor became intermittent.	Engineering MOPs showed normal operation. Operation in Backup Mode did not improve data. Analysis indicated monitor failure rather than functional failure of press. Mission continued.
9	Stellar Camera Platen Press Monitor failure.	Redundant electronics showed no improvement. Analysis indicated monitor failure. Mission continued.
4-22	Increase in Optical Bar B torque (Aft Camera).	Operations were restricted and sequences modified to prevent possible malfunction. One operation per rev, no rewind, no nested operations. Torque decreased and normal operations were resumed on Day 22.
33-91	Decreased thrust from Primary RCS Thrusters No. 4 and No. 8.	None. SV control remained within specifications. Pitch and yaw maneuver tests were conducted at intervals to measure thrust.

SATELLITE BASIC ASSEMBLY SUBSYSTEMS

SECTION III

SATELLITE BASIC ASSEMBLY SUBSYSTEMS

3.1 INTRODUCTION

The following paragraphs summarize the performance of the Satellite Basic Assembly (SBA) Subsystems that could be verified from flight data.

3.2 ATTITUDE CONTROL SYSTEM (ACS)

The ACS performed as expected during the mission except for the PACS yaw gyro rate bias anomaly.

3.2.1 BV/SV Separation

BV/SV separation was completed at approximately 543.5 seconds SVT. Vehicle time started 67.04 seconds prior to lift-off. Master clear-off (MCLR), which enables the pitch, roll, and yaw integrators to accumulate angle, was at 513.4 seconds and SECO, which terminates BV attitude control, occurred at 531.5 seconds 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 presents the times in which the SV attitudes and rates came back within the specified limits following BV/SV separation (capture).

3.2.2 Payload Operations

A PACS yaw gyro rate bias began on Rev 45 and resulted in roll and yaw attitude offsets of varying magnitude until control was transferred to RACS on Rev 66. The roll attitudes as measured with the Horizon Sensor (HS) and the yaw attitudes as calculated with the relationship below are tabulated in Table 3-2 for each SS Payload (P/L) operation.

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

where:

ψ_ϵ = Yaw attitude (degrees)

H_ϕ = Roll HS to Roll gain (.0055 sec^{-1})

H_ψ = Roll HS to Yaw gain (.01667 sec^{-1})

ω_o = Orbital rate (.0012 radian/second)

ω_z = Yaw gyro rate as observed on controlling ACS (degrees/second)

ψ_I = Yaw integrator output (degrees)

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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		Δ(SECO - SEPARATION)		ATTITUDE		RATE	
	Specified (deg/sec)	Actual (seconds)	Specified (degrees)	Actual (seconds)	Specified (degrees)	Actual[5] HS/Integrator	Specified[1] (degrees)	Actual[2] (seconds)	Specified[3] (deg/sec)	Actual[4] (seconds)
Pitch	±.752	-.131	13.0 to -21.7	2.88	±3.5	0.16/ 0.02	±.70		±.014	
Roll	±.786	-.241	±10.6	1.12	±3.5	1.28/ 0.91	±.70	SEE NOTE 6	±.021	SEE NOTE 6
Yaw	±.752	.087	11.1 to -11.4	-	4.5 to -3.5	-/ 1.65	±.64		±.014	

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.
[6] Nominal performance, indicating pointing requirements are satisfied, was observed at a nominal settling time of 520 seconds after the commanded switch to fine mode (663.3 seconds after separation). The total 1183.3 seconds is well within the spec of 1500 seconds and no closer study was performed.

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TABLE 3-2

PAYLOAD OPS DURING PERIOD OF YAW RATE BIAS

Rev	SS Payload Ops	Attitude (degrees) Pitch HS	Roll HS	Yaw[1]	Rate (degrees/second) Pitch[2]	Roll	Yaw
48	37	.0	.22	1.4	.0	-.011	.007
48	38	.06	.12	1.1	-.002	-.006	-.005
48	39	.08	.0	0.5	-.002	-.006	-.006
54	40	.08	.10	1.1	-.002	-.003	.007
55	41	.08	.14	1.3	-.001	.006	.007
56	42	.08	.10	0.9	-.002	-.007	.007
56	43	-.10	.20	0.9	-.003	-.012	.007
58	44	.10	.02	0.6	-.003	.007	.007
58	45	.08	-.02	0.3	-.002	.005	.004
58	46	.08	.02	0.7	-.003	-.006	.005
64	47	.08	-.06	0.3	-.002	.006	.007

NOTES: [1] Yaw attitude is calculated from yaw rate bias.

[2] The value shown here is the deviation from the average orbital pitch rate of -.068 degrees/second.

3.2.3 Mapping Camera Module (MCM) Operations

The SV behavior during the ST operations and the calibration maneuvers are discussed in this section. The Stellar/Terrain RV recovery is discussed in paragraph 3.2.4.

3.2.3.1 ST Operations

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

TABLE 3-3

STELLAR/TERRAIN OPS DURING PERIOD OF YAW RATE BIAS

Rev	ST+ (seconds)	ST- (seconds)	Attitude (degrees) Pitch	Roll	Yaw	Peak Rate (degrees/second) Pitch	Roll	Yaw
58	308997.8	309056.6	.10	.02	.6	-.070	-.002	-.001
58	309205.0	309312.6	.08	.04	.4	-.072	-.004	-.006
58	309359.8	309459.0	.08	.02	.7	-.072	.006	-.008
59	314691.0	314873.2	.08	.04	.8	-.071	-.005	-.001

3.2.3.2 MCM Calibration Maneuvers

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

Since no attitude measuring capability existed during the sequence at angles greater than ±10°, the attitude performance may be inferred only by noting that the entire sequence was executed as planned. The predicted pitch attitude at the final geocentric rate connect (196825.6 seconds) was -.4° and the actual was -2.0° as measured with the pitch HS. This -1.6° pitch error at sequence completion was within the ±3° requirement of the initial pitch-down maneuver.

The vehicle rates at the first frame of each calibration are shown in Table 3-4.

TABLE 3-4

VEHICLE RATES FOR MCM CALIBRATIONS

	Vehicle Time (seconds) ST+	Frame 001	Vehicle Rates at Frame 001 (degrees/second) Pitch	Roll	Yaw
Calibration 1	195527.0	195557.8	-.001	.004	.001
Calibration 2	195918.4	195944.6	-.002	.002	.000
Calibration 3	196308.4	196334.6	-.004	-.003	-.001

3.2.4 Recovery

The pitch-down maneuvers preceding the four RVs and the ST-RV (RV-5) separations were all within specification and are summarized in Table 3-6. The RV separation performance summary is shown in Table 3-7.

The RV-5 recovery is performed with the SV yawed 180° and pitched-down, with the release taking place along the SV X-axis. The vehicle rate and attitude parameters at RV-5 separation are listed in Table 3-5.

TABLE 3-5

RATE AND ATTITUDE PARAMETERS AT RV-5 SEPARATION

	Attitude (degrees)	Rate (degrees/second)
Pitch	-61.7	.069
Roll	.18	.001
Yaw	-.12	-.003

3.2.5 Inertial Reference Assembly (IRA) Anomalies

The PACS yaw bias was first observed on Rev 45. Control was transferred on Rev 66 to RACS cross-strapped to the Primary Reaction Control System. After transfer, the bias was monitored and remained in the range of 0 to -.012 degree/second until Rev 373 when the bias increased and the IRA began switching between high rate mode and low rate mode. Similar switching was again observed on Rev 379 after which the bias decreased through 0 to -.005 degree/second. On Rev 782, the gyro rate output switched to the high rate mode and remained at rates of -1.3 to -1.6 degrees/second. These rates are beyond the limit of control and remained this way throughout the rest of the mission.

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

A mini-yaw maneuver was performed on Rev 203. The positive and negative rates achieved were sufficiently large enough to determine variation in the yaw bias as a function of the yaw rate. Based upon previous analysis, the expected rate bias variation with yaw input rate for location and resistance of the short can be calculated.

The mode switching on Revs 373 and 379 are indicative of a gyro torquer short with 10 to 20K ohms resistance. With such a short, the rate bias falls in the high rate/low rate mode switching region of the IRA and instability results.

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

The RACS IRA 1018, which operated successfully for 91 days, had been retrofitted to alleviate the effects of gyro shorts from torquer to case. The retrofit isolated torquer circuits and their returns from signal or case ground and inserted a diode in the collector circuit of the torquer switching semiconductors to eliminate reversed offset currents. The PACS IRA 1011, which exhibited the yaw bias, had not been retrofitted and did not contain the torquer isolation and blocking diode.

TABLE 3-6

PITCH-DOWN PERFORMANCE PRECEDING RECOVERY VEHICLE SEPARATION

	Pitch-Down Angle		Maneuvering Time to ≤ 0.1 Deg/Sec		Pitch-Down Coast Rate		
RV/Rev	Desired ±3.0 Deg (degrees)	Actual (PDWN) (degrees)	Spec (seconds)	Actual (seconds)	Command Rate (deg/sec)	Coast Rate Expected (deg/sec)	Coast Rate Actual (deg/sec)
1/196	-34.9	-35.2[1]	150	77.2	-.705	-.75 ±.05	-.70
2/505	-38.9	-38.1	150	82.2	-.705	-.75 ±.05	-.71
3/926	-39.6	-38.8	150	86.2	-.705	-.75 ±.05	-.71
4/1202	-37.5	-37.6[2]	150	81.2	-.705	-.75 ±.05	-.70
5/683	-63.3	-61.7	-	-	-.705	-.75 ±.05	-.72

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

2. Same as Note 1, except that the error was 4.1 degrees.

TABLE 3-7

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)	Pitch-Down 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 Spec (degrees)	Angle Meas H/S (degrees)
1/310	1.56	11.2	143	-35.2	99.4	139158	16.7	±1.0	-.04
2/505	1.34	7.0	128	-38.1	98.1	120410	15.9	±1.0	-.06
3/296	1.45	9.7	131	-38.8	97.4	92380	14.6	±1.0	-.08
4/1202	1.36	11.0	159	-37.6	36.0	84601	14.1	±1.0	-.02

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The cause and failure mechanism of the torquer shorts are under investigation to determine a final engineering solution; in the interim, all IRAs to be flown subsequent to SV-6 will incorporate the torquer isolation as a tentative measure.

