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HEXAGON

SENSOR SUBSYSTEM

FLIGHT MODEL (S/N 015)

ACCEPTANCE TEAM REPORT

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This Acceptance Team Report for S/N 015 Hexagon Sensor Subsystem has been reviewed and approved by:

P. Petty, Deputy General Manager — Date: [illegible] Aug 75

D. Raspet, Special Projects Office — Date: 22 Aug 75

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SECTION 1

SUMMARY

1.1 ACCEPTABILITY

Hexagon Sensor Subsystem S/N 015, intended to be used as the payload in SV-12, was accepted for delivery on 26 September 1974.

The resolving capability of both cameras at all collimator positions and at all test temperatures exceeds the performance requirements. An on-orbit performance prediction, using camera-measured values, is a resolution (at nadir at 70°F) of 192 cycles/mm for the FWD-looking camera and 188 cycles/mm for the AFT-looking camera. These predictions closely agree with the corrected peak mean resolution measurements at nadir at 70°F in Chamber A of 187 cycles/mm for the FWD-looking camera and 190 cycles/mm for the AFT-looking camera.

The measured color resolving capability of both cameras at nadir at 70°F was 118 cycles/mm or better, a performance comparable to the color performance of previous models.

The system's film-to-image synchronization performance met the performance requirements for all collimator positions, applicable temperatures, and operating speeds with the following three exceptions:

Camera	Vx/h	Value	Amount Out of Spec
FWD (A)	0.052	CT/0° - Mean @ 93°F	0.004 ips
AFT (B)	0.036	IT/0° - 2σ @ 70°F	0.005 ips
AFT (B)	0.036	IT/45°- 2σ @ 70°F	0.015 ips

The on-orbit performance prediction for the FWD camera at 0° scan angle and 0° field position at 93°F is 178 cycles/mm; the prediction for the AFT camera at 0° scan angle and 0° field position at 70°F is 188 cycles/mm; the prediction for the AFT camera at 45° scan angle and 0° field position at 70°F is 185 cycles/mm.

1.2 ACCEPTANCE TEST HISTORY

The standard test flow used for acceptance testing a Sensor Subsystem is shown in Figure 1-1 including the MFN (manufacturing flow number) and the designation of each test. The chronological testing sequence for Sensor Subsystem S/N 015, given in Table 1-1, includes highlights of significant deviations from the standard test flow. The major deviations, in turn, are described in Paragraphs 1.2.1 through 1.2.3.

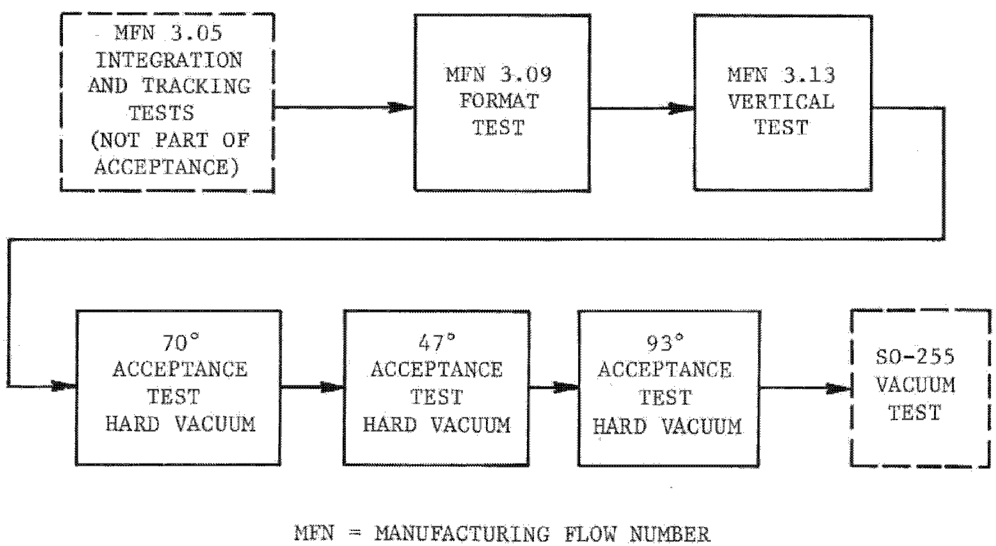


Figure 1-1. Simplified Acceptance Test Flow, Hexagon Sensor Subsystem

TABLE 1-1

S/N 015 MILESTONE HISTORY

Activity	Completion Date
1. Supply installed in MS	4 April 1974
2. TCA installed in MS	5 April
3. MFN 3.05 started	29 April
4. MFN 3.05 mini-format test	20 May
5. FWD tracking investigation	14 June
6. Preliminary photo test (in-air)	17 June
7. MR 5477, FWD and AFT film break due to improper command	17 June
8. System health verification and repair (and shutter spring retrofit)	18 June
9. Mini-format test	25 July
10. MFN 3.09 format test	27 July
11. MFN 3.11 vertical test	27 July
12. In-air photo test	30 July
13. 1st hard vacuum baseline test	1 August
14. MR 5494, FWD 100 Hz oscillation (replaced FWD 3A1-B)	2 August
15. 2nd hard vacuum baseline test	5 August
16. MR 5499, FWD material break due to take-up failure	7 August
17. In-air photo test	8 August
18. 70° ACCEPTANCE TEST	14 August
19. 47° ACCEPTANCE TEST	17 August
20. 93° ACCEPTANCE TEST	20 August

TABLE 1-1 (Continued)

Activity	Completion Date
21. Color photo test, color mini-format (at vacuum)	22 August
22. Pitch test (at vacuum)	23 August
23. Supply reloaded with SO-208 (UUTB) stacks	19 Sept.
24. Replaced PN module due to low pressure transducer failure (MR 5514)	23 Sept.
25. Tech cert signed by the Customer	26 Sept.
26. Mini-format	26 Sept.
27. SO-208 visual tracking	26 Sept.
28. Down-loaded SO-208 stacks	3 Oct.
29. Supply 4-inch roller investigation and repair (MR 5517)	21 Oct.
30. Supply installed in MS	23 Oct.
31. Mini-format and system caging	31 Oct.
32. Shipment to SBAC	20 Nov.

1.2.1 Pre-Acceptance Testing

Pre-acceptance testing was highlighted by a FWD side tracking investigation, a malfunction when the film was broken in both FWD and AFT paths, and the resultant rework and retest associated with this malfunction. Initial MFN 3.05 testing showed FWD side tracking to be unsatisfactory. The AFT steerer was found to be defective and was fixed, but tracking remained marginal on short scan runs. It was decided at this point to conduct a preliminary photo test prior to the scheduled platen removal for the shutter spring retrofit (ECO 11830).

During the final run of this chamber test an incorrect command caused the system to behave uncontrollably, breaking the film in both paths (MR 5477). Due to the possibility of damage, all film path elements (rollers, drive rollers, air bars, seal doors) were tested and where necessary adjusted, realigned, or replaced. During this rework, the platen shutter springs were retrofitted. When the system was rebuilt, both sides tracked satisfactorily and the system proceeded into acceptance test.

1.2.2 Acceptance Testing

Acceptance testing was completed with minimum interruption. Only two anomalies occurred: (1) 100 Hz oscillation on fwd output film drive (MR 5494) and (2) take-up fwd builder roller failure (MR 5499). Troubleshooting and repair of both anomalies was routine.

1.2.3 Post-Acceptance Testing

After acceptance testing, the Customer gave direction to proceed with a test plan for the evaluation of SO-208 UUTB (ultra ultra thin base) film. The supply was reloaded with stacks containing 20,000 feet of SO-208, tracking tests with normal (type 1414) film were conducted first and then the transition to SO-208 was made, and tracking was evaluated.

Tracking with SO-208 film proved to be unsatisfactory and further testing on this flight system was deemed inadvisable. The film stacks were then downloaded and transferred to the development model. The supply was reloaded, tracking verified, and the midsection was prepared for shipment.

1.3 PERFORMANCE SUMMARY

1.3.1 Optical Bars

Both optical bars passed the pre- and post-vibration Modulation Transfer Function (MTF) at 70°F and at 93°F, but the FWD OB failed the MTF specification at 47°F. Both OBs passed the flange focal length specification, but the AFT OB failed the passive focus shifts at 47°F. The Chamber A performance prediction based on Chamber D data and budgeted errors, however, indicates good performance (See Table 1-2).

TABLE 1-2

PREDICTED AVERAGE RESOLUTION (cycles/mm at 47°F)

Field Angle (Degrees)	FWD Camera		AFT Camera	
	Scan Angle (Degrees) 0	±50	Scan Angle (Degrees) 0	±50
-2.5	149	133	153	137
0	185	183	186	180
+2.5	152	138	151	131

These results at 47°F (worst case) indicated that both bars exceed system level requirements; therefore, they were considered acceptable. Both optical bars met the longitudinal color performance requirements, at all measured wavelengths.

1.3.2 Resolution

Both cameras fully meet the tri-bar resolution performance requirements. (See Table 1-3, summary of the resolution values and acceptance criteria at all three temperatures). The focus position for each camera, for all three temperatures in Chamber A vacuum acceptance tests, is

FWD Camera	42 microns
AFT Camera	66 microns

TABLE 1-3

SUMMARY OF TRI-BAR RESOLUTION S/N 015
(AVERAGE GEOMETRIC MEAN OF FLIGHT AND SCAN IN CYC/MM
VACUUM, Vx/h = 0.052, CONT. ILLUM., IMC DISABLED)

Camera Temperature				FWD			AFT		
				70°	47°	93°	70°	47°	93°
Scan Angle	Field Position	Acceptance Criteria 70°	Acceptance Criteria 47° & 93°	*42μ	42μ	42μ	66μ	66μ	66μ
45°	2.5°	130	110	175	183	177	165	173	153
Nadir	0°	150	150	183	207	159	185	198	168
55°	2.0°	130	110	174	188	166	157	169	142

*Average of three readers

1.3.3 Film Synchronization

The sync-flash evaluation resulting from three temperature vacuum acceptance tests is presented in tabular form in Paragraph 3.5.1 with out-of-specification values noted. The following paragraphs summarize the analysis of these out-of-specification conditions.

1.3.3.1 FWD Camera, Cross-Track Mean

The nadir position for Vx/h = 0.052 at 93°F indicates a mean WOG (without gravity) value of 0.054 inches per second versus a specification of 0.050. Although this value is only slightly out-of-specification, it is supported by EM Performance Data. A hump in the FBS signal occurred in the vicinity of the nadir collimator such that the sync value increased beyond the specification (See PM-1470X, "Investigation of FBS Disturbance (Hump Anomaly)" dated 6 August 1973); a waiver has been issued as part of the S/N 015 Technical Certification.

1.3.3.2 AFT Camera, In-Track Two Sigma (2σ)

The nadir and 45° collimator positions for Vx/h = 0.036 at 70°F indicates 2σ in-track values of 0.042 and 0.052 ips respectively versus a specification of 0.037 ips maximum. Analysis of EM performance data does not support the photographic results; a waiver has been issued as part of the S/N 015 Technical Certification.

1.3.4 Dynamic Focus

The dynamic focus results of the 70°F tests at Vx/h = 0.052 and 0.036 and the other individual test conditions at 47°F at Vx/h of 0.052 and 93°F at Vx/h of 0.052, show both cameras to be well within 4.9 microns (2σ).

1.3.5 Midsection, Film Markings

No significant anomalous film markings occurred during acceptance testing. Spurious or misplaced SOF marks were nonexistent.

1.3.6 Electromechanical Performance

The analysis of all acceptance EM data for this model indicates that all EM data requirements were met. A detailed discussion of the EM performance is contained in Section 4 of this report.

SECTION 2

SIGNIFICANT ANOMALIES

2.1 MALFUNCTION REPORTS

The anomalies discussed in this section have been deemed significant because they impacted performance, or because they caused a configuration modification during the test flow. The complete tabulation of Malfunction Reports (MRs) against S/N 015 has been provided as an integral part of the Technical Certification package. There are no outstanding MRs against S/N 015 as it completed acceptance.

2.2 MR 5447 - AFT SIDE FRAME ARTICULATOR TORSION ROD SUPPORT BRACKET TCA VIBRATION FAILURE

Acceptance level vibration testing of the Two Camera Assembly (TCA) induced fractures in two places on the AFT camera torsion rod support bracket (621-3216).

Subsequent investigation of this malfunction report indicated that the sinusoidal vibration exposure spectrum for this TCA had started at 200 Hz and swept down to 5 Hz. This differed from all previous models tested where the spectrum started at 5 Hz and swept up to 200 Hz. It was observed that component brackets swept from low to high frequencies started to exhibit minute (0 - 1/8-inch) cracks only after repeated vibration cycles. Brackets swept from high to low frequencies, however, fractured completely on the first sweep.

A minute crack in this bracket at a resonant point causes the resonant frequency to shift lower, so that as the acceptance vibration frequency sweeps downward it tends to follow the resonance shift, thus aggravating the minute fracture and causing a complete rupture. When the vibration is swept in the opposite direction, the resonance shift is opposite to the direction of vibration application and thus there is no continued vibration at the shifted resonance point. Subsequent analysis and test has also shown that the acceptance vibration envelope is more severe than the vehicles see on an average.

The bracket design has been modified to correct this marginal condition, and a bracket built to the modified design has been successfully tested for structural integrity. Brackets of the modified design have been installed on both sides of S/N 015, and this MR has thus been closed.

2.3 MR 5457 - ABNORMAL PLATEN (PL) OPERATION

This MR was prepared on May 6, 1974 during pre-acceptance in-air testing. The AFT platen operated erratically as evidenced by the breakup of the Photo Mode Error (PME), Recycle Mode Error (RME) and PL Tach electromechanical signals. A resultant detailed data evaluation program indicated the anomaly was related to platen operation only.

The film drives and platen were removed from the midsection, and the platen was submitted to a thorough visual examination. No indications of mechanical interference were detected. The next phase of the MR investigation addressed itself to the possibility that some type of electrical transient had precipitated the anomalous performance.

The platen servo electronic box (2A1) was replaced with another 2A1 box with an inherently higher noise threshold. No difference in performance was noted; the anomaly still existed, indicating that the source of the problem was probably external to the 2A1 box.

The investigation subsequently focused on the possibility of excessive noise pickup in the cables that interface with the 2A1 unit, causing erratic platen behavior. The results of this testing indicated that the shielding configuration on the cable leading to the platen motor had a direct effect on platen performance, specifically, (1) when either end of the shield on the motor cable was disconnected, the platen would malfunction in the same mode as the original malfunction and (2) separating the motor and encoder cables by at least four inches decreased the noise on the platen servo 0° marker line (a counter reset signal) by approximately 55 percent. The shield terminations were reconnected and a new cable routing scheme was implemented to provide more separation between the motor and encoder cables.

Over 5,000 platen operations have been run since the motor and encoder cables were disconnected, examined and reconnected. No repetition of this anomaly has occurred.

In conclusion it is felt that this anomaly was caused by a faulty shield connection in the 2A1 motor cable. This MR has been closed.

2.4 MR 5477 - FILM BREAKAGE, FWD AND AFT CAMERAS

This MR was written on June 18, 1974 at the end of a series of special Chamber A tests. Data review indicated that a system constraint was violated, namely that when running at constant velocity (cv) the system must be brought below camera power off before subsequently recommanding film transports on. The following coarse path command sequence occurred as a result: the velocity command ramped to maximum reverse, then ramped to maximum forward, then stepped immediately to maximum reverse, followed by a film break on both cameras in the supply compartment.

As a result of the failure, the system was disassembled and all major subassemblies were inspected for damage and reworked as required. Film was found broken on both sides in the SU. Static and dynamic SU brake torque tests indicated a slightly out-of-specification condition on the high limit. Brakes were readjusted.

In the FEV, the AFT side tensioner roller was found out of alignment. Several rollers on both FWD and AFT sides failed roller rundown tests and were either replaced or had preload adjusted.

Material from both stacks was retrieved, pieced together, and processed. On the FWD side, the film had been broken in four places in the SU. In addition, 26 inches had been pulled through a closed seal door; required force was 20 to 22 pounds.

On the AFT side, the film was broken in two places. In addition, 43 inches had been pulled through a closed seal door; required force was also 20 to 22 pounds.

Analysis determined the tension in the film on the SU side of the seal door (both sides) reached about 74 pounds. In the TCA, it probably reached 54 pounds. Based on reasonable air bar coefficient of friction values, the tension in the PL area was calculated at about 20 to 22 pounds.

All rollers on the FWD and AFT sides were checked for preload, runout, and rundown. Seventeen rollers required adjustment and 12 rollers were replaced. Alignments in critical areas were checked and adjusted as required.

Test flow was resumed successfully.

2.5 MR 5494 - 100 Hz OSCILLATION OUTPUT FILM DRIVE SUMMED ERROR

This MR was prepared as a result of a complete review of the electromechanical signals on July 30, 1974 prior to Chamber A in-air testing. This data review is standard practice.

The FWD camera output film drive summed error exhibited an abnormal 600 millivolt peak-to-peak oscillation at 90 to 103 Hz. The output film drive servo box (3A1) was replaced with another unit and the anomaly disappeared. The new unit (S/N 1032) was retained for all subsequent testing, and will stay with this model. The suspect 3A1 box (S/N 1022) was subsequently installed and tested on the AFT side of S/N 015, on the validation model, on both sides of S/N 016, and on the AFT side of S/N 017. In every case, operation was nominal. The anomaly did repeat when the S/N 1022 box was reinstalled on the FWD side of S/N 015. The unit was returned to the vendor for investigation, and no anomalous condition was found. The acceptance test was rerun and the box passed. The box has been added to the suspect box list and will continue to be monitored on the AFT side of S/N 017.

2.6 MR 5485 PNEUMATIC TUBING KINK

This MR was written as a result of an emergency shutdown (ESD) that occurred on the FWD side during a creep run. Investigation found a severely kinked urethane tube that supplies nitrogen to the Crossover Air Bar. The kink in the tubing cut off the nitrogen to the air bar causing high drag on the film. The ESD resulted subsequently when the looper drifted into its stop. A tube with an internal spring has been substituted along with a length callout to correct this situation.

SECTION 3

PHOTO-OPTICAL PERFORMANCE

3.1 OPTICAL BARS

3.1.1 Optical Set Identification

The operational cameras for S/N 015 Sensor Subsystem are identified as FWD camera (Optical Bar A) and AFT camera (Optical Bar B). The optical glass sets are identified as 036 for the FWD camera and 043 for the AFT camera. These set nomenclatures (See Table 3-1) serve as camera identifiers for operational purposes and for post flight analysis, etc.

TABLE 3-1

CAMERA IDENTIFICATION

Optical Bar	Flight Direction	Optical Set
A	Forward	036
B	Aft	043

3.1.2 Physical Characteristics

The two physical characteristics (Table 3-2) measured for both cameras are focal length and T number. Note from the tabular values, both cameras are within acceptable design specification requirements.

TABLE 3-2

PHYSICAL CHARACTERISTICS, FWD AND AFT CAMERAS

Characteristic	Specification	FWD Camera	AFT Camera
Focal Length (inches)	60 ± 0.2 (2σ)	59.9704	59.9963
T Number	3.5 maximum	3.46	3.46

3.1.3 Longitudinal Color

The on-axis longitudinal color response (Figure 3-1) was plotted for both optical bar sets, and the focus position was measured at six wavelengths: 4720Å, 5175Å, 5500Å, 6050Å, 6630Å, and 6975Å.

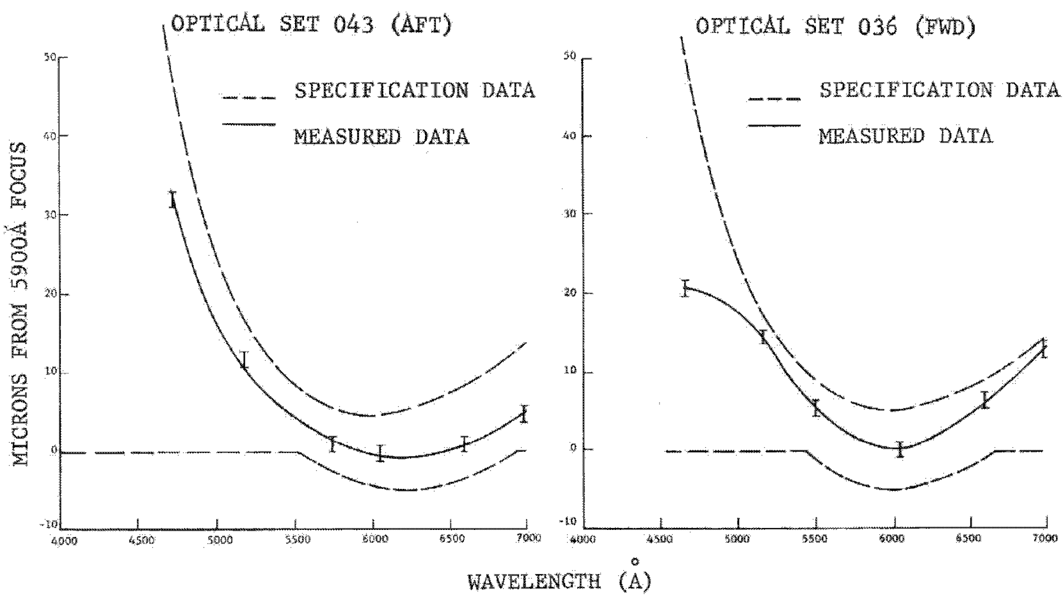


Figure 3-1. On-Axis Longitudinal Color Response

3.1.4 Focal Plane Tilt

The field curvature for both optical bar sets was plotted (See Figure 3-2), and as the plots indicate, curvature was determined from monochromatic data taken in Chamber D. Chambers A and A-2 sign conventions were used to facilitate additional plotting of the film plane profile across the slit based upon the resolution data. Also shown are both in-track and cross-track best focus.

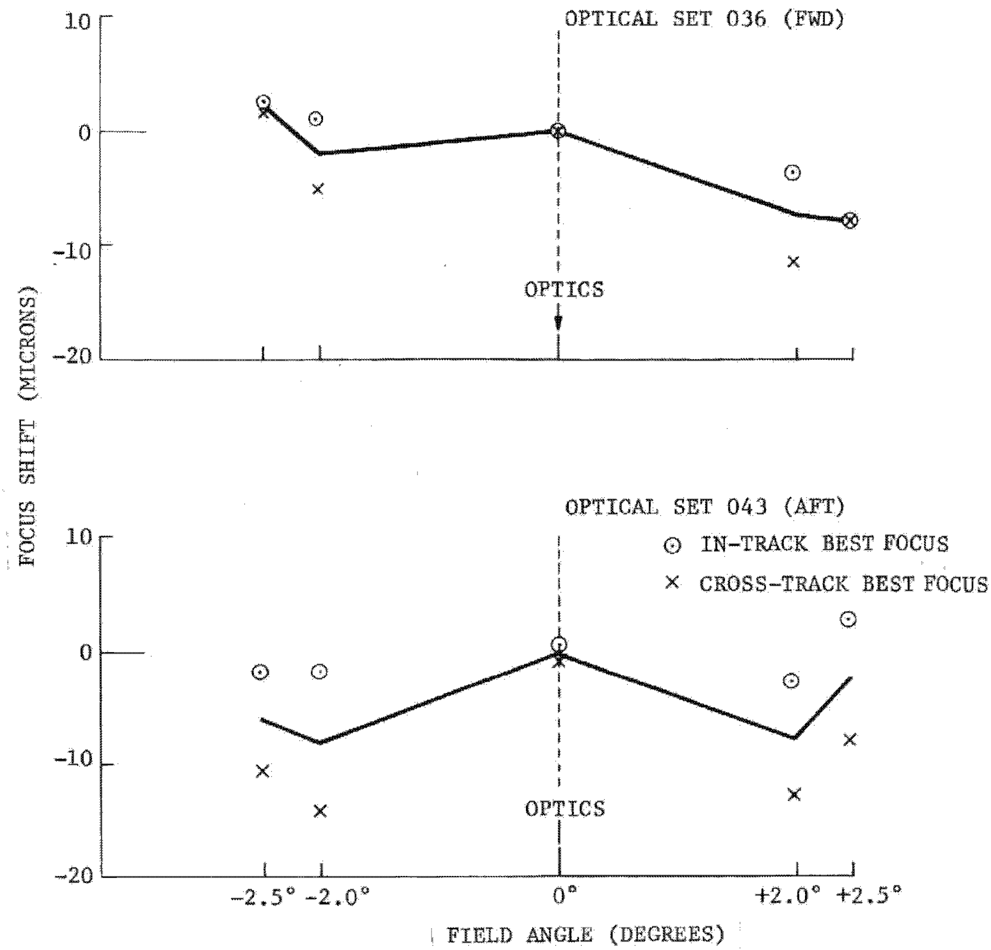


Figure 3-2. Field Curvature, Optical Bar, Glass Sets 036 and 043, FWD and AFT Cameras

This Chamber D data showed:

a. Optical Bar Set 036 has a 9μ tilt (4.4μ per 1/2 slit) in the advance direction.

b. Optical Bar Set 043 has a 2μ tilt (1.2μ per 1/2 slit) in the retreat direction.

3.1.5 MTF Comparison

Modulation transfer functions (measured at 70°F, 93°F and 47°F) and their respective specification curves for each optical bar were compared as shown in Figures 3-3 through 3-8. The comparisons show the off-axis MTFs at 47°F fall below specification for the FWD optical bar at the ±2.5° fields in both flight and scan direction; these were at various frequencies greater than 132 l/mm for the flight direction and greater than 164 l/mm for the scan direction.

The major cause of the low MTFs was gravity-induced astigmatism in the fold. After accounting for this error, however, the MTFs and predicted resolution are above specification (See Section 6).

For 70°F, the MTF ratios of post-vibration to pre-vibration values at 140 cy/mm indicate optical performance to be essentially unchanged by exposure to acceptance vibration (See Table 3-3).

TABLE 3-3

MTF RATIOS, POST-VIBRATION TO PRE-VIBRATION AT 140 CYC/MM

Field Angle	Optical Bar Set			
	036 (FWD)		043 (AFT)	
	Flight	Scan	Flight	Scan
+2.5°	1.02	1.02	0.93	0.92
0°	1.01	1.02	0.94	0.96
-2.5°	1.00	1.01	0.93	0.95

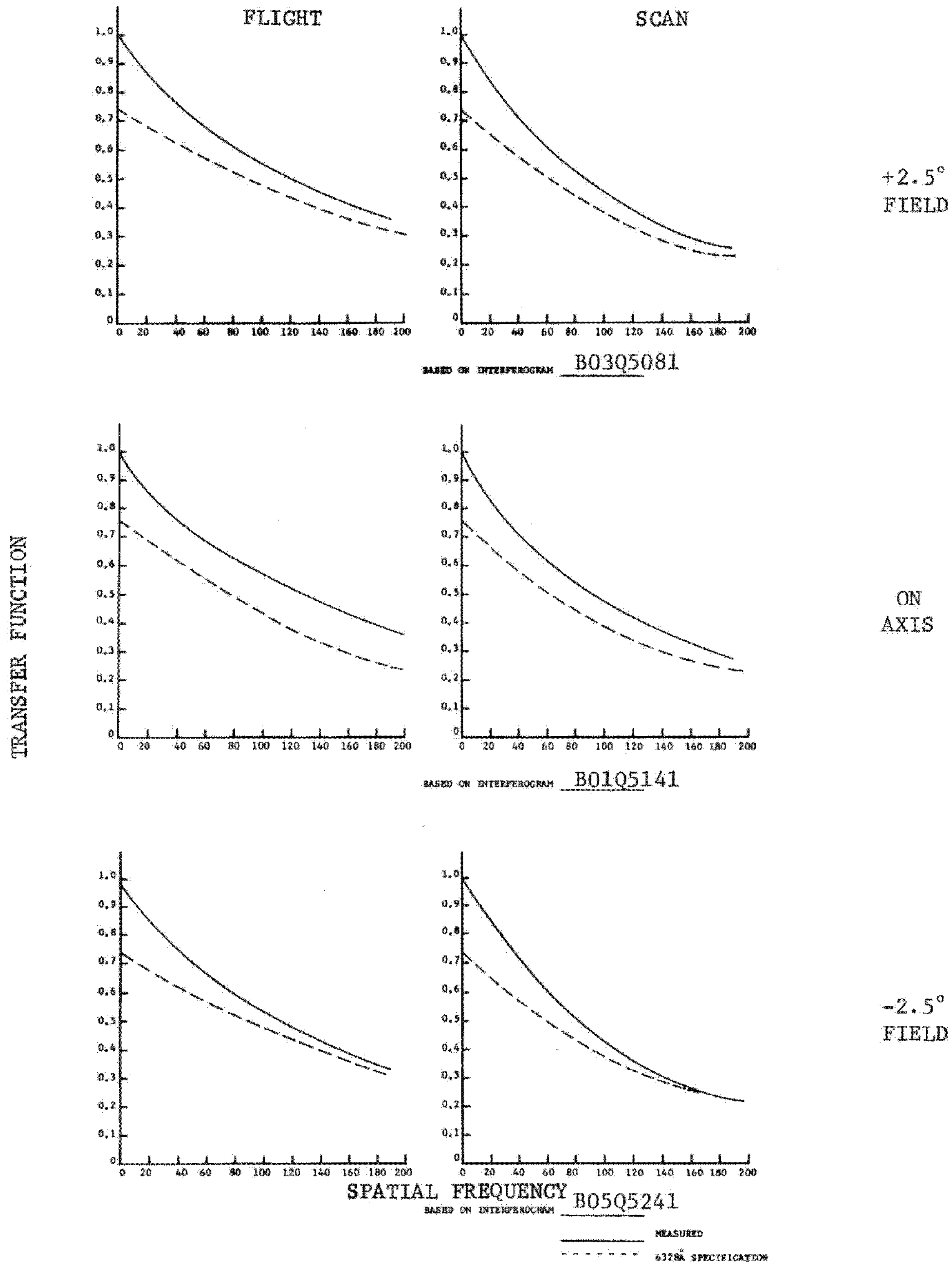


Figure 3-3. Monochromatic Post Vibration MTF at 70°F, Glass Set 043, On-Axis and ±2.5° Field, AFT Camera

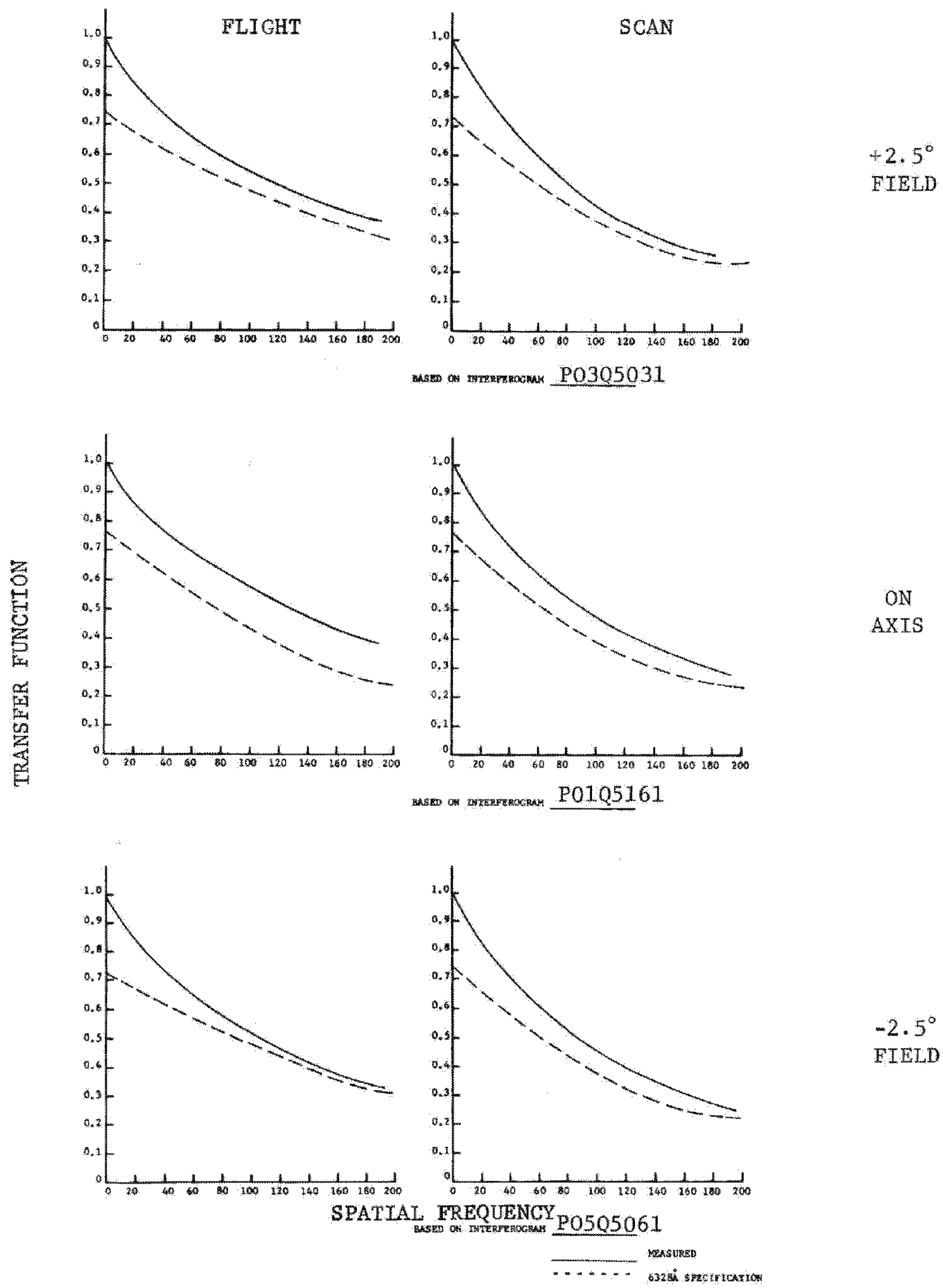


Figure 3-4. Monochromatic Post Vibration MTF at 93°F, Glass Set 043, On-Axis and $\pm$2.5° Field, AFT Camera

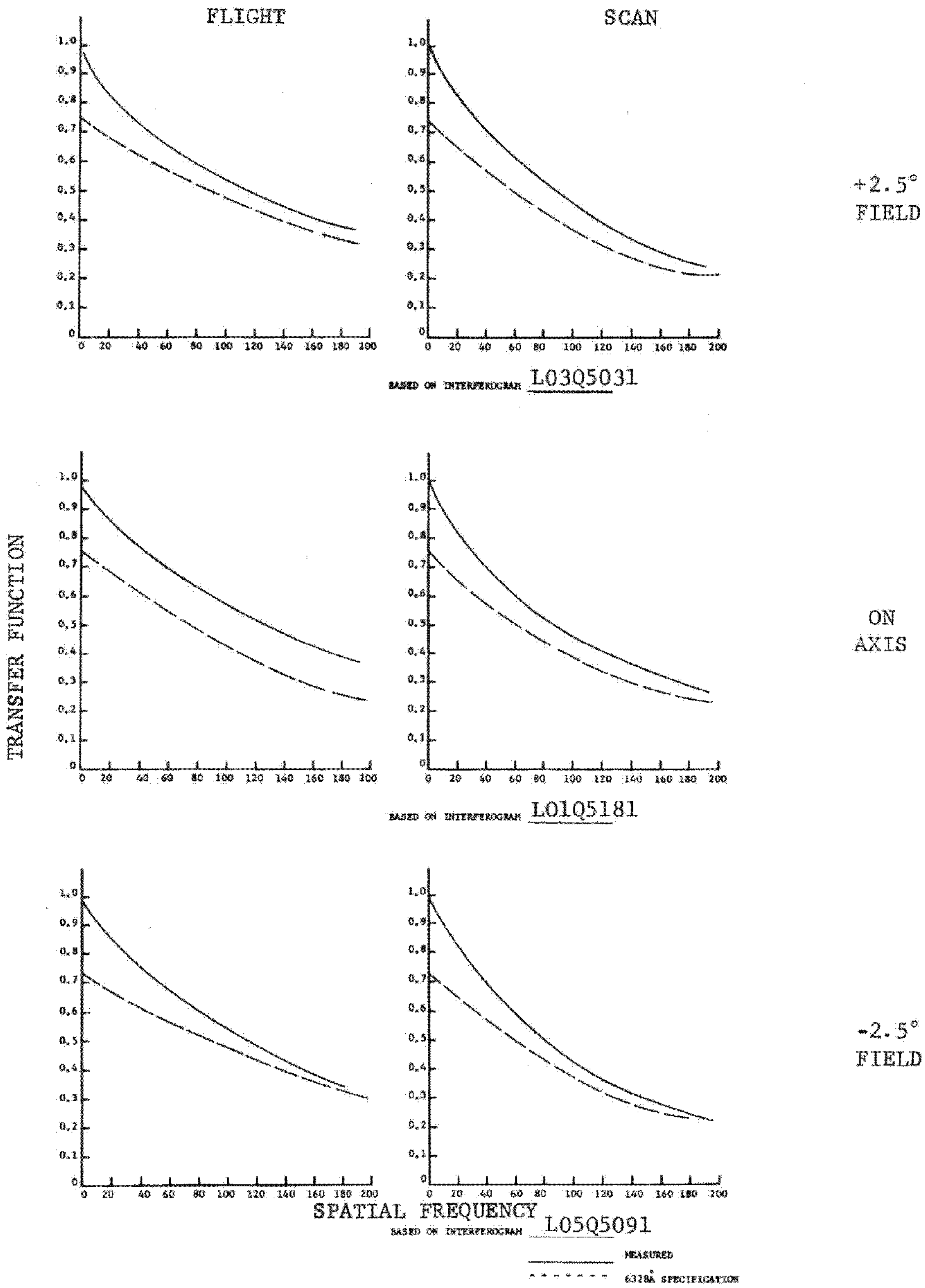


Figure 3-5. Monochromatic Post Vibration MTF at 47°F, Glass Set 043, On-Axis and ±2.5° Field, AFT Camera

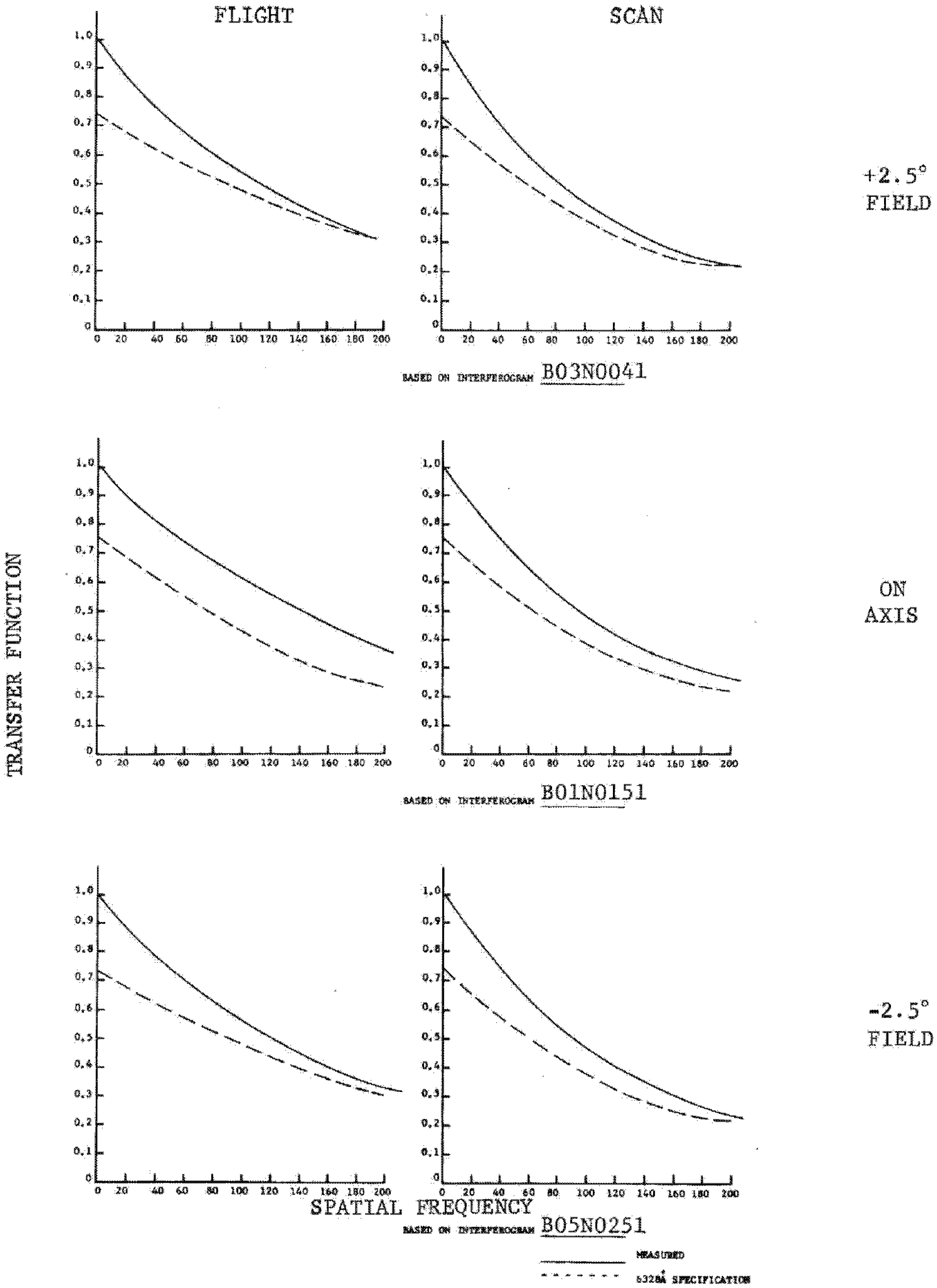


Figure 3-6. Monochromatic Post Vibration MTF at 70°F, Glass Set 036, On-Axis and ±2.5° Field, FWD Camera

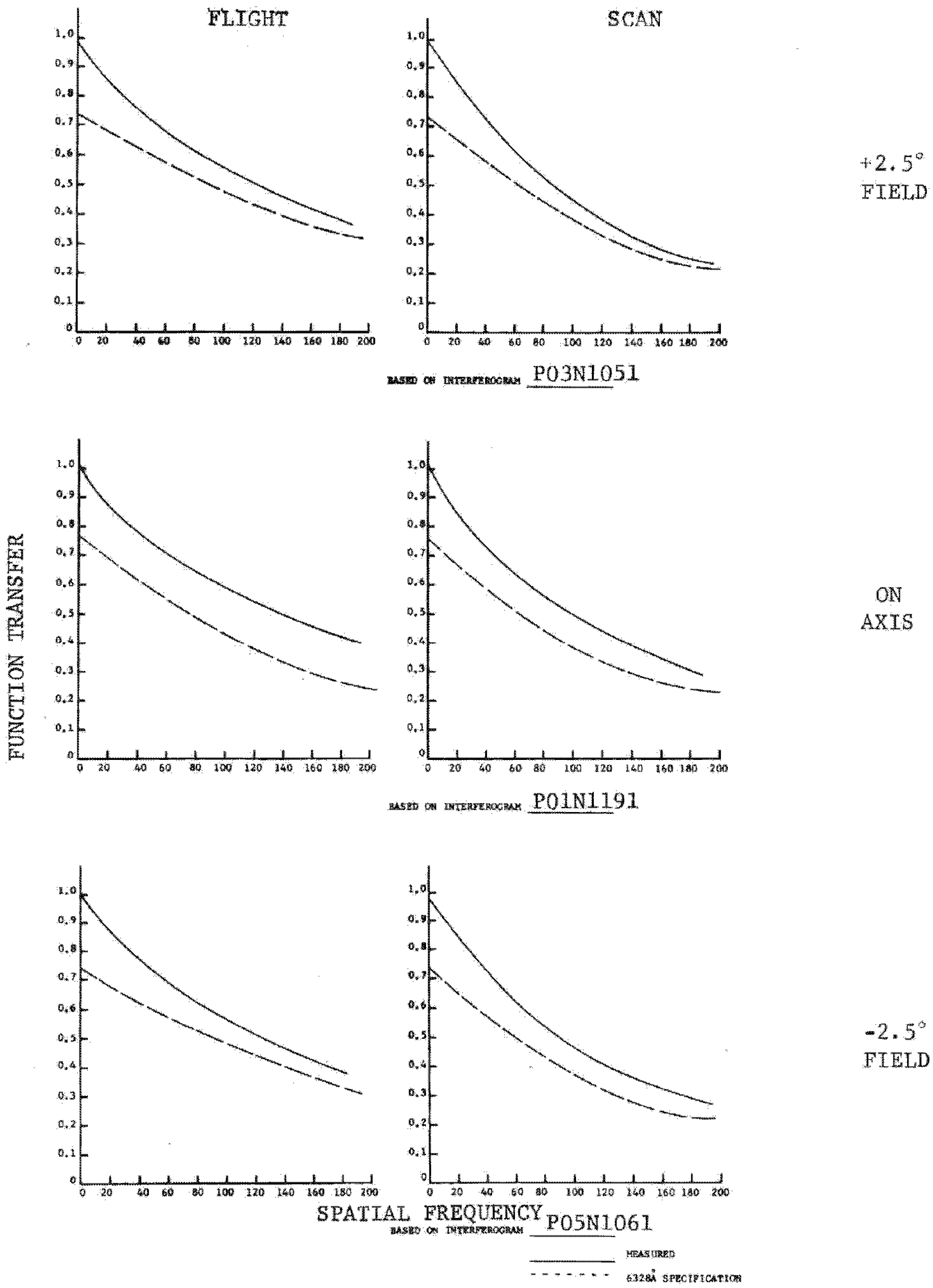


Figure 3-7. Monochromatic Post Vibration MTF at 93°F, Glass Set 036, On-Axis and ±2.5° Field, FWD Camera

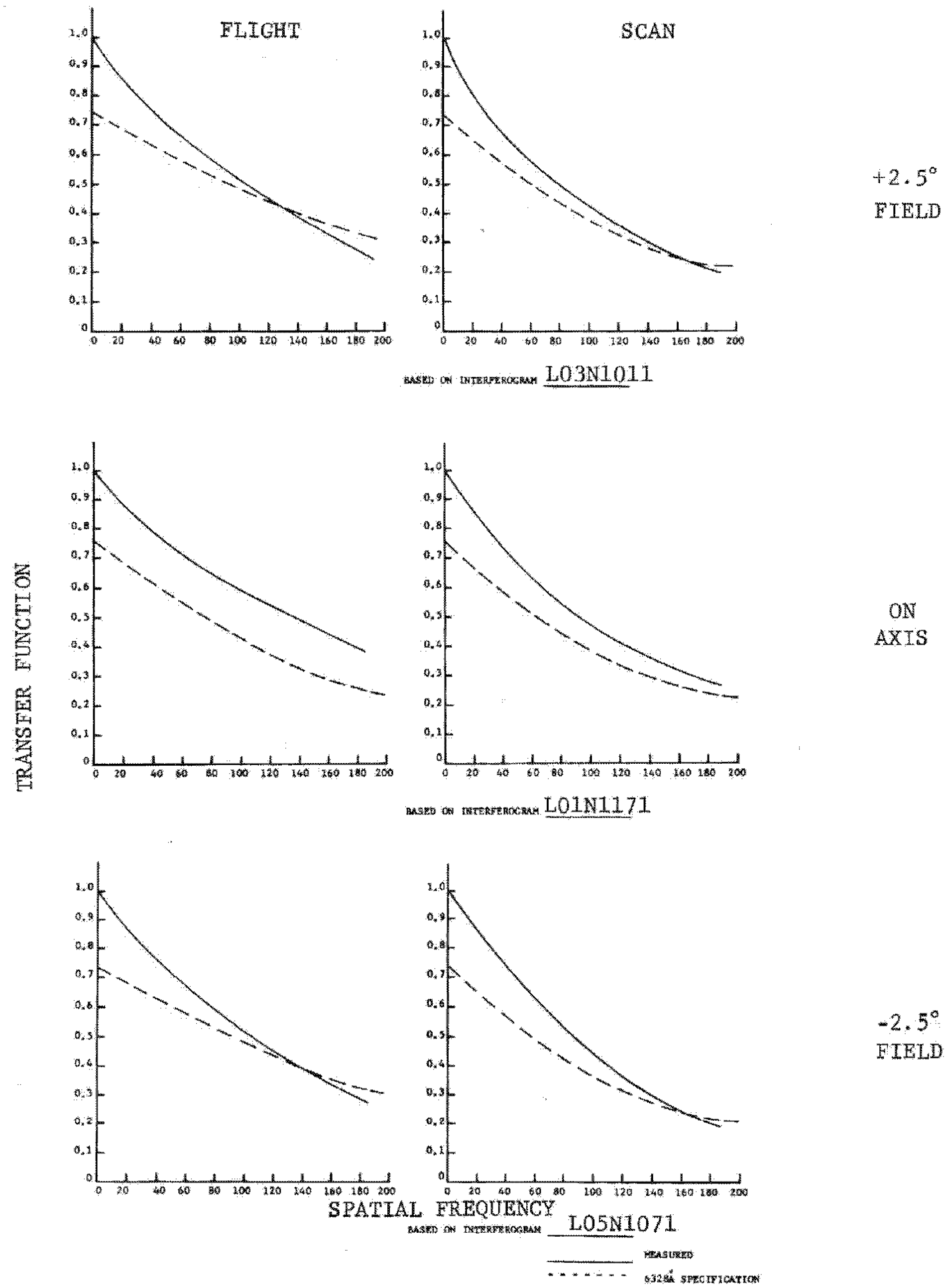


Figure 3-8. Monochromatic Post Vibration MTF at 47°F, Glass Set 036, On-Axis and ±2.5° Field, FWD Camera

3.1.6 Passive Focus Shift

Both cameras were tested in a Chamber D test environment. Following thermal stabilization at each of the 47°F and 93°F environments, focus change was measured. The amount of defocus at field positions 0° and ±2.5° is related to the focus positions established at 70°F. Focus data (Table 3-4) is essentially a measure of the optic's ability to maintain, passively, the best focus position over the operating thermal range. The signs shown in the table reflect the normal Chamber A sign convention of plus being away from the last optical surface.

TABLE 3-4

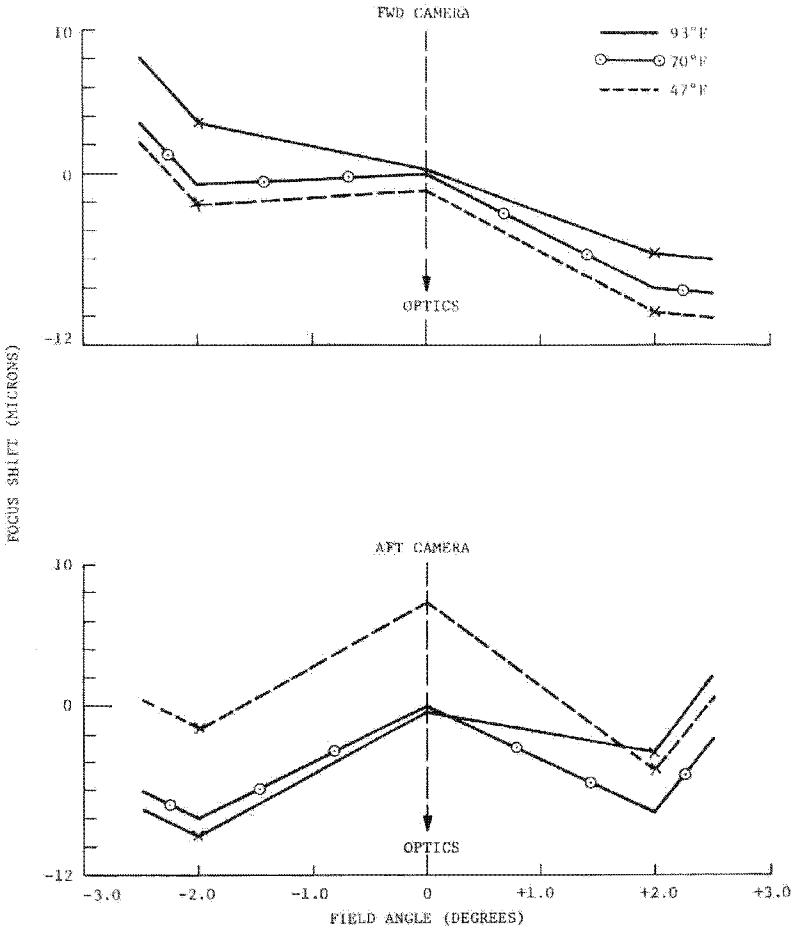
PASSIVE FOCUS POSITION DATA

Optical Bar		036 (FWD)	043 (AFT)
Temperature (°F)	Field Position (Degrees)	Defocus (Microns)	Defocus (Microns)
93	2.5	+2.6	+4.5
	0	+0.4	-0.3
	-2.5	+4.5	-1.3
47	2.5	-1.7	+3.0
	0	-1.1	+7.3
	-2.5	-1.2	+6.3

The data (Table 3-4 and Figure 3-9, passive focus error effects on field curvature and tilt) shows the following:

a. The FWD optical bar meets the ±4.5μ performance requirement at both 93°F and 47°F in all fields.

b. The AFT optical bar does not meet the requirement at 47°F in the 0° and -2.5° field positions, but does at 93°F in all field positions.



NOTE: Temperature data collected at 0°, ±2.0° and ±2.5° of field at 70°F only. The ±2.0° data (X) is extrapolated for 93°F and 47°F.

Figure 3-9. Effect of Temperature on Field Curvature and Tilt, FWD and AFT Cameras

Although optical bar 043 does not meet the ±4.5μ passive focus control specification, predicted on-orbit performance of this optical bar was well above specification at all temperatures. This prediction assumed the worst-case condition -- focus would not be actively controlled based on known temperatures. As a result of predicted performance, this optical bar was moved ahead in assembly.

3.1.7 Gravity Induced Defocus and Aberration

Testing in a gravity field causes errors in focus and wavefront aberration that should be accounted for. The measured gravity induced defocus and astigmatism for this system are as follows:

At Nadir	FWD Camera	AFT Camera
Gravity induced defocus	7.1μ	8.1μ
Gravity induced 0° - astigmatism	-0.08λ	-0.14λ
Chamber D Correction		
Gravity induced 45° - astigmatism	0.08λ	0.08λ

Plus defocus is away from the optics.

3.1.8 Dynamic Gravity Corrections

Dynamic gravity corrections (Table 3-5) for both optical bars are used to adjust the measured image motion values for both chambers (A and A-2).

3.2 MIDSECTION RESOLUTION PERFORMANCE

3.2.1 Thru-Focus Resolution

3.2.1.1 Acceptance Data

The resolution acceptance criteria, specified in Paragraph 3.1.1 of S/N 015 CEI specification and listed in Table 3-6 herein are to be met at a Vx/h of 0.052 rad/sec at a single selected plane of best focus in the 120° scan mode. Raw data is obtained by reading tri-bar resolution targets recovered from CEI runs 101, 111 and 115 (70°F, 47°F and 93°F, respectively). This raw data is read in both the in-track and cross-track directions, and the geometric mean is calculated for each frame. These geometric means are then arithmetically averaged for the total number of frames at each focus setting for each collimator position. The in-track and cross-track points of best focus are selected by a computer program that evaluates the output of automicrodensitometer scanning of the line targets. The arithmetic average of these points establishes the point of best focus for each collimator position (see Figures 3-10 through 3-15, raw in-track, cross-track, and geometric mean data).

TABLE 3-5

GRAVITY CORRECTIONS, CHAMBERS A AND A2

CHAMBER A	FWD OB #5036						AFT OB #5043					
	IN-TRACK			CROSS-TRACK			IN-TRACK			CROSS-TRACK		
	45°	0°	55°	45°	0°	55°	45°	0°	55°	45°	0°	45°
31.2 rpm Vx/h = 0.052	0.032	-0.008	-0.044	-0.023	-0.035	-0.018	0.042	-0.002	-0.055	-0.025	-0.040	-0.026
26.4 rpm Vx/h = 0.044	0.028	-0.007	-0.037	-0.019	-0.030	-0.013	0.036	-0.002	-0.046	-0.022	-0.034	-0.023
21.6 rpm Vx/h = 0.036	0.023	-0.006	-0.030	-0.016	-0.025	-0.012	0.030	-0.002	-0.038	-0.016	-0.027	-0.019

CHAMBER A2	FWD OB #5036				AFT OB #5043			
	IN-TRACK		CROSS-TRACK		IN-TRACK		CROSS-TRACK	
	0°	37°	0°	37°	0°	37°	0°	37°
31.2 rpm Vx/h = 0.052	-0.008	-0.038	-0.035	-0.024	-0.002	-0.041	-0.040	-0.035
26.4 rpm Vx/h = 0.044	-0.007	-0.032	-0.030	-0.019	-0.002	-0.034	-0.034	-0.031
21.6 rpm Vx/h = 0.036	-0.006	-0.026	-0.025	-0.016	-0.002	-0.029	-0.027	-0.026

1. All values given in inches/sec.
2. All values in OB coordinate system.

TABLE 3-6

RESOLUTION ACCEPTANCE CRITERIA,
SUMMARY OF TRI-BAR RESOLUTION

(Average Geometric Mean of Flight and Scan in cyc/mm Vacuum,
Vx/h = 0.052, Continuous Illumination, IMC Disabled)

Camera				FWD			AFT		
Temperature				70°	47°	93°	70°	47°	93°
Scan Angle	Field Position	Acceptance Criteria							
		70°	47° & 93°	*42μ	42μ	42μ	*66μ	66μ	66μ
45°	2.5°	130	110	175	183	177	165	173	153
Nadir	0°	150	150	183	207	159	185	198	168
55°	2.0°	130	110	174	188	166	157	169	142

*Average of Three Readers

A point of best focus of 42μ for the FWD camera and 66μ for the AFT camera was selected to give best performance across the three collimator positions at all temperatures for S/N 015. The raw data resolution values at these positions are tabulated in Table 3-6. All values exceed their corresponding specification criteria.

3.2.1.2 Acceptance Data Analysis

Realistic system operational performance evaluation is based upon the analysis of corrected acceptance resolution data. Modifying raw resolution data for collimator defocus, gravity and film flatness characteristics results in the corrected data.