3.3 REACTION CONTROL SYSTEM

3.3.1 Flight Summary

Satisfactory vehicle and rate control was provided by the Reaction Control System (RCS) during the entire 91 day flight. The primary system (RCS-1) was used exclusively during the 75 day active mission and for approximately the first seven days of Solo operations. During this entire period, all control fuel was drawn from the OA tank; therefore, no non-volatile residue (NVR) associated valve leakage problems were anticipated or experienced. During Rev 1443 (Day 90), RCS-1 was isolated from the OA tank and RCS Tank No. 1 supplied fuel to RCS-1 for approximately 1/4 of a revolution. Thrust of all Reaction Engine Assemblies (REAs) increased in proportion to the increase in propellant feed pressure of the RCS tank. During the latter half of Rev 1443, the standby RCS was activated and supplied by the OA tank alone. Two days later, the OA tank and RCS Tank No. 1 were brought into pressure equilibrium and together supplied propellant to the standby RCS through the time of deboost. RCS-2 (standby) performed nominally during its brief period of operation.

3.3.2 Propellant Consumption

RCS propellant consumption during the 75 day active mission was computed to be 348 pounds. An additional 26 pounds were drawn from the OA tank and RCS Tank No. 1 during Solo operations. RCS Tanks 1, 3, and 4 were capped and not filled for this mission.

3.3.3 Thruster Performance

During the operation of the primary RCS (RCS-1), thrust levels were determined using the individual REA chamber pressures. The performance of the individual REAs tracked the preflight blow-down predictions except: (1) during Rev 350, REA 8 dropped to 1.88 pounds, which is below specification limits of 2.5 pounds, and (2) REA 4 dropped to 1.30 pounds near Rev 800. Just prior to the transfer of RCS-1 from the OA tank to RCS tankage, REAs 8, 4, and 7 had degraded to 1.71 pounds, 1.19 pounds, and 2.22 pounds, respectively. While operating from the high pressure RCS tank, these thrust levels increased to 3.18 pounds, 2.78 pounds, and 4.56 pounds, respectively. These thrust increases can be attributed solely to the higher feed pressure and do not represent any significant performance recovery. Although none of these degraded thrusters gave any sign of "washing out" when fed high pressure propellant, the time of operation at high pressure was too brief to permit a thorough evaluation. Insufficient operating time was accumulated on RCS-2 (standby) to determine if NVR contaminated fuel would again cause REM valve leakage problems. An increase in the temperature of REA 8 on Rev 68 and a further increase after Rev 98 indicated that a leak had developed. Because of the signature of the temperature increase (sudden rise), the leak was attributed to seal damage such as a scratch or particle lodged on the lip of the poppet.

3.4 ORBIT ADJUST SYSTEM (OAS)

3.4.1 Orbit Control

The Orbit Adjust System (OAS) was fired 34 times during the active mission and 5 times during Solo operations. Engine performance and engine nozzle temperature indicated slightly higher than normal values; however, engine predictability was within specification limits of ±5 percent. Table 3-8 presents a summary of OAS performance.

After OA Burn 29, the catalyst bed pressure drop showed the same decaying trend observed on SV-3 thru SV-5. However, this decaying trend began later in life than on SV-5 and did not reach as low a level. Because of a lack of fuel reserves, no long out-of-plane burn was made to evaluate washout performance as had been done on SV-5. The deboost firing was segmented into a series of short burns to avoid any possibility of engine washout.

3.4.2 Deboost

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

3.5 LIFEBOAT II SYSTEM

3.5.1 Bay 10 Battery Induced Errors

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

A. Telemetry bias on both P and Q magnetometers was 0 to 1.5 milligauss; therefore, no correction is required for TM bias.

B. Permanent magnetism produces an error of approximately ±1 milligauss on the P and R magnetometers and a -3 milligauss error on the Q magnetometer.

C. Induced magnetism errors are similar to those on SV-5 and are the largest error source, depending on magnetic field magnitude and direction. Error ranges are: (1) Q +2 to -6 milligauss, (2) P +6 to -5 milligauss, and (3) R +4 to -5 milligauss.

D. Based on the errors encountered, it was concluded that the Lifeboat System would operate within specified attitudes if it were used.

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	30	4249	6.58	6.51	-1.00
2	62	8313	12.87	12.76	-0.86
3	94	15359	23.83	23.65	-0.76
4	96	8218	-12.96	-12.71	-1.93
5	127	5965	9.22	9.22	0
6	159	7935	12.42	12.30	-0.97
7	192	15943	24.70	24.77	0.28
8	194	7672	-12.03	-11.97	-0.50
9	224	6921	10.73	10.78	0.47
10	257	8573	13.32	13.41	0.67
11	289	15472	24.26	24.27	0.04
12	291	6147	-9.60	-9.66	0.62
13	321	6728	11.35	11.47	1.05
14	354	7478	12.77	12.77	0
15	386	19029	32.42	32.64	0.68
16	388	10997	-18.77	-18.93	0.85
17	435	11098	18.93	19.16	1.22
18	485	10887	18.73	18.86	0.69
19	532	21773	37.42	37.86	1.17
20	534	11678	-20.02	-20.39	1.85
21	581	8993	17.15	17.19	0.23
22	630	11954	22.73	22.90	0.75
23	685	14202	27.04	27.34	1.10
24	727	10356	20.44	20.51	0.34
25	776	23133	45.67	46.04	0.80
26	778	8775	-17.80	-17.54	-1.46
27	824	8463	16.85	16.97	0.71
28	873	16007	32.01	32.21	0.62
29	928	13552	27.25	27.41	0.59

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TABLE 3-8 (CONT'D)

OA Firing No.	Rev Number	Impulse Delivered (lbs/sec)	Planned ΔV (feet/sec)	Achieved ΔV (feet/sec)	Error ΔV (percent)
30	970	9364	20.76	21.05	1.40
31	1019	10886	24.41	24.58	0.69
32	1068	11406	25.55	25.56	0.04
33	1116	8877	20.23	20.22	-0.05
34	1167	17032	38.54	38.93	1.00
35	1214	3608	9.37	9.28	-0.96
36	1216	5481	14.09	14.12	0.21
37	1278	21578	55.16	55.95	1.38
38	1400	6965	18.04	18.15	0.61
39	1448	3221	8.32	8.44	1.43
Deboost	1471	-	-420	*	-

NOTE: Asterisk (*) denotes ephemeris data not available; however, re-entry tracking during VAST was highly successful.

Additional data confirming the Lifeboat ability to meet attitude specification was obtained during RV-1 and RV-4 when the P and Q magnetometer outputs were compared with computed values from DPMAP. The results imply less than a .5° error in pitch and yaw, well within the specified error limit of 2.5 degrees.

No deboost simulation was performed; however, data obtained during the yaw attitude determination tests (paragraph 3.5.2) can be used to derive the magnitude of the errors that would be encountered in deboost. These were .8° to 1.4° in yaw and .6° in pitch, well within the error limits of 1.7 degrees.

3.5.2 Yaw Attitude Determination

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

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

This data is shown in Figure 3-1. During these tests, yaw attitude was approximately 0 degrees. A 1° yaw error will result in a 6 milligauss change in the ΔQ magnetometer from DPMAP. This magnitude of error would be difficult to detect without the establishment of the magnetometer distortion error while the ACS control is normal.

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

3.6 ELECTRICAL DISTRIBUTION AND POWER (EDAP)

3.6.1 Solar Arrays

Solar arrays were extended on Rev 1. Power output from each leg exceeded the specification value. Degradation from the initial output to the end of 1206-4 was 5.2 percent. The solar array degraded to 3.5% during the first 30 days, which is within the predicted degradation of 3 to 5 percent. Total degradation after the RV-5 drop was 4.6 percent.

The degradation associated with the RV-5 drop was not isolated before and after flight data as it was on SV-5. However, the 1.1% increase in degradation that occurred after the first 30 days until the Stellar/Terrain RV drop on Day 43 is considerably less than the 1.6% increase on SV-5 that occurred over the two day interval that included the Stellar/Terrain RV drop. This indicates that the Stellar/Terrain RV drop produced considerably less contamination of the solar arrays on SV-6 than it did on SV-5.