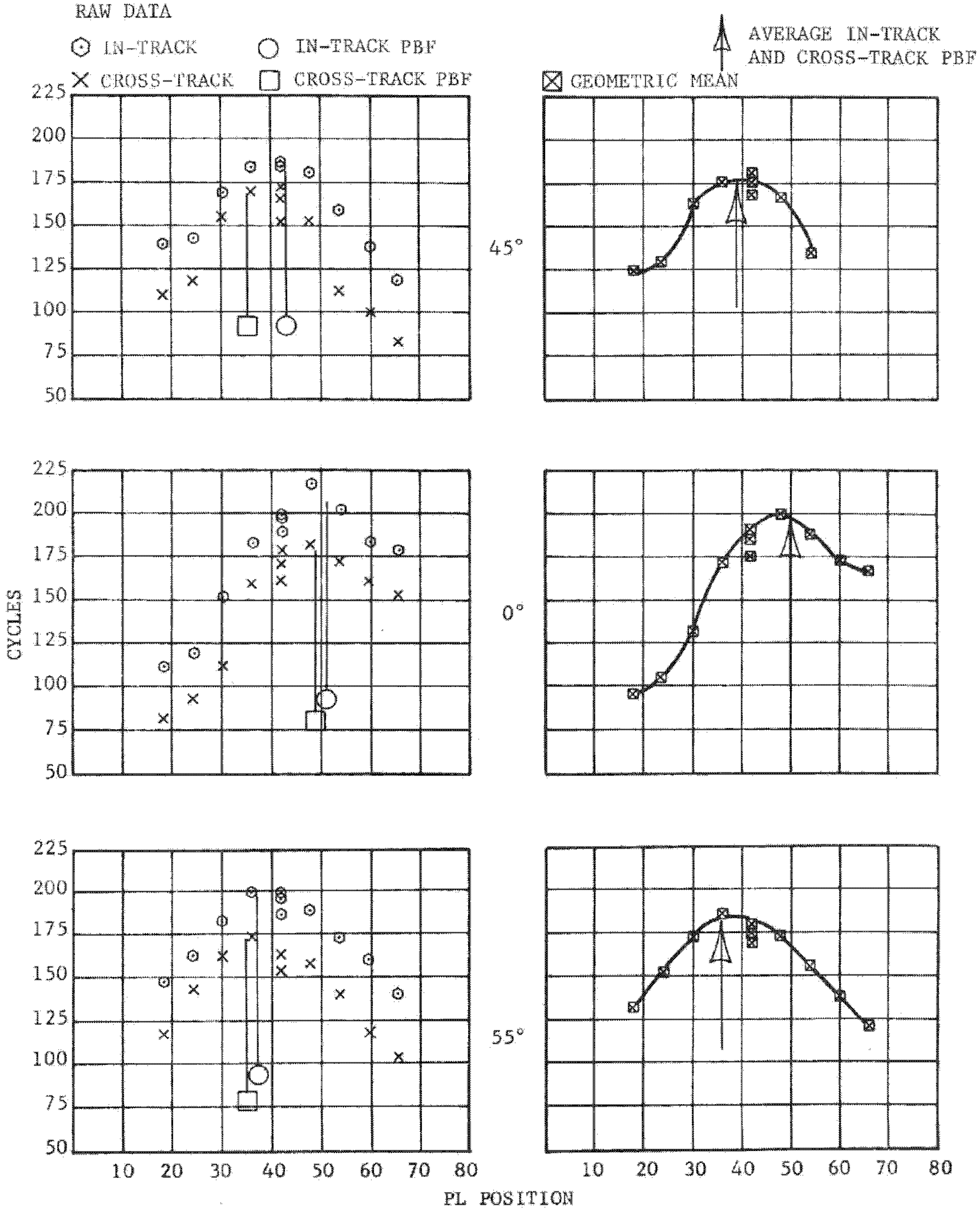


Figure 3-10. Performance Plot, Rad X = 0.052, 70°F, CEI 101, FWD Camera

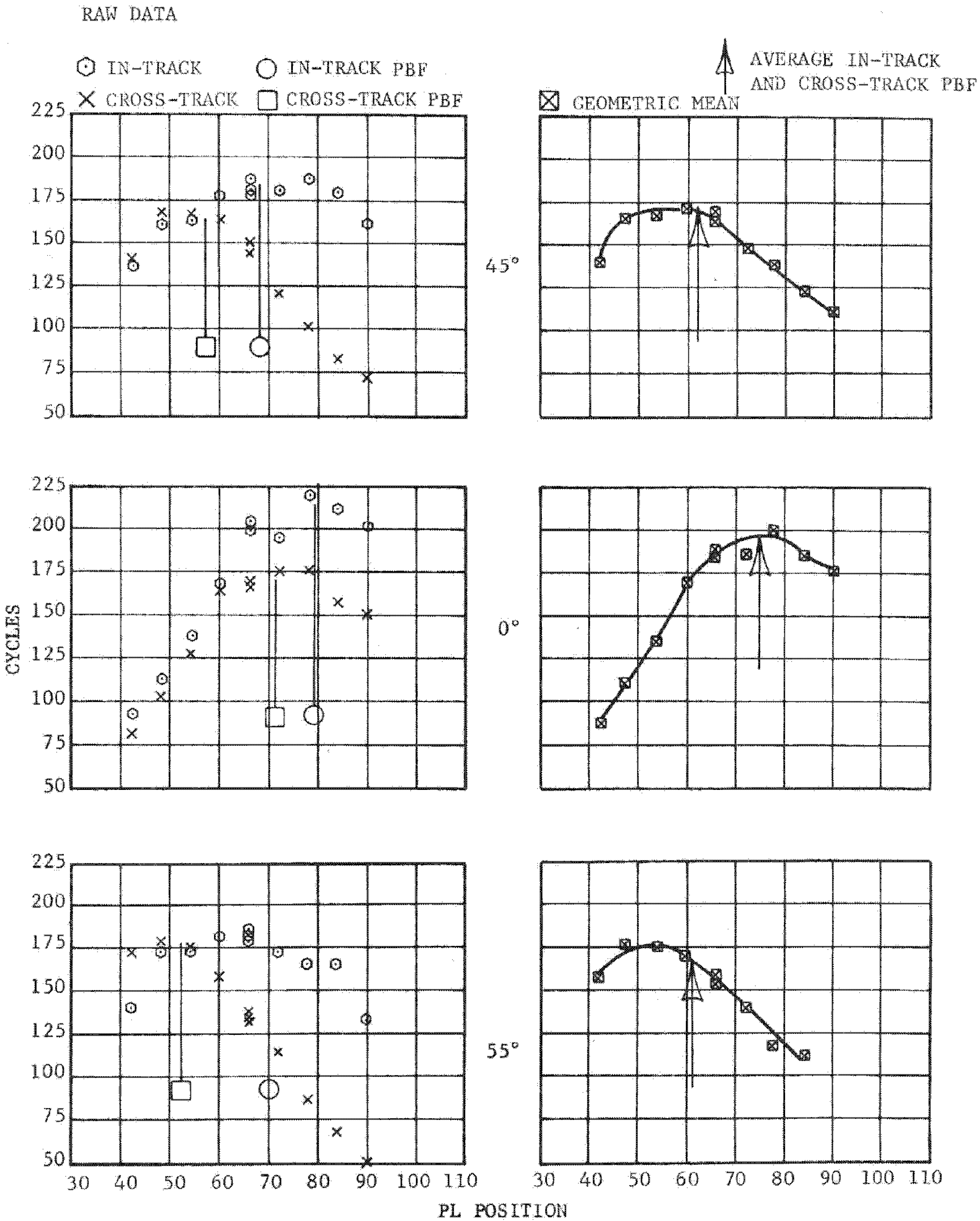


Figure 3-11. Performance Plot, Rad X = 0.052,
70°F, CEI 101, AFT Camera

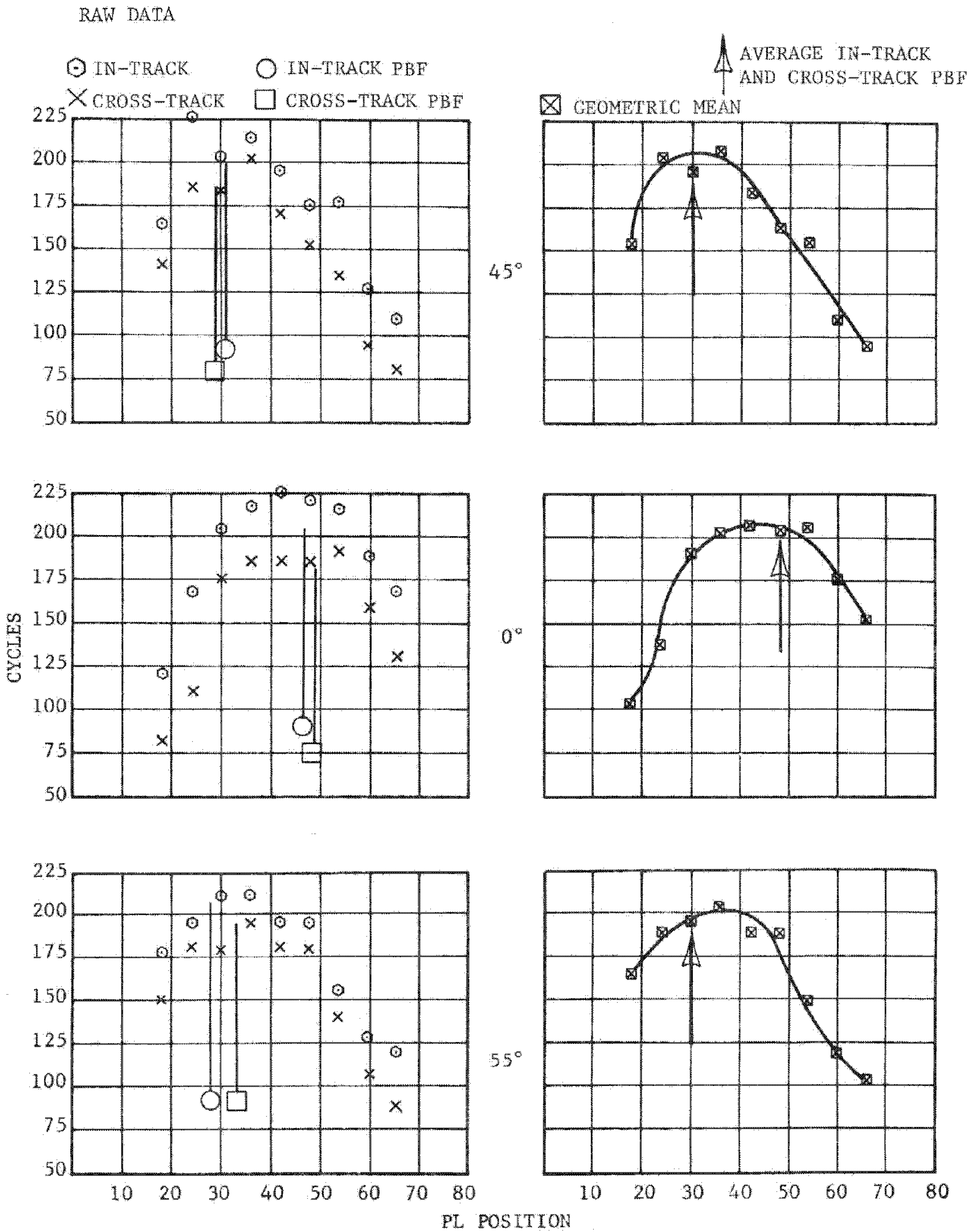


Figure 3-12. Performance Plot, Rad X = 0.052, 47°F, CEI 111, FWD Camera

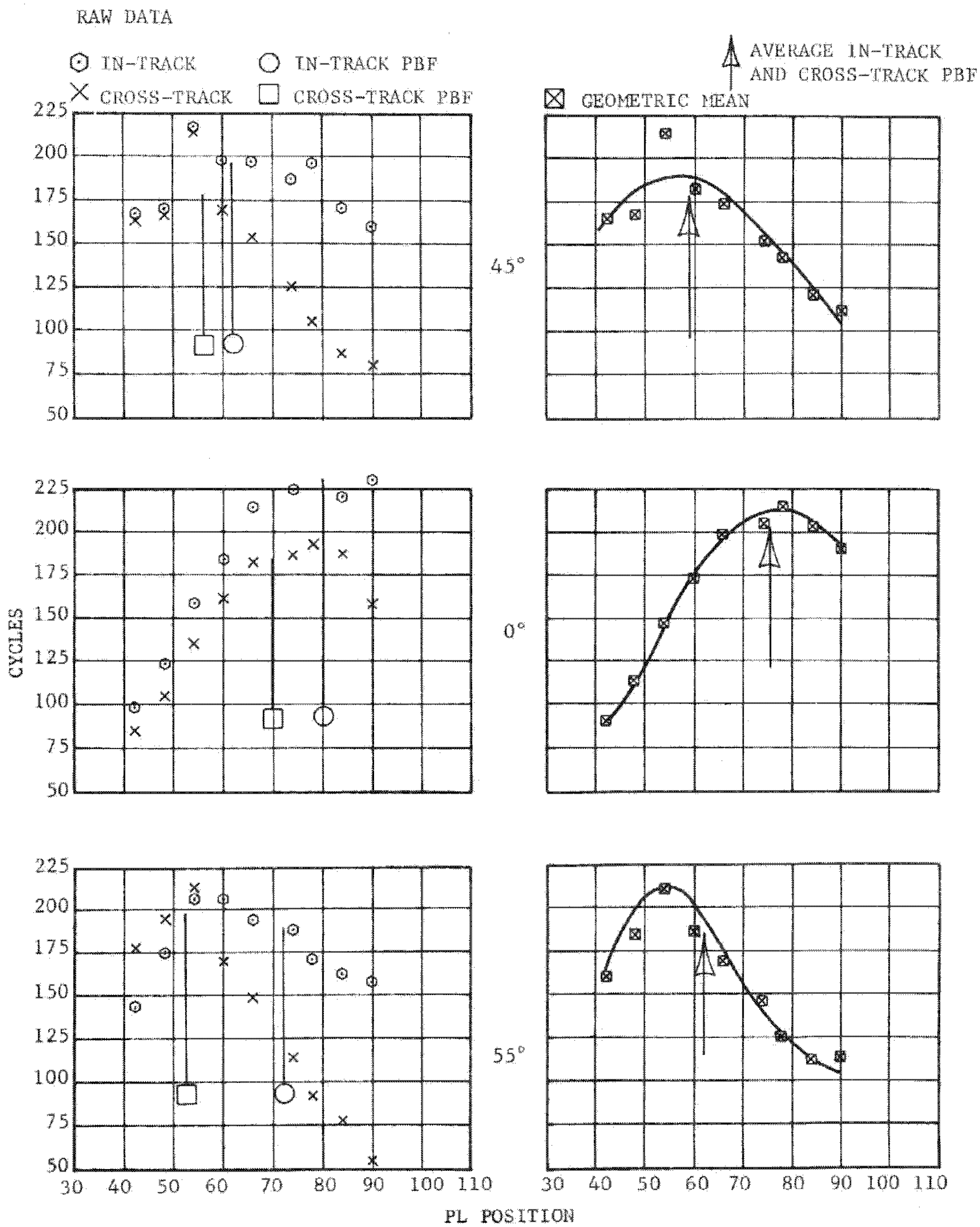


Figure 3-13. Performance Plot, Rad X = 0.052, 47°F, CEI 111, AFT Camera

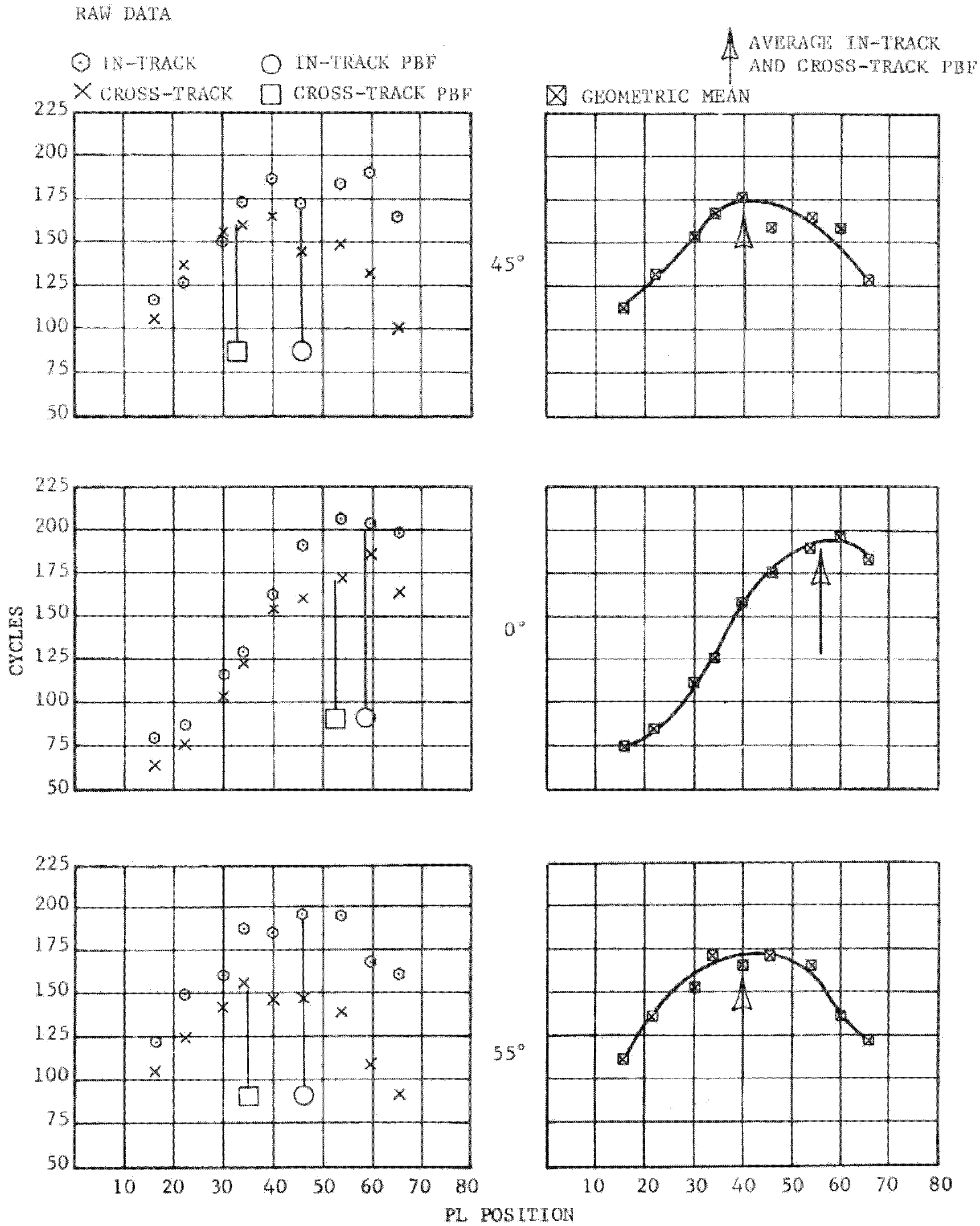


Figure 3-14. Performance Plot, Rad X = 0.052, 93°F, CEI 115, FWD Camera

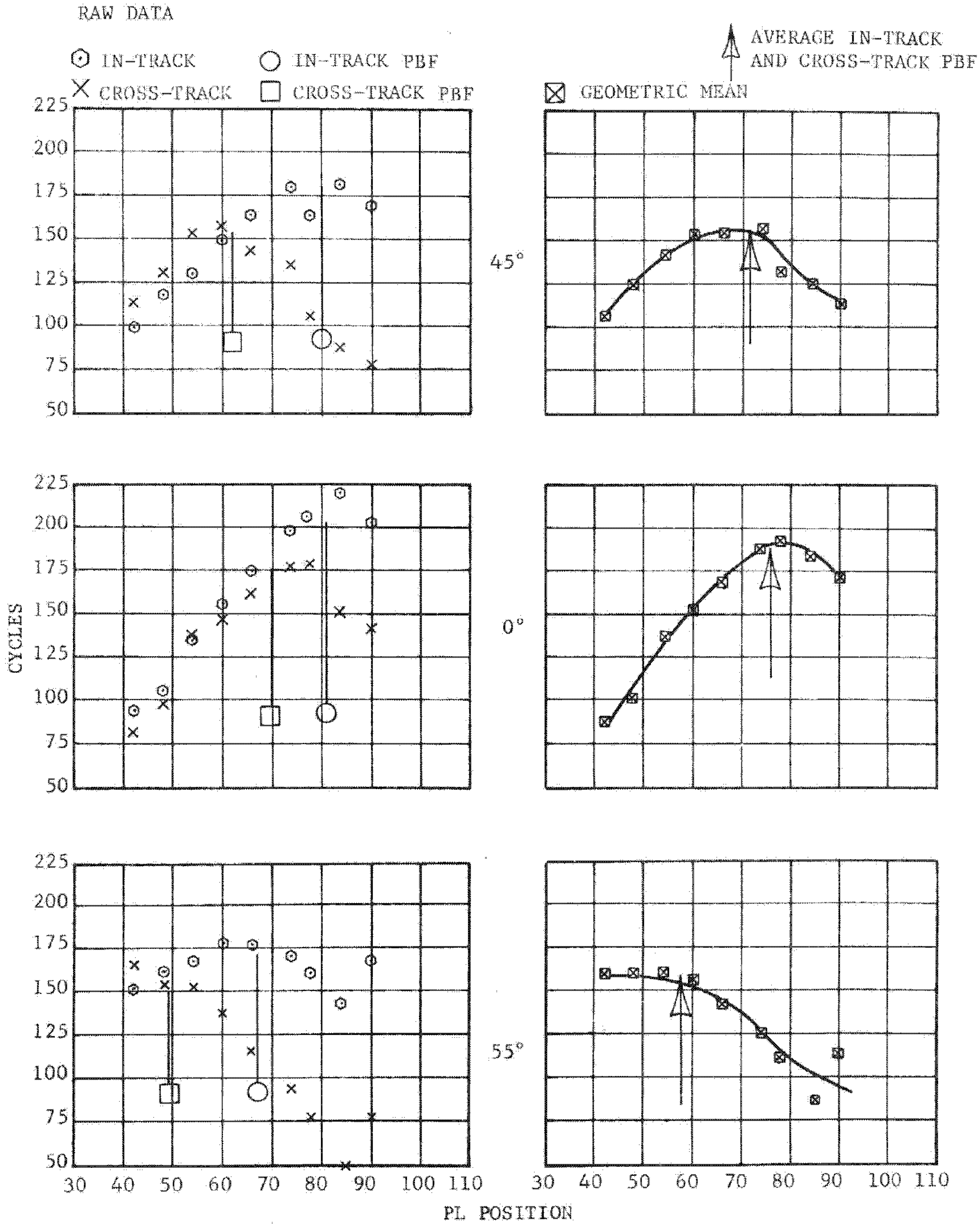


Figure 3-15. Performance Plot, Rad X = 0.052, 93°F, CEI 115, AFT Camera

Collimator defocus corrections account for any deviation of the target reticle from the true infinity focus position. These deviations are determined interferometrically via the reticle corner cubes; Tables 3-7 and 3-8 tabulate these magnitudes. The correction factor for gravity compensates for its varying effect on the optical elements at different orientations as the bar rotates. The values tabulated in Tables 3-7 and 3-8 reflect the average measured values from a series of tests on several optical bars in Chamber C.

Film flatness effects are determined by a series of measurements made on selected segments of film used during the CEI through-focus runs; these film samples are cut out prior to processing and tested on the abbreviated film path (AFP). Traces are made across the film web with a photonic sensor having measurement repeatability of one micron. Also tabulated in Tables 3-7 and 3-8 are these film flatness corrections.

Applying these tabulated correction factors to the in-track and cross-track raw acceptance data brings about a shift in focus position of the curves; and because the magnitudes of the in-track and cross-track focus corrections are different, the resultant mean curves shift in focus as well as resolution value. In Figures 3-16 and 3-17 are corrected in-track, cross-track and geometric mean resolution data for S/N 015 at 70°F. A corrected point of best focus of 36μ for the FWD camera and 54μ for the AFT camera results in the corrected resolution values listed in Table 3-9. These corrected values now represent a measure of system operational performance. Note that these focus positions are chosen to give best performance across the field at infinity focus; they are not intended to reflect the final flight focus settings.

3.2.1.3 Resolution Performance at Vx/h = 0.036

Resolution performance determination at a Vx/h of 0.036 is categorized in the CEI specification as an essential test for information; acceptance criteria do not apply. In Table 3-10, the resolution data for CEI run 103 is tabulated. Note from the table that a re-read of the FWD camera data revealed grossly different results; reader variability is a problem (see Paragraph 3.2.1.4).

TABLE 3-7

FOCUS CORRECTION FACTORS (MICRONS), FILM FLATNESS, FWD CAMERA

CEI TEST	COLL. POS.	FIELD POS.	RAW FOCUS DATA IN-TRK	RAW FOCUS DATA CR-TRK	RAW FOCUS DATA AVG.	COLL. CORR. IN-TRK	COLL. CORR. CR-TRK	GRAVITY CORR. IN-TRK	GRAVITY CORR. CR-TRK	FILM FLAT.	CORRECTED FOCUS DATA IN-TRK	CORRECTED FOCUS DATA CR-TRK	CORRECTED FOCUS DATA AVG.
101 (70°F)	-45°	-2.5°	43	35	39	-1	0	-11	-3	0	31	32	32
	0°	0°	51	49	50	+3	+4	-16	-4	-5	33	44	39
	+55°	+2°	37	35	36	+2	+2	-10	-2	-2	27	33	30
111 (47°F)	-45°	-2.5°	31	29	30	+1	+2	-11	-3	0	21	28	25
	0°	0°	47	49	48	+3	+4	-16	-4	0	34	49	42
	+55°	+2°	28	33	31	0	+1	-10	-2	-3	15	29	22
115 (93°F)	-45°	-2.5°	46	33	40	+1	+2	-11	-3	+1	37	33	35
	0°	0°	59	53	56	+3	+4	-16	-4	-2	44	51	48
	+55°	+2°	46	35	41	0	+1	-10	-2	-3	33	31	32

TABLE 3-8

FOCUS CORRECTION FACTORS (MICRONS), FILM FLATNESS, AFT CAMERA

CEI TEST	COLL. POS.	FIELD POS.	RAW FOCUS DATA IN-TRK	RAW FOCUS DATA CR-TRK	RAW FOCUS DATA AVG.	COLL. CORR. IN-TRK	COLL. CORR. CR-TRK	GRAVITY CORR. IN-TRK	GRAVITY CORR. CR-TRK	FILM FLAT.	CORRECTED FOCUS DATA IN-TRK	CORRECTED FOCUS DATA CR-TRK	CORRECTED FOCUS DATA AVG.
101 (70°F)	+45°	+2.5°	68	57	62	-1	-1	-11	-3	0	56	53	55
	0°	0°	79	71	75	+1	+1	-16	-4	-7	57	61	59
	-55°	-2°	70	52	61	0	-1	-10	-2	-8	52	41	47
111 (47°F)	+45°	+2.5°	62	56	59	+1	+1	-11	-3	-4	48	50	49
	0°	0°	80	70	75	+2	+2	-16	-4	-3	63	65	64
	-55°	-2°	72	52	62	-1	-3	-10	-2	0	61	47	54
115 (93°F)	+45°	+2.5°	80	62	71	+1	+1	-11	-3	-5	65	55	60
	0°	0°	81	70	76	+2	+2	-16	-4	-2	65	66	66
	-55°	-2°	67	49	58	-1	-3	-10	-2	0	56	44	50

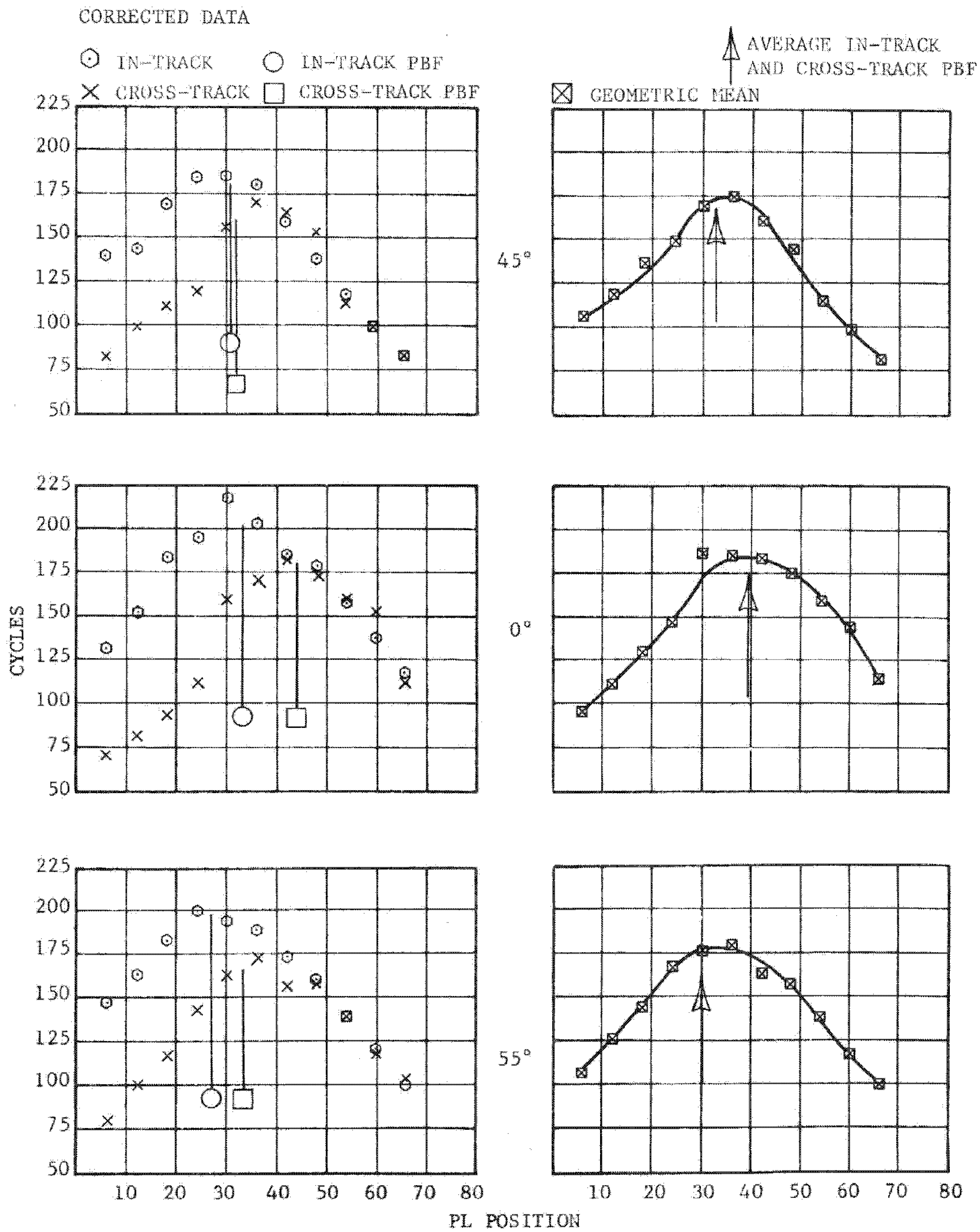


Figure 3-16. Performance Plot, Rad X = 0.052, 70°F, FWD Camera, Test No. 5, CEI 101

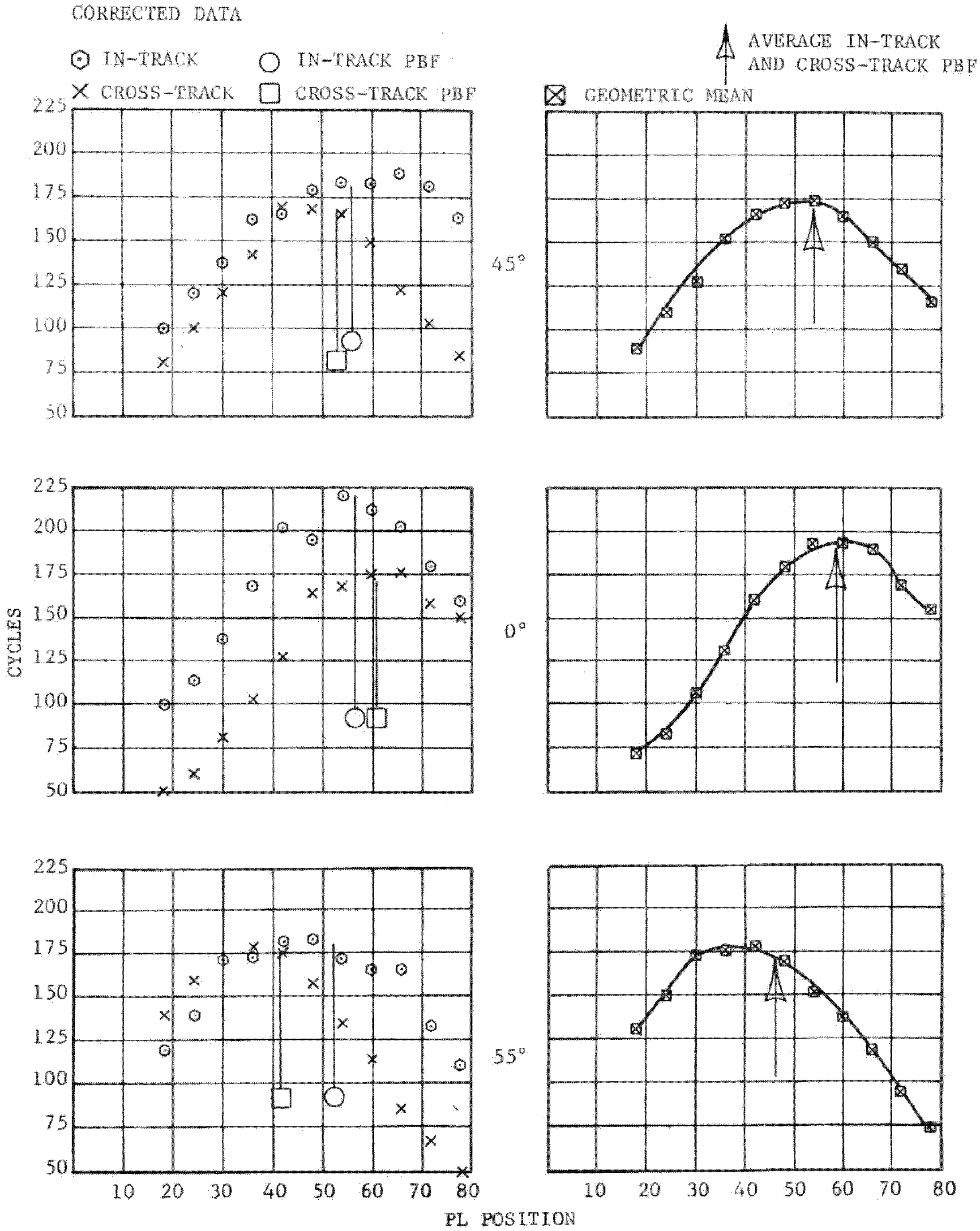


Figure 3-17. Performance Plot, Rad X = 0.052, 70°F, AFT Camera, Test No. 5, CEI 101

TABLE 3-9

CORRECTED TRI-BAR RESOLUTION DATA SUMMARY
FWD AND AFT CAMERAS (cyc/mm)

Test Description	45°			0°			55°		
	IT	XT	M	IT	XT	M	IT	XT	M
Fwd Camera CEI 101 Data 70°F Corrected FPP = 36μ	181	170	175	203	171	186	189	173	181
Aft Camera CEI 101 Data 70°F Corrected FPP = 54μ	183	165	174	221	169	193	172	135	152

TABLE 3-10

RESOLUTION PERFORMANCE TEST RESULTS, Vx/h = 0.036 (cyc/mm)

Description	FOCAL PLANE POS.	45°			0°			55°		
		IT	XT	M	IT	XT	M	IT	XT	M
FWD CEI 103	42μ	154	119	135	172	131	150	153	127	139
FWD (reread)	42μ	186	156	170	199	177	187	195	161	176
AFT CEI 103	66μ	190	138	162	185	159	171	193	115	149

Comparing aft camera performance and reread forward camera performance with their associated mean acceptance data (CEI 101) indicates excellent repeatability. Through-focus plots of this geometric mean performance for CEI 103 are shown in Figure 3-18.

3.2.1.4 Reader Variability

CEI Run 101 for both the FWD and AFT cameras, as well as CEI Run 103 FWD camera were reread at AFSPPF by the same personnel in response to Customer direction. The results of CEI 103 FWD camera reread were shown in Table 3-10; the results of CEI 101 reread are shown in Table 3-11 in comparison form. Reviewing Table 3-11 shows a significant problem -- a wide range of reader variability -- when attempting to evaluate system performance.

TABLE 3-11

RESOLUTION DATA, REREAD VALUES (cyc/mm)

(AFSPPF Readings)

AFT Camera Test No. 101	45°			0°			55°		
	IT	XT	M	IT	XT	M	IT	XT	M
Original Data	183	149	165	203	169	185	183	135	157
Reread Data	162	131	146	172	158	164	165	118	139
FWD Camera Test No. 101									
Original Data	186	164	175	196	171	183	194	157	174
Reread Data	161	138	149	174	158	166	166	139	152

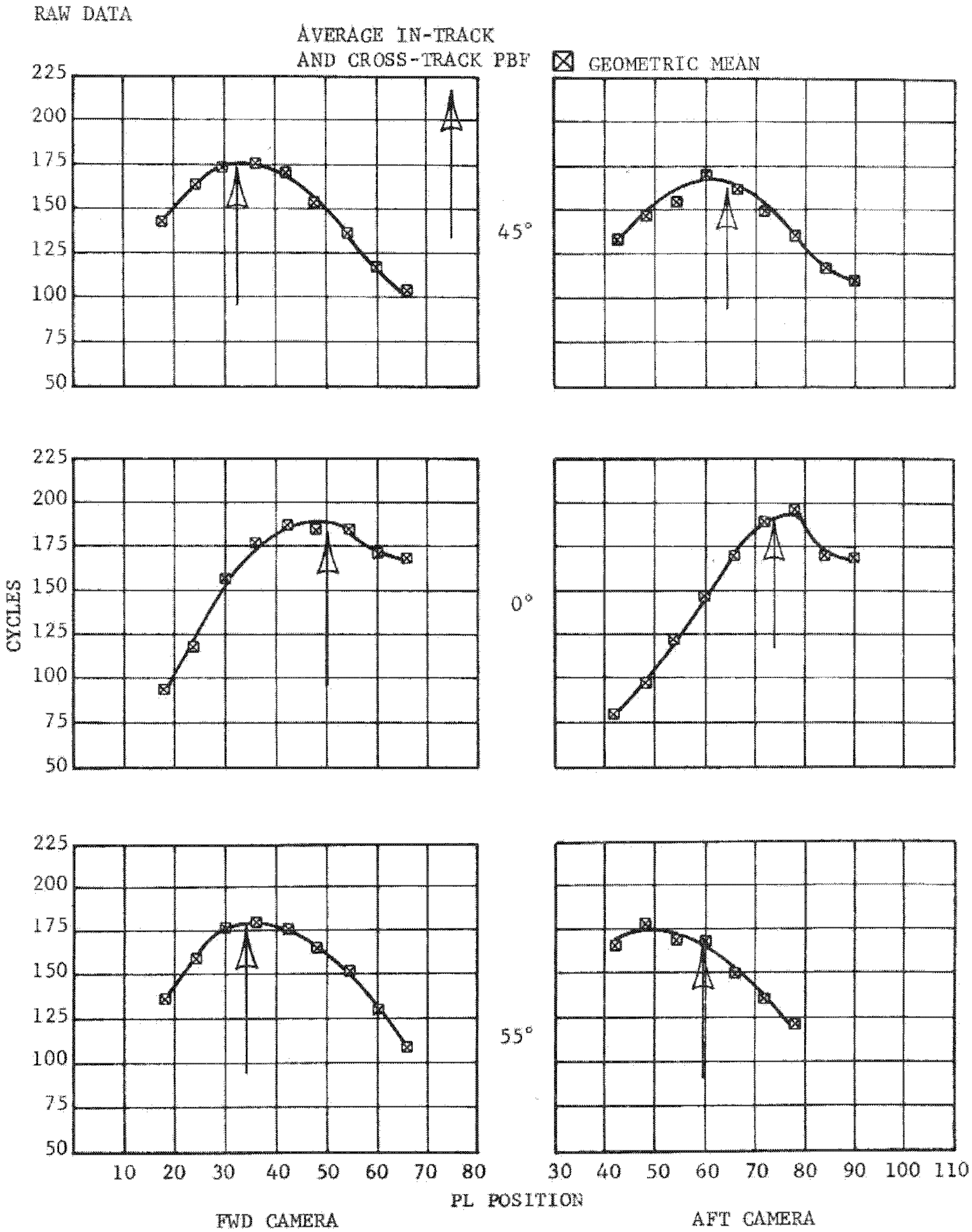


Figure 3-18. Performance Plot, Geometric Mean, Rad X = 0.036, 70°F, FWD and AFT Cameras, Test No. 103

3.2.2 Performance at 0.6-Inch Slit Width

CEI Runs 109 (0.3-inch slit width) and 110 (0.6-inch slit width) are dual gamma runs for information; acceptance criteria do not apply. A meaningful analysis of these runs (see Tables 3-12 and 3-13) would be:

a. to compare CEI Run 109 with CEI Run 101 to evaluate differences in dual gamma processing.

b. to use the measured smear performance from CEI 109 and 110 (three count and seven pulse count, respectively), predict the 0.6-inch slit width resolution performance and compare this prediction with the actual measured resolution data.

Comparing tri-bar resolution values for CEI 101 and 109 for FWD and AFT cameras shows both 0.3-inch slit width runs exhibit essentially equivalent performance. Reviewing predicted 0.6-inch slit width performance versus actual shows good agreement on the FWD camera. However, the AFT camera comparison shows the 0.6-inch slit width measured performance to be much higher than predicted, and as a point on interest higher than the 0.3-inch slit width data in most cases.

The AFT camera differences are attributed either to reader variability or to the fact that measured smear performance tabulated does not completely describe the image motion characteristics.

3.2.3 Color Performance, SO-255

Tri-bar resolution for S/N 015 with SO-255 color film (see Table 3-14) is typical of resolution experienced in previous systems. Also typical of previous systems are the through-focus plots of Figure 3-19 indicating an approximate focus shift of 30 microns from 1414 black and white film focus position.

3.2.4 In-Flight Changeable Filter Performance

The interchangeable filter (filter/flop) test for CEI 102 was conducted to confirm tri-bar resolution and focus performance as the Wratten 12 and 2E3 filters are interchanged in the optical path. The interchange was made three

TABLE 3-12

SCAN ANGLE LENGTH CONTROL TESTS, DUAL GAMMA, FWD CAMERA
IMAGE MOTION (IN./SEC) RESOLUTION (CYC/MM)

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-109	Mean	TARGET CLIPPED			0.003	0.019		-0.020	0.036	
052 Disabled 3 Pulse Counts	2σ				0.049	0.060		0.067	0.070	
CEI-110	Mean	0.043	0.008		0.003	-0.015		-0.043	0.026	
052 Disabled 7 Pulse Counts	2σ	0.029	0.060		0.033	0.065		0.031	0.052	
CEI-101 FP 42μ Average of 3 Readers	0.3	186	164	175	196	171	183	194	157	174
CEI-109 FP 42μ	0.3	184	150	166	198	170	183	178	147	162
CEI-110	0.6	139	142	140	196	165	179	151	142	146
PREDICTED 0.6 IN. SLW RESOLUTION USING 0.3 IN. SLW DATA AS A BASELINE AND APPLYING CHAMBER "A" IMAGE MOTION ERROR AND 2σ VALUES		158	144		195	160		153	139	

TABLE 3-13

SCAN ANGLE LENGTH CONTROL TESTS, DUAL GAMMA, AFT CAMERA
IMAGE MOTION (IN./SEC) RESOLUTION (CYC/MM)

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-109	Mean	0.068	0.027		0.008	0.007		-0.070	0.028	
052 Disabled 3 Pulse Counts	2σ	0.057	0.059		0.046	0.070		0.051	0.067	
CEI-110	Mean	0.047	0.024		0.010	0.002		-0.064	0.018	
052 Disabled 7 Pulse Counts	2σ	0.043	0.041		0.048	0.041		0.030	0.038	
CEI-101 FP 66μ Average of 3 Readers	0.3	183	149	165	203	169	185	183	135	157
CEI-109 FP 66μ	0.3	173	136	153	180	169	174	184	130	154
CEI-110	0.6	176	149	161	204	171	186	162	135	148
PREDICTED 0.6 IN. SLW RESOLUTION USING 0.3 IN. SLW DATA AS A BASELINE AND APPLYING CHAMBER "A" IMAGE MOTION ERROR AND 2σ VALUES		148	128		175	167		141	127	

TABLE 3-14

SO-255 TESTING, FWD AND AFT CAMERAS
TRI-BAR RESOLUTION SUMMARY (CYC/MM)

TEST DESCRIPTION	45°			0°			55°		
	IT	XT	M	IT	XT	M	IT	XT	M
Test No. 4-2 Seq 272 8-23-74 FWD Camera FP 72μ	102	89	95	123	111	116	128	111	119
AFT Camera FP 94μ	122	94	107	113	106	110	106	83	94

times at the best focus position for each camera (see Table 3-15); focus variations were found by evaluating the line focus targets (see Table 3-16). Resolution performance is equivalent for both cameras within the reader variability; and reviewing the data shows excellent focus repeatability.

3.2.5 Low Voltage Verification

The low voltage verification test (CEI Run 108) is performed to evaluate resolution performance when the primary vehicle power source voltage is at the lowest allowable level. Performance degradation is measured by comparing the CEI Run 108 performance with CEI Run 101, an equivalent run at nominal primary voltage. The results (see Table 3-17) indicate no significant performance degradation when the primary voltage is low.

3.2.6 Operational Mode Verification

Operational mode verification tests are designed to measure the resolution performance at scan angles and centers other than 120° and zero center. The CEI specification states that this data is to be provided for information only, but that as a goal, the acceptance requirements apply.

Note from the measured resolution performance of the operational mode tests tabulated in Tables 3-18 and 3-19 that all values were obtained at the same platen position as the acceptance data. The data shows results only for those collimator positions where a complete target is available. Reviewing

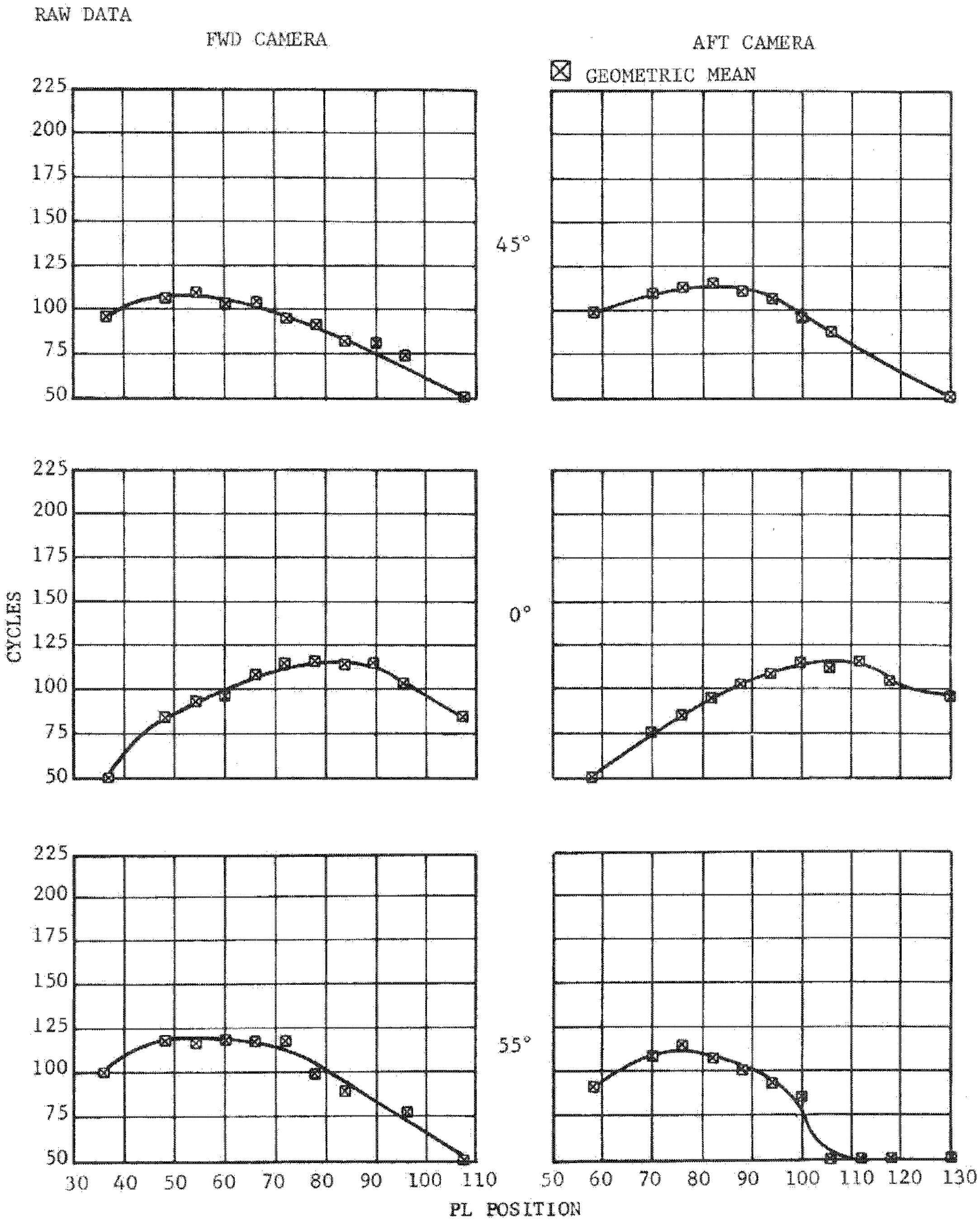


Figure 3-19. Performance Plot, Geometric Mean, Rad X = 0.052, 70°F, FWD and AFT Cameras, Test No. 272, SO-255 Film

TABLE 3-15

INTERCHANGEABLE FILTER TEST, TRI-BAR RESOLUTION (CYC/MM)
FWD AND AFT CAMERAS

WRATTEN 12/2E3 — AFSPPF READINGS

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-102 SEQ 425 FWD CAMERA FPP 42μ	W-12	186	171	178	211	183	196	194	165	178
	2E3	180	156	168	215	187	200	181	156	168
	W-12	185	168	176	211	186	198	186	156	170
	2E3	163	151	157	201	178	189	188	156	171
	W-12	184	160	171	192	180	186	183	169	176
	2E3	179	166	172	206	169	186	193	161	176
AFT CAMERA FPP 66μ	W-12	182	132	154	192	167	179	187	130	156
	2E3	168	125	145	186	156	170	188	134	158
	W-12	179	130	152	180	159	169	169	139	153
	2E3	179	129	152	178	152	164	161	129	144
	W-12	176	133	153	173	150	160	174	128	148
	2E3	175	120	145	178	144	160	175	130	150

TABLE 3-16

INTERCHANGEABLE FILTER TEST,
FOCUS FROM RAW LINE TARGET DATA (MICRONS)
FWD AND AFT CAMERAS

WRATTEN 12/2E3

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-102 SEQ 425 FWD CAMERA FP 42μ	W-12	39	30	34	49	49	49	33	37	37
	2E3	44	33	38	49	50	49	35	35	35
	W-12	40	31	36	49	50	49	38	37	38
	2E3	44	33	38	50	50	50	36	36	36
	W-12	41	31	36	50	50	50	38	36	37
	2E3	46	35	40	50	50	50	37	37	37
AFT CAMERA FP 65μ	W-12	65	53	59	79	72	75	69	50	60
	2E3	64	54	59	79	70	75	68	50	59
	W-12	65	55	60	80	71	75	69	50	60
	2E3	64	55	60	82	72	77	69	51	60
	W-12	66	55	60	79	71	75	70	51	60
	2E3	64	54	59	81	71	76	69	51	60

TABLE 3-17

RESOLUTION TEST RESULTS, LOW VOLTAGE VERIFICATION (CYC/MM)

Camera	CEI	FP	45°			0°			55°		
			IT	XT	M	IT	XT	M	IT	XT	M
FWD	101	42μ	186	164	175	196	171	183	194	157	174
	108		191	158	173	201	169	184	189	155	171
AFT	101	66μ	183	149	165	203	169	185	183	135	157
	108		185	135	158	206	159	181	187	127	154

the data shows the goal of acceptance resolution values has been exceeded at every position by at least 34 cycles/mm for the FWD camera and 22 cycles/mm for the AFT camera. Generally the performance of both cameras at the scan angles and centers shown is equivalent to the acceptance resolution performance indicated at a 120° scan angle.

3.3 MIDSECTION DYNAMIC FOCUS

The mean and two sigma values at each of the three test temperatures (see Tables 3-20 and 3-21) were obtained by reading raw line target data, from CEI Runs 101, 103, 111 and 115. The measured two sigma values, in particular, are all well controlled, the greatest value being 3.2 microns. The average of the in-track and cross-track two-sigma values at each temperature is shown in the tables in parentheses. These values meet the dynamic focus criteria of a value no greater than ±4.9 microns (2σ) for each individual test condition, as specified in Engineering Change Proposal No. 11302 (approved 27 April 1974).

The dynamic focus results for all test temperatures combined at Vx/h = 0.052 in Table 3-22 show the average of the in-track and cross-track two-sigma values for the FWD camera (7.35μ) is over the specification limit of 6.5μ. ECP No. 11302 has eliminated this method of calculation for all systems beyond S/N 015.

TABLE 3-18

OPERATIONAL MODE VERIFICATION, FWD CAMERA

TRI-BAR RESOLUTION IN CYC/MM AT FPP 42μ

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-130	30°/-45°	198	159	177						
CEI-131	30°/0°				237	181	206			
CEI-132	30°/+45°							226	173	197
CEI-133	60°/-30°	212	168	188						
CEI-134	60°/-15°				213	177	194			
CEI-135	60°/0°				201	168	184			
CEI-136	60°/+15°				198	175	186			
CEI-137	60°/+30°							182	157	168
CEI-138	90°/-15°	187	158	172	201	170	184			
CEI-139	90°/0°				210	177	193			
CEI-140	90°/+15°				204	172	187	200	168	183

TABLE 3-19

OPERATIONAL MODE VERIFICATION, AFT CAMERA

TRI-BAR RESOLUTION IN CYC/MM AT FPP 66μ

TEST DESCRIPTION		45°			0°			55°		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
CEI-130	30°/-45°							198	132	161
CEI-131	30°/0°				217	185	200			
CEI-132	30°/+45°	212	164	186						
CEI-133	60°/-30°							200	156	176
CEI-134	60°/-15°				214	172	191			
CEI-135	60°/0°				207	181	193			
CEI-136	60°/+15°	196	152	173	192	176	184			
CEI-137	60°/+30°	173	143	157						
CEI-138	90°/-15°				181	170	175	172	131	150
CEI-139	90°/0°	183	145	163	180	170	175			
CEI-140	90°/+15°	164	145	154	178	165	172			

TABLE 3-20

SUMMARY OF BEST POSITION FROM LINE DATA, FWD CAMERA, 48 MICRONS POSITION

TEMP.	RADX		IN (MICRONS)	CR (MICRONS)	AVERAGE IN & CR
47	0.052	MEAN	47	49	48
		TWO SIGMA	2.7	2.1	(2.4)
70	0.036	MEAN	51	48	50
		TWO SIGMA	3.1	3.0	(3.0)
	0.052	MEAN	51	49	50
		TWO SIGMA	3.4	2.0	(2.7)
93	0.052	MEAN	59	53	56
		TWO SIGMA	2.4	2.3	(2.4)

TABLE 3-21

SUMMARY OF BEST POSITION FROM LINE DATA, AFT CAMERA, 78 MICRONS POSITION

TEMP.	RADX		IN (MICRONS)	CR (MICRONS)	AVERAGE IN & CR
47	0.052	MEAN	80	70	75
		TWO SIGMA	2.8	3.7	(3.2)
70	0.036	MEAN	79	70	75
		TWO SIGMA	2.2	2.3	(2.2)
	0.052	MEAN	79	71	75
		TWO SIGMA	1.9	1.7	(1.8)
93	0.052	MEAN	81	70	76
		TWO SIGMA	1.6	2.1	(1.9)

Dynamic focus test results at 70°F for the two operational speeds of Vx/h = 0.052 and 0.036 shown in Table 3-23 demonstrate that both cameras fully meet CEI specification requirements of 4.9μ average 2σ.

3.4 MIDSECTION FOCAL PLANE TILT AND FIELD CURVATURE

3.4.1 Focal Plane Tilt

Platen tilt determination plots compare Chamber "A" line target focus data with Chamber "D" focus data that has been adjusted for zero tilt and normalized at nadir for 70°F. The tilt plots of raw CEI data for all three test temperatures are shown in Figure 3-20, and the required tilt corrections calculated from the raw line target data for all Chamber "A" vacuum tests are summarized in Table 3-24. The correction factors for gravity, collimator defocus, and film flatness (See Paragraph 3.2.1.2) have been applied to this raw data; the results are also summarized in Table 3-24. A ten micron mechanical tilt was incorporated in the FWD camera platen based on Chamber D data. Since no electrical tilt corrections have been made in either camera, a ±20 micron electrical tilt capability remains.

3.4.2 Apparent Field Curvature

The values shown in Table 3-25, summary of raw field curvature data, are typical of previous systems. A meaningful data evaluation would be to reduce Chamber "A" raw data to optical performance and compare these results to Chamber "D" data.

The effects of gravity, collimator defocus, and film flatness are shown in Paragraph 3.2.1.2; the magnitude of each correction factor relative to field angle is shown in Tables 3-7 and 3-8. In addition, recent tests performed on the Engineering Model have indicated a dynamic film profile exists during recycle at 120° scan. This scan angle to field angle relationship is shown in Figure 3-21 with tabulated magnitudes.

Figures 3-22 and 3-23 present the field curvature evaluation for CEI 101 with the corrections reducing raw Chamber "A" data to optical performance applied incrementally. Table 3-26 summarizes the evaluation of optical field curvature performance in Chamber A for all vacuum runs.

TABLE 3-22

DYNAMIC FOCUS TEST RESULTS
(47°F, 70°F, 93°F)
RADX = 0.052

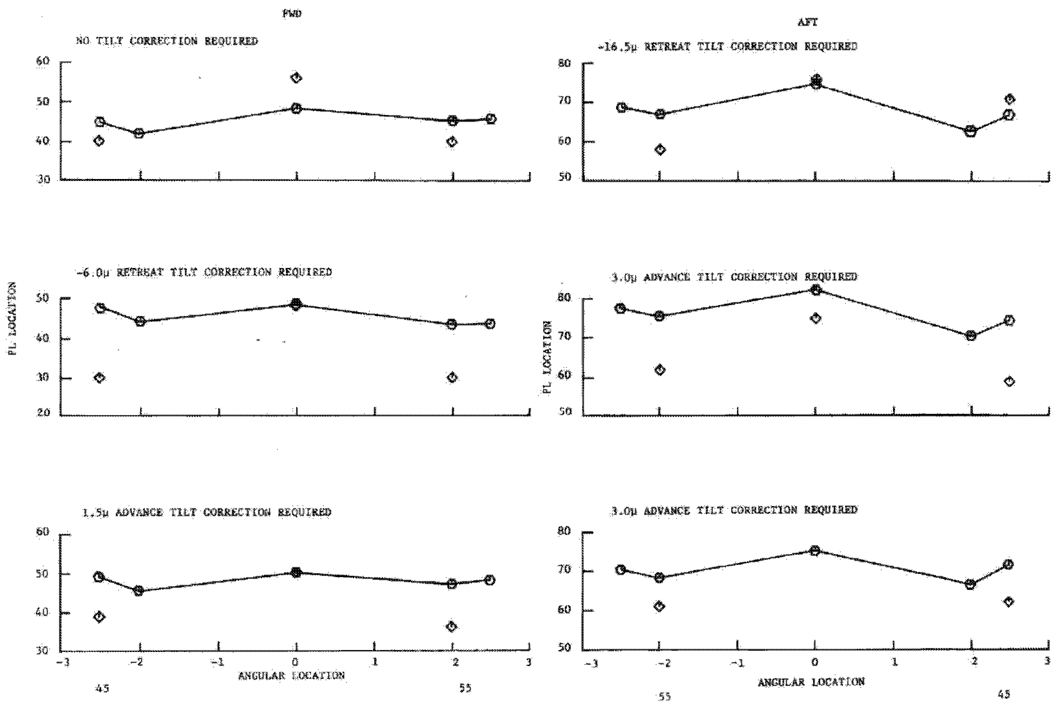
FWD CAMERA		AFT CAMERA	
IN (2 SIGMA)	CR (2 SIGMA)	IN (2 SIGMA)	CR (2 SIGMA)
10.68	4.02	2.56	2.33
IN AND CR AVERAGE		IN AND CR AVERAGE	
7.35		2.44	
ALL VALUES GIVEN IN MICRONS. CEI SPEC. 6.5 MICRONS			

TABLE 3-23

DYNAMIC FOCUS TEST RESULTS
(70°F)
RADX = 0.052, 0.036

FWD CAMERA		AFT CAMERA	
IN (2 SIGMA)	CR (2 SIGMA)	IN (2 SIGMA)	CR (2 SIGMA)
3.2	2.7	2.0	2.4
IN AND CR AVERAGE		IN AND CR AVERAGE	
2.97		2.23	
ALL VALUES GIVEN IN MICRONS. CEI SPEC. 4.9 MICRONS			

TE 0515



CHAMBER "D" DATA
LINE DATA

Figure 3-20. Tilt Determination, FWD and AFT Cameras, Raw Data

TABLE 3-24

PLATEN TILT SUMMARY

\- RETREAT
\+ ADVANCE

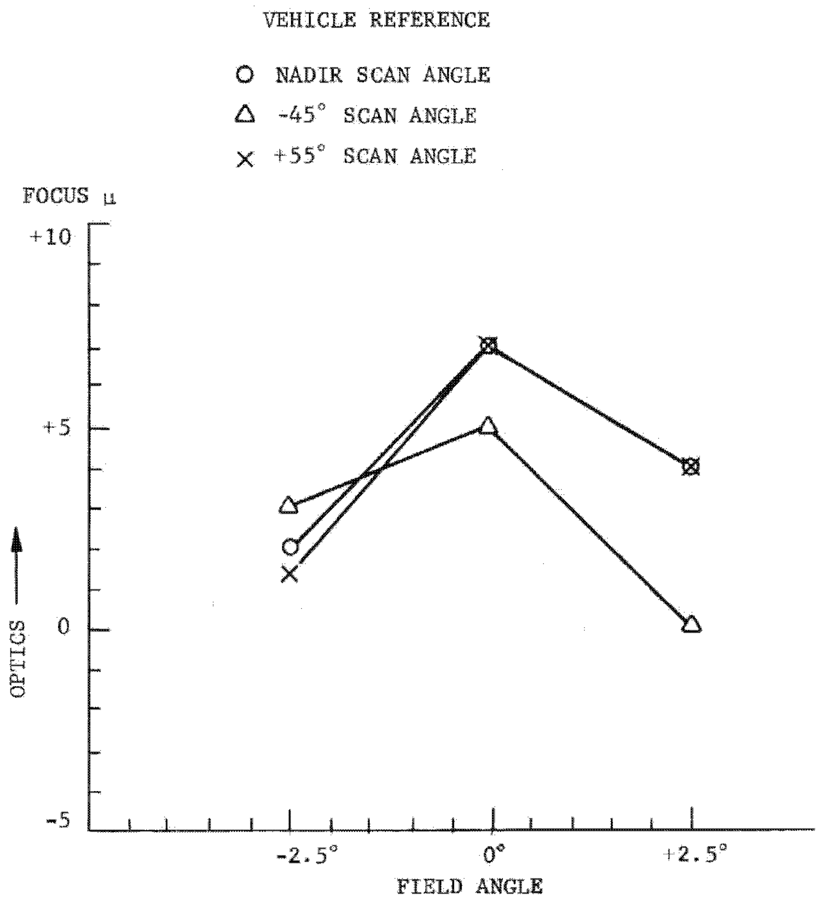
S/N	OB S/N	CHAMBER A TESTS	DATE	CHAMBER D TILT	CALC. TILT CORRECTION REQ'D FROM LINE TARGETS: RAW DATA	CALC. TILT CORRECTION REQ'D FROM LINE TARGETS: CORRECTED DATA	TILT CHANGES
ROLL NO. 2430							
015	036	FWD CAMERA		+10.5			+10.0 MECHANICAL
		#4 BASELINE	8-01-74		-4.5		
		#4-1 BASELINE	8-05-74		-3.0	-7.5	
		CEI-101 70° ACCEPT. (052)	8-13-74		+1.5	0	
		CEI-103 70° ACCEPT. (036)	8-13-74		-4.5	-7.5	
		CEI-111 47° ACCEPT.	8-17-74		-6.0	-3.0	
		CEI-115 93° ACCEPT.	8-21-74		0	+4.5	
ROLL NO. 2440							
015	043	AFT CAMERA		-3.0			
		#4 BASELINE	8-01-74		0		
		#4-1 BASELINE	8-05-74		0	0	
		CEI-101 70° ACCEPT. (052)	8-13-74		+3.0	-6.0	
		CEI-103 70° ACCEPT. (036)	8-13-74		-1.5	-9.0	
		CEI-111 47° ACCEPT.	8-17-74		+3.0	+6.0	
		CEI-115 93° ACCEPT.	8-21-74		-16.5	-12.0	

TABLE 3-25

SUMMARY OF FIELD CURVATURE CHAMBER A TESTING

UNCORRECTED RAW DATA

MATERIAL ROLL NO.	TEST DATE	TEST NO.	LINE TARGET FOCUS POSITION NORMALIZED TO NADIR -2.5°	0°	+2.0°	FIELD CURVATURE	INCREASE OF CHAMBER A FROM CHAMBER D	REMARKS
CHAMBER D			1	0	3	2		OB-036
2430	8-01-74	4	11		9	10	8	
FWD CAMERA	8-05-74	4-1	15		14	14	12	
	8-13-74	103	18		16	17	15	RADX = 0.036
	8-13-74	101	11		14	12	10	RADX = 0.052
	8-17-74	111	18		18	18	16	
	8-21-74	115	16		16	16	14	
			+2.5°	0°	-2.0°			
CHAMBER D			2	0	7	4		OB-043
2440	8-01-74	4	14		18	16	12	
AFT CAMERA	8-05-74	4-1	12		16	14	10	
	8-13-74	103	10		15	12	8	RADX = 0.036
	8-13-74	101	13		14	14	10	RADX = 0.052
	8-17-74	111	16		13	14	10	
	8-21-74	115	5		18	12	8	



	45°	0°	55°
FWD CAMERA	(-2.5° FLD) -3µ	(0° FLD) -7µ	(+2° FLD) -4µ
AFT CAMERA	(+2.5° FLD) 0	(0° FLD) -7µ	(-2° FLD) -2µ

Figure 3-21. Focus Delta Between Recycle (052/120°) and CV Mode

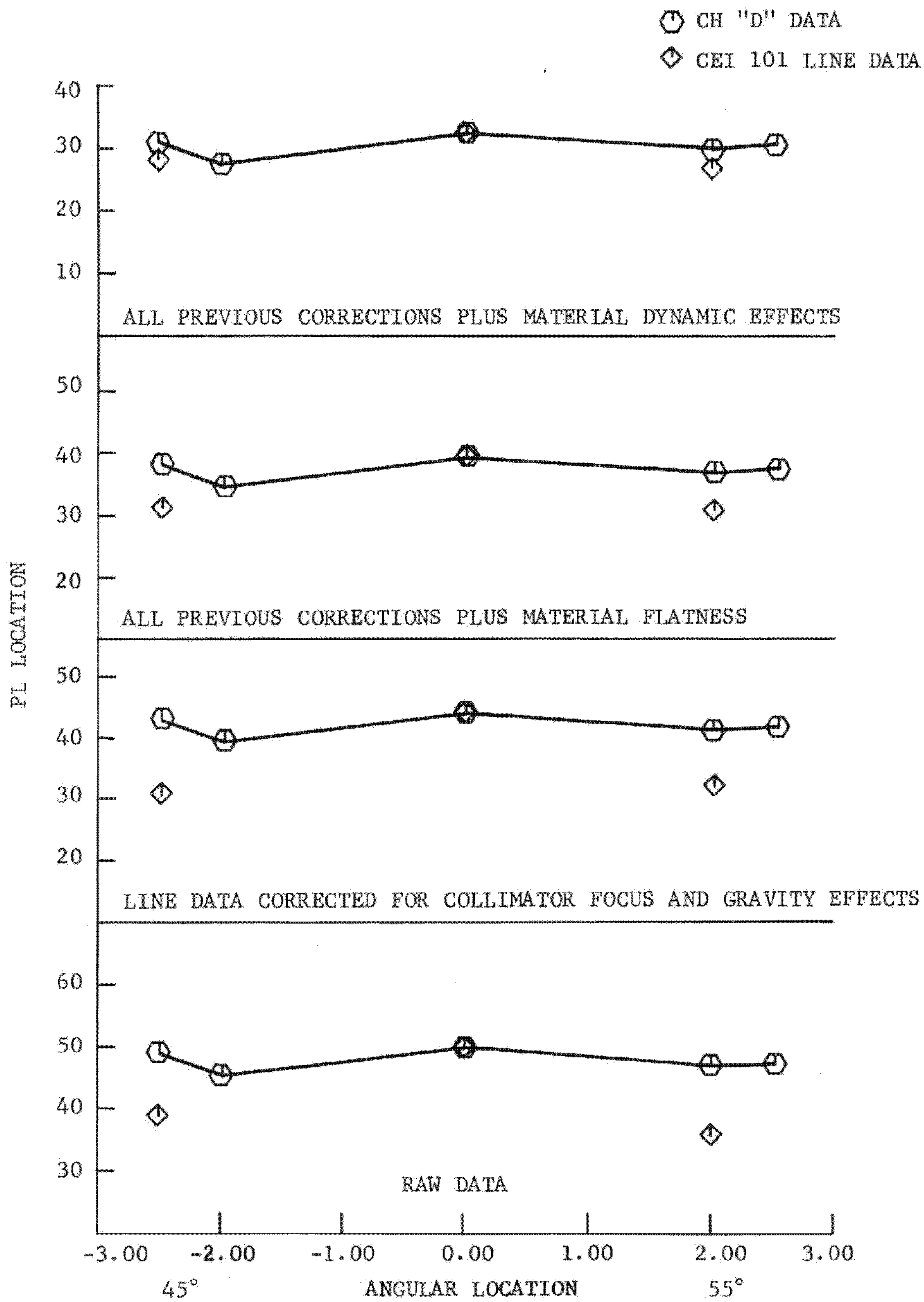


Figure 3-22. Field Curvature Evaluation, FWD Camera

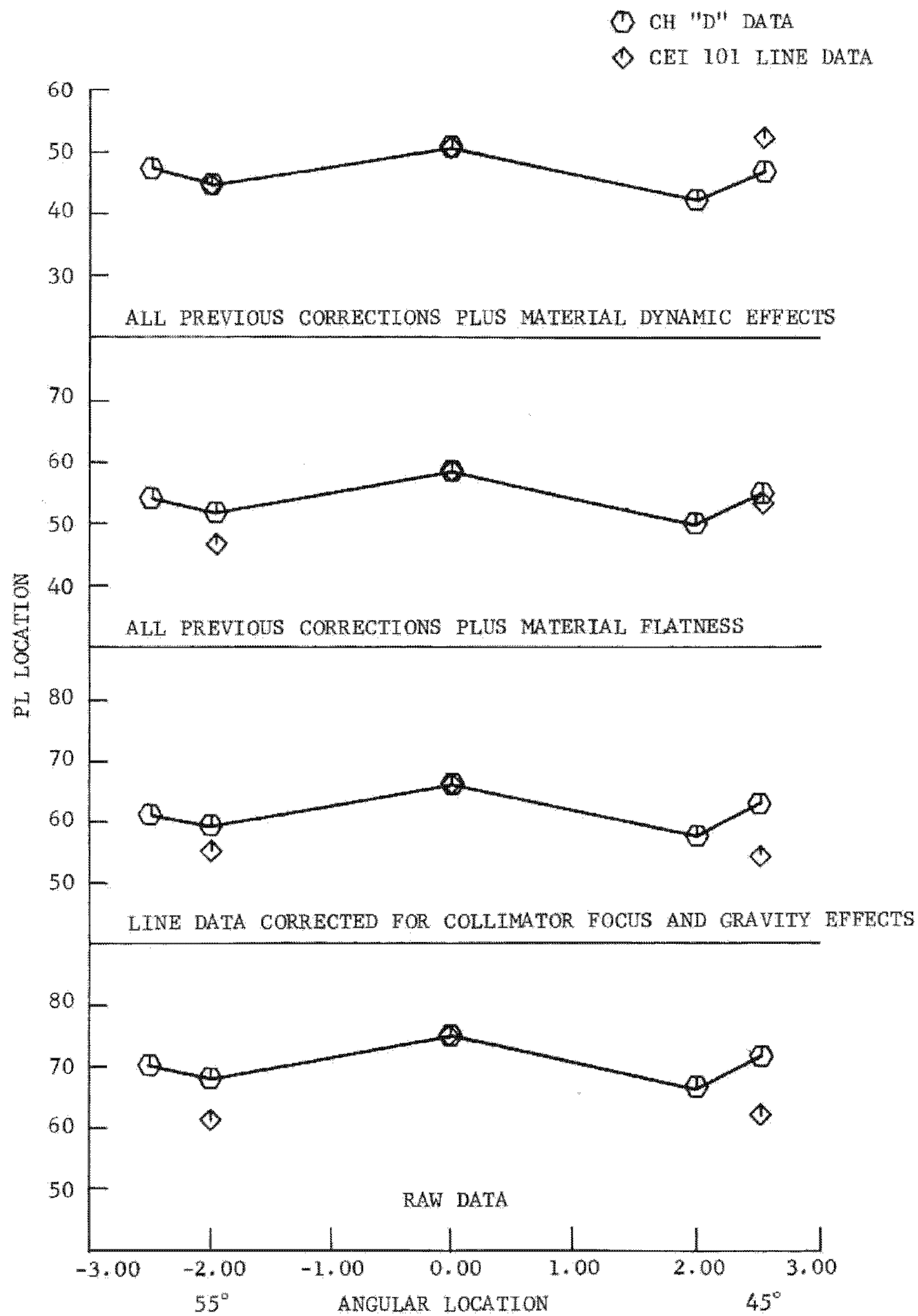


Figure 3-23. Field Curvature Evaluation, AFT Camera

TABLE 3-26

SUMMARY OF FIELD CURVATURE CHAMBER A TESTING

DATA CORRECTED FOR COLLIMATOR FOCUS, GRAVITY, MATERIAL FLATNESS AND MATERIAL DYNAMIC EFFECTS.

MATERIAL ROLL NO.	TEST DATE	TEST NO.	LINE / FOCUS POSITION NORMALIZED TO NADIR		TARGET	FIELD CURVATURE	INCREASE OF CHAMBER A FROM CHAMBER D	REMARKS
			-2.5°	0°	+2.0°			
CHAMBER D			1	0	3	2		OB-036
2430	8-05-74	4-1	11		8	10	8	
FWD CAMERA	8-13-74	103	10		7	8	6	RADX = 0.036
	8-13-74	101	3		6	4	2	RADX = 0.052
	8-17-74	111	14		17	16	14	
	8-21-74	115	9		13	11	9	
			+2.5°	0°	-2.0°			
CHAMBER D			2	0	7	4		OB-043
2440	8-05-74	4-1	4		10	7	3	
AFT CAMERA	8-13-74	103	-4		9	2	-2	RADX = 0.036
	8-13-74	101	-2		8	3	-1	RADX = 0.052
	8-17-74	111	8		5	6	2	
	8-21-74	115	-1		11	5	1	

3.5 FILM SYNCHRONIZATION

3.5.1 Acceptance Data

The acceptance data requirements for sync flash measurements apply to type 1414 film at Vx/h values of 0.052, 0.044 and 0.036 at a temperature of 70°F (Tables 3-27 through 3-29). Acceptance requirements at 47°F and 93°F apply at a Vx/h value of 0.052 only. The appropriate mean and two sigma CEI specification limits are shown at the tops of Tables 3-27 through 3-29.

As mentioned in Section 1, the out-of-specification data points are:

Camera	Vx/h	Value	Amount Out of Spec
FWD (A)	0.052	CT/0° - Mean @ 93°F	0.004 ips
AFT (B)	0.036	IT/0° - 2σ @ 70°F	0.005 ips
AFT (B)	0.036	IT/45° - 2σ @ 70°F	0.015 ips

The FWD camera anomaly, which occurred at 93°F, was caused by a film-to-bar synchronization (FBS) "hump"; this hump occurred during the time that the "C" targets were flashed on the nadir collimator in Chamber A. (The phenomenon of "humps" was investigated in detail; the results were presented in PM-1470-X.)

In summary, these FBS humps are caused by transient voltage inputs to the metering capstan servo from the MC/OB phase lock loop. These transients are caused by non-linearities in the phase detector output that occur when the position error passes through zero. This condition, however, does not reflect any hardware failure or degradation; it represents a predictable occurrence of a normal system.

The AFT camera in-track two-sigma out-of-specification values at Vx/h of 0.036 are not supported by an evaluation of electromechanical data. There is no indication of a hardware malfunction causing this anomaly, and, therefore, no corrective action has been taken. A waiver has been issued as part of the technical certification.

TABLE 3-27

SUMMARY OF SYNCH-FLASH ANALYSIS, Vx/h = 0.052

V_x/h 0.052 (+) IN-TRACK ERROR MEANS PLATEN LEAD OB

V_y/h 0.0017 7 PULSE COUNTS (+) CROSS-TRACK ERROR MEANS FILM TOO FAST

SEQ CEI RUN NO.		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
CEI SPEC	MEAN W/O GRAV.	±0.050	±0.050	±0.050	±0.050	±0.050	±0.050
	MEAS. 2σ	0.050	0.050	0.050	0.100	0.100	0.100
FWD CAMERA							
70° 105 SEQ 411	MEAS. MEAN	0.036	-0.007	-0.015	-0.051	-0.055	0.019
	MEAN W/O GRAV.	0.004	0.001	0.029	-0.028	-0.020	0.037
	MEAS. 2σ	0.029	0.045	0.026	0.065	0.069	0.065
47° 112 SEQ 412	MEAS. MEAN	0.022	-0.018	-0.030	-0.040	-0.071	-0.003
	MEAN W/O GRAV.	-0.010	-0.010	0.014	-0.017	-0.036	0.015
	MEAS. 2σ	0.036	0.026	0.043	0.047	0.096	0.057
93° 116 SEQ 412	MEAS. MEAN	0.048	-0.007	0.005	-0.027	0.019	0.024
	MEAN W/O GRAV.	0.016	0.001	0.049	-0.004	0.054	0.042
	MEAS. 2σ	0.029	0.049	0.037	0.049	0.061	0.066
AFT CAMERA							
70° 105 SEQ 411	MEAS. MEAN	0.040	-0.013	-0.098	-0.015	-0.063	-0.037
	MEAN W/O GRAV.	-0.002	-0.011	-0.043	0.010	-0.023	-0.011
	MEAS. 2σ	0.035	0.033	0.030	0.040	0.044	0.042
47° 112 SEQ 412	MEAS. MEAN	0.037	0.003	-0.098	-0.024	-0.067	-0.066
	MEAN W/O GRAV.	-0.005	0.005	-0.043	0.001	-0.027	-0.040
	MEAS. 2σ	0.024	0.028	0.020	0.039	0.052	0.045
93° 116 SEQ 412	MEAS. MEAN	0.035	0.006	-0.084	0.017	-0.029	-0.003
	MEAN W/O GRAV.	-0.007	0.008	-0.029	0.042	0.011	0.023
	MEAS. 2σ	0.034	0.037	0.031	0.046	0.051	0.062

TABLE 3-28

SUMMARY OF SYNCH-FLASH ANALYSIS, Vx/h = 0.044

V_x/h 0.044

V_y/h 0.0023   7 PULSE COUNTS

(+) IN-TRACK ERROR MEANS PLATEN LEAD OB

(+) CROSS-TRACK ERROR MEANS FILM TOO FAST

SEQ CEI RUN NO.		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
C E I SPEC	MEAN W/O GRAV.	±0.050	±0.050	±0.050	±0.050	±0.050	±0.050
	MEAS. 2σ	(0.050)	(0.050)	(0.050)	(0.100)	(0.100)	(0.100)
FWD CAMERA							
70° 106 SEQ 334	MEAS. MEAN	0.035	-0.015	-0.014	-0.048	-0.046	0.007
	MEAN W/O GRAV.	0.007	-0.008	0.023	-0.029	-0.016	0.020
	MEAS. 2σ	(0.024)	(0.028)	(0.028)	(0.052)	(0.063)	(0.074)
47° 113 SEQ 346	MEAS. MEAN	0.022	-0.013	-0.027	-0.071	-0.078	-0.019
	MEAN W/O GRAV.	-0.006	-0.006	0.010	-0.052	-0.048	-0.006
	MEAS. 2σ	(0.026)	(0.029)	(0.035)	(0.068)	(0.077)	(0.064)
93° 117 SEQ 346	MEAS. MEAN	0.039	0.018	0.004	-0.057	-0.009	0.004
	MEAN W/O GRAV.	0.011	0.025	0.041	-0.038	0.021	0.017
	MEAS. 2σ	(0.029)	(0.053)	(0.028)	(0.050)	(0.065)	(0.058)
AFT CAMERA							
70° 106 SEQ 334	MEAS. MEAN	0.032	-0.004	-0.078	-0.013	-0.041	-0.036
	MEAN W/O GRAV.	-0.004	-0.002	-0.032	0.009	-0.007	-0.013
	MEAS. 2σ	(0.042)	(0.038)	(0.025)	(0.052)	(0.047)	(0.053)
47° 113 SEQ 346	MEAS. MEAN	0.035	-0.002	-0.075	-0.019	-0.048	-0.050
	MEAN W/O GRAV.	-0.001	-0-	-0.029	0.003	-0.014	-0.027
	MEAS. 2σ	(0.032)	(0.027)	(0.016)	(0.033)	(0.046)	(0.040)
93° 117 SEQ 346	MEAS. MEAN	0.043	-0.004	-0.065	0.002	-0.008	-0.018
	MEAN W/O GRAV.	0.007	-0.002	-0.019	0.024	0.026	0.005
	MEAS. 2σ	(0.038)	(0.040)	(0.028)	(0.058)	(0.049)	(0.044)

TABLE 3-29

SUMMARY OF SYNCH-FLASH ANALYSIS, Vx/h = 0.036

V_x/h 0.036

V_y/h -0.0021 7 PULSE COUNTS

(+) IN-TRACK ERROR MEANS PLATEN LEAD OB

(+) CROSS-TRACK ERROR MEANS FILM TOO FAST

SEQ CEI RUN NO.		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
CEI SPEC	MEAN W/O GRAV.	0.045	0.035	0.045	0.045	0.045	0.045
	MEAS. 2σ	(0.037)	(0.037)	(0.037)	(0.098)	(0.098)	(0.098)
FWD CAMERA							
70° 107 SEQ 416	MEAS. MEAN	0.014	-0.016	-0.018	-0.061	-0.037	-0.002
	MEAN W/O GRAV.	-0.009	-0.010	0.012	-0.045	-0.012	0.010
	MEAS. 2σ	(0.027)	(0.035)	(0.029)	(0.037)	(0.057)	(0.056)
47° 114 SEQ 347	MEAS. MEAN	0.009	-0.018	-0.018	-0.039	-0.057	-0.027
	MEAN W/O GRAV.	-0.014	-0.012	0.012	-0.023	-0.032	-0.015
	MEAS. 2σ	(0.037)	(0.040)	(0.048)	(0.050)	(0.062)	(0.048)
93° 118 SEQ 347	MEAS. MEAN	0.023	0.011	-0.006	-0.044	-0.010	-0.001
	MEAN W/O GRAV.	-0-	0.017	0.024	-0.028	0.015	0.011
	MEAS. 2σ	(0.030)	(0.058)	(0.026)	(0.055)	(0.053)	(0.056)
AFT CAMERA							
70° 107 SEQ 416	MEAS. MEAN	0.014	-0.009	-0.052	-0.002	-0.025	-0.019
	MEAN W/O GRAV.	-0.016	-0.007	-0.014	0.014	0.002	-0-
	MEAS. 2σ	(0.052)	(0.042)	(0.023)	(0.044)	(0.039)	(0.043)
47° 114 SEQ 347	MEAS. MEAN	0.015	-0.013	-0.063	-0.015	-0.043	-0.051
	MEAN W/O GRAV.	-0.015	-0.011	-0.025	0.001	-0.016	-0.032
	MEAS. 2σ	(0.031)	(0.023)	(0.022)	(0.041)	(0.034)	(0.033)
93° 118 SEQ 347	MEAS. MEAN	0.016	-0-	-0.063	-0.014	-0.017	-0.019
	MEAN W/O GRAV.	-0.014	0.002	-0.025	0.002	0.010	-0-
	MEAS. 2σ	(0.041)	(0.050)	(0.038)	(0.048)	(0.043)	(0.054)

3.5.2 Operational Mode Verification, Synchronization

These operational mode verification tests (CEI Runs 119 through 129) are run as essential tests for information. The CEI specification states that the smear velocity errors calculated from the test results shall be provided with the acceptance data for information only.