3.6.2 Main Bus Voltage

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

3.6.3 Power Capability and Usage

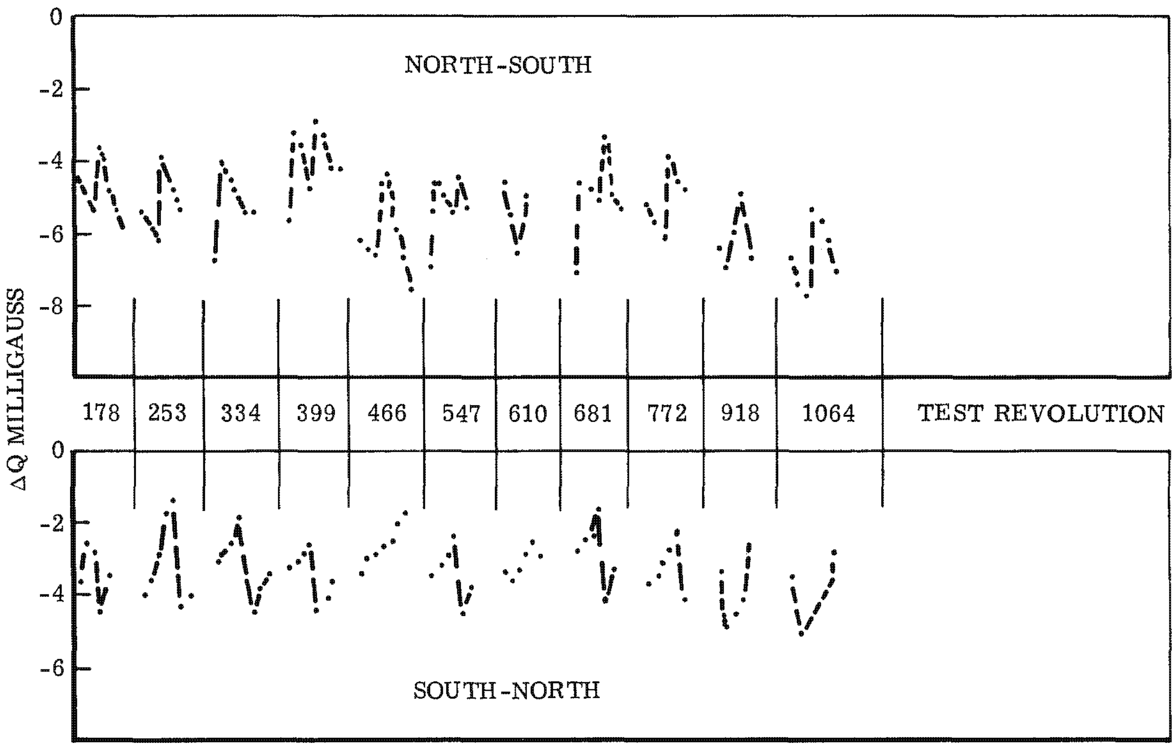
Power usage ranged from 320 to 390 amp-hours/day. Average usage over the mission was 339 amp-hours/day which was below the average available capacity of 379 amp-hours/day.

3.6.4 Type 29 Battery Performance

All Type 29 Batteries operated in a desirable environment (44° F to 50° F) throughout the mission. Two battery heaters cycled abnormally during the flight. On Rev 7, the heater on Battery 3 began a 10 second ON and a 4 second OFF cycling that continued until Rev 89 when the heater resumed a normal operation. On Revs 211 and 212, Battery 2 exhibited a similar short ON/OFF cyclic operation. In both cases, the batteries were maintained in the desirable temperature range of 44° F to 50° F. The cyclic behavior is attributed to the action of a bimetallic disc within the thermostat which moves toward a concave position before snapping to that position as it cools. This motion releases pressure on the switch contact, increasing resistance which resulted in a heating of the disc causing it to turn off again. The worst consequence of a complete failure would be a continual ON position raising the battery temperature

FIGURE 3-1

YAW ATTITUDE DETERMINATION TESTS



NOTE: ΔQ is the difference between magnetometer reading and predicted reading (DGMAP).

to 65°F; however, this would be tolerable. A solid state device is scheduled to replace this item on Block III. In the interim, additional testing has been introduced to screen out switches that might incorporate discs that would give this cyclic performance. No other action is contemplated.

3.6.5 Pyro Battery Performance

Pyro battery performance is summarized in Table 3-9.

TABLE 3-9

PYRO BATTERY PERFORMANCE

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

3.6.6 Lifeboat Battery Performance

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

3.7 TRACKING, TELEMETRY, AND COMMAND (TT&C)

3.7.1 Tracking

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

The turn-on sequence of events was as follows:

A. The transponder was turned on 7 seconds prior to starting uplink "S" pulses.

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

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

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

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

3.7.2 Telemetry

3.7.2.1 Anomalous P-Monitor Data

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

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

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

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

3.7.2.2 General Performance

Telemetry system performance was satisfactory throughout the flight. Out of a total of 1,323 active station contacts through Rev 1201, PCM Side 1 was utilized on 1,320 station contacts and SGLS Side 1 was utilized on 1,222 station contacts. PCM Side 2 was utilized on Rev 9 KODI and Revs 18 POGO and 18 HULA with normal performance. SGLS Side 2 (a cubic transponder) was operated periodically throughout the flight for a total of 101 station contacts to observe the performance of the new transponder to be flown on Block II vehicles (reference the LMSC Solo Report on SV-5 for the anomaly involving the Side 2 cubic transponder on that flight). In addition, operation of the PCM System during tape recording and operation of the Tape Recorders (TR 1 and TR 2) was normal throughout the flight except during Solo at the beginning of TR 2 where the recorder required a few playback/rewind sequences before good data was obtained. This is a known idiosyncrasy of these TRs.

3.7.2.3 Instrumentation

The following instrumentation anomalies existed at lift-off:

A. A439 - A known erratic temperature monitor that was used as is.

B. P222 - A known erratic temperature monitor that was used as is.

3.7.3 Command

3.7.3.1 Uplink Operation

The vehicle SGLS command equipment received approximately 14.5 million bits with no indications of vehicle problems.

3.7.3.2 GFE Command System

A. Extended Command System (ECS)

The ECS responded satisfactorily in all command modes resulting in the loading of 185,713 Stored Program Commands (SPCs) in memory. Of these loaded SPCs, 94,896 were output by both Programmable Memory Units (PMUs) for decoder processing. The remainder were erased prior to their time label matches.

In loading the 185,713 SPCs, there were no command rejects except for the following:

(1) Rev 113 POGO — Commanding difficulties because of an RTS problem.

(2) Rev 600 COOK — Command capability lost throughout pass due to RTS procedural error as noted in paragraph 3.7.1.

(3) Rev 910 POGO — When the emergency Variable Block Erase (VBE) message for Event 3 was used on this rev, a delay in erasing both PMUs occurred when the initial commands conflicted with SPC readouts, which have priority.

None of these rejects are attributable to the ECS.

B. ECS Clock Operation

The accuracy and stability of the ECS clock, as computed for each flight segment, are listed in Table 3-10

TABLE 3-10

ECS CLOCK PERFORMANCE

Mission Segment	Accuracy	Stability (Average 6 Hour Period)
1206-1	1.43 parts in 10^7	6.02 parts in 10^{10}
1206-2	1.43 parts in 10^7	6.02 parts in 10^{10}
1206-3	2.05 parts in 10^7	3.63 parts in 10^{10}
1206-4	2.34 parts in 10^7	2.64 parts in 10^{10}

C. Minimal Command Subsystem (MCS)

The MCS responded correctly to all commands.

D. Remote Decoder/Backup Decoder

Both sides of the remote decoder were used for each of the five recoveries. Performance of both sides was determined to be acceptable through analysis of telemetry data.

E. Command System Usage Summary

Table 3-11 presents the command system usage through Rev 1201.

TABLE 3-11

COMMAND SYSTEM USAGE SUMMARY

(hours)

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

3.7.3.3 375 MHz Receiver

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

3.7.3.4 Data Interface Unit (DIU)

The Data Interface Unit performed satisfactorily throughout the flight.

3.8 THERMAL CONTROL

3.8.1 Passive Systems

All flight data indicates that the thermal design of the Forward and Mid-sections provided the required temperature control. No design changes are forthcoming as a result of the SV-6 flight performance analysis. Acceptable Aft-section temperature control was maintained throughout the flight. All equipment temperatures remained within design and qualification limits.

The SV-6 Aft-section was configured as follows:

A. Type 29 Batteries were located in Equipment Section (ES) Bays 10 and 3. This was first done on SV-5.

B. Battery bay doors as well as Bays 11 and 2 doors were covered with a Flexible Optical Solar Reflector (FOSR), replacing the white silicone paint. This was first done on SV-5.

C. Heat straps were installed in the Attitude Reference Module (ARM) and the ES Bay 7 door was painted white in order to provide capability for dual ACS operation. This was first done on SV-4.

A Block II IRA and Horizon Sensor were flown in the ARM. Flight data indicates that battery and

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

Equipment and structural temperatures indicated contamination degradation to external vehicle thermal control surfaces similar to that of all other flights. The amount of degradation was within the bounds of preflight analysis. Solar absorptance (α_s) for the degraded FOSR was estimated to be .27 to .41 less than the α_s of .50 assumed for the worst case.

3.8.2 Active Thermal Control (ATC)

The temperature of the Forward-section film path remained relatively constant throughout the active mission. The RV heater zones which were actively controlled relative to the reference temperature, were generally within 1° of this reference.

3.9 MASS PROPERTIES

The vehicle weight history is presented in Table 3-12.

TABLE 3-12

VEHICLE WEIGHT HISTORY
(pounds)

Event	Weight
Prelaunch Weight	28,983
Separation from Stage 2	21,002
Arrays Deployed 0°	21,002
Prior to Drop 1	20,433
After Drop 1	18,883
Prior to Drop 2	18,551
After Drop 2	17,025
After Drop 5	16,630
Prior to Drop 3	15,924
After Drop 3	14,386
Prior to Drop 4	13,996
After Drop 4	12,514

3.10 STRUCTURE AND DYNAMICS

3.10.1 Solar Array

The erection and deployment time histories for the solar arrays were nominal. The arrays were deployed at the first station pass, INDI, and were fully deployed and erected by the next station, POGO, where they were repositioned from 18° to 0° for the maximum output at the flight beta angle of -1.9 degrees.