The tests are conducted with the Servo Inhibit Assembly (SIA) enabled. Tables 3-30 and 3-31 provide the data required by the CEI specification. The acceptance criteria shown in Tables 3-27 through 3-29 are to be used as a design goal for these tests. A review of the gravity-corrected mean data shows that all values on both cameras, and all 2σ values, with one exception (0.007 ips out of design goal), meet the design goal requirements.

3.5.3 On-Orbit Adjust Assembly (OOAA) Calibration

The On-Orbit Adjust Assembly calibration data provided herein is required as an essential test for information by the CEI specification. The specific CEI wording is: "the OOAA shall be verified on each camera in both the in-track and cross-track directions at OOAA settings as described in test numbers 105, 106 and 107". The calibration curves reflecting the test data for these runs are presented in Figures 3-24 and 3-25.

3.5.4 SO-255 Performance, Synchronization

The synchronization performance of color film (SO-255) is measured during Chamber A testing. The test film was measured at WAFB and the results are presented in Table 3-32. No CEI performance requirement exists for color film; however, the performance measured is typical of color performance on previous models.

3.6 FILM MARKINGS

Film markings such as static discharge marks and fog marks either appear light, occur infrequently, or are confined to areas outside of the photographic format. Overall light, intermittent emulsion scratches are found

TABLE 3-30

UNCOMPENSATED MOTION
FWD CAMERA

(+) IN-TRACK ERROR MEANS DEVICE LEADS OB.

(+) CROSS-TRACK ERROR MEANS MATERIAL TOO FAST.

S/N 015

TEST/ DATE	SEQ/ RUN NO.	IMC	V/h		IN-TRACK			CROSS-TRACK		
					45°	0°	55°	45°	0°	55°
5 8-14-74	CEI 119 452 30°/ -45°	EN	052	MEAS. MEAN	0.037			-0.065		
				MEAN W/O GRAV.	0.005			-0.042		
				MEAS. 2σ	(0.045)	( )	( )	(0.050)	( )	( )
	CEI 120 452 30°/0°	EN	052	MEAS. MEAN		-0.002			-0.049	
				MEAN W/O GRAV.		0.006			-0.014	
				MEAS. 2σ	( )	(0.039)	( )	( )	(0.075)	( )
	CEI 121 452 30°/ +45°	EN	052	MEAS. MEAN			0.003			0.010
				MEAN W/O GRAV.			0.047			0.028
				MEAS. 2σ	( )	( )	(0.045)	( )	( )	(0.064)
	CEI 122 452 60°/ -30°	EN	052	MEAS. MEAN	0.032	-0.001		-0.058	-0.095	
				MEAN W/O GRAV.	-0-	0.007		-0.035	-0.060	
				MEAS. 2σ	(0.036)	(0.038)		(0.060)	(0.083)	( )
	CEI 123 452 60°/ -15°	EN	052	MEAS. MEAN		-0.008			-0.011	
				MEAN W/O GRAV.		-0-			0.024	
				MEAS. 2σ	( )	(0.028)	( )	( )	(0.069)	( )
	CEI 124 452 60°/0°	EN	052	MEAS. MEAN		-0.009			-0.054	
				MEAN W/O GRAV.		-0.001			-0.019	
				MEAS. 2σ	( )	(0.039)	( )	( )	(0.098)	( )
	CEI 125 452 60°/ +15°	EN	052	MEAS. MEAN		-0.004			-0.031	
				MEAN W/O GRAV.		0.004			0.004	
				MEAS. 2σ	( )	(0.034)	( )	( )	(0.067)	( )
	CEI 126 452 60°/ +30°	EN	052	MEAS. MEAN			-0.019			0.011
				MEAN W/O GRAV.			0.025			0.029
				MEAS. 2σ	( )	( )	(0.042)	( )	( )	(0.054)
	CEI 127 452 90°/ -15°	EN	052	MEAS. MEAN	0.043	-0.004		-0.057	-0.055	
				MEAN W/O GRAV.	0.011	0.004		-0.034	-0.020	
				MEAS. 2σ	(0.028)	(0.026)	( )	(0.059)	(0.064)	( )
	CEI 128 452 90°/0°	EN	052	MEAS. MEAN		-0.012			-0.020	
				MEAN W/O GRAV.		-0.004			0.015	
				MEAS. 2σ	( )	(0.034)	( )	( )	(0.039)	( )
	CEI 129 452 90°/ +15°	EN	052	MEAS. MEAN		-0.017	-0.027		-0.060	-0.013
				MEAN W/O GRAV.		-0.009	0.017		-0.025	0.005
				MEAS. 2σ	( )	(0.033)	(0.032)	( )	(0.066)	(0.058)

TABLE 3-31

UNCOMPENSATED MOTION
AFT CAMERA

(+) IN-TRACK ERROR MEANS DEVICE LEADS OB.

(+) CROSS-TRACK ERROR MEANS MATERIAL TOO FAST.

S/N 015

TEST/ DATE	SEQ/ RUN NO.	IMC	V/h		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
	CEI 119			MEAS. MEAN			-0.086			-0.014
5 8-14-74	452	EN	052	MEAN W/O GRAV.			-0.031			0.012
	30°/ -45°			MEAS. 2σ	( )	( )	(0.037)	( )	( )	(0.057)
	CEI 120			MEAS. MEAN		-0.013			-0.033	
	452	EN	052	MEAN W/O GRAV.		-0.011			0.007	
	30°/0°			MEAS. 2σ	( )	(0.057)	( )	( )	(0.048)	( )
	CEI 121			MEAS. MEAN	0.036			-0.032		
	452	EN	052	MEAN W/O GRAV.	-0.006			-0.007		
	30°/ +45°			MEAS. 2σ	(0.039)	( )	( )	(0.053)	( )	( )
	CEI 122			MEAS. MEAN			-0.096			-0.038
	452	EN	052	MEAN W/O GRAV.			-0.041			-0.012
	60°/ -30°			MEAS. 2σ	( )	( )	(0.033)	( )	( )	(0.050)
	CEI 123			MEAS. MEAN		0.001			-0.011	
	452	EN	052	MEAN W/O GRAV.		0.003			0.029	
	60°/ -15°			MEAS. 2σ	( )	(0.039)	( )	( )	(0.042)	( )
	CEI 124			MEAS. MEAN		-0.012			-0.044	
	452	EN	052	MEAN W/O GRAV.		-0.010			-0.004	
	60°/0°			MEAS. 2σ	( )	(0.032)	( )	( )	(0.040)	( )
	CEI 125			MEAS. MEAN	0.051	-0-		-0.024	-0.026	
	452	EN	052	MEAN W/O GRAV.	0.009	0.002		0.001	0.014	
	60°/ +15°			MEAS. 2σ	(0.038)	(0.026)	( )	(0.043)	(0.050)	( )
	CEI 126			MEAS. MEAN	0.058	-0.029		-0.043	0.005	
	452	EN	052	MEAN W/O GRAV.	0.016	-0.027		-0.018	0.045	
	60°/ +30°			MEAS. 2σ	(0.045)	(0.036)	( )	(0.051	(0.055)	( )
	CEI 127			MEAS. MEAN		-0.015	-0.094		-0.032	-0.009
	452	EN	052	MEAN W/O GRAV.		-0.013	-0.039		0.008	0.017
	90°/ -15°			MEAS. 2σ	( )	(0.042)	(0.028)	( )	(0.069)	(0.044)
	CEI 128			MEAS. MEAN	0.033	0.007		-0.049	-0.025	
	452	EN	052	MEAN W/O GRAV.	-0.009	0.009		-0.024	0.015	
	90°/0°			MEAS. 2σ	(0.049)	(0.047)	( )	(0.045)	(0.045)	( )
	CEI 129			MEAS. MEAN	0.039	0.002		-0.011	-0.028	
	452	EN	052	MEAN W/O GRAV.	-0.003	0.004		0.014	0.012	
	90°/ +15°			MEAS. 2σ	(0.035)	(0.049)	( )	(0.038)	(0.049)	( )

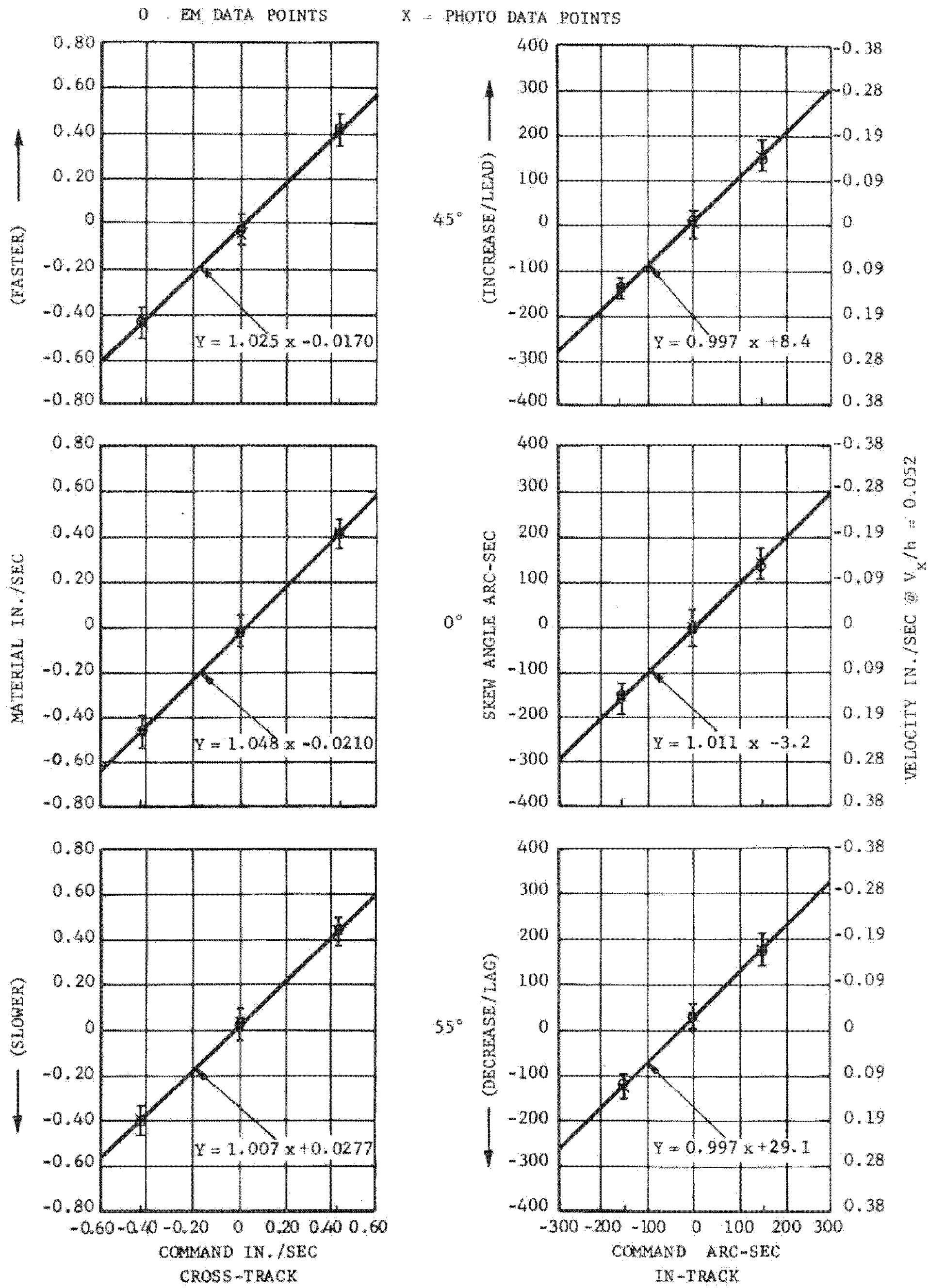


Figure 3-24. Synch Flash Tests WOG Mean Cross-Track vs OOAA Velocity Command and In-Track vs OOAA Skew Command, FWD Camera

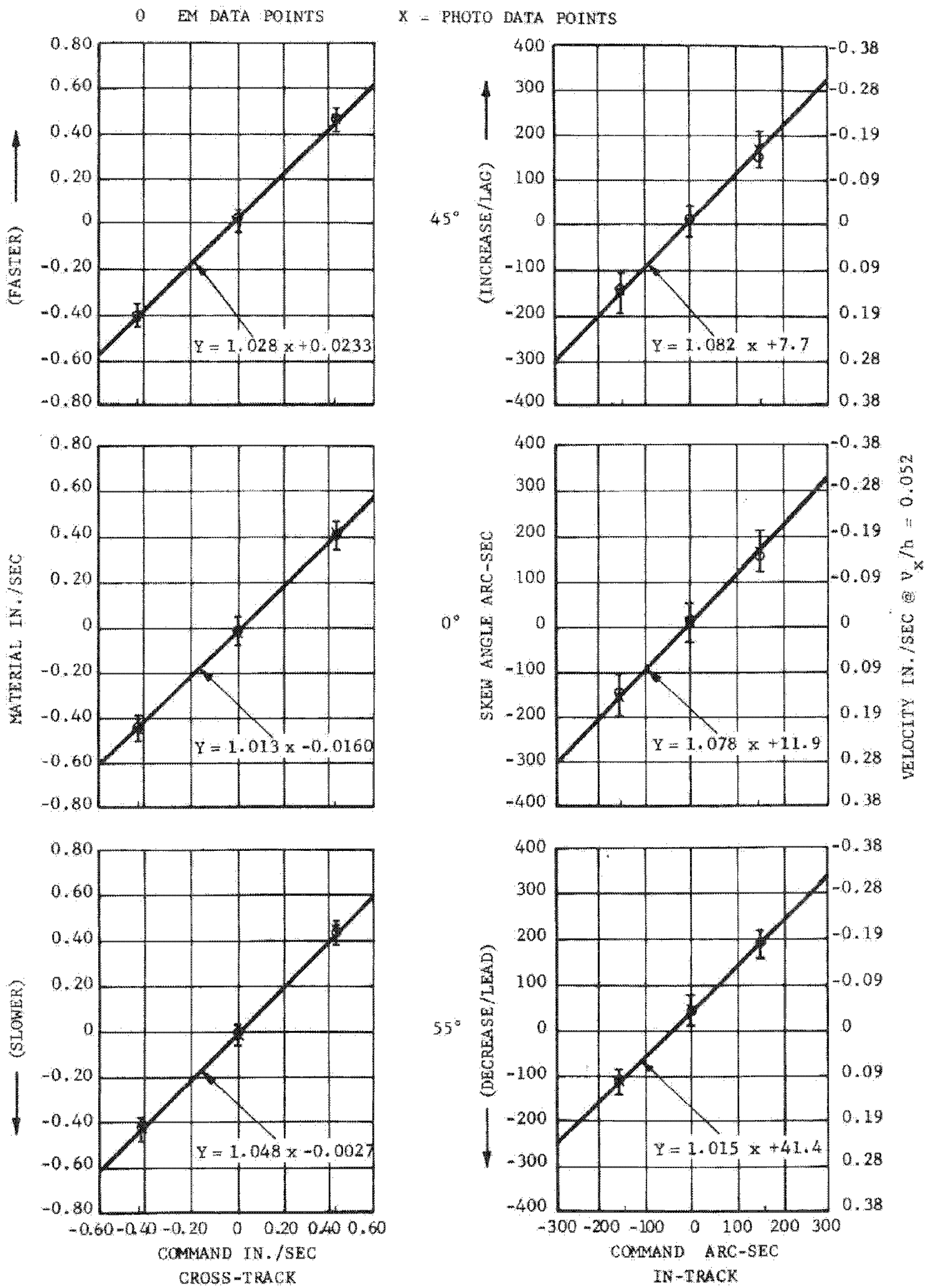


Figure 3-25. Synch Flash Tests WOG Mean Cross-Track vs OOAA Velocity Command and In-Track vs OOAA Skew Command, AFT Camera

TABLE 3-32

UNCOMPENSATED IMAGE MOTION, SO-255 PERFORMANCE

FWD CAMERA

TEST/ DATE	SEQ/ RUN NO.	IMC	V/h		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
4-2 8-23-74	273 T	EN	052	MEAS. MEAN	0.041	0.004	0.034	-0.060	-0.040	-0.032
				MEAN W/O GRAV.	0.009	0.012	0.078	-0.038	-0.005	-0.014
				MEAS. 2σ	0.033	0.030	0.038	0.063	0.075	0.074
	274 T	EN	036	MEAS. MEAN	0.014	0.012	0.028	-0.060	-0.032	-0.028
				MEAN W/O GRAV.	-0.008	0.018	0.058	-0.044	-0.007	-0.015
				MEAS. 2σ	0.019	0.033	0.027	0.040	0.048	0.041

AFT CAMERA

TEST/ DATE	SEQ/ RUN NO.	IMC	V/h		IN-TRACK 45°	IN-TRACK 0°	IN-TRACK 55°	CROSS-TRACK 45°	CROSS-TRACK 0°	CROSS-TRACK 55°
	273 T	EN	052	MEAS. MEAN	0.005	-0.028	-0.142	-0.019	-0.040	-0.030
				MEAN W/O GRAV.	-0.037	-0.025	-0.087	0.006	-0-	-0.004
				MEAS. 2σ	0.036	0.026	0.031	0.043	0.051	0.063
	274 T	EN	036	MEAS. MEAN	-0.001	-0.031	-0.099	-0.006	-0.043	-0.034
				MEAN W/O GRAV.	-0.030	-0.030	-0.061	0.011	-0.016	-0.016
				MEAS. 2σ	0.021	0.025	0.019	0.037	0.036	0.036

ALL VALUES IN INCHES/SEC:

(+) IN-TRACK ERROR MEANS PLATEN LEADS OB

(+) CROSS-TRACK ERROR MEANS FILM TOO FAST throughout all testing; this situation reflects normal performance as noted on all previous systems. And, no misplaced or spurious start-of-operations or start of frame marks were noted during both format tests and 70°F vacuum acceptance tests.

3.7 FORMAT TESTING

All photographic format measurements comply with the format drawing tolerances and CEI specification requirements.

3.8 MIDSECTION ASSEMBLY, PITCH TEST

The purpose of the pitch test, conducted during Chamber A testing of S/N 015, was to continue the investigation into the causes of the apparent field curvature as measured in Chamber A. Data correlation is also achieved by repeating the test in Chamber A-2. The test matrix was similar to that used in Chamber A-2 testing. A through-focus run of 20 frames at each of the focus positions was made at each of the following field positions, ±2.5°, ±2.0°, ±1.0° and 0° using a 30° scan angle length at a 0° scan center.

The Westover readings of the peak geometric mean tri-bar resolution at each pitch and consequent field angle are summarized in Table 3-33. The geometric mean through-focus plots for each pitch angle are shown in Figure 3-26.

The field curvature evaluation technique used in Paragraph 3.4.2 can be applied to evaluate the pitch test data. The data must be corrected for collimator and gravity effects; in addition, the data must be corrected for four microns of tilt due to primary mirror decentration and four microns due to a change in mirror deformation and metering rod compression that results from variations in pitch angle. The material corrections consist of both film flatness characteristics and material dynamic effects. The latter stems from the recent series of testing on the Engineering Model; these tests indicated that a dynamic film profile exists during recycle at 052/30°/0°. This scan angle to field angle relationship is shown in Figure 3-27 with tabulated magnitudes. Table 3-34 shows all of the required corrections to reduce pitch test line data to optical performance.

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at the operating feed pressure of 106 psia. Figures 3-1 and 3-2 are a history of calculated thrust values for RCS-1 and RCS-2 through Rev 2862. Thrusts are calculated from thrust chamber instrumentation, except the REA-4 thrust which was calculated from attitude gyro response after Rev 1352. The dashed lines (called the repeatability bands) on Figures 3-1 and 3-2 represent the expected variations (based on ground tests) in the undegraded steady state thrust levels at the flight feed pressures.

Although it was later determined that thrust levels would have been adequate for all maneuvers, startup thermal effects and pulse shape distortion on the high duty cycle pitch thrusters (REA 3 and REA 7) led to the conservative option of switching to RCS-2 thrusters for RV-3, RV-4, and deboost. Similar startup transients and pulse shape distortion had preceded thermal choking in ground tests under heat soak-back conditions which can occur during the RV hold period. The solo pitch and hold test on Rev 2862 did not show the thermal choking that was experienced in ground test even though more pulses had been accumulated and the feed pressure was lower. It is theorized that the higher feed pressures, the lower propellant temperature, and the lower duty cycle during the SV-13 flight delayed the onset of thermal choking. It is also noted that considerable differences between thrusters were experienced in the ground testing.

REA 3 stayed within the repeatability bands throughout the flight. REA 7 is estimated to have fallen out of the repeatability bands at about 139 days which exceeded the minimum prediction of 120 days. REA 7 then lost thrust more slowly than would be expected from Block I and Block II experience. REA 3 can be considered to have exceeded and REA 7 to have equalled the performanced expected from ground test results for high duty cycle thrusters. Four of the low duty cycle thrusters (REAs 2, 1, 4, and 8) fell out of the repeatability bands between 100 and 140 days, whereas they had been expected to stay within the bands for a minimum of 160 days. Like the high duty cycle REAs, the thrust decay was slow and the thrust level did not fall below the minimum required for control during the flight. The lifetimes of the low duty cycle thrusters were estimated based on the ground tests of only four thrusters; confidence in the estimated lifetimes will increase as flight experience is accumulated.

Estimated total pulse counts for both RCS-1 and RCS-2 thrusters are shown in Table 3-2.

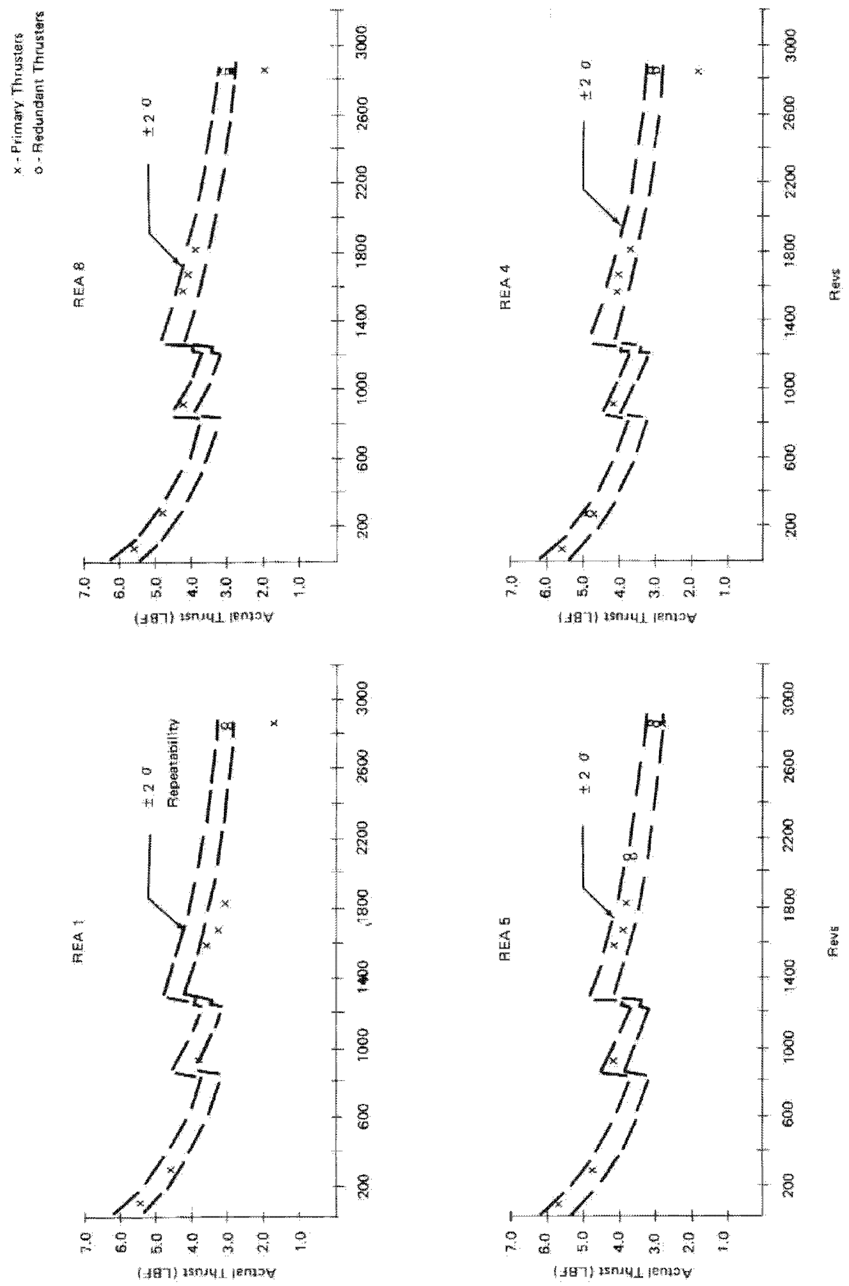
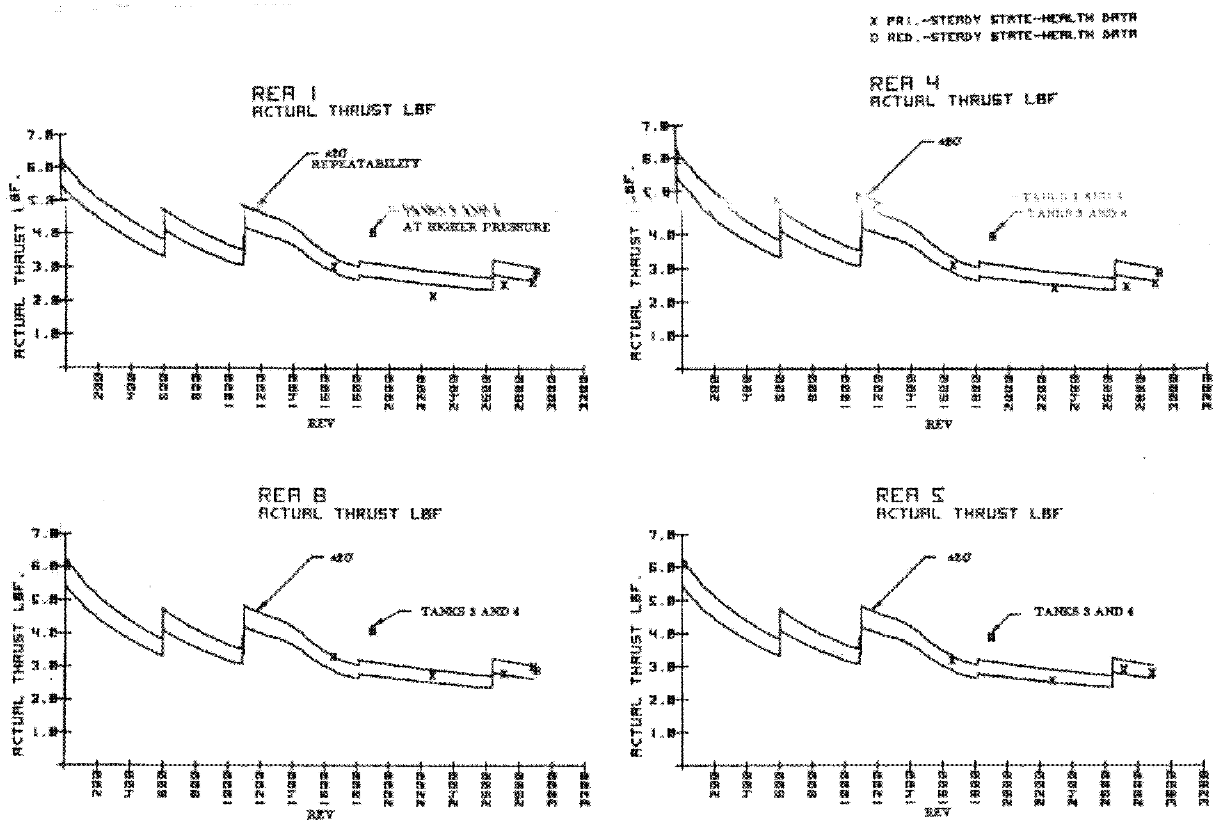


FIGURE 3-1: YAW/ROLL THRUSTERS



YAW / ROLL THRUSTERS

CALCULATED THRUST VALUES

FIGURE 3-1

TABLE [redacted]

RCS TOTAL THRUSTER PULSES
(REV 0 THROUGH 2910)

THRUSTER (REA)	RCS-1	RCS-2	TOTAL
1	33,805	1,893	35,698
2	42,263	2,861	45,124
3	483,485	25,792	509,277
4	17,509	1,805	19,314
5	35,553	2,862	38,415
6	23,427	2,034	25,461
7	428,691	22,103	450,794
8	19,948	1,185	21,133

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reverse for deboost on Rev [illegible]. RCS-1 and RCS-2 thrust is calculated by thrust chamber instrumentation and compared to the expected steady state thrust level without degradation at flight feed pressure plus or minus thruster-to-thruster and run-to-run repeatability.

Although thrust levels were adequate for all maneuvers, repeated spiking above feed pressure observed during high activity maneuvers on REA 6 and REA 7 led to the conservative option of switching to RCS-2 thrusters for RV-3, RV-4, RV-5, pitch down maneuvers and deboost. Since thrust chamber pressure is not observed by telemetry during payload operations, spiking trends cannot be established for payload activity. Single bar mono operation causes high thruster activity with long pulses and high thruster temperatures, conditions which cause maximum thrust chamber spiking. Concern for vehicle safety and potential thruster leakage from reverse propellant flow through the thruster valve during the single bar payload operation prompted switching to RCS-2 thrusters for attitude control on Rev 2726 until the completion of the mission. It should be noted that normal two-bar mono and stereo use only minimum impulse bit pulses which do not cause spiking. Observed spike magnitudes during non-payload maneuvers reached a maximum 173 psia during the mapping camera calibration maneuvers on Rev 1659 which is far below the Reaction Engine Module (REM) structural limit of 650 psia. However, low feed pressure operation from the revised propellant management requirements resulted in spike energies above feed pressure (0.50 lb-sec/in.^{2}) greater than SV-13 (0.15 lb-sec/in.^{2}) or ground test experience (0.20 lb-sec/in.^{2}). No thruster valve leakage from reverse flow was experienced even though SV-13 and ground test experience was exceeded.

All pitch/roll thrusters (REA 2, REA 3, REA 6 and REA 7) and two yaw thrusters (REA 1 and REA 8) performed close to the upper limit thrust decay prediction which was established based on SV-13 and ground test experience. Yaw REA-4 performed between the average and lower limit thrust decay prediction and yaw REA-5 was r than predicted. REA 1 fell out of the repeatability band at approximately 120 days, REA 4 at 130 days and REA 3 at 150 days, but as expected from SV-13 experience, thrust decay slopes were gradual. The thermal choking experienced on REA 7 during the Rev 2889 solo RV simulation is within predicted thermal margin limits based on number of pulses, duty cycle, propellant temperature and feed pressure.

Results of SV-14 thruster performance are being factored into thruster life prediction models.

Estimated total pulse counts for both RCS-1 and RCS-2 thrusters are shown in Table 3-2 and indicate relative activity of the thrusters.

3.3.4 RCS-1 Thrust Chamber Pressure Output Anomaly

Beginning with thruster firings for orbit adjust 30 on Rev 1352, the thrust chamber pressure transducer (B004) for yaw thruster REA-4 indicated no output. The REA 4 nozzle temperature (B054) and a comparison of REA 4 and REA 5 valve driver activity to the yaw gyro rate data showed that REA 4 thrust output was normal. Switchover from PCM 1/Remote A to PCM 2/Remote B showed that the anomaly was due to lack of signal output from the REM pressure transducer. An output reading was observed on B004 for two seconds during RV-5 (Rev 1825) indicating an intermittent condition in the transducer electrical circuit.

The most probable cause of the output loss was an open pressure transducer input power circuit. Pressure transducer ground testing uncovered a weakness in the input power EMI suppression inductor (MS90537-57) where temperature cycling caused broken wires and welds inside the inductor. Beginning with SV-14, a higher reliability version of the inductor (M39010) has been incorporated in the pressure transducer design. Vendor testing at both the pressure transducer assembly and inductor piece part level has confirmed improved reliability under temperature cycling conditions.

TABLE 3-2

RCS TOTAL THRUSTER PULSES
(Revs 0 through 2914)

Thruster (REA)	RCS-1	RCS-2	Total
1	76,000	4,000	80,000
2	50,000	4,000	54,000
3	367,000	16,000	383,000
4	16,000	1,000	17,000
5	14,000	1,000	15,000
6	14,000	1,000	15,000
7	370,000	14,000	384,000
8	39,000	4,000	43,000

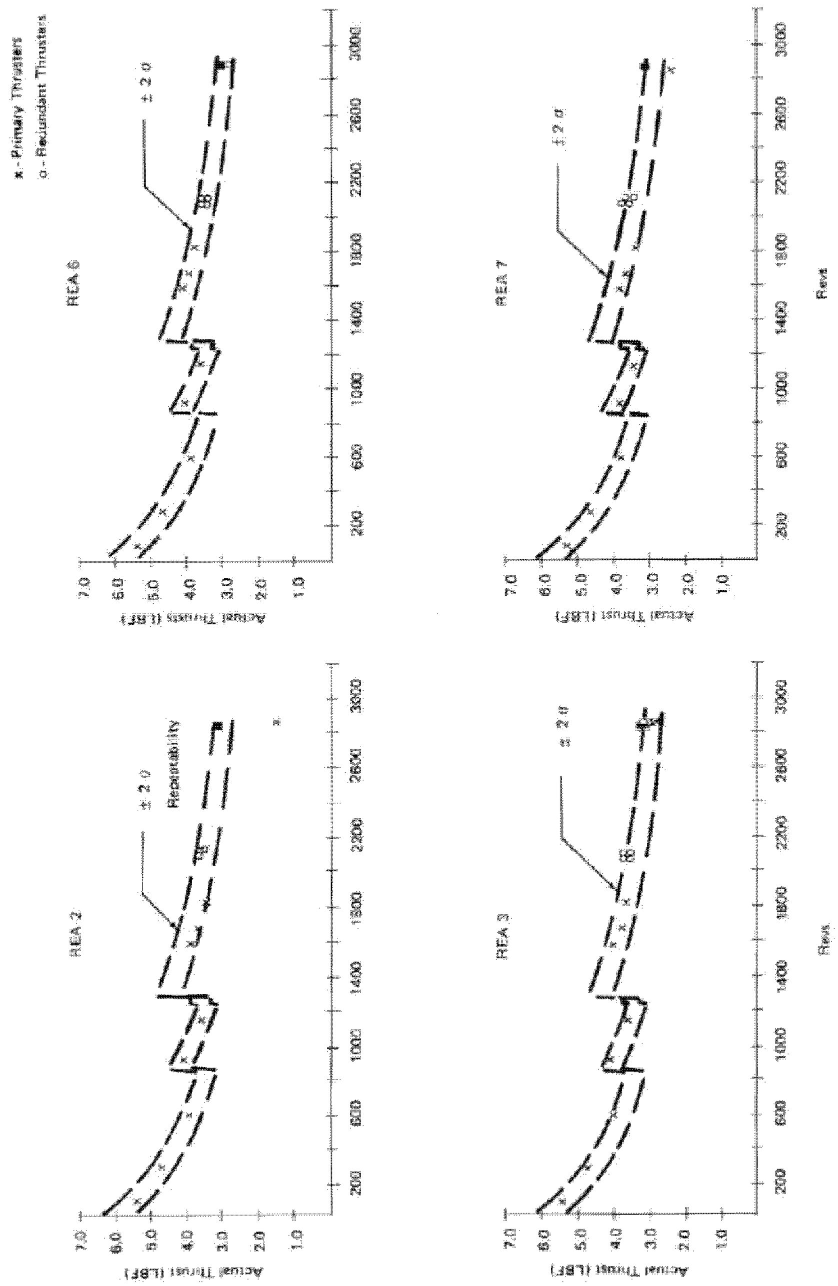
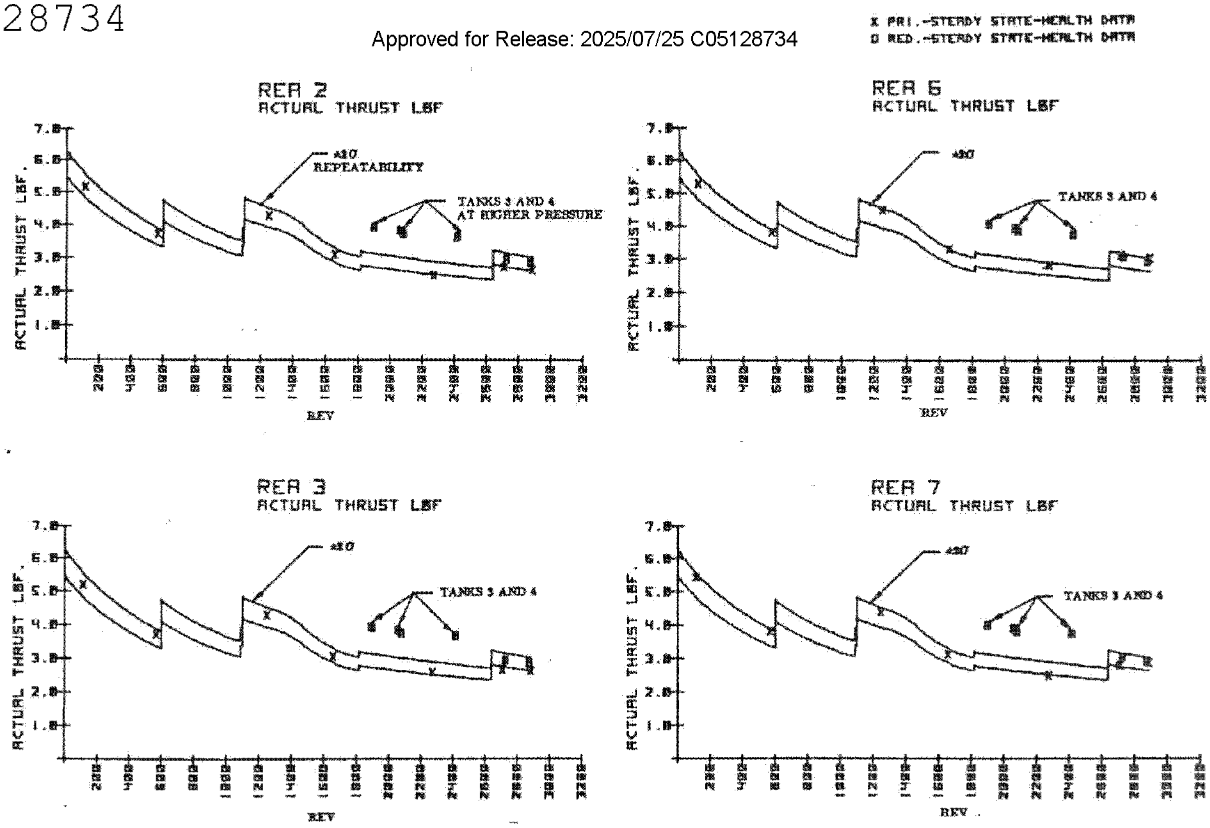


FIGURE 3-2: PITCH/ROLL THRUSTERS



PITCH/ROLL THRUSTERS
CALCULATED THRUST VALUES

FIGURE 3-2 ~~1 (continued)~~

were positioned at +18° for the remainder of the active mission. The solar array deployment mechanism has been modified for Block III and the similar deployment histories of the two arrays correlated closely with ground test results thereby indicating that the objective of eliminating the uncontrolled friction has been achieved.

The solar array output varied from 24.0 ampere-hours/rev to 24.4 ampere-hours/rev throughout the flight exceding the specification value. Degradation of the solar arrays was less than 3% in the first 30 days and less than 1% during the remainder of the mission.

3.6.2 Main Bus Voltage

The main bus voltage varied from a low of 26.5 volts during payload operations with a bus load of 66.0 amperes to a high of 31.4 volts in solo operations during the K-2 bypass relay close test.

3.6.3 Power Capability and Usage

In the beginning of the mission, power usage exceeded the total power generated by the solar arrays. Adequate power was available to support all primary payload operations. Power management during this period consisted of alternating and reducing the operations of the life-boat tank heaters, NAVPAC, MESA, the nickel-hydrogen battery experiment, [redacted] By Rev 1477 (with an improved beta angle and lower loads through the recovery of RV-1 and RV-2), sufficient power was available for all.

During the primary mission the power usage ranged from an average of 23.9 ampere-hours/rev during the first 15 days to 20.4 ampere-hours/rev during segment 4. The maximum period without a K-2 was 81 revs (Rev 184 to Rev 265). During this period the minimum system state-of-charge was 182.4 ampere-hours (76%).

3.6.4 Type 40 Battery Performance

Battery performance was excellent throughout the flight. As observed in the sunrise ES record data, the four battery voltages did not vary by more than 0.2 volts. Maximum sunrise load share variation observed was 0.4 amperes. After thermal stabilization, the battery temperatures cycled between 44°F and 49°F.

3.4 ORBIT ADJUST SYSTEM (OAS)

The orbit adjust system was operated 60 times during the active mission and four times during solo operations. Following the deboost, a propellant depletion firing was accomplished. The average propellant usage was 19.1 pounds/day during the active mission. The total propellant consumption (including deboost) was 3607 pounds. OA burns occurred every three days and the orbit parameters were such that only two negative firings were needed to control the argument of perigee.

The catalyst bed pressure drop factor (K-factor) began its decline earlier than on previous flights and stabilized at a value of approximately 16 instead of the previous range of 18 to 22. Engine performance, however, was normal throughout the mission.

3.5 LIFEBOAT SYSTEM

The lifeboat system was enabled for a health check on Rev 18 and for each RV separation. Performance of the magnetometers and gyros was normal, and no anomalies were noted.

3.6 ELECTRICAL DISTRIBUTION AND POWER (EDAP)

The Block III solar array deployment mechanism has been modified but operationally remains the same. There were four type 40 batteries: three for the main bus and one for the lifeboat bus. A commandable K-2 bypass relay was added to each charging circuit to provide a redundant capability in the event of a K-2 relay malfunction such as the one that occurred on SV-12. The lifeboat battery could also be connected to the main bus and an automatic disconnect triggered by a high main bus current or a low lifeboat battery state of charge was included to protect the lifeboat battery. Also a gross main bus overcurrent would open an 80 ampere fuse, isolating the lifeboat battery. Modifications were also made to permit the nickel-hydrogen battery experiment to receive that portion of the solar array output that is not used when the K-2 relay is in the open position.

3.6.1 Solar Arrays

The SV beta angle varied from +22° to +10° so, after deployment at the first station pass (Indi), the solar arrays

The Orbit Adjust System (OAS) was operated 63 times during the active mission and for a two segment deboost (followed by a burn-to-depletion firing). Other than deboost and the depletion burn, no negative firings were performed.

The average propellant usage for orbit adjusts was 18 pounds/day for the mission length. The total propellant consumption through the orbit adjust engine (including deboost and depletion burn) was 3446 pounds. ~~A summary of the orbit adjust~~

The catalyst bed pressure drop factor (K-factor) exhibited characteristics quite similar to that observed during the last mission (SV-13). It stabilized at a value of approximately 15 for the later half of the mission, as before, but with a slight decaying trend during the last few OA firings.

OA engine performance, however, was nominal and satisfactory throughout the mission series.

3.5 LIFEBOAT SYSTEM

The Lifeboat System was enabled for a health check on Rev 18 and for each RV separation. The magnetometer and gyro performances were normal and no anomalies were noted.

3.6 ELECTRICAL DISTRIBUTION AND POWER (EDAP)

The SV-14 configuration, with one major exception, was basically similar to SV-13. The S77-2 experiment was installed on +Y Pallet, replacing the NiH_2 battery experiment. This resulted in heavier than usual loads, especially in the early stages of the flight.

3.6.1 Solar Arrays

Insert Y The SV beta angle varied from 18.5 degrees to 22.5 degrees so the solar arrays were positioned at +18 degrees throughout the mission except for solo testing of the position switches.

mission.

3.6.2 Main Bus Voltage

The minimum bus voltage during payload operations was 26.8 volts, on Rev 1985, with a bus load of 66.0 amperes. The highest voltage observed was 31.7 volts on Rev 2389 HULA.

3.6.3 Power Capability and Usage

The solar array output varied from 25.66 ampere-hours/rev on Rev 7 to 23.42 ampere-hours/rev on Rev 2859 throughout the mission. During the primary mission the power usage ranged from an average of 382 ampere-hours/day during the first 36 days to 360 ampere-hours/day during Segment 4. The maximum period without a K2 was 172 revs (Rev 1884 to Rev 2056). During this period, the minimum system state-of-charge was 158 ampere-hours.

3.6.4 Type-40 Battery Performance

Battery performance was excellent throughout the mission. As observed in the sunrise ES record data, the four battery voltages did not vary by more than 0.2 volts. Maximum sunrise load share variation observed was 0.7 amperes. After thermal stabilization, the battery temperatures cycled between 35°F and 43°F.

3.6.5 Charge Current Controller (CCC) Performance

The CCC performance was very good throughout the mission. No K2 relay problems were encountered. No actual count on relay openings was available since the sunset ES record was deleted due to the requirement to minimize tape recorder cycling.

3.6.6 Type-40 Battery, 37°F Temperature Modification

This modification consists of a change in the temperature set point for the battery heater thermostats. Prior to SV-14, the thermostat set point had been 47°F. This modification provides for lowering the set point to 37°F in order to achieve power savings.

Calculations using normalized data from SV-13 and SV-14 indicate a power savings of 12 ampere-hours/day.

3.7 Tracking, Telemetry, and Command (TT&C)

3.7.1 Vehicle Communication Transponder System (VCTS)

3.7.1.1 Tracking

The tracking system performance throughout the mission was excellent, operating well within its required limits.

3.7.1.2 Antenna Radiation Characteristics

SGLS 2/PCM2 was checked weekly for the first 60 days, and monthly thereafter, to obtain signal strength data from the HULA tracking station with no degradation observed.

3.6.7 Structure Current Anomaly

Vehicle structure current was observed during horizon sensor fairing and shroud separation and also during subsatellite erection.

During the fairing and shroud separation the structure current monitor indicated current flow. The pyro bus 1 current monitor and battery 4 current monitor confirmed this flow. The current flow occurred for the duration of the booster staging timer command, WECO commands and booster flight programmer backup commands, thus indicating a continuous short.

Subsatellite erection data revealed that there was structure current during the command duration. Contact with other programs confirmed that a number of vehicles have experienced similar structure current in connection with pyrotechnic events.

Aerospace Corporation performed analyses of similar pyrotechnic devices and ascertained that electrode-to-electrode and electrode-to-structure shorts are indeed possible in ASI squibs. However, the duration of the squib shorts in the analyses is short compared to those encountered on vehicle SV-14.

To further investigate the occurrence of ASI squib shorting, an ASI squib current test was performed. This test consisted of ten pin puller squib firings in a thermal-vacuum chamber with 10^{-5} Torr vacuum. One of the squibs developed an electrode-to-case continuous short.

Analysis of the fired squibs is continuing.

3.7.2 Telemetry

The telemetry system performed satisfactorily throughout the mission.

3.7.3 Tape Recorder (TR) 1 Anomaly

Tape Recorder 1 failed to start from BOT during Rev 220.2 and Rev 547. In both cases the tape recorders started with the next command. At Rev 220.2, 32 seconds of data was lost and at Rev 547, 180 seconds of data was lost. No critical data was lost. The two possible causes were identified; either the tape recorder did not respond to the command or a failure occurred in the command system. The most probable cause was a failure in the tape recorder BOT logic circuitry. Investigation is continuing. On Rev 681, the tape recorder was moved away from BOT and an operational sequence was generated to prevent returning to BOT.

3.7.4 Tape Recorder (TR) 2 Anomaly

During the real time operation on Rev 600, telemetry indicated a loss of 97 seconds of recorded data out of the middle of a 500 second record sequence. Analysis of the data revealed that bits in multiples of 5 were added or dropped. These bits could be identified and the data could be recovered by manual analysis. No critical data was lost during real time operation.
An occasional one to three seconds of data drop-outs occurred during the real time analysis for the remainder of the flight. The analysis of this data revealed the cause to be "O" bits in the sync word, changing to "1" bits and addition/drop of 5 bits. Only one or two main frames of data were affected with each occurrence. Other cases of "O" bits changing to "1" bits occurred. No significant loss of data was experienced in real time and most of the data was recoverable.

3.7.5 Instrumentation

Data obtained throughout the mission indicated that excellent instrumentation performance was achieved. There were no instrumentation anomalies at lift-off.

3.6.5 Charge Current Controller (CCC) Performance

The CCC performance was very good throughout the flight. No K-2 relay problems were encountered. The K-2 relay on battery 3 opened and closed 1750 times and the battery 1 relay opened 1557 times. Batteries 2 and 4 experienced less K-2 relay openings. During solo testing a K-1 relay open was observed on battery 4 during the lifeboat battery isolation test, and K-1 relay openings occurred on batteries 1 and 3 during the K-2 bypass relay close test.

3.6.6 State-of-Charge Indicator (SOCI) Performance

The state-of-charge indicator (SOCI) performed within specifications limits. Allowable error is ±0.25 ampere-hours per hour, performance was -0.13 ampere-hours per hour.

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

3.7.1 Vehicle Communication Transponder System (VCTS)

3.7.1.1 Tracking

Tracking system performance throughout the flight was excellent, operating well within its required limits.

3.7.1.2 Antenna Radiation Characteristics

Weekly health tests were performed on the Block II VCTS, located in the SGLS-2 position, to ascertain transmitter signal strength and detect any recurrence of the SV-8 anomaly when a significant loss in signal strength occurred. Signal strength measurements were taken at Hula RTS throughout the flight mission and no degradation was observed.

3.7.2 Telemetry

The telemetry system performed satisfactorily throughout the flight mission.

3.7.3 Tape Recorder (TR)

Commencing with Rev 1923, TR-1 (type-34 Block III design) exhibited main frame sync bad (MFSB) indications. On Rev 1933 the mission operational tape recorder was switched from TR-1 to TR-2 (type-28 Block II design). To obtain a comparison, a parallel TR-2/TR-1 record during the OA burn on Rev 1938P was accomplished. When played back, TR-2 had no MFSB indications and TR-1 had two. TR-1 was fast forwarded and, when played back, repeated the MFSBs indicating that the error was on the tape.

Analysis of the tape recorder construction and the playback data indicates that the most probable cause was particles on the tape. A new head design having a hard face (alfesil) was incorporated in this design for longer missions and "plowing" of the tape may have produced the particles. It was recommended that spooling (an end-to-end run) would clear the head of particles. This was accomplished on Revs 1992, 2170, 2637, and 2645, and the MFSB indications decreased substantially.

Tape Recorder 2 (type 28 Block II design) operated satisfactorily throughout the remainder of the mission.

3.7.4 Instrumentation

The thrust chamber pressure transducer (B004) failed on Rev 1352 and is discussed in paragraph 3.3.4. Table 3-3 presents the instrumentation anomalies at lift off.

3.7.5 Telemetry and Tracking (T&T) Equipment On/Off Cycles and Operating Time

Utilization of major T&T equipment throughout the flight mission (through Rev 2848) was:

T & T Equipment Cycles and Operating Times

Utilization of major T & T equipment (all Block III) through deboost is as follows:

Equipment	On/Off Cycles	Operate Time (Hours)
SGLS 1	3151	293.4
SGSL 2	75	7.0
PCM 1	12570	1252.3
PCM 2	187	20.1
TR 1 (Type-35)	2857	140.1
TR 2 (Type-34)	9285	527.9

3.7.7 Command

3.7.7.1 [redacted] Extended Command System (ECS)

The Extended Command System (ECS) executed all required stored program and real time commands. The total commands stored in memory during the primary mission were 370430 of which 256803 commands were executed. Those commands not executed were erased. No anomalies were noted.

3.7.7.2 [redacted] Minimal Command System (MCS)

The Minimal Command System (MCS) executed all required commands during the primary mission.

3.7.7.3 [redacted] Remote Decoders/Backup Decoder

The remote decoders executed all required commands for each of the five recovery operations. The performance of both channels was verified for each recovery operation. The backup decoder was used in place of remote decoder-B for the RV-5 recovery operation. The backup decoder operational capability was verified during health checks and whenever it was used with the ECS.

Usage summary of the command system through Rev 2876 is as follows:

System	Total Operating Time (hours)
ECS	4250.2
MCS	4.4
RD	17.0
BUD	0.1

TABLE 3-3

INSTRUMENTATION ANOMALIES AT LIFT-OFF

Monitor	Item	Condition
A951 A952	Shroud separation monitor	Block III design changed monitor calibration. Calibration record 37158 issued to correct the calibration tape.
B008	Primary REA 8 chamber Pressure monitor	The transducer voltage output reads high—approximately 0.16 volts (4.8 psi). Transducer operates correctly between 40 and 115 psia.
C031	Structure current monitor	Random sampling on sensor telemetry output signal provided indications of low level single sample structure current. Amplitude of transients was approximately 50 millivolts.
C042	Main bus current monitor	Whenever ECS PMU search and mid section operates, a negative spike occurs. This is an inherent condition of the ampere-hour unit.
C607 C607/C609	Forward power distribution J-box K2 relay status Forward power distribution J-box K3 relay status	Either or both monitors can respond with the application of any RV reset command.
H337	MCS word quantity monitor	Whenever the MCS is in any state other than standby/sleep and there are commands loaded in memory, the monitor may drift. This condition was introduced with the replacement of the delay line with MOSFET registers.
P235	TU bulkhead temperature	Temperature sensor failed during factory test.
X862	NiH_2 battery monitor	Erratic and noisy strain gage amplifier output may read any value at any time.

Equipment	Block	On/off cycles	Operating Time (hours)
SGLS 1	III	2910	266.10
SGLS 2	II	23	2.48
PCM 1	III	13109	815.97
PCM 2	III	23	5.73
TR 1	III	8398	440.83
TR 2	II	4042	249.93

3.7.6 Command

3.7.6.1 Extended Command System (ECS)

The ECS executed all required stored program and real time commands. The total commands stored in memory during the primary mission were 269,957, of which 179,458 were executed. The remainder were erased. No anomalies were noted.

3.7.6.2 Minimal Command System (MCS)

The MCS executed all required commands during the primary mission.

3.7.6.3 Remote Decoder/Backup Decoder

The remote decoders executed all required commands for each of the five recovery operations. The performance of both channels was verified for each recovery operation. The backup decoder operational capability was verified during health checks.

Usage summary of the command system through Rev 2484 is:

System	Total operating time (hours)
ECS	4202.0
MCS	5.7
ED	28.6
BUD	0.2

3.8 MASS PROPERTIES

A chronology of SV mass properties throughout the mission is shown in Table 3-10.

3.9 PREFLIGHT WINDS ALOFT LOADS ANALYSIS

Table 3-11 presents a chronological tabulation of the prelaunch winds aloft loads analysis for SV-14; the results are plotted in Figure 3-2. All parameters were well within limits at all times and no delay of launch was indicated.

3.10 THERMAL CONTROL

3.10.1 Mid and Forward Section Lift-Off Conditions

During pre-launch operations, the ground air conditioning temperatures for the forward and mid sections were set to provide average temperatures of 73°F and 71°F respectively. The temperature levels were selected to minimize the thermal settling time required to achieve on-orbit thermal equilibrium of the primary payload and thus reduce the RV heater consumption.

The initial value predicted for the primary reference temperature, T_{ref}, based on a planned launch date, orbit beta angle range and altitude was 71°F (for actual flight parameters, the predicted T_{ref} = 72°F).

On day 3, T_{ref} was 72.3°F; by day 8, T_{ref} was 73.1°F; on day 32, T_{ref} was 71.6°F. The orbit average temperature of the two mid section compartments similarly rose in the early days of the flight, probably due to the heavy payload activity during this period.

3.8 MASS PROPERTIES

A history of SV mass properties throughout the flight is tabulated in Table 3-4.

3.9 PRELAUNCH WINDS ALOFT ANALYSIS

The results of the SV-13 loads analyses of prelaunch winds aloft are plotted in Figure 3-3. The analyses are based on Rawinsonda and Jimsphere balloon soundings taken on 26 and 27 June 1976. All parameters were well within limits at all times, and all recommendations were "go--continue count" and finally "go for launch."

3.10 THERMAL CONTROL

Flight data indicated that the average temperatures of the aft, mid, and forward sections were well within design limits. There were no thermal anomalies.

The flight temperatures of the NAVPAC (-Y pallet) and the NiH_2 battery (+Y pallet) remained within design limits throughout the flight. The minature electrostatic accelerometer (MESA), which is a functional part of the NAVPAC module, is attached to the +Z surface of bay 4 rather than the -Y pallet. The MESA temperatures were within limits throughout the flight; however, the orbital temperature swings were larger than desired (approximately 26°F from the minimum to maximum levels). A thermal shield addition has been designed to cover the MESA on future vehicles which will reduce the orbital temperature swings.

TABLE 3-4

SV-13 MASS PROPERTIES

		Center of Gravity (inches)		
		SV Station		
Description	Weight (lbs)	X	Y	Z
At launch	26435.8	1973.9	0.58	3.45
Separated from Stage 2	23383.6	1985.0	0.68	3.90
After separation of:				
RV-1	20916.8	1992.4	0.76	3.71
RV-2	18604.1	1997.8	0.85	3.33
RV-5	17240.4	1991.0	1.11	4.41
RV-3	15243.6	2002.9	1.06	3.36
RV-4	12734.7	1999.2	1.27	2.72
At deboost	12385.2	1994.2	1.30	2.81

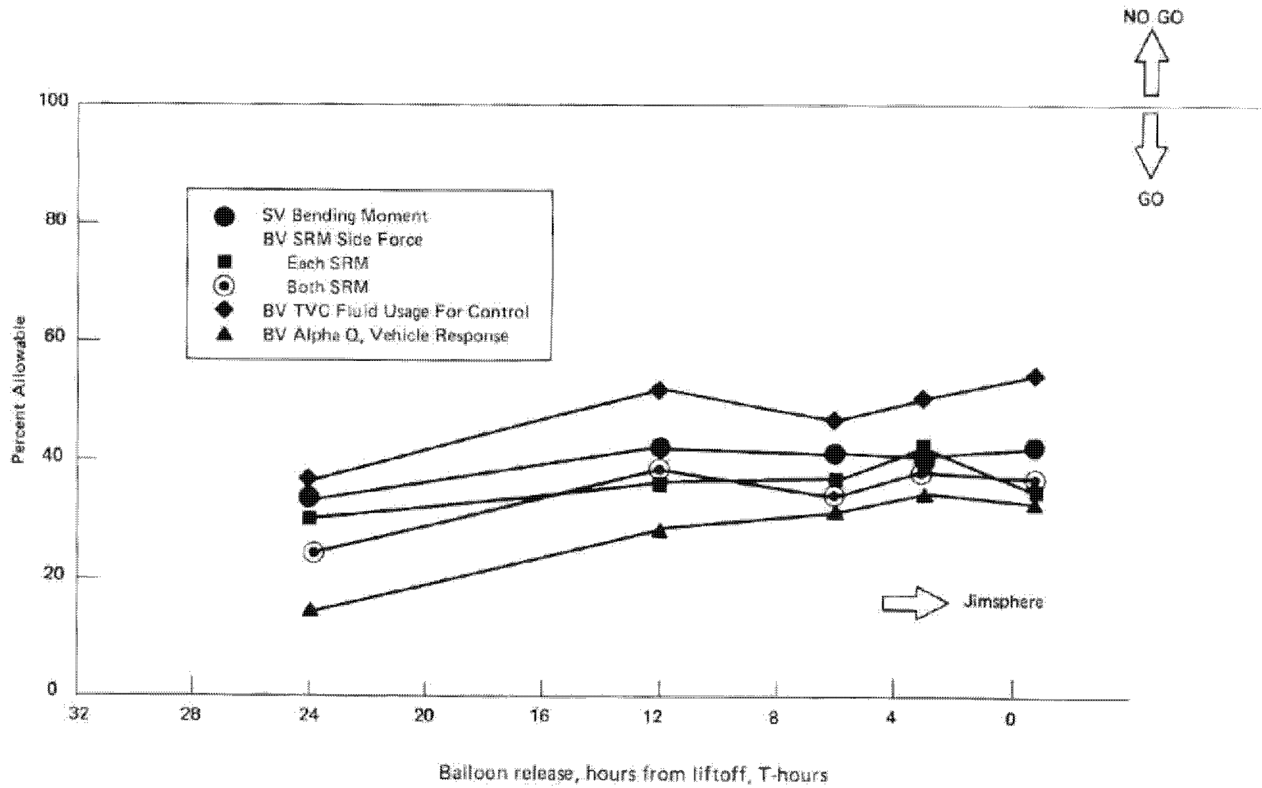


FIGURE 3-3: WINDS ALOFT CRITICAL PARAMETER SUMMARY

3.10.2 Mid Section, Forward Section and MCM Orbit Temperatures

Tables 3-12 and 3-13 present orbit average temperatures for critical vehicle parameters for Rev 506, orbit beta angle = 22°. The data was derived from vehicle temperature monitors using methods described in detail in the respective Interface Control Documents. The vehicle temperatures and temperature differentials were well within allowable limits.

3.10.3 Aft Section Thermal Performance

The aft section equipment configuration and thermal control design of SV-14 are essentially identical to those of SV-13. The only significant difference is that battery heater set points were lowered by 10° F for SV-14, as a power-saving design change. Flight temperatures are similar to those of SV-13 with the exception of the lower battery temperatures, and no thermodynamic anomalies were noted.

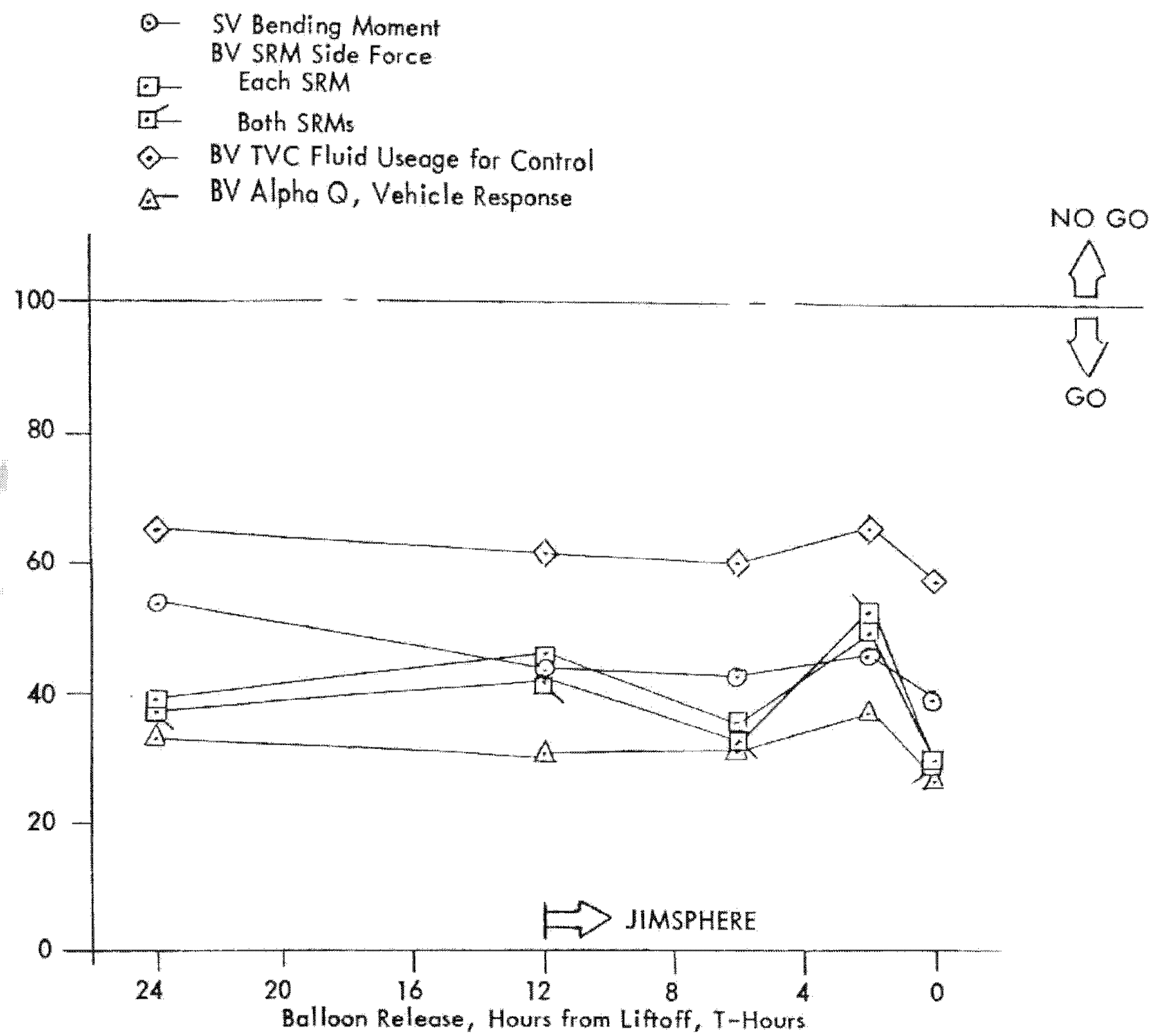
All equipment operated well within design limits and battery temperature was controlled satisfactorily by the new lower heater setting.

3.10.4 Pallet Experiments

The +Y and -Y Pallet payload temperatures are tabulated in Table 3-15. These temperatures are the orbit average values and were well within design limits. The temperature data indicated that the thermal control design adequately controls component temperatures.

FIGURE 3-3

WINDS ALOFT CRITICAL PARAMETER SUMMARY



(1) The T-3 Jimsphere Balloon burst at 43,703 feet altitude and was replaced by the T-2 Balloon.

SECTION IV

PAYLOADS

4.1 PANORAMIC CAMERA SYSTEM

4.1.1 Camera Operations and Performance

Mission 1213 represented a number of significant and unique milestones:

a. This was the first of the Block III design, incorporating several system improvements with increased reliability.

b. Both cameras demonstrated the capabilities to utilize the new generation of thinner-base films. As a result, on future missions the thinner-base SO-208 will replace 1414 as the primary film, resulting in an increase of approximately 16% in the film supply. Both cameras also demonstrated the capability to successfully utilize the new, special film types (SO-460, SO-464, and 7011).

c. This was the first mission in which the film path was purposefully maintained above a minimum pressure (0.55 psi) to minimize image degradation. The required pre-pumping of the path to this minimum was performed 73 times during the mission, consuming an additional 1.6 lbs of pneumatics.

d. The active photographic mission duration of 175 days was the longest to date. The previous maximum was Mission 1212 at 155 days.

e. More operations were executed than on any previous mission. The total of 1068 operations exceeded the Mission 1212 record of 1048.

4.1.2 Camera Data

Panoramic camera data are summarized in Table 4-1.

TABLE 4-1

PANORAMIC CAMERA STATISTICS

Item	Forward Camera			Aft Camera		
Camera designation	A			B		
Focal length (inches)	60.0378			60.0319		
Optical set number	072			071		
Film spool number	3050			3070		
Film supply weight (lbs)	941.0			941.1		
Film type:	Footage	Filter	Focus	Footage	Filter	Focus
1414[a]	104,154	W-12	70	88,308	W-12	56
SO-130[b]	---	--	--	5,503	W-12	86
SO-255[c]	---	--	--	3,488	W-2E3	86
SO-208	7,911	W-12	52	11,946	W-12	38
SO-460[d]	3,984	W-2E3	48	2,992	W-2E3	34
SO-464	5,114	W-2E3	48	3,991	W-2E3	34
7011[e]	---	--	--	1,941	W-2E3	48

Pneumatics (lbs)	
Initial	70.0
Estimated remaining	28.3

[a]High-definition, black-and-white, UTB
[b]False color infrared
[c]Natural color
[d]High definition, black-and-white, UUTB
[e]Monodispersed cubic (J-coating), black-and-white.