3.10.2 Shroud Separation

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

IV

PAYLOADS

Approved for Release: 2020/12/01 C05131452

SECTION IV

PAYLOADS

4.1 SENSOR SUBSYSTEM

4.1.1 Camera Operations and Performance

Overall, Mission 1206 was a successful HEXAGON operation. The Sensor Subsystem (SS) performed very well, all of the film was transported and recovered, and there were no significant anomalies. In addition, 1206 contained 21,000' of SO-255 Color Film on the Aft Camera, the largest amount of color film ever flown on a satellite mission. Also, 500' of the new SO-130 IR Color Film were included at the end of the Forward Camera Supply. This was the first time this film had been employed in the HEXAGON Camera System. While the SO-130 was successfully exposed and transported, the film itself was virtually useless due to the IR layer having been inadvertently fogged by the manufacturer during Supply buildup. The primary use of SO-255 was to study the status of the Soviet wheat crop. The SO-130 was included to operationally test its performance and quality in the HEXAGON System.

4.1.2 Summary of HEXAGON Sensor Subsystem Performance, Missions 1201-1206

Mission 1206 employed the last of the first group of six HEXAGON Camera Systems. These six camera systems have clearly demonstrated that the Sensor Subsystem was able to meet its basic specifications on-orbit. The following are some of the highlights of the SS performance over the first six missions:

A. Image Quality

The original specification was that the Sensor Subsystem should produce 139 cycles/mm at nadir and no worse than 95 cycles/mm anywhere else on the format 96% of the time. This specification was for a contrast of 2:1 and 30° solar altitude. This equates to a mean performance expectation of 150 cycles/mm at nadir and no worse than 110 cycles/mm anywhere else in the format. VEM analysis has generally shown that the SS has produced a resolution at 2:1 contrast equal to or better than the original specification. Mean performances have consistently run at 150 to 170 cycles/mm.

B. Days On-Orbit

The original specification for the first six Sensor Subsystems required an on-orbit life of 30 to 45 days. The performance of the SS in this regard has been outstanding without any change in Sensor design. The first six missions demonstrated an on-orbit capability of well in excess of the 45 day maximum envisioned when the program started. Mission 1206 had active SS operations for 75 days, the longest of the six missions.

C. Reliability

The Sensor Subsystem has demonstrated a reliability in excess of the original requirement. The initial specification called for a reliability of .78. Simply stated, this means that over the six missions, 78% of the film was to be returned. In fact, the Forward Cameras have successfully transported 609,614' of film or 95.4% of the total available. The Aft Cameras have successfully transported 553,620' of the film or 86.4% of the total available. Both percentages are significantly higher than the original specification.

D. Other Capabilities

In addition to better-than-specification performance, the SS demonstrated capabilities beyond the original requirements. The use of color film was not envisioned in the original specification, yet the last three missions have shown the HEXAGON Cameras to be well suited to handle SO-255 Color Film. Further, the on-orbit focus adjust capability and the recently added On-Orbit Adjust Assembly (OOAA) and smear slits have demonstrated that it is possible to instrument the SS so that on-orbit performance can be optimized. It was also demonstrated that it is possible to include devices in the SS that allow a better understanding of Sensor performance than that which can be obtained from deployed formal targets.

The only major problems evidenced on the first six systems were related to film tracking and the resultant inability to rewind. This rewind inability prevented 15% to 20% of the film to be unexposed. This problem was initially studied by the PFA Team, (see PFA Technical Report No. 1, entitled, "Coarse Path Tracking in the HEXAGON Camera System", BYE 15327-72) and a solution was found. The hardware implementation of the solution (major modifications to the Take-up Assemblies) was such that it cannot be accomplished until Mission 1210. In summary, the first six HEXAGON Sensor Subsystems performed exceedingly well.

4.1.3 Camera Data

The Panoramic Camera data for 1206 is summarized in Table 4-1.

TABLE 4-1

CAMERA STATISTICS

Parameter	Forward Camera	Aft Camera
Camera Designation	A	B
Film	1414/SO-130	1414/SO-255
Focal Length (inches)	60.0103	60.0088
Equivalent Filter Type	W-12	Clear (W-2E)
Initial Focus Setting (microns)*	-7	57
Supply Footage (feet)	109,317/500	81,700/21,000
Supply Spool No.	2271	2340
Supply Film Weight (lbs)	876.2	879.8

NOTE: *Focus was not changed on either camera.

TABLE 4-1 (CONT'D)

<table>
<tr><th>Parameter</th><th>Forward Camera</th><th>Aft Camera</th></tr>
<tr><td>Optical Set Numbers</td><td>023</td><td>021</td></tr>
<tr><td>Initial Pneumatics (lbs)</td><td colspan="2">33.9</td></tr>
<tr><td>Estimated Remaining Pneumatics (lbs)</td><td colspan="2">3.8</td></tr>
</table>

4.1.4 Camera Operations

The mission was active for 75 days, the longest HEXAGON mission to date. The SS had the following constraints on its operation:

A. No rewinds greater than 5 inches/second.

B. No 30° scan mode operations at $\pm$45° scan centers.

C. Transitions from 1414 to SO-255 were to be preceded by operations of 10 frames or longer.

The only anomaly worth noting was an increase in the start-up and running torque of the Aft Camera optical bar (starting with Op 25). This problem continued and by Op 85 the torque increase was occasionally significant enough to saturate the OB summed error telemetry signal. By Op 154, constraints were imposed on the camera operations to minimize the risk of a catastrophic failure. By Op 160, both the start-up and running torque values began to decrease and finally stabilized.

Starting with Op 221, these operational constraints were removed and no further action was necessary during the remainder of the mission.

4.1.5 Photographic Image Quality

The photographic performance of both cameras was very good. The mean performance (considering all field/scan angles) between the two cameras was essentially the same, approximately 166 cycles/mm. The phenomenon, seen on Missions 1203 and 1204 known as "McDonald's Arches", was again observed on 1206. The cause of this problem remains essentially unknown. There was excessive vehicle-induced yaw bias between Ops 37 and 47, which caused a measurable effect on image quality. Other than that problem, no other camera or system-induced anomalies that adversely affected photographic image quality were noted.

The most significant degraders of image quality on the mission were again haze and unfavorable acquisition conditions. Historically, summer missions are more significantly affected by haze than winter missions. Mission 1206 was no exception, but was more significantly affected by unfavorable acquisition conditions. These conditions were directly a result of Mission 1206's launch time. The time of launch caused two undesirable conditions to be prevalent during the mission, particularly during the first two mission segments.

The first problem was related to the occurrence of specular reflections and front-lighting (shadowless acquisitions). The launch time chosen caused these problems to be located at nadir, with specular reflections occurring on the Forward Camera and front-lighting on the Aft Camera. These problems started at approximately 40° north latitude and proceeded south as the mission progressed. Both problems occurred frequently within ±5° of the latitude predicted and within ±10° of scan nadir. The front-lighting problem was most severe on the Middle East acquisitions where the scene contrast is poor to begin with. The second, and somewhat related problem is the fact that the late launch made the average acquisition solar altitude very high particularly on the first two buckets. This also reduced scene contrast as shadows are very small with the high solar altitudes. The mean acquisition solar altitudes were: 63° for 1206-1, 61° for 1206-2, 51° for 1206-3, and 45° for 1206-4.

Analysis of the combined VEM data indicates that the mean GAWA 2:1 contrast GRD from Mission 1206 was 2.4' between ±30° of scan, 4.4' for acquisitions beyond ±30° of scan, and 6.4' for acquisitions beyond ±45° of scan. Based on this 2:1 contrast VEM data, the GAWA resolution for 1206 was 3.3 feet. For average intelligence targets, the GAWA resolution is estimated at 5.1 feet. Between ±30° of scan, the mean GRD for typical intelligence targets was estimated at 3.5', 6.8' for acquisition beyond ±30° of scan, and 10.1' for acquisitions beyond ±45° of scan.

The computation of the GAWA resolution (for typical intelligence targets) and its variation on Missions 1201 thru 1206 have clearly shown a relationship between predictable system performance and the suitability of the imagery for the photointerpreter. Factors such as camera performance, haze, weather, use of high scan angles, etc., all have a distinct effect on image quality as seen by the PI. The purpose of this work, initially, was part of a study to verify the CRYSPER Computer Program and its predictions. If there is no correlation between CRYSPER GRD prediction and PI suitability, then the utility of the program is marginal at best. The correlation achieved over the first six missions has been surprisingly good. The correlations have been sufficiently high to warrant consideration of the more direct use of the CRYSPER Program and premission planning in the attempt to maximize image quality. Further evaluation of the GAWA concept should be greatly facilitated when the new National Imagery Interpreter Rating Scale (NIIRS) is implemented on Mission 1207. The significant advantage of this new rating scale is that all segments of the photography will be rated by the photointerpreter. This data then should correlate directly with GAWA computation and not be subject to the inconsistencies inherent in the use of target only readout data.

4.1.6 Focus

Mission 1206 was the first HEXAGON mission to require no on-orbit focus change for the 1414 Film. The SO-255 required a 6 micron retreat focus adjustment to optimize quality.

4.1.7 Film Synchronization

For the first time on the HEXAGON System, smear slits were used to evaluate film synchronization. Results show that the Forward Camera IMC parameters were set properly in Chamber A-2, whereas the Aft Camera needed on-orbit adjustments of three and four count changes for the cross-track and in-track directions respectively.

Superior accuracy and simplicity of the smear slit technique as compared with CORN line analysis led the PFA Team to terminate further mobile line deployments on the mission and to further recommend that smear assessment be carried out via smear slit analysis for future missions.

4.1.8 Exposure

The exposure analysis performed on the 1206 black and white record (1414 Film) originally indicated the need for a two-slit exposure reduction bias. Implementation of the bias resulted in good exposure for urban area imagery with vegetation surround.

Similar imagery on the color record (SO-255) was also found to be satisfactory after two biases had been applied to the initial exposure recommendation. Tone reproduction, as evidenced by Five-Step Gray Scale Target density analysis, was also considered good. Subjective appraisals agreed with the measured data of both records.