4.1.3 Camera Operation

Operational photography began on Rev 7, but was temporarily suspended after Rev 13 because of an anomaly in the shutter open/close logic during Ops 6, 7, and 8. The randomly recurring failure caused the shutter to open in the fail-safe mode and to close in an erratic timing pattern. The failure was successfully circumvented by switching to SCC Block II, with a return to normal operations on Rev 39.

On Rev 107 Op 48, there were two instances where Forward camera frame reference times coincided with shutter open rather than the first five degree mark. This was deemed to be a recurrence of an infrequent, sporadic phenomenon seen on past vehicles having no significant impact on operational performance.

On Rev 124 Op 56, the Forward camera first frame reference time did not appear on telemetry and the DIU counter did not increment. Subsequent data analysis showed an absence of the frame 1 request pulse caused by the OB reaching constant velocity too late to allow request pulse gating from the SCC. A change to the start-up command sequence was implemented forcing the OB to be commanded on one cycle earlier. The problem was not seen for the remainder of the mission.

Based on the predicted stack-height clearance remaining, four short ops were planned just prior to the recovery of RV-1. At the completion of the rewind on Op 202 Rev 563, the Forward camera "TU-Exceeds" switch initiated an ESD, precluding the execution of the remaining three ops. Normally, as the take-up stack approaches its outer limits, the raising of the builder roller during rewind will trigger the "TU-Exceeds" switch, but the associated IESD logic disables the monitor during rewind. However, for this op, the electrical/mechanical hysteresis in the switch was sufficient to inhibit the resetting of the switch as the builder roller lowered at the completion of rewind. At that point, the logic was re-enabled and sensed the triggered switch thus initiating the ESD. These switches will be disabled on future systems.

Camera operations were again interrupted on Rev 791 Op 274 by an ESD initiated by a momentary loss of the seal door verify signal. The phenomenon occurred again on Rev 971 during an attempted camera start-up, precluding execution of a nested pair of ops. Because of its momentary nature and low incidence of occurrence, corrective action was not taken. The problem did not recur.

During Rev 2334 Op 838, the film path vent valve failed to open at the designated pressure. This anomalous condition continued throughout the remainder of the mission. The build-up of potentially catastrophic chute pressure was avoided by active management of operations and pneumatics-ON time.

The active photographic mission was terminated with RV-4 recovery on day 175 following depletion of both film supplies. The Forward supply was depleted on Rev 2840 Op 1070. This was also the last operation on the Aft camera, its supply depleting during the final CV which pulled the film tails onto the take-up.

Figures 4-1 through 4-6 present various mission histograms based on actual film usage. These histograms are representative of typical Hexagon missions. Figures 4-1 and 4-2 depict film usage in feet and frames, respectively, as functions of scan width, scan center, and scan sector. Figures 4-3 and 4-4 present histograms of exposed film footage as a function of vehicle altitude and latitude. Figures 4-5 and 4-6 illustrate the distribution of photographic coverage in terms of land mass (area) and fully framed targets, respectively, as functions of scan sector.

4.1.4 Focus

Analysis of the through-focus engineering photography, using VEM, optical power spectrum, and subjective data, indicated that the prelaunch focal plane settings on both cameras were less than optimum. The Forward focal plane was retreated four micrometers and the Aft retreated six micrometers.

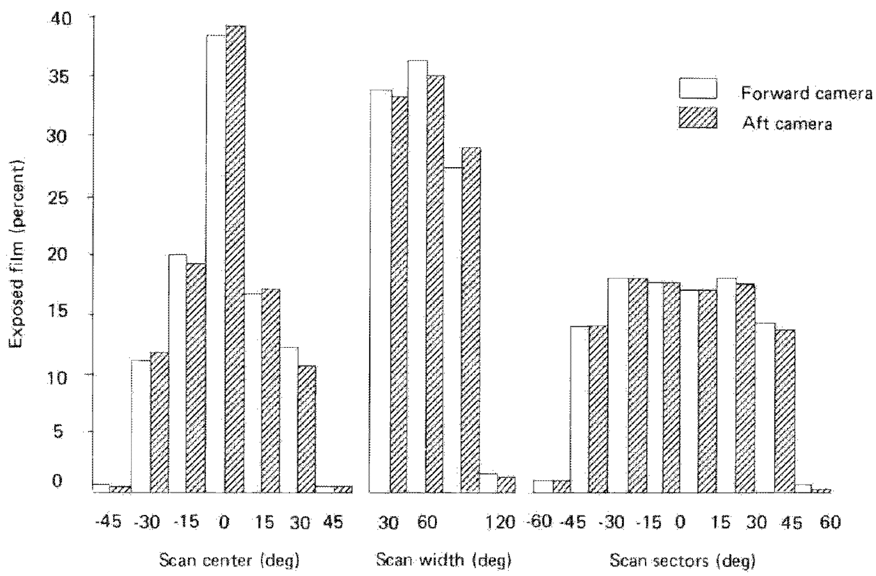


FIGURE 4-1: PERCENTAGE OF FILM EXPOSED BY SCAN CENTER, SCAN WIDTH, AND SCAN SECTOR

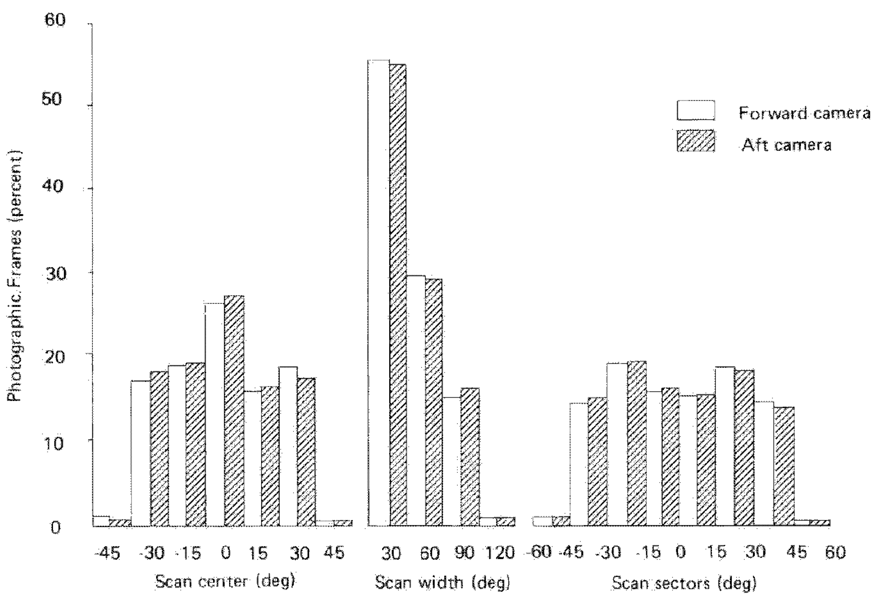


FIGURE 4-2: PERCENTAGE OF PHOTOGRAPHIC FRAMES BY SCAN CENTER, SCAN WIDTH, AND SCAN SECTORS

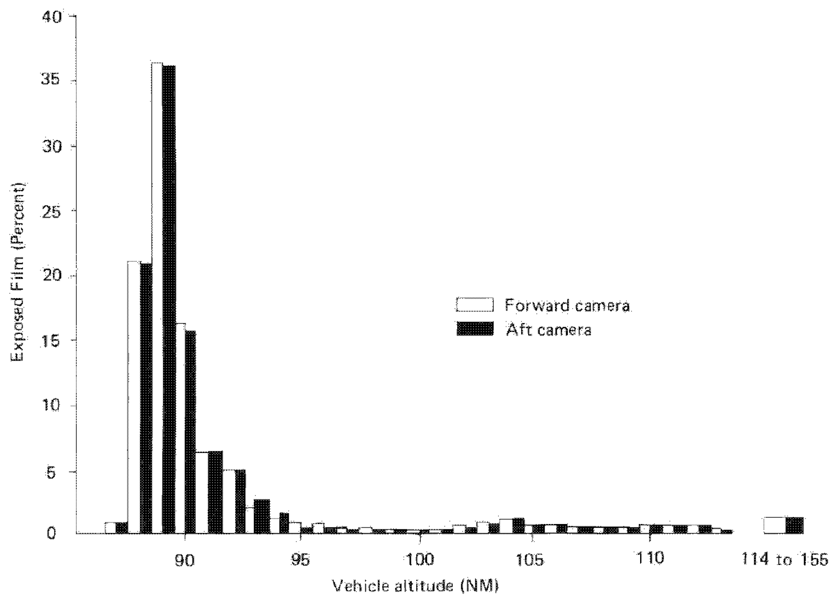


FIGURE 4-3: PERCENTAGE OF FILM EXPOSED AS A FUNCTION OF VEHICLE ALTITUDE

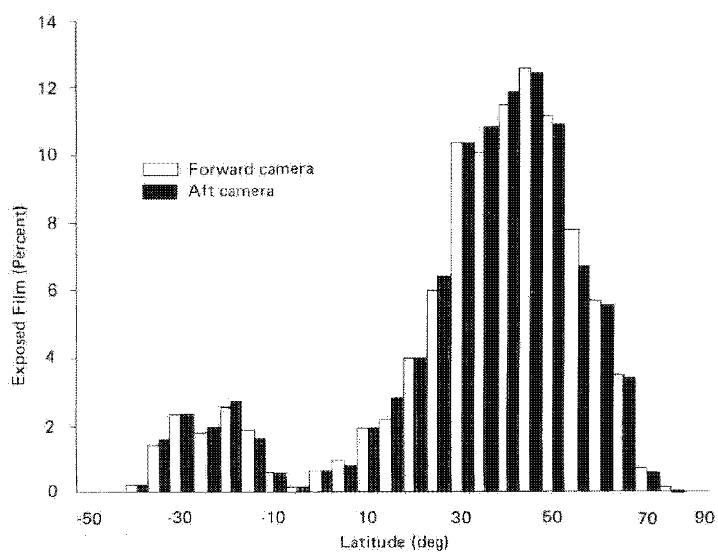


FIGURE 4-4: PERCENTAGE OF FILM EXPOSED AS A FUNCTION OF LATITUDE

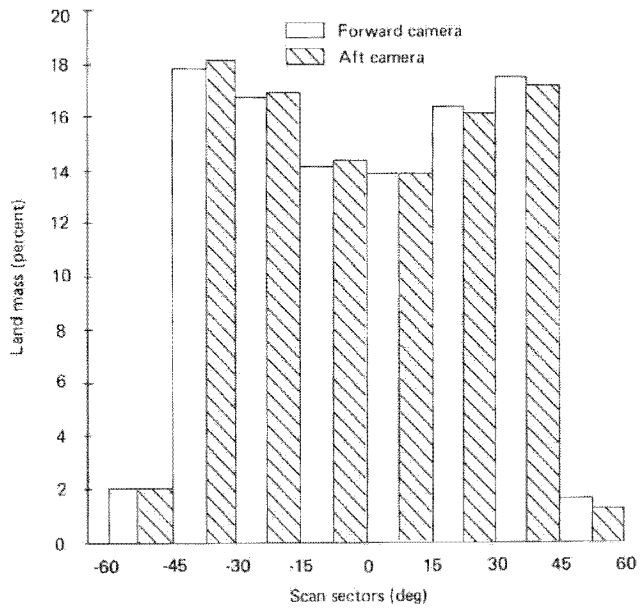


FIGURE 4-5: PERCENTAGE OF LAND MASS ACQUIRED AS A FUNCTION OF SCAN SECTOR

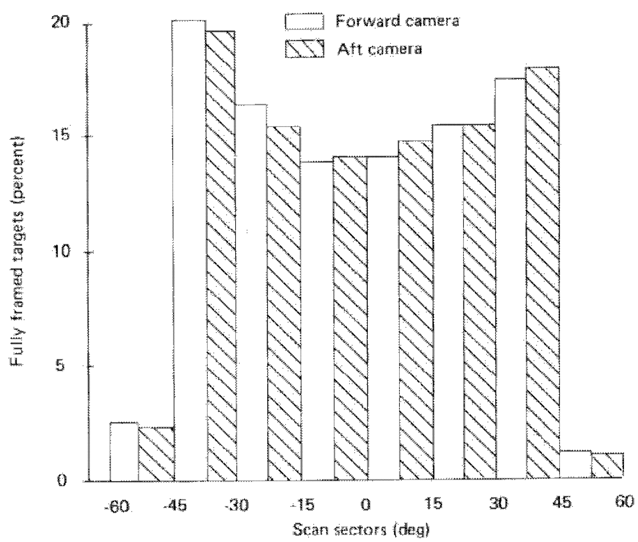


FIGURE 4-6: PERCENTAGE OF FULLY FRAMED TARGETS AS A FUNCTION OF SCAN SECTOR

4.1.5 Film Synchronization

Mission 1213 nominal OOAA settings for 1414 film are summarized as follows:

Camera	Direction	1213-1	1213-2	1213-3	1213-4
Forward	In-track	0	-2	-2	-2
	Cross-track	-2	-2	-2	-2
Aft	In-track	0	-1	-1	-1
	Cross-track	2	2	2	2

Analysis of smear slit imagery from OOAA engineering operations resulted in changes to the initial settings. Smear variability was determined to be within the system design goal.

4.1.6 Photographic Image Quality

Overall image quality on both the Forward and Aft cameras for the entire mission ranged from good to poor, with the majority rated fair. The Aft camera image quality was considered slightly better than that of the Forward camera. The poor imagery was typified by heavy haze and clouds.

Mean VEM resolution was 154 lines/mm on the Forward and 157 lines/mm on the Aft camera. Ground resolved distances (geometric mean) on 1414 film, as determined from 9 CORN tribar acquisitions, ranged from 2.08 to 2.85 feet with varying format location and contrast. Two acquisitions each with SO-130 and SO-255 averaged 4.9 feet and 4.1 feet, respectively. There were also 9 CORN tribar acquisitions with SO-208 film, indicating GRD values of 2.45 to 3.24 feet. The tribar target readings acquired with the special films (SO-460, SO-464, and 7011) ranged from 1.96 to 2.95 feet. The overall quality of Mission 1213 was considered to be somewhat less than that of the previous two missions.

4.1.7 Exposure

Microdensitometric analysis of urban/industrial imagery throughout Mission 1213 indicated nominal exposure for 1414, whereas the special black-and-white films in segment 1213-4 were generally overexposed with regard to their respective aim densities. Subjectively, all films appeared adequately exposed except for 7011 at solar elevations of less than 10°. This was the result of the smear exposure trade-off bias used for the first time in the 1213 exposure algorithm.

The exposure of the early mission SO-255 and SO-130 acquisitions were judged subjectively to be underexposed. An increase of 3 counts (0.01 log E) and 4 counts (0.13 log E) in the exposures of SO-130 and SO-255, respectively, resulted in satisfactory exposure for the remainder of the mission.

4.1.8 Engineering Tests

Twenty-two engineering tests were planned for Mission 1213. Nineteen of these tests were at least partially accomplished and produced satisfactory results; the others were deleted because of undefinable requirements or lack of appropriate acquisition opportunities. Three tests performed on Mission 1212 were eliminated from this mission, and eleven new engineering requirements were identified. Several of the new tests pertained to the evaluation of the special films included in this mission. Table 4-2 summarizes the objective and status of each test.

4.1.9 Processing and Reproduction

The core locking pins were in place on all mission segments. Initial inspection of RV-2 revealed significant amounts of moisture on the external structure due to the water recovery. Subsequent inspection showed the interior to be dry with no damage to the film stacks. Although there were some changes in the processing equipment used, the system production curves and standards remained unchanged from previous missions.

TABLE 4-2

SUMMARY OF ENGINEERING TESTS

	Test	Objective	Status
1	Through-focus (1414)	Optimize focus settings	Successfully completed and confirmed in RV-1
3A	Smear slits	Determine optimum skew angle and film velocity OOAA settings	Successfully completed in RV-1

TABLE 4-2 (CONT'D)

SUMMARY OF ENGINEERING TESTS

	Test	Objective	Status
3D	Smear slits/ specular	Evaluate use of specular images for OOAA settings	Successfully completed in RV-1
3E	Smear slits/ chute pressure	Evaluate effect of chute pressure on smear errors	Requirement deleted
3F	Smear slits/ thru Vx	Correlate on-orbit smear with ground test through-Vx results	Accomplished in RV-2
4A	Radiometric cal (SO-255)	Determine image transfer & radiometric calibration	Completed in RV-3 and RV-4
4C	Special processing (SO-255)	To assess processing & duplication techniques	Completed in RV-3
5A	Radiometric cal (SO-130)	Dupe tone reproduction & radiometric calibration	Successfully accomplished in RV-2, RV-3, RV-4
7A	Tucson acquisition (1414)	Standard scene for mission-to-mission quality comparison	Accomplished in RV-1, RV-2, RV-3, RV-4
7D	Quality monitor	Monitor image quality during the mission	Accomplished in RV-2, RV-3, RV-4
7E	Quality comparison	Comparison of film types (SO-208/460/464/7011)	Accomplished in RV-4
9	Tribars for resolution (1414)	Photo quality assessment	Successfully accomplished in RV-1, RV-2, RV-3, RV-4
9A	Tribars (SO-208/460/464/7011)	Resolution transfer and tone reproduction	Accomplished in RV-4

TABLE 4-2 (CONT'D)

SUMMARY OF ENGINEERING TESTS

	Test	Objective	Status
18D	Insite wheat field (SO-130)	Insite calibration	Accomplished in RV-2 only
19	Van acquisitions	Evaluate atmospheric effects on image quality	Accomplished in RV-1, RV-3, RV-4
24	Special targets (SO-130)		Deleted - No targets defined
25	Through-exposure (SO-208/460/464/7011)	Establish exposure/quality relationship for special films	Completed for SO-208/464 only in RV-4
26	Orbital/sensitometry	Evaluate on-orbit sensimetry	Completed in RV-1, RV-4
27	Parabolic dish mensuration	Test mensuration programs	Accomplished in RV-3
28	Diffusion model	Study viscous processing diffusion effects	Accomplished in RV-3
29	Bar XC (1414 & special films)	Measure film distortion characteristics	Accomplished in RV-2, RV-4 (types 7011 & SO-464 not completed)
30	Low light level	Evaluate low light level processing techniques	Requirement deleted

NPIC's evaluation of the black-and-white duplicate positives from Mission 1213 show them to be slightly lower in quality than those of previous missions. The resolution losses do fall within the expected bounds of resolution transfer characteristics and, hence, do not constitute a significant problem.

4.1.10 Exploitation Suitability

The overall average NIIRS rating of Mission 1213 was 3.6, which is 0.4 NIIRS lower than Mission 1212 and 0.6 NIIRS lower than Mission 1210. This average is based on a reduced number of ratings because of changes in the read-out requirements. The lower performance level was not attributable to scan angles, vehicles altitudes, or solar elevations, but did show some preference to geographic area.

Analysis of color imagery indicates PI suitability of SO-255 and SO-130 from Mission 1213 to be similar to those film types from previous summer missions. These films are very useful for agricultural assessments, economic intelligence in mining and shipping operations, and monitoring possible nuclear weapons development in the third world areas.

A special evaluation of the new films was performed to determine whether they have the potential to provide an improvement in NIIRS values over the standard 1414/SO-208 emulsion. The evaluation was designed to eliminate the influence of altitude, target type, scan angle, and solar elevation. The overall results indicate a significant confidence that the 7011 (SO-315) and SO-464 films will provide better quality imagery than the present standard emulsion.

4.2 MAPPING CAMERA SYSTEM

4.2.1 Operations and Performance

The Mission 1213 mapping camera system operated on 201 revs between Rev 3 and Rev 1816, with RV-5 recovery on Rev 1825. A total of 2115 frames were exposed in the terrain camera and a corresponding number of frame pairs in the stellar camera. This total includes 22 frames of film type 3401 and 60 frames of film type 1414 in the terrain camera for in-flight calibration and ultra-thin base film image quality evaluation.

Post flight analyses conducted at the processing site, the contractor facility, and the Defense Mapping Agency Topographic Center (DMATC) have shown that mission objectives were met with a high level of success, and that this terrain camera produced image quality and resolution comparable to past mapping camera missions. Image analysis performed on 1414 film showed no significant differences between 3414 and 1414 films. An adequate distribution of sixth magnitude stars was acquired on the stellar frames, and ancillary data generated by both units were acceptable.

Weather during photographic operations showed improvement over Mission 1212. Approximately 35% of all frames were 90-100% cloud free.

Table 4-3 summarizes significant mapping camera activities.

TABLE 4-3

SUMMARY OF SIGNIFICANT MAPPING CAMERA SYSTEM ACTIVITIES

Rev	Activity	Event
-	Ascent	No anomalies
3	Photography	Health check
146	Photography	Bar XC acquisition
960	Photography	Bar XC acquisition
1546	Photography	Bar XC acquisition
1677	Photography	In-flight calibration
1684-1816	Photography	1414 acquisitions
1790	Photography	Bar XC acquisition
1825	RV-5 recovery	Successful air recovery

4.2.2 Mapping Camera System Data

Mapping camera system data for Mission 1213 is presented in Table 4-4.

TABLE 4-4

MAPPING CAMERA SYSTEM STATISTICS

Element	Camera		
	Terrain	Stellar	
		+Y	-Y
Focal length (mm)	304.779	252.878	252.324
Filter type	W-12	none	none
Reseau S/N	020	041	040
Lens S/N	009	018	017
Supply spool S/N	065	105	
Supply film weight (lbs)	56.72	10.07	

Film data:

Terrain camera: Film type (feet) 3414 (3270)/MCD(2)/3401(30)1414(100)
Stellar camera: Film type (feet) 3400(1872)/SO-344(230)

4.2.3 Image Quality

The majority of the image quality from the terrain camera was good to excellent and appeared consistent throughout the flight. The average resolution derived by VEM analysis was 94 lines/mm. Target imagery of the Ft. Huachuca resolution range was not available for evaluation on this mission. Stellar imagery was good for both units. On evaluated frames, each stellar camera recorded 6th magnitude and fainter star images.

4.2.4 Exposure

Density measurements made at the processing facility indicated that the exposure levels were slightly higher than nominal. An adjusted exposure algorithm for 1414 film and equivalent Wratten 12 filtration will be implimented on Mission 1214.

4.2.5 Thermal Profile

Following on-orbit stabilization, the terrain camera average temperature was steady at 74.0°F and the stellar cameras at 74.5°F.

4.2.6 Pressure Profile

Average film path pressure stablized at 16 micrometers. A maximum of 17 and a minimum of 16 micrometers were recorded during the flight.

4.2.7 On-Orbit Calibration

In addition to the preflight calibration data, two additional calibration steps--range and stellar, which are distinctly separate operations--are conducted in-flight.

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, conducted at the end of the S/T mission, is accomplished by inverting the vehicle to simultaneously give each of the S/T lenses a view of the starfield.

4.3.1 The Navigational Package (NAVPAC) flight unit operated without failure for the entire mission. Doppler frequency data collected was of high quality.

The NAVPAC uplink antenna deployment data gave indication of less than full deployment. Although subsequent analysis confirms this situation, the data being analyzed is suspect. In-house testing procedures for future systems have been modified to provide more confidence in the operational deployment data. The antenna was successfully operational.

The Miniature Electronic Static Accelerometer (MESA) orbital cyclic temperature variations experienced on SV-13 were reduced on SV-14 by the addition of a heat shield to protect the MESA from direct sun. This maintained the baseplate temperature at 84°F ±5°F which was functionally acceptable. However, to reduce the ±5°F excursion, SV-15 will include heaters to maintain the baseplate temperature at 105°F with minimal excursion. The MESA X and Y axis noise, present on SV-13 was also present on SV-14. To correct this problem on SV-15, low noise preamplifiers will be added and full scale limits on all three axes will be decreased.

Some of the experiment results were as follows:

- Dual Tracking Loop (DTL) calibrations were successfully accomplished.
- A NAVPAC/MESA power-down - power-up sequence was performed to obtain MESA start up data.

With the MESA off, two high rate data storage tests were conducted. Also with MESA off, two direct read-out tests were conducted. One utilized transmitter 1 and the other utilized transmitter 2. Both sets of tests were successful.

4.5 DOPPLER BEACON SUBSYSTEM (DBS)

The Doppler Beacon Subsystem (DBS) performed normally in support of the longest mapping camera mission to date (118 days). The primary transmitter, oven and oscillator combination was used throughout the mission, which provided good signal strength (100 - 125 dBm) on both doppler frequencies.

At the conclusion of themapping camera's mission, all the redundant DBS commands and functions were exercised without incident. The SV command and telemetry support was satisfactory. No anomalies were reported.

4.3 NAVPAC, MESA, AND DOPPLER BEACON SYSTEMS (DBS)

4.3.1 The NAVPAC flight unit operated without failure for the entire mission. Doppler frequency data collected by the NAVSAT receiver portion of the hardware was of high quality. One day's worth of data was lost after a command computer failure at Boss prevented the sending of a tape recorder stop and reset commands at the end of a readout. Subsequent units have been modified so that the logic is reset automatically when beginning of tape is reached.

The MESA system produced questionable data for two reasons:

a. The thermal environment induced short duration anomalies and bias variations about the orbit. For future missions, a thermal shield is to be placed over the MESA assembly.

b. Acceleration through orbit adjusts (OA's) were not measured because the 2-second delay time in the automatic instrument range selection was too long. This has been reduced to .25 seconds and the measurements have been successfully read in ground tests.

The following experiments and calibrations were successfully completed.

a. The 36-hour warm-up of the NAVPAC primary oscillator was more than adequate to reach the required frequency stability.

b. Eight dual tracking loop calibration tests of twelve hours duration each were conducted to evaluate the relative performance of the three receivers.

c. One twelve-hour test of high speed telemetry data (MESA off, mode 1) was run to evaluate short term behavior of the receiver system.

d. Various modes and back-up equipment were tried and the hardware operated as expected.

4.3.2 The doppler beacon system (DBS) performed normally in support of the longest mapping camera mission to date (113 days). The primary transmitter, oven, and oscillator combination was used throughout the mission, which provided good signal strength (100-125 db) on both doppler frequencies. At the conclusion of the mapping camera's mission, all the redundant DBS commands and functions were exercised without incident. The SV command and telemetry support was satisfactory; no anomalies were reported.

4.2.8 Summary of Anomalies

The only mapping camera anomalies occurred on Revs 91 and 93. The redundant stellar pressure monitor indicated three erratic pressure signatures. The primary pressure monitor indicated normal operation. Engineering analysis indicates the erratic signal was attributed to the telemetry microswitch. It caused no operational problem and did not recur.

4.2.9 Exploitation Suitability

Technical analysis of Mission 1213 imagery by the DMA Post Flight Analysis Team included a comparison of the photography with system specifications. As a result of their instrument measurements and various other metric evaluations, it was determined that the system satisfied all critical performance requirements.

4.2.10 Processing and Reproduction

The RV arrived at the processing site in good condition at 1000 hours EST, 18 October 1977. Both film spools were also in good condition.

Defilming was accomplished on 18 October, and no static discharges or film sticking were noted during the presplice operation.

The terrain and stellar records were processed without incident. The 3401 and 1414 portions of the terrain record were processed separately.

A 52-foot strip of stellar record was removed and processed as a test to assess fog levels.

Optical titling was accomplished on 95% of the terrain 3414 film. The stellar record was 67% optically titled. The remaining were hand-titled.

All duplicate copies were printed on the Kingston printers using the Actinic-Butterfly Contrast Control (ABCC) technique. Duplicate positives of the 3414/1414 terrain films were prepared on SO-192. Duplicate positives of the 3401/SO-284 terrain films were prepared on Kodak Aerographic Duplicating Film (Estar base). Duplicate positives of the stellar 3400/SO-344 film were prepared on SO-284. All duplicate negatives were prepared using Kodak Direct Duplicating Aerial Film (Estar base) 2422.

S77-2 Pallet Experiment

The S77-2 Pallet system performed successfully for 172 days in orbit except for a ROCA failure late in the mission and an SRE/TRE anomaly on day 57. Approximately 728 hours of data were read into the pallet tape recorders and subsequently read out and transferred to SAMTEC (the SAMSO-designated flight data processing agency). There were several interruptions in the S77-2 system tasking, caused by conflicting host vehicle activities and power shortages; however, all of the objectives of the S77-2 flight requirements and operations plan including coverage of primary SRE/TRE special interest areas were met. Based on observation of the pallet status telemetry, which was monitored continuously throughout the flight, it was concluded that all contractor, GFE and experiments operated normally, except for the ROCA and the SRE mirror drive system. All S77-2 data tapes, command listings and orbital vectors have been sent to the appropriate agencies (SAMTEC, AFTAC and SAMSO) for merging with and to facilitate processing of pallet downlink data.

Some of the more pertinent results were as follows:

- Seven complete and one partial twenty day tasking cycles were completed during the mission.
- Successful tests of the pre-modulation filter bypass and the tape recorder bypass modes were conducted.
- A horizon scan test was conducted for CRL 246 during solo.
- Special coverage of Kwajelein during cooperative sounding rocket launches was made for the benefit of the NRL 607 experiment.
- The pallet thermal control system performance was essentially as predicted.

4.5 NICKEL-HYDROGEN (NiH_2) BATTERY PALLET EXPERIMENT

All the NiH_2 battery flight tests were successfully completed. The experiment demonstrated that the battery could survive the space environment and could support both a 1 amp operational NAVPAC/MESA load (127 days) and a 5 amp simulated load (52 days). The battery was charged to a K2 level (90% state-of-charge) 141 times and was discharged using the load bank 26 times with expected results each time.

The only operational problems to arise were:

a. Early in the flight, an error was discovered in the flight support data base that caused the battery bus to voltage to appear low.

b. After the host vehicle began supplying a near continuous low current charging the battery, the NiH_2 battery temperature started rising. Since the battery was at a high state-of-charge (approximately 90%), most of the charging current was converted to heat. By switching the NAVPAC/MESA load (1 amp) back to the host vehicle bus and using the load bank to periodically discharge 5 amps for 3 revs, the battery temperature limits were maintained.

~~4.8~~ 4.6 SUBSATELLITE

A classified Subsatellite (SSU-32) was carried into orbit on the -Y side of SV-14. Total weight of the SSU system was 649.3 pounds of which 590.9 pounds separated from the SV. Separation of the SSU occurred at SV Rev 13.5 at 2° South latitude on a descending node. The SV yawed -18.6 degrees for the SSU separation event. The SSU went on to achieve its intended orbit and function.

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SECTION V

REENTRY VEHICLE SUMMARY

5.1 SUMMARY

Recovery statistics are shown in Tables 5-1 and 5-2. All reentry vehicle (RV) on-orbit and reentry events occurred as planned, and the RV flights followed the predicted trajectories. All five flights were successfully AERIAL retrieved near the PIP. ~~four aerially and one from the water surface.~~

All payloads were recovered in good condition with no deficiencies attributable to the RVs. All subsystems performed satisfactorily and met all mission requirements. ~~On RV-2 the target cone did not properly inflate and recovery was made using the back-up water recovery mode.~~

5.2 MARK VIII REENTRY VEHICLE SYSTEMS

All on-orbit functions for the Mark VIII (pan camera) RVs were normal and occurred on time. The SV provided a satisfactory pitch angle for each RV separation. All other SV/RV interface functions were nominal. The RVs were adequately spin stabilized during the vacuum coast phase and aerodynamically stable during the atmospheric phase of the reentry trajectory.

All subsystems performed satisfactorily with the following ~~two~~ exception~~s~~:

~~Recovery system target cone: on RV-2 the target cone did not deploy which precluded aerial retrieval and resulted in a surface recovery. Postflight investigation indicated that during parachute deployment some of the geodetic lines, which are a part of the target cone design, wrapped around the cone pack preventing proper deployment. Analysis indicates that the system design concept does involve a minor threat rather than this being a unique deficiency of the RV-2 recovery system. Even though the present recovery system threat is considered low, changes are being incorporated to further reduce the threat.~~

SMDC line separation: during postflight inspection, deposition on recovered components indicated that several ~~the~~ SMDC lines had separated from connectors during RV/SV separation. In all cases,

TABLE 5-1

MARK VIII RECOVERY SUMMARY

	RV-1	RV-2	RV-3	RV-4
RV serial number	54 / 56	53 / 55	27A / 31A	26A / 32A
Recovery rev number	588 / 571	1141 / 1253	2118 / 2081	2848 / 2976
Recovery date	2 August 1977 / 20 April 1978	5 September 1977 / 1 June 1978	4 November 1977 / 31 July 1978	19 December 1977 / 9 Sept 1978
Payload weight (lb) (A; B) (measured weight from recovered RV)	A = 234.2 / 238.3 B = 230.3 / 235.8	A = 231.8 / 232.2 B = 231.9 / 232.3	A = 235.7 / 236.1 B = 235.1 / 355	A = 236.4 / 233.4 B = 240.8 / 237.5
Unbalance (percent)	1.3 / 0.5	0	0.2 / 79.1	1.5 / 1.4
SV orbit (hp x ha/ωp)*	90.6 x 144.3/117.9 / 91.5 x 138.3/108.9	89.9 x 139.6/112.2 / 93.6 x 142.9/109.3	89.8 x 136.4/115.0 / 93.5 x 142.5/111.4	90.01 x 152.3/101.6 / 94.0 x 140.7/115.9
SV pitch angle (degrees)	−35.2 / −36.5	−39.4 / −40.3	−39.4 / −39.5	−40.5 / −41.0
Nominal PIP latitude (°N)	26.00 / 16.50	24.00 / 16.00	20.00 / 28.00	15.00 / 17.50
Impact location error (EPPD versus Teapot evaluation)				
Overshoot (NM)	11.2 / 13.5	5.0 / 6.1	8.2 / (1.1)	3.3 / 13.8
Cross-track (NM)	0.9 W / 3.2 W	6.3 E / 1.1 E	3.2 E / 2.7 E	5.3E / 2.6 E
Recovery (aerial)				
Altitude (ft)	12,900 / 14,700	Water entry / 12,700	13,300 / 11,600	11,300 / 12,000
Parachute condition	Normal	Gone not inflated / Normal	Normal	Normal
Retrieval pass	1	N/A / 1	1 / 2	2 / 1
RC/payload condition	Good	Good	Good	Good

*hp = altitude of perigee (NM), ha = altitude of apogee (NM), ωp = argument of perigee (degree)

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bolt fracture and SMDC line detonation occurred normally. This event has occurred on previous flights and no further corrective action is considered necessary.

5.3 MARK V (STELLAR/TERRAIN) RECOVERY VEHICLE SYSTEM (RV-5)

RV-5 (S/N ~~1809~~ 1810) was successfully recovered on Rev ~~1825~~ 1902 after ~~113~~ 117 days. Recovery statistics are shown in Table 5-2. All RV subsystems performed normally. The SV provided a satisfactory pitch angle after a yaw reverse and all other interface functions were nominal.

The miss distance between the predicted impact point (PIP) and the estimated point of parachute deployment (EPPD) was calculated to be ~~3.87~~ 8.8 NM long and ~~0.70~~ 6.1 NM east of the ground track. The capsule was recovered at ~~13,500~~ 13,200 feet on the first pass.