Sand surround scenes within the present desert polygons were more overexposed than previously observed. Desert surround areas in the Southwest portion of the United States showed considerable overexposure (approximately .15 log E). This condition agrees with some data acquired from previous missions and suggests that use of a U. S. Southwest polygon would be desirable.

A solar altitude dependent exposure bias above 40° solar altitude was instituted for the SO-255 segments based on early mission subjective observations of shadowless acquisitions. Scan data on subsequent 1206 acquisitions neither confirmed nor denied this trend. A solar altitude dependent function, upon which this bias was based, will be permanently incorporated into KSCOPE in the near future.

The effective contrast of the CORN resolution targets as presented to the cameras was estimated by backing out the micro-edge effects of the Five-Step Gray Scales and determining their relative log exposure through macrosensitometry.

A study on the effects of specular reflections and no-shadow imagery, using urban scene imagery exposure as criteria, showed that specular reflection effects were measurable in the scene density distributions while those of no-shadow imagery were primarily a visual anomaly. Examples were found where specular reflections caused increased scene exposure (> .30 log E) and severe scene range reduction. No-shadow imagery caused no significant change in mean scene exposure.

4.1.9 Engineering Tests

Engineering tests for this mission were identified as ten separate items. Half of these tests called for CORN deployment of lines, tribars, gray scales, and/or radiometric color patches. The other half depended totally on cloud-free culture at particular scan locations. Four of these tests were used to support the optimization of focus and image motion compensation which are summarized above. Of the six remaining tests, two were specifically designed for color and infrared color assessment on this mission.

Four of the 10 engineering tests were required for investigation purposes. As on the two previous missions, a successful attempt was made to measure on-orbit modulation transfer functions via the PFALINES routine. Basically, this analysis shows a general consistency between Chambers D/A-2 and on-orbit measurements for the Aft Camera only. There are a number of instances with the Forward Camera in which the mission MTFs are lower than chamber MTFs. There was also the continuing acquisition of Tucson, Arizona as a standard clear weather reference scene and tribar resolution targets near culture to support the NIIRS validation study. Finally, the PFA Team designed a test based on mission smear slit image assessment which attempted to delineate smear as a function of scan angle location. Unfortunately, this test could not be completed before the mission terminated.

4.1.10 Processing and Reproduction

Defilming operations of all RVs were accomplished without major difficulty even though loose, creased, and festooned film was present on all Take-ups except RV-4 where the core locking pins did not shear. Original negative processing, breakdown/compositing, and reproduction were accomplished without major problems. Original positive processing and duplication were accomplished without incident.

NPIC analysis showed the quality of the duplicate copies to be consistent with previous HEXAGON missions. The color duplicates continue to be much poorer in image quality than the original positive.

Specialized duplication techniques were employed for low contrast target areas of particular interest to the PIs.

4.1.11 Exploitation Suitability

The overall interpretation suitability of Mission 1206 was Fair.

The prime degrading factors influencing the interpretation throughout the mission were cloud cover, haze, and obliquity. Some imagery from the first two mission segments was severely degraded by full front-lighting, specular reflections, and high acquisition solar elevations.

The duplicates from black and white operations continue to be better for interpretation of strategic intelligence than those of color operations. Although the green record duplicate positive can be used to satisfy most interpretation requirements, it is of lower quality than the black and white duplicate positives. The exploitation of the color duplicate positive is hampered by a significant loss in resolution from the color original positive.

The color balance of the production color duplicate positives has not been satisfactory for exploitation of some economic intelligence targets.

4.2 MAPPING CAMERA SUBSYSTEM

4.2.1 Mapping Camera Operations and Performance

Mission 1206 Stellar/Terrain Mapping Camera Subsystem operated on 122 revolutions between Rev 7 and Rev 667 and recovery was effected on Rev 683. A total of 2,057 frames were exposed in the Terrain Camera and a corresponding number of frame pairs were exposed in the Stellar Camera. These exposures included 61 frames of SO-131 (IR/False Color) exposed on the Terrain Camera and 16 frames from both cameras which were used for in-flight calibration. Following completion of the calibrate mode, an additional 144 cycles were operated to deplete the Stellar Supply.

Post flight analysis conducted at the processing facility, the camera contractor's facility, and at DMATC, revealed that the operation and performance of the ST Camera Subsystem was highly successful.

As with Mission 1205, the Terrain photography for this mission exceeded the predicted quality levels which were based on acceptance test results.

Stellar photography was comparable to Mission 1205 with the majority of frames recording approximately 100 stars and many frames with up to 150 star images.

The engineering changes installed on the Terrain thermal door proved effective, allowing unrestricted photography in all latitudes.

Weather conditions during photography were generally not as good as on Mission 1205. Approximately 60% of the photography was cloud free as compared to 66% on 1205. The effects of seasonal haze were detectable on many Terrain frames.

Table 4-2 summarizes the ST Camera System activities.

TABLE 4-2

SUMMARY OF SIGNIFICANT STELLAR/TERRAIN CAMERA ACTIVITIES

Rev	Activity	Comments
-	Ascent	No anomalies
8	Health check	Two one-frame operations. All functions normal, temperatures stabilized.
23	Photography	First mission photography.
91	Photography	First TM indication of Terrain platen press anomaly.
97	Diagnostic MOP	Terrain press evaluation.
113	Photography	Bar XC Range.
137	Photography	First TM indication of Stellar platen press anomaly.
165	Photography	Redundant electronics for Stellar platen press.
178	Photography	Bar XC Range.

TABLE 4-2 (CONT'D)

Rev	Activity	Comments
211	Diagnostic MOP	Platen press evaluation.
219	Diagnostic MOP	Change to backup mode to evaluate Terrain platen press.
226	Diagnostic MOP	Change to normal mode operation.
405	Photography	Bar XC Range.
535	Material Change Detector (MCD) shutdown	End 3400 Film.
543	Photography	SO-131 IR Film.
658	MCD shutdown	End SO-131 Film.
666	Calibrate	In-flight calibration.
668	Film runout	Deplete Stellar Supply.
683	RV-5 (ST) recovery	Routine air recovery.

4.2.2 Mapping Camera Data

The Mapping Camera data for Mission 1206 is summarized in Table 4-3.

TABLE 4-3

MAPPING CAMERA STATISTICS

		Stellar	
Camera Designations	Terrain	+Y	-Y
Focal Length (inches)	12.002	9.967	9.969
Filter Type	W-21	None	None
Reseau Serial No.	016	026	027
Lens Serial No.	005	009	011
Supply Spool Serial No.	108	069	
Supply Film Weight (lbs)	57.4	10.7	
Film Type/Length (feet)	3400/3197, MCD/1.5, SO-131/100, MCD/1.5, 3401/22, 2403/10	3401/1995	

4.2.3 Image Quality

Under optimum exposure conditions, the image quality of the Terrain photography was comparable to the best imagery on Mission 1205. High solar elevation, solar azimuth, and seasonal atmospheric conditions encountered during 1206 contributed to the overall reduction from the high quality photography achieved on Mission 1205.

Visual edge matching (VEM) measurements taken at the processing facility by contractor personnel produced an average of 57.5 lines/millimeter.

This was the first ST Subsystem to use SO-131 (IR False Color) Film in the Terrain Camera. Use of SO-131 through the system produced exceptionally good photography with an estimated 50' to 75' ground resolution.

The Stellar photography was excellent in quality and resulted in an adequate distribution of sixth magnitude stars on both units.

4.2.4 Exposure

Density measurements of urban scenes with vegetation surround were made at the processing facility. Analysis of these measurements indicated that Mission 1206 photography was correctly exposed.

4.2.5 Thermal Profile

The control and resulting thermal distribution for the ST Camera were excellent. Paint patterns were modified for this flight which increased the Main Instrument System Electronics Assembly (MISEA) temperatures by 11 degrees. There is no evidence of photographic or functional degradations which can be attributed to thermal control.

4.2.6 Pressure Profile

The average chute pressure for all operations remained stable at 30 to 32 microns. This level is on the low end of the predetermined corona-free window of 25 to 40 microns. A maximum of 42 microns and a minimum of 26 microns were recorded as the extremes during this operation.

4.2.7 On-Orbit Calibration

In addition to the preflight calibration data, two additional calibration steps are conducted in flight. The two in-flight calibrations, Range and Stellar, are distinctly different operations.

Range Calibration is conducted while operating the camera in the normal mode over a ground range containing accurately measured control points. A typical range is the Bar XC located in the Arizona - New Mexico area.

Stellar Calibration was accomplished in three separate operations. The calibration requires the vehicle to be yawed and pitched to an attitude that points all three camera lenses at the stars. The camera system is then operated in the calibrate (C) mode to record star imagery on the Terrain and Stellar formats simultaneously. In the Terrain Camera, special films used for this operation were 3401 and 2403. Twenty to twenty-five star images were recorded on Terrain frames with 3401 Film during the calibrate operation. Grain size and overexposure of the reseau made star image location impossible on the 2403 Film. All system/operational aspects were completed successfully; however, due primarily to film/exposure parameters, the calibration of the Terrain Camera is inadequate because of the number and distribution of star images.

4.2.8 Summary of Anomalies

A. Telemetry Anomalies

(1) Anomaly (Terrain Platen Press). On Rev 91, the Terrain platen press monitor indicated lack of press during the last frame of Op 2. After this initial indication, the monitor continued to indicate the possibility of abnormal platen press actuation.

Analysis - An engineering diagnostic manual operation of 7 frames was performed on Rev 97. The analysis of all telemetry data from this engineering MOP concluded that improper operation of the TM microswitch was the most likely cause. During ensuing revs, the platen press TM monitor recorded a variety of indications ranging from "normal" to "no press," until Rev 207 when telemetry indicated "no platen press" on all eight frames. Another engineering diagnostic manual operation was then programmed for Rev 211. The TM from this engineering MOP was similar to the Rev 207 data. In order to gain more data on the problem, the system was commanded to the backup (B) mode on Rev 219. Since there was essentially no change in the press telemetry in the B mode, the system was commanded back to normal mode on Rev 226. Throughout the remainder of the mission, the TM monitor continued to indicate inconsistent operation of the platen press.

A number of frames was selected for flatness measurements at DMATC. This selection included samples of all the different press conditions, including "normal" operation, that were recorded during this mission. Reduction of the flatness measurements produced a standard deviation of 8.73 microns. Rejection criterion for these measurements at DMATC is 12.90 microns. Results of an independent analysis conducted at the contractor's facility support the conclusions drawn by DMATC.

Action - A potentiometer will be installed to provide continuous TM monitoring of the platen press travel.

(2) Anomaly (Stellar Platen Press). Telemetry for two frames on Rev 137 and one frame on Rev 150 indicated abnormal operation. This telemetry indication occurred randomly throughout the remainder of the mission.

Analysis - On Rev 156, the Stellar platen press electronics were commanded to redundant circuitry. The TM indications remained essentially the same. The remainder of the mission was flown in the redundant mode with telemetry indicating varying platen press functions.

During operation, press of the -Y platen, data block clamping, and press of the +Y platen are actuated sequentially (in order given) from a common mechanical drive. For the 21 frames affected during Ops 93 and 94, the -Y platen pressed on command; at this point the sequence stopped which left the data block unclamped and the +Y platen not pressed.

Film analysis performed at the contractor's facility and DMTAC revealed:

(a) +Y Frames 020 thru 027, Op 93, and 001 thru 013, Op 94, were not pressed during exposure and are unusable for mensuration.

(b) Stellar data blocks associated with these 21 frames were not clamped.

(c) Flatness measurements performed on Stellar frames are acceptable with the exception of the 21 +Y frames on Ops 93 and 94.

Action - A potentiometer will be installed to provide continuous TM monitoring of the platen press travel.

(3) Anomaly (Phase locks). Starting on the first operation, telemetry randomly recorded 29 instances of phase lock dropout.

Analysis - The 29 phase lock dropouts included 14 rotary shutter, 3 FMC, and 17 Terrain transport dropouts (more than one phase lock dropout can occur on one frame). Phase locks are required to be stable by the first frame exposure of each operation. The sampling rate in normal telemetry modes is such that it is possible to record an out of phase lock condition prior to exposure but is not fast enough to sample the "in" phase lock condition when exposure occurs. Under certain conditions, it is possible to obtain higher sampling rate diagnostic modes and CEC recorder records of camera performance. Of the 29 frames for which dropouts were initially recorded, diagnostic data and image evaluation have shown all phase locks were stable prior to midexposure.

B. Terrain and Stellar Camera Systems Anomalies

(1) Anomaly (Corona marking). Excluding Ops 100 and 116, all others from Ops 89 (Rev 365) thru 131 (Rev 530) and Ops 152, 153, and 154 (Rev 666) exhibited varying degrees of corona marking.

Analysis - Correlation of pressure data to operations has shown:

(a) Average pressure for all operations was at the low end, but within the prespecified pressure range.

(b) High and low pressure levels, recorded for each operation, dropped as a function of time on-orbit resulting in some pressure values outside the corona window. It is felt that this was primarily due to a decrease in film outgassing which normally contributes to the overall pressure levels.

Historically, films have a propensity for marking which appears to be proportional to the length of time on-orbit and the lack of moisture in the film. Both Stellar and Terrain Films exhibited characteristics associated with being "dried out", e.g., emulsion cracking, curling, etc.

Analysis performed at the contractor's facility and at DMATC has shown that, except for the 3401 Film used in the calibration mode, the density of the corona marking was within specification levels designated for preflight test.

The corona marking, which occurred during the Stellar Calibration, did not appear to affect star image location on 3401 Film.

DMATC has determined that automatic reader correlation is not degraded and the corona marking is mainly an aesthetic disturbance that will affect only ortho-picto displays.

Action - Procedures, criteria, and pressure transducer calibration used to determine corona windows at the manufacturing facility and during final test at the integration facility are being reviewed and changes will be initiated to improve correlation between flight and test parameters.

(2) Anomaly (Stellar Data Block). Random occurrence of data block malfunctions.

Analysis - Starting on Op 3 and recurring throughout this mission were four different data presentation anomalies associated with the Stellar data block. Eighty-eight data blocks were affected in the following manner:

(a) Blurred data blocks - 21 frames. This anomaly is attributed to the lack of clamp on Ops 93 and 94 discussed in paragraph 2.2.7.

(b) Loss of column 2 (vehicle time) - 14 frames.

(c) Overexposure or double exposure of columns 3 and 5 (-Y half open/half close time) - 66 frames.

(d) Combination of b and c above - 12 frames.

Redundancy provided in the Stellar and Terrain data blocks has reduced this anomaly to minor significance. However, system malfunction is obvious and a cause of failure is needed to preclude the recurrence in the form of a more serious anomaly. Analysis of this problem is not complete but present data indicates the problem to be electrical "noise firing" which degrades columns 2, 3, and 5, and a possible mechanical malfunction in the press sequence that could result in loss of data block clamp.

Action - Investigations are currently in progress to determine and correct the causes of these anomalies.

4.2.9 Exploitation Suitability

The technical analysis of the Mission 1206 product by the DMA Post Flight Analysis Team included a comparison of the photography with the system specifications. As a result of the instrument measurements and various metric evaluations, the system provided the necessary data and all critical performance requirements were satisfied.

The film flatness evaluation was particularly important due to telemetry data that indicated possible malfunction of the platen press mechanisms of the three cameras. Several of the frames were specifically selected because of their correlation to telemetry information that indicated a possible no press condition for the Terrain platen press. All of the Terrain frames evaluated indicate that the film flatness was within the specified tolerance. Evaluation of the Stellar film indicated only 21 starboard (+Y) frames out-of-tolerance.

4.2.10 Processing and Reproduction

The RV arrived at the processing site in good condition at 1030 hours EDT, 25 August 1973. A preliminary inspection was made by removing the cover and making a total dark search for anomalies.

Approximately 30' (9 wraps) of the Stellar film tag end had slipped over the outer diameter of the Take-up flanges.

The top of the RV was then replaced and the unit was stored in a conditioned environment until 27 August 1973 when despooling of both films was accomplished.

No static discharges were noted at any time during despooling. There were two minor buckles and two long indentations made in the base of the Terrain film during despooling. This affected 13 frames and has been attributed to the puck arm on the film Take-up accidentally releasing and hitting the film.

Only 41% of the Terrain film was optically titled. This was a result of a software difficulty where fiducial mark areas were being mistaken for frame process marks. Some fiducials had optical titling imaged over them. The software problem was related to a modification that incorporated percent overlap data into the titles. The problem has been corrected. The Stellar film was 95% optically titled. The majority of the frames after Op 122 were not optically titled. These operations were short and caused synchronization problems.

All black and white duplicate copies were printed on the Kingston Printer. Duplicate positives of the Terrain record were prepared using Kodak Aerial Duplicating Film (Estar Base) SO-467 and those for the Stellar record were prepared using Kodak Aerographic Duplicating Film (Estar Base) 2420. The duplicate negatives of both records were prepared using Kodak Direct Duplicating Aerial Film (Estar Base) 2422. All duplicate processing was accomplished on viscous Dalton Processors.

All color duplicate copies of the SO-131 were printed on the Rainbow Printer. Kodak Ektachrome Aerographic Duplicating Film (Estar Base) SO-360, processed in a Ektachrome RT Processor, Model 1811, was used for these reproductions.

RE-ENTRY VEHICLE SUMMARY

SECTION V

RE-ENTRY VEHICLE SUMMARY

5.1 SUMMARY

The primary re-entry vehicle summary is presented in Table 5-1. Subsystem performance is shown in Table 5-2. The re-entry vehicles fulfilled the primary mission requirement of returning the payload from orbit in good condition. Limited film damage occurred on the loose outer wraps that resulted from sheared Take-up core pins on RV-1, RV-2, and RV-3.

Recovery statistics of the Stellar/Terrain re-entry are shown in Table 5-3. All RV subsystems performed normally. The outer wraps of Terrain film spilled over the Take-up flanges. Telemetry analysis of the last operations on-orbit did not indicate any problems that could be associated with this anomaly. It is possible at this time only to conjecture that: (1) the anti-backup solenoid failed or (2) the locking mechanism was broken during the recovery/catch operation.

5.2 PRIMARY RE-ENTRY VEHICLE PERFORMANCE

As in the case of previous flights, aerial retrieval environments were severe enough to shear Take-up core pins on RV-1, RV-2, and RV-3. This resulted in outer wraps of film being torn and loose due to relative motion occurring between the film stack and the RVs after the pin failure. Development of loads (accelerations) in excess of core pin capacity during aerial retrieval is not unexpected.

No environmental limits were compromised during the orbital, re-entry, and recovery phases, or during post recovery handling and transportation.

All RVs followed predicted trajectories and events occurred as planned except for the inadvertent activation of the Water Recovery Sequences on RV-1, RV-3, and RV-4 (this is the same type of anomaly encountered and reported on SV-5).

Subsystems performed satisfactorily and all mission requirements were met.

5.3 STELLAR/TERRAIN RE-ENTRY VEHICLE

RV-5 was successfully recovered on Rev 683. Recovery statistics are shown in Table 5-3. All RV subsystems performed normally. The SV provided a satisfactory pitch angle after a yaw reverse and all other interface functions were nominal.

The predicted impact point (PIP), the estimated point of parachute deployment (EPPD), and the air recovery point are shown in Table 5-3. The miss distance between the PIP and EPPD was calculated to be 15.22 NM short and 3.57 NM east of the ground track. The offset of the PIP and EPPD is attributed to wind.

The capsule was recovered at an altitude of 12,800' on the first pass with no damage to the chute or capsule.

TABLE 5-1

RECOVERY VEHICLE RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
RV Serial No.	26	27	25	28
Recovery Rev No.	310	505	926	1202
Recovery Date (1973)	1 Aug	14 Aug	8 Sep	25 Sep
Payload Weight (lbs) (Measured weight from recovered RV)				
Forward	233.8	212.0	224.0	206.4
Aft	234.2	227.0	225.0	193.6
Unbalance Percent	.1	5.5	.4	4.9
SV Orbit (hp x ha/ω p)	87.9 x 151.1/135.6	88.2 x 155.1/128.4	87.5 x 145.9/131.2	89.0 x 152.0/124.5
Nominal PIP Latitude	27.00°N	21.01°N	26.00°N	25.50°N
Nominal PIP Longitude	164.05°W	173.68°W	157.09°W	163.59°W
Impact Location Error (EPPD versus Teapot Eval)				
Overshoot (NM)	18.55	9.47	6.68	1.39
Undershoot (NM)	18.55	9.47	6.68	1.39
Cross-Track (NM)	3.31E	1.21E	6.74W	.97W
Recovery (Aerial)				
Altitude (feet)	8,700	9,800	13,500	14,000
Parachute Condition	minor cone damage	no damage	some cone damage gore 13 torn in main	some cone damage gore 34 torn in main
Retrieval Pass	2	2	1	1
Recovery Capsule Payload Condition	Good	Good	Good	Good

NOTES:
1. hp = Altitude of Perigee (NM)
2. ha = Altitude of Apogee (NM)
3. ωp = Argument of Perigee (degrees)

TABLE 5-2

RE-ENTRY VEHICLE SUBSYSTEM PERFORMANCE SUMMARY

RV Subsystem/Function	Performance Assessment
On-Orbit Thermal Protection	Normal.
Trim and Seal	Normal.
Electrical Power and Distribution	Normal.
Sequential Subsystem	On RV-1, RV-3, RV-4, the Water Recovery Sequence initiated during tow, RV-2 was normal.
Pyro Subsystems	RV-1, RV-2, RV-3 normal. On RV-4, the heat shield detonating cord separated from the connector block. This caused no problems.
Spin Stabilization	Normal.
Retro Motor	Normal.
Tracking, Telemetry, Instrumentation	Normal.
Heat Shield	Normal.
Base Thermal Protection	Normal.
Structure	Normal.
Recovery System	RV-1 experienced a small tear in the cone, high oscillations and lateral movement of canopy, also flashing light soft cover lanyard failed. RV-2 no damage, high oscillations and lateral movement of canopy were observed. RV-3, two 3' to 6' tears in cone skirt to main canopy, system stable. RV-4 vertical tear, apex to skirt of main canopy, system stable.

TABLE 5-3

RV-5 RECOVERY SUMMARY

Recovery Rev	683
Date	24 August 1973
Payload Weight at Recovery (lbs)	69.33
SV Recovery Orbit	
Perigee (NM)	87.7
Apogee (NM)	147.0
Argument of Perigee (degrees)	126.7
SV Pitch Angle after yaw around (degrees)	-64.4

	PIP	EPPD	Air Recovery
Latitude	22° 27.8'	22° 42'	23° 00'
Longitude	163° 54.6'	163° 48'	163° 45'
Altitude	–	–	12,800'

OPERATIONAL SUPPORT

VI

Handle via Byeman
Controls Only

SECTION VI

OPERATIONAL SUPPORT

6.1 SOFTWARE

The software configuration used to support Mission 1206 was 'TUNITY MOD 2. This version of 'TUNITY contained numerous changes from MOD 1BR, used for Mission 1205. The more significant improvements in MOD 2 provided for increased flexibility in redundant sequence usage, additional PCM/TR duty cycle and timing constraint logic, and better command deletion logic. With MOD 2, contingency procedures (required on previous missions) were not needed to run 'TUNITY when the mission length exceeded 1,000 revs.

AOES/System II configuration was 13.1F SST, Corrector Tape CT 13.1F.7B. A nominal one rev load cycle was used during the mission phase. A total of 1,051 command messages were generated, of which 867 were loaded into the vehicle. Ten software problems (SPRs) were encountered during the mission phase which were considered flight critical. Each problem was corrected during the mission and a change made to the appropriate software module. These SPRs are discussed below:

6.1.1 SPR MD2-6187 ('TFRTIN)

Card reading in MPR during processing of BIAS cards could occasionally skip a rev when the current rev reading was terminated by a "REV" or "TERM" card. This resulted in improper MPR film totals.

6.1.2 SPR MD2-6191 ('TFUSE)

Both interop and photo footages on an operation were calculated to be zero in MPR, causing resource management problems and requiring manual changes.

6.1.3 SPR MD2-6198 ('TFRTFIX)

An attempt to remove a bad data entry using "MODF" card in 'TFRTFIX was unsuccessful.

6.1.4 SPR MD2-6199 ('TUMP)

Thru focus commanding via sequence cards gave improper execution where focal plane transitions occurred during frames.

6.1.5 SPR MD2-6017 ('TELPRO)

'TELPRO forces an abort when a parity error is detected. A complex procedure was required to delete the record.

6.1.6 SPR MD2-6232 ('TBALL)

'TBALL outputs a zero in the scorefield if a MOP is input for an operation or if a MOP combines with an automatic selection. This makes score determination impossible with manual inputs.

6.1.7 SPR MD2-6235 (MPR)

MPR listed slit biases of 0.000 in the reporting on an operation. The slit bias values had to be inserted manually.

6.1.8 SPR MD2-6236 ('TFRTIN)

MPR was unable to process a one frame ST operation which required separate processing and caused a delay in receiving the output.

6.1.9 SPR MD2-6239 ('TREPLAY)

'TREPLAY does not compute the correct score for SS MOPs.

6.1.10 SPR MD2-6245 ('TLMP)

A 'TFRTFIX run showed earlier rev data after the end of current rev data. 'TMB had to be rebuilt before the MPR could be run.

6.2 SATELLITE CONTROL FACILITY (SCF)

The performance of the SCF in support of the sixth HEXAGON mission was commendable. Equipment and operational problems were encountered but were solved without impact on the mission. Command message generation and transmission, and down link TM reception and processing were satisfactory to support the operation. During the first week of the mission, problems were encountered with the microwave transmission system between VTS and STC resulting in some payload data being delayed.

6.2.1 Readiness

A 34 Rev Development Rehearsal using 'TUNITY MOD 2 and MODEL 13.1F was begun on 30 May 1973 and successfully concluded on 1 June 1973. A 64 Rev Dress Rehearsal was conducted from 30 June to 4 July 1973 and a 19 Rev Dress Rehearsal on 9 and 10 July 1973.

6.2.2 Orbit Operation

One dedicated CDC 3800 Computer was used throughout the operation; a second computer was used for 722 hours of operation. The computer usage rate was 1.38 computer hours per day. Table 6-1 provides a breakout by remote tracking station (RTS) of the anomalies that occurred during this operation.

TABLE 6-1

TRACKING STATION ANOMALIES

(occurrences)

Equipment	Guam (GTS)	Hula (HTS)	Kodi (KTS)	Indi (IOS)	New Hampshire (NHS)	Pogo (OL 5)	Vandenberg (VTS)	STC	Total
1230 mTc	0	1	2	0	1	10	0	0	14
CDC 160A *	5	2	5	0	0	13	6	-	31
1200-bps dataline	3	2	0	3	2	45	1	-	56
Microwave system	-	-	-	-	-	-	6	-	6

NOTE: Asterisk (*) indicates station associated with bird-buffer problem.

The paragraphs that follow discuss significant anomalies:

A. OL-5, Revs 193, 194, 198, and 199

As a result of a phase reversal in the azimuth-smoothing unit, there was no auto-tracking capability. The station unsuccessfully attempted to automatically track the vehicle on Revs 193 and 194; hence, the antenna was slaved to the slave bus for the remainder of the two passes. On Revs 198 and 199, the station was unable to slave the antenna, so the vehicle was manually tracked via the slave bus throughout both passes. Fix: The problem was resolved by replacing a burned out tube and repairing a faulty cable connection to the azimuth dc amplifier. Impact: No tracking data was obtained during these revs.

B. OL-5, Rev 910

Because of a personnel error, the command plan was not accomplished as briefed. An incorrect command status was reported to the Test Control Team after an alarm (reject) condition. Fix: Commanding was completed at the backup station. Impact: The command plan could not be completed due to lack of time.

C. KTS, Rev 1210

KTS was unable to go active with its antenna; a Category E Outage (32691023) was opened. Fix: The station switched back and forth between the antenna and dummy load until switching action occurred. Impact: The station was 160 seconds late in going active for support. Support was accomplished with no mission impact.

D. OL-5, Rev 1442

The station was unable to process telemetry data throughout the pass. When Mode 11 was reselected, PCM Decom 1 did not display data transfer, and the computer printed out "PCM load NG" (No Good). Fix: Mode 11 was reselected five more times, but the results were the same each time. The computer was recovered and the mode reselected, but the problem remained. Commanding was accomplished with verification disabled in accordance with the Test Control Team/TA's direction. Impact: Real time telemetry data processing capability at the station was lost.

6.2.3 Recovery Operations

6.2.3.1 Recovery 1206-1

The first capsule was aerially recovered at 8,700' on the second pass. The pilot aborted the first pass because of severe oscillation of the system (over 20° with considerable lateral movement).

6.2.3.2 Recovery 1206-2

The second capsule was aerially recovered at 9,800' on the second pass. No parachute damage was noted on the look/see pass. The pilot aborted the first pass because of oscillation (over 20° with lateral movement).

6.2.3.3 Recovery 1206-3

The first recovery attempt on Rev 910 was aborted because of bad weather in the recovery area. The second attempt on Rev 926 was moved 2° north to improve weather conditions. The third capsule was aerially recovered at 13,500' on the first pass. The following parachute damage was noted: two tears varying from 3' to 6' in length. The tears started in the cone skirt area and continued to the main canopy. The parachute system was unusually stable on the recovery pass. However, prior to the recovery pass, the main canopy was oscillating and at one time, a near complete collapse of the cone was noted.

6.2.3.4 Recovery 1206-4

The fourth capsule was aerially recovered at 14,000' on the first pass. The main parachute had a vertical tear from the apex to the skirt area. The parachute was much more stable than any of the previous systems.

6.2.3.5 Recovery 1206-5

The RV-5 capsule was aerially recovered at 12,800' on the first pass. Condition of the parachute was normal. There were no unusual conditions or events.

6.2.4 Command Message Generation

A one rev load philosophy was employed, whereby the [redacted] is generated each (b)(1)
rev in order to use the latest weather data. There were 942 command messages generated during the (b)(3)
primary mission of which 15% were rejected. The major cause of rejection was that no new payload selections were found in the new message after generation. Minor causes were: (1) hardware constraint violations, (2) problems with meshing of sequences, and (3) problems with non-standard payload operations.

APPENDIX A - REFERENCES

APPENDIX B - GLOSSARY

APPENDIX A

REFERENCES

1. HEXAGON Program Preliminary Post Flight Report Flight No. 6. Technical Advisory Report, BIF-107W-71035-73, 26 October 1973. (S/H)

2. Flight Test Engineering Analysis Report for the HEXAGON Program Satellite Vehicle No. 6 BIF-003W/2-090260-73, 9 November 1973, LMSC Integrating Contractor. (TS/H)

3. Satellite Control Facility Operations Evaluation Report, IRON 8261, 9 November 1973. (S/H)

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.
AOB	Air Order of Battle.
AOES/System II	General Purpose Satellite Flight Support Software at STC.
AUGIE	Acronym for Data Compression Technique Used for RTS to STC Data Transmission.
AVE	Aerospace Vehicle Equipment.
BBRT	Bird Buffer Retrieval Tape. Records at STC From Transmissions From RTS.
BRIDGEHEAD	Primary Film Processing and Immediate Post Flight Evaluation Facility.
BUFT	Backup Film Transport.
C-	Camera Power-off Command.
C+	Camera Power-on Command.
CEI	Contract End Item.
CEWG	Color Evaluation Working Group.
Chamber A	Photographic Vacuum Test Chamber Located at East Coast SSC Facility.
Chamber A-2	Photographic Vacuum Test Chamber Located at SVIC Facility.
CIE	Commission Internationale de l'E' clairage (lighting).
c/mm	Cycles Per Millimeter.
COMIREX	USIB Committee on Imagery Requirements and Exploitation.
CORN	Controlled Range Network.
CORREL	On-orbit Adjust Assembly Calibration Test Program.
CRYSPER	On-orbit Performance Prediction Program Combining Target Acquisition, Atmospheric, Illumination, and Camera Performance Models.
CRYSTAL BALL	Photometric Atmospheric Model Computer Program. Used to Calculate Exposure for Orbital Acquisitions.
CV	Constant Velocity.
CW	Continuous Wave.
DEA	Decision Element Array.
DGMAP	Computer Program for Magnetic Force Field Predictions.
DIM	Dynamic Image Motion.

APPENDIX B (CONT'D)

D log E Curve	Sensitometric Response of Film to Light. Plot of 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.
DREWL	Double Row East-West Line CORN Target.
ECO	Engineering Change Order.
ECS	Extended Command System.
EM	Electromechanical.
EMI	Electromagnetic Interference.
END	Equivalent Neutral Density.
EOD	Electro-optical Department.
ESD	Emergency Shutdown.
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.
FFL	Flange Focal Length.
FIDAP	Flash Image Displacement Analysis Program.
FOCMO	Thru Focus Motion Plot and Line Indicated Focus Program.
Fwd	Forward-looking Camera, Camera A.
FPP	Focal Plane Position.
fps	Feet Per Second.
FT	Film Transport.
FT +	Film Transport-on Command.
FT -	Film Transport-off Command.
FTFD	Field Test Force Director.
GAWA	Grand Area Weighted Average.
GMT	Greenwich Mean Time.
GOB	Ground Order of Battle.
GRD	Ground Resolved Distance.

APPENDIX B (CONT'D)

HFLIP	Data Strip and Print Program.
HOPE	Operational Performance Estimated Report. Summarizes Key Performance Related TM Data for Mission Engineering Operations.
HWT	Hardwire Tester.
Hz	Hertz (Cycles Per Second).
IAS	Imagery Analysis Service.
ICD	Interface Control Document.
IMC	Image Motion Compensation.
IOR	Interop Runout.
ips	Inch(es) Per Second.
IR	Infrared.
KALEIDOSCOPE	Radiometric Acquisition Model. Used to Calculate Basic Exposure Time Versus Solar Altitude, Haze Level, and Target Spectral Reflectance Characteristics.
LIFEBOAT	Incorporates Minimal Command System and Tertiary Attitude Reference System for Achieving Alignment to Effect Recovery of Two RVs and to Deboost the SV in case of Mission Terminating Command System or Attitude Control System failure.
LMODE	Off-line Program that Extracts Camera Data From BBRT for MPR Generation.
LP	Lincoln Plant at BRIDGEHEAD.
LSFS	Lateral Separation Focus Sensor.
MAA	Mission Analysis Area.
MACFACT	Mission Accomplishment Factor Program. Used to Process Key Performance Related Electromechanical Data.
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.
MFA	Measurement Filter Assembly.
MIP	Mission Information Potential.
MIPOLPER	Program which Combines the Optical Transfer Function Program with the Performance Prediction Program.
MONO	Monoscopic Operation.
MP^2	Multi-purpose Processor at Lincoln Plant.
MPR	Mission Performance Report.
MR	Malfunction Report.
MRB	Material Review Board.

APPENDIX B (CONT'D)

MTF	Modulation Transfer Function.
MWC	Midwest Contractor.
NBS	National Bureau of Standards.
NCVU	Negative Constant Velocity Unit.
NIIRS	National Imagery Interpretability Rating Scale.
NM	Nautical Miles.
NPIC	National Photographic Interpretation Center.
OAK	NPIC Publication that Lists First Phase Exploitation Results.
OAS	Orbit Adjust System.
OB	Optical Bar.
OFK	Orbital Fixed Knowns.
ON	Original Negative.
OP	Camera System Operation.
OTD	Optical Technology Division of SSC.
OOAA	On-orbit Adjust Assembly.
PBF	Plane of Best Focus.
PBM	Power Bus Module.
PCM	Pulse Code Modulation.
PDS	Power Distribution System.
PERFORM	Camera Resolution Performance Prediction Program.
PERSAP	TM Resolution Performance Prediction Program. Estimates From Metering Capstan Telemetry and Measured Optical Performance.
PFA	Post Flight Analysis.
PFALINES	Post Flight Analysis Line Program. Computes 2:1 Resolution Performance and Estimates Image Motion Amplitudes.
PI	Photointerpreter.
PN NEG (-)	Pneumatics-off Command.
PN PLUS (+)	Pneumatics-on Command.
psi	Pounds Per Square Inch.
rad/sec	Radians Per Second.
RCS	Reaction Control System.
REV	Orbital Revolution.
RMS	Root Mean Square.
ROM	Rough Order of Magnitude.

APPENDIX B (CONT'D)

RTS	Remote Tracking Station.
RV	Recovery Vehicle.
SAL	Scan Angle Length.
SBA	Satellite Basic Assembly.
SBAC	Satellite Basic Assembly Contractor.
SCF	Satellite Control Facility.
[redacted]	
SETS	Sensor Subsystem Engineering and Technical Support Staff.
SLC-4E	Space Launch Complex-4 East.
SOC	Satellite Operation Center.
SOF	Start of Frame.
Solo	System Engineering Test after Fourth RV Separation.
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.
SVFRT	Satellite Vehicle Frame Reference Time.
SVIC	Satellite Vehicle Integrating Contractor.
SVT	Satellite Vehicle Time.
SWA	Forward Camera Slit Width.
SWB	Aft Camera Slit Width.
SYNCER	FIDAP Subroutine for Determining Film Synchronization Error.
TBALL	'TUNITY Executive Program for the Sensor Event Generator.
TCA	Two-Camera Assembly.
THISUM	Command Message Update in History Generator for 'TUNITY.
TM	Telemetry.
TMOTION	Estimate of Image Smear Program for Laboratory Tests.
TOBACC	Time for OB Velocity Command.
TOT	Time over Target.
TR	Tape Recorder.
TU	Take-up Unit.

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

APPENDIX B (CONT'D)

TUNITY	Computer Program for HEXAGON mission support at the STC.
USIB	United States Intelligence Board.
UTB	Ultra Thin Base Film.
VAFB	Vandenberg Air Force Base.
VEM	Visual Edge Match.
VEM/MES	Visual Edge Match for Mission Evaluation Score.
VEM/PAS	Visual Edge Match for Performance Assessment.
Vx/h	Orbital Angular Rate, In-track.
Vy/h	Orbital Angular Rate, Cross-track.
WCFO	West Coast Field Office (Contractor).
WCPO	West Coast Project Office (Government).