The only exception to an otherwise normal recovery sequence was after the execution of the trim and seal sequence (closure) when one of two microswitches monitoring the seal door closing remained open. It registered the proper position after approximately ~~150~~ 75 seconds. ~~Postflight examination revealed that the monitor had an inorganic deposit on the external surface of the switch plunger.~~

TABLE 5-2

RV-5 RECOVERY SUMMARY

Recovery rev	1902
Date	11 JULY 1978
Payload weight (100%)	65.51 lbs
SV recovery orbit	
Perigee (NM)/apogee (NM)/argument perigee (deg)	94.416/147.179/118.970
SV pitch angle after yaw around (deg)	-63.504

	PIP	EPPD	Air Catch
Latitude	18° 8.82' N	17° 59' N	17° 58' N
Longitude	154° 25.8' W	154° 21' W	154° 22' W
Altitude	55,000 feet	—	13,200 feet

SECTION VI

OPERATIONAL SUPPORT

6.1 SATELLITE CONTROL FACILITY (SCF)

The performance of the SCF in support of Mission 1213 was excellent. This was the longest low altitude satellite mission in Air Force history. The 180-day lifetime exceeded the previous mission record by 14%. The 1,214 command messages generated during the flight is a first for this program. The 2,914 rev duration led to a significant increase in nearly all resources. Several equipment and operational problems were encountered; however, the problems caused minimal impact to the overall mission. Command message generation and transmission and downlink TM reception and processing supported the operation satisfactorily.

6.1.1 Preflight Readiness

Hardware and software interfaces were validated during four readiness exercises. Development rehearsals were conducted during the periods 24-28 January, 21-25 March, and 24-27 May 1979. A 48-rev dress rehearsal was conducted during 14-17 June 1979. Activities included day one testing, normal flight operations per the profile, and telemetry playbacks for the first five revs.

6.1.2 Orbital Operations

A nominal one-rev load cycle for the payload was employed during the mission. A total of 2356 command messages were planned, of which 1214 were generated and 1189 were actually loaded into the vehicle. The major reasons for nongeneration of planned command messages was that no payload selections occurred within the new message generation space. The major causes for rejection of generated messages were (1) vehicle problems, (2) station problems, and (3) message generation/cycle-related problems. One dedicated CDC 3800 computer was used throughout the operation; a second computer was used as required. Approximately 5,910 computer hours were used for a mission average of 32.8 hours per day. This resulted in the use of 1.50 computers per day. The Varian 73 (EBC), CDC 160A, and 1230 MTC computers were also successfully utilized. There were 2,959 contacts made with the SV through the remote tracking stations. The totals for each station are listed below:

inability to properly strip telemetry data from the bird buffer tape for use by MPR. The second problem concerned reporting of zero data for a panoramic camera health check which could not be properly processed by the user agency. Corrections to both problems were successfully made.

APPENDIX

GLOSSARY OF TERMS

-A-

ACS	Attitude Control System.
Aft	Aft-looking ("B") camera.
A-H	Ampere-Hours.
AOES/System II	General-purpose satellite flight support software at satellite test center (STC).
ATC	Active thermal control.
AUGIE	Acronym for data compression technique used for transmitting data from remote tracking station (RTS) to STC.

-B-

BBRT	Bird buffer retrieval tape. Records RTS transmission at STC.
BRIDGEHEAD	Facility for primary film processing and immediate postflight evaluation.
BUD	Back-up decoder.
BUFT	Back-up film transport.
BV	Booster vehicle.

-C-

CATS	Camera, target, and sun angular relationship. Angle at target between line from target to sun and target to satellite vehicle (SV).
CCC	Charge current controller.
Chamber A	Photographic vacuum test chamber located at East Coast sensor subsystem contractor (SSC) facility.
Chamber A-2	Photographic vacuum test chamber located at satellite vehicle integrating contractor (SVIC) facility.
CORN	Controlled Range Network.
CRYSPER	Program for predicting on-orbit performance that combines models of target acquisition, atmosphere, illumination, and camera performance.
CSI	Current signal integrator.
CV	Constant velocity.

-L-

LIFEBOAT	Incorporates minimal command system and tertiary attitude reference system for achieving proper alignment to effect recovery of two RVs and to deboost the satellite vehicle (SV).

-M-

MAA	Mission Analysis Area.
MCD	Materiel change detector.
MCM	Mapping camera module.
MCS	Minimal command system.
MESA	Miniature electrostatic accelerometer.
MFA	Measurement filter assembly.
Mono	Monoscopic operation or viewing.
MPR	Mission performance report.
MTF	Modulation transfer function.
MWC	Midwest contractor (RV 1 through 4 contractor).

-N-

NIIRS	National Imagery Interpretability Rating Scale.
NM	Nautical miles.
NPIC	National Photographic Interpretation Center.

-O-

OA	Orbit adjustment.
OAK	NPIC publication that lists results of first phase photo exploitation.
OAS	Orbit adjust system.
OB	Optical bar.
OOAA	On-orbit adjust assembly (smear adjustment).
Op	An operation of camera while in orbit.
OTD	Optical Technology Division of SSC.

-P-

PACS	Primary attitude control system.
PBF	Plane of best focus.
PCM	Pulse code modulation.
PDS	Power distribution system.
PFA	Post flight analysis.
PI	Photointerpreter

-T-

TCA	Two-camera assembly.
TM	Telemetry.
TR	Tape recorder.
TT&C	Telemetry, tracking, & command.
TU	Take-up unit.
'TUNITY	Computer program for 1200 series mission support at the STC.

-U-

UTB	Ultra thin base film (1.5 mil).
UUTB	Ultra ultra thin base film (1.2 mil).

-V-

VAFB	Vandenberg Air Force Base.
VBE	Variable block erase.
VEM	Visual edge match.

TABLE 3-33

TRI-BAR RESOLUTION READINGS
PITCH TESTS

TEST DESCRIPTION		FWD			AFT		
		IN TRACK	CROSS TRACK	GEOM. MEAN	IN TRACK	CROSS TRACK	GEOM. MEAN
TEST 9-1	+2.5°	151	136	143	193	160	175
8-23-74	+2.0°	146	126	135	188	164	175
SEQ 648							
PITCH ANGLE	+1.0°	170	141	155	208	173	190
	0°	202	174	188	204	173	188
	-1.0°	196	175	184	201	167	183
	-2.0°	191	164	176	184	166	174
	-2.5°	175	160	167	173	154	163

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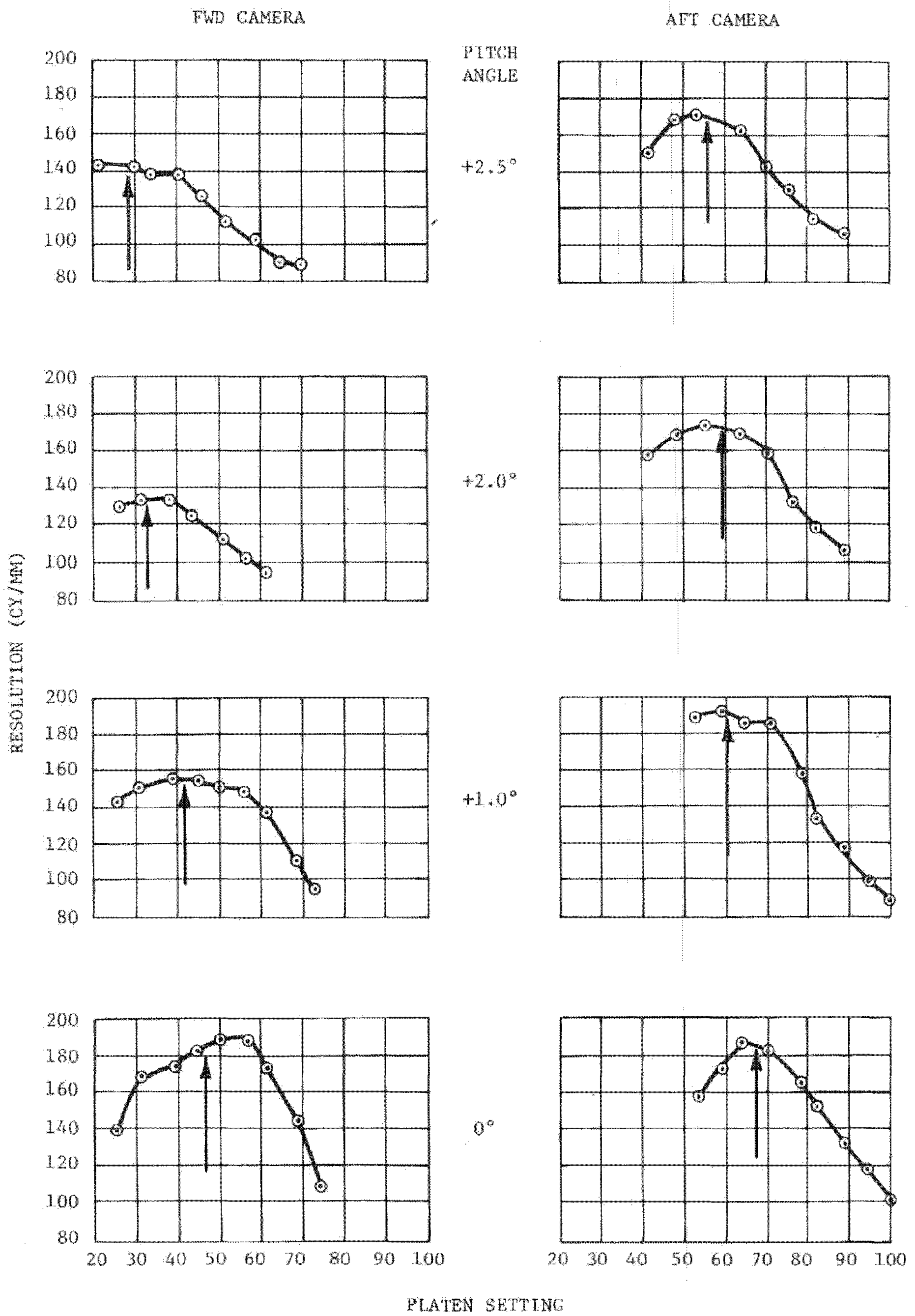

Figure 3-26. Performance Plot, Geometric Mean, Rad X = 0.052, Pitch Test, FWD and AFT Cameras (Sheet 1 of 2)

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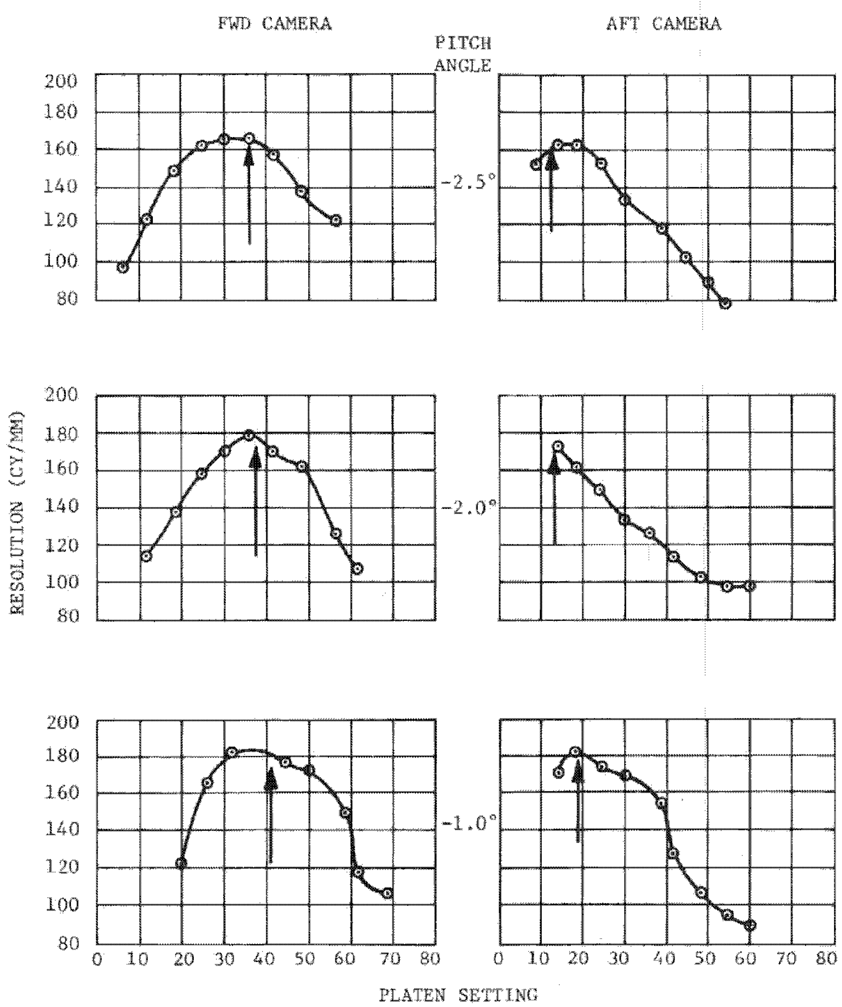
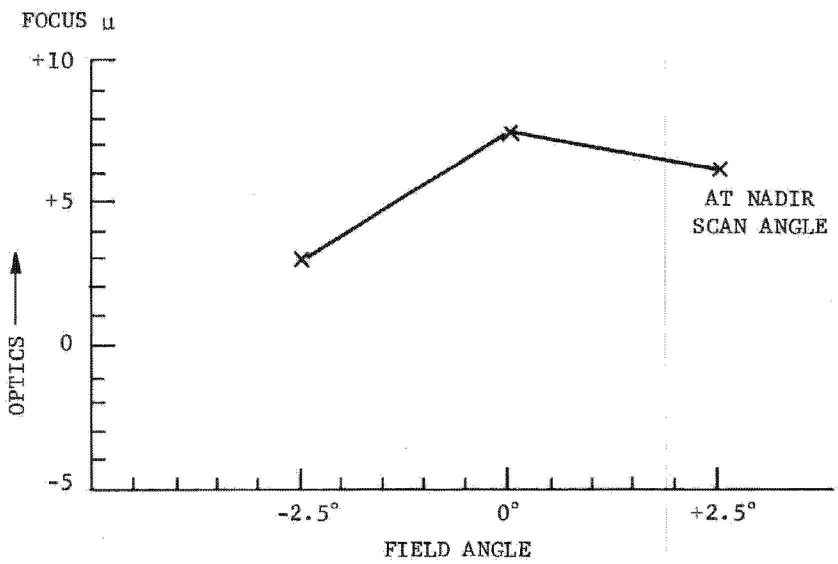


Figure 3-26. Performance Plot, Geometric Mean, Rad X = 0.052, Pitch Test, FWD and AFT Cameras (Sheet 2 of 2)



DYNAMIC MATERIAL CORRECTIONS TO LINE TARGET DATA:

FWD CAMERA NADIR SCAN	(-2.5° FLD) --3µ	(0° FLD) -8µ	(+2° FLD) -6µ
AFT CAMERA NADIR SCAN	(+2.5° FLD) -6µ	(0° FLD) -8µ	(-2° FLD) -4µ

Figure 3-27. Delta Between Recycle and CV Modes at 052/30°/0°

TABLE 3-34

FOCUS CORRECTION FACTORS AND FOCUS DETERMINATION

TEST NO./DATE	COLL.	FIELD ANGLE	RAW FOCUS FROM LINE TARGETS			COLL. IN-TRK	C/C CORR. CR-TRK	GRAVITY IN-TRK	CORRECT. CR-TRK	PITCH CORRECT.	CORRECTED FOCUS			MATERIAL FLATNESS	CORRECTED FOCUS	DYNAMIC MATERIAL	FINAL FOCUS
			IN-TRK	CR-TRK	AVE.						IN-TRK	CR-TRK	AVE.				
FWD SIDE PITCH TEST 8-23-74	2	-2.5°	40.5	31.6	36.1	+2.5	+3.3	-16	-4	-3.5	23.5	27.4	25.4	+5	30.4	-3	27.4
	2	0°	47.2	44.0	45.6	+2.5	+3.3	-16	-4	0	33.7	43.3	38.5	+3	41.5	-8	33.5
	2	+2.0°	36.6	30.8	33.7	+2.5	+3.3	-16	-4	+2.8	25.9	32.9	29.4	-4	25.4	-6	19.4
AFT SIDE PITCH TEST 8-23-74	5	+2.5°	65.3	48.9	57.1	-0.2	-0.2	-16	-4	+3.5	52.6	48.2	50.4	-3	47.4	-6	41.4
	5	0°	72.2	61.2	66.7	-0.2	-0.2	-16	-4	0	56.0	57.0	56.5	+3	59.5	-8	51.5
	5	-2.0	67.2	39.6	53.4	-0.2	-0.2	-16	-4	-2.8	48.2	32.6	40.4	+6	46.4	-4	42.4

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Figures 3-28 and 3-29 present the pitch test field curvature evaluation with the corrections applied incrementally to the raw line target data. To illustrate the range of values experienced to date in pitch test measurements, the Chamber A-2 raw data is plotted in Figures 3-30 and 3-31 and Chamber A raw data in Figures 3-32 and 3-33.

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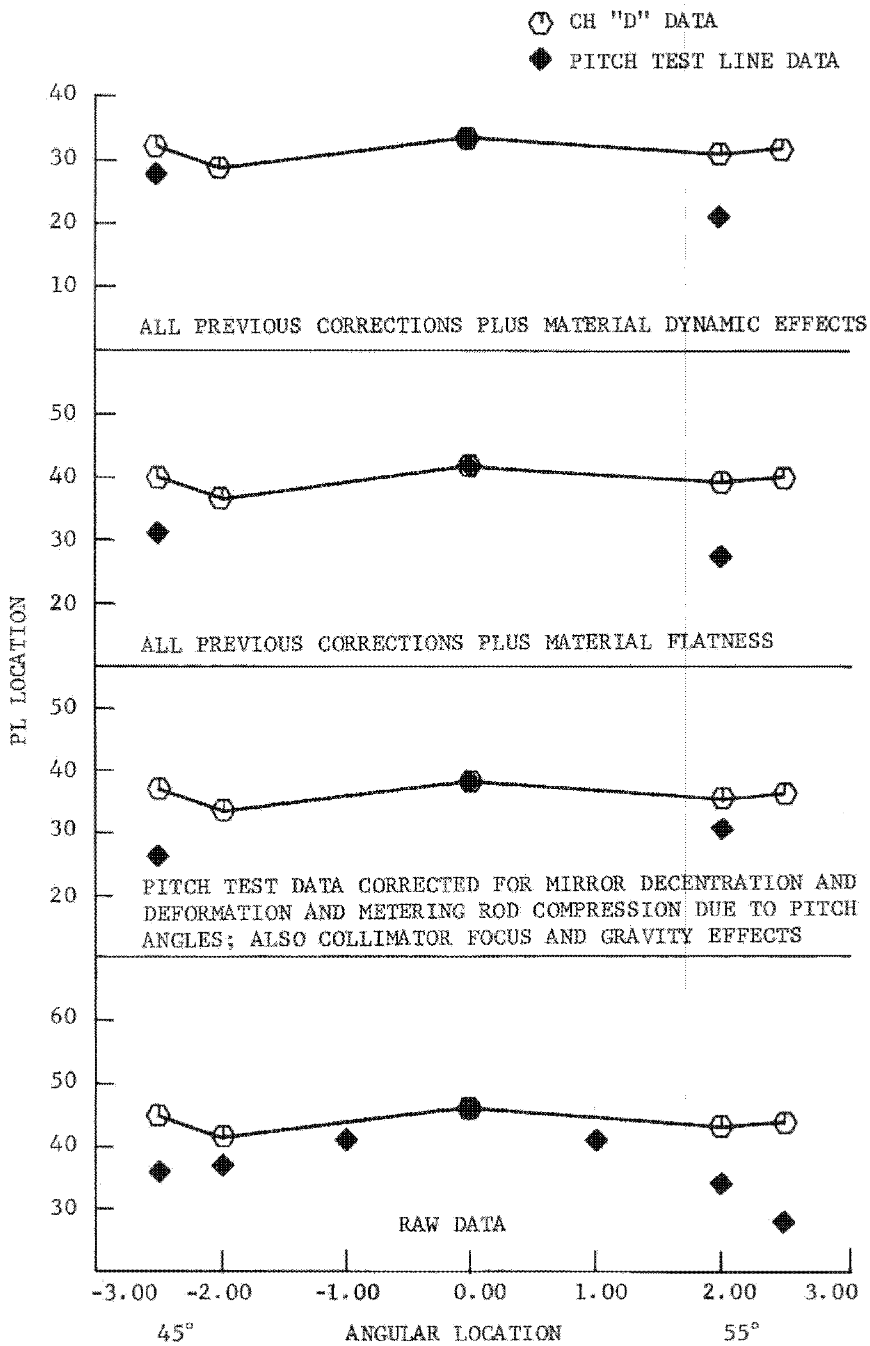

Figure 3-28. Pitch Test Evaluation, FWD Camera

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TE 0515

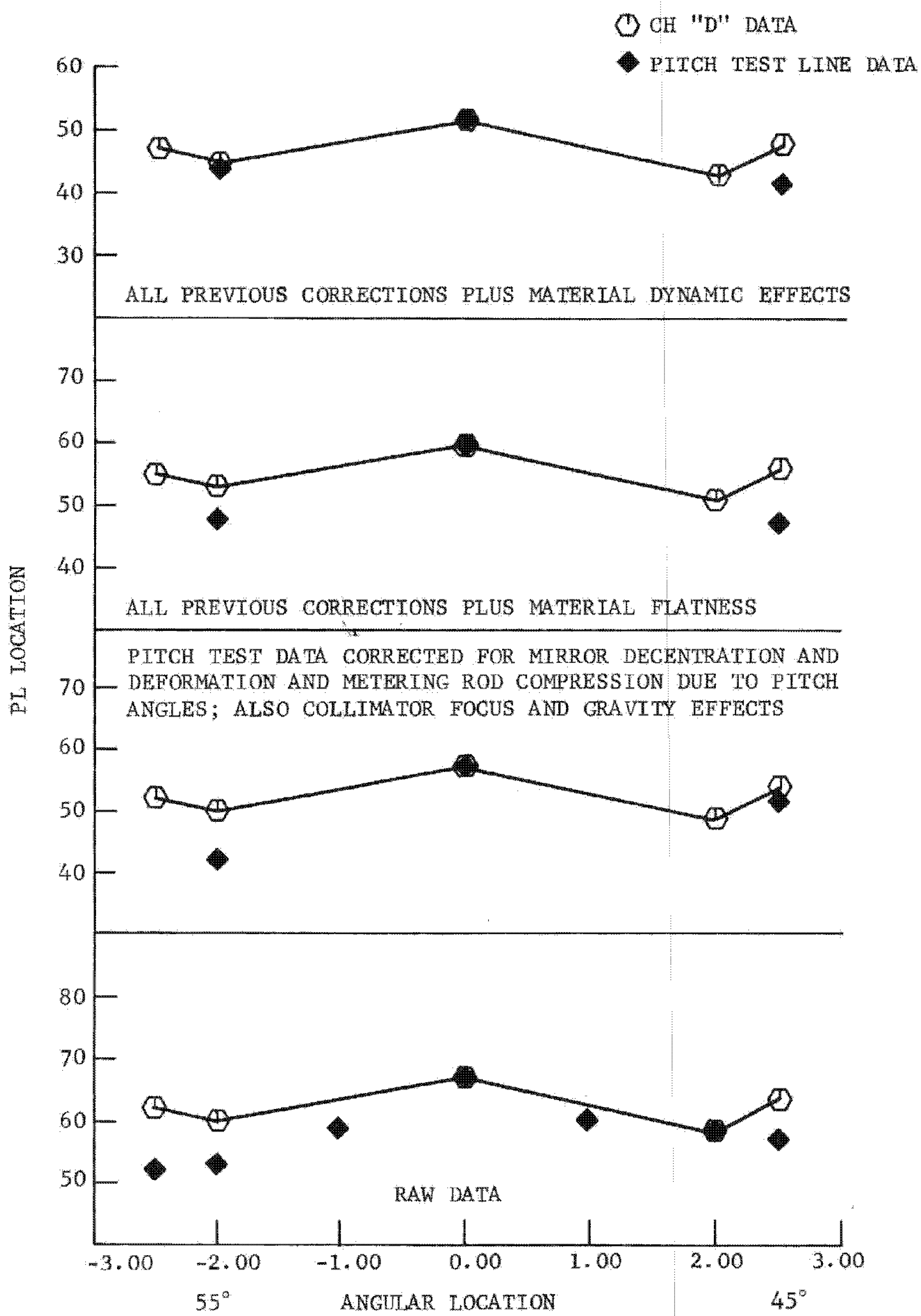

Figure 3-29. Pitch Test Evaluation, AFT Camera

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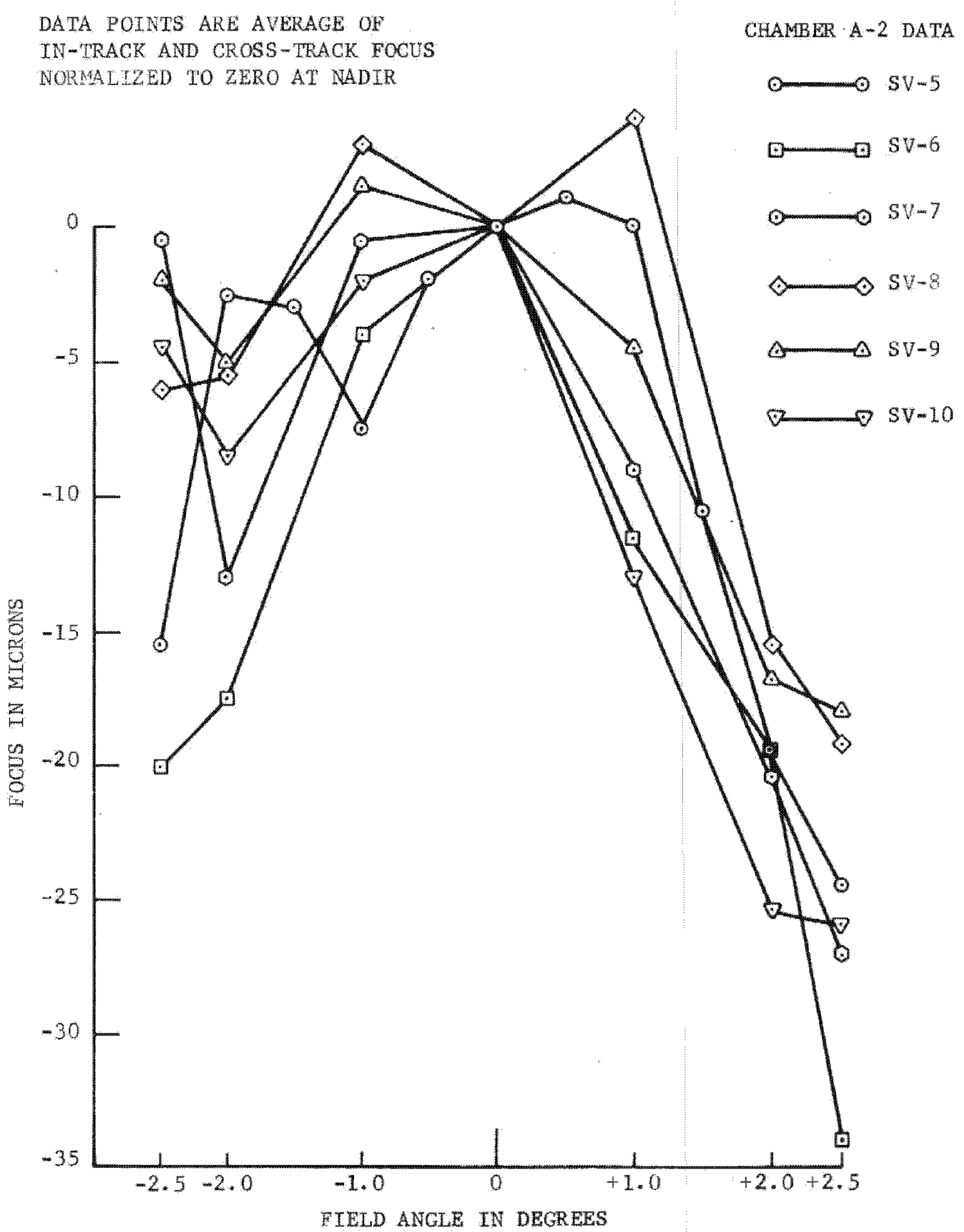


Figure 3-30. Chamber A-2 Pitch Test, FWD Camera

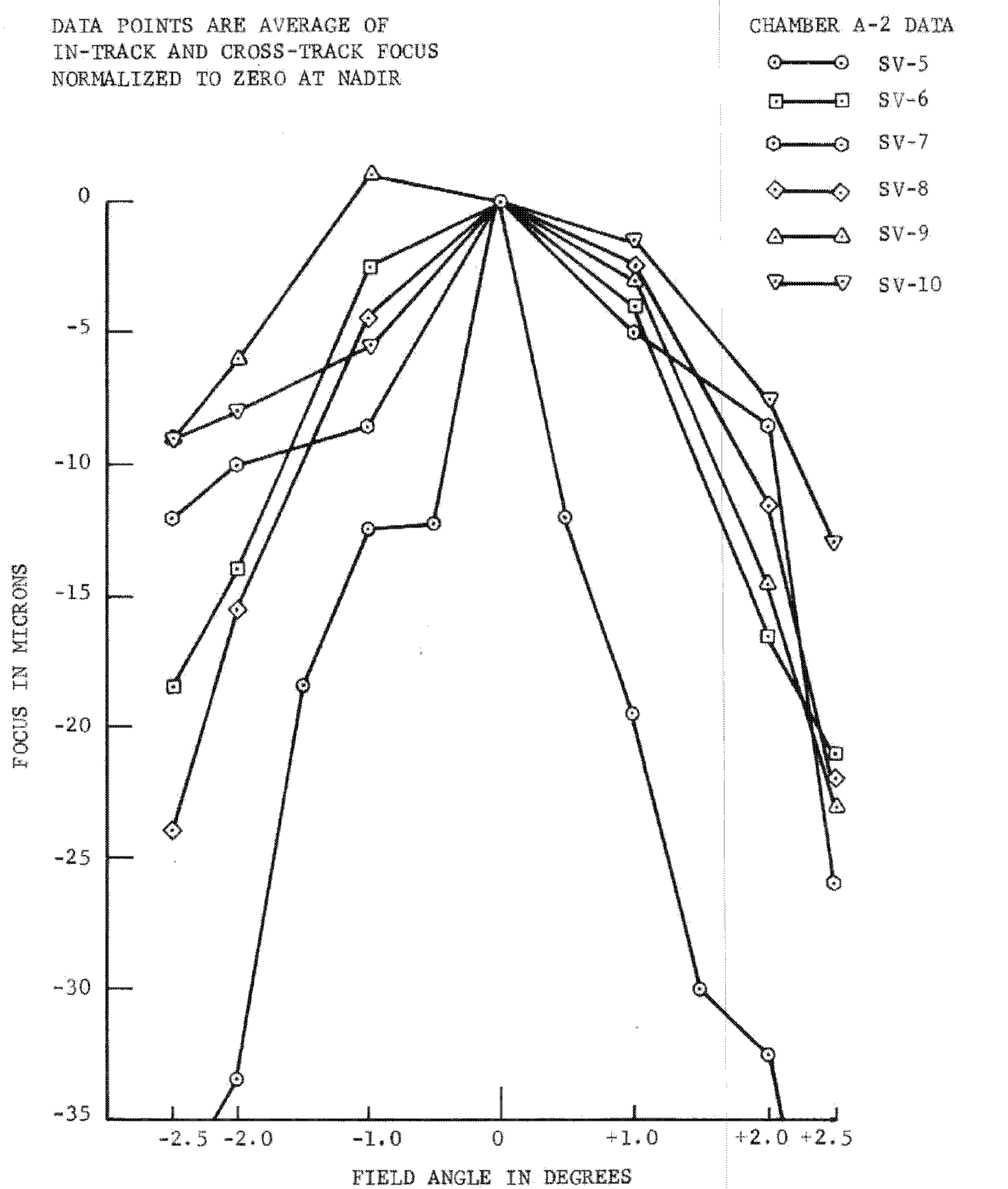


Figure 3-31. Chamber A-2 Pitch Test, AFT Camera

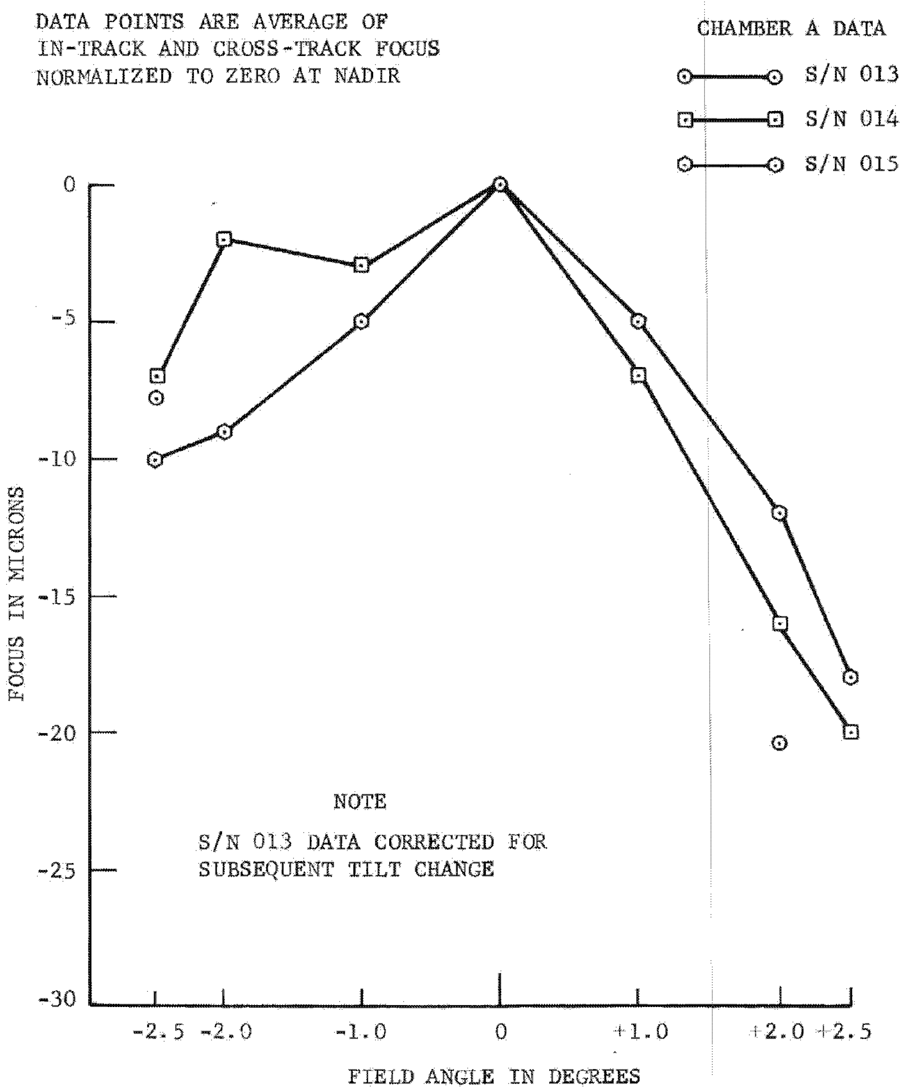


Figure 3-32. Chamber A Pitch Test, FWD Camera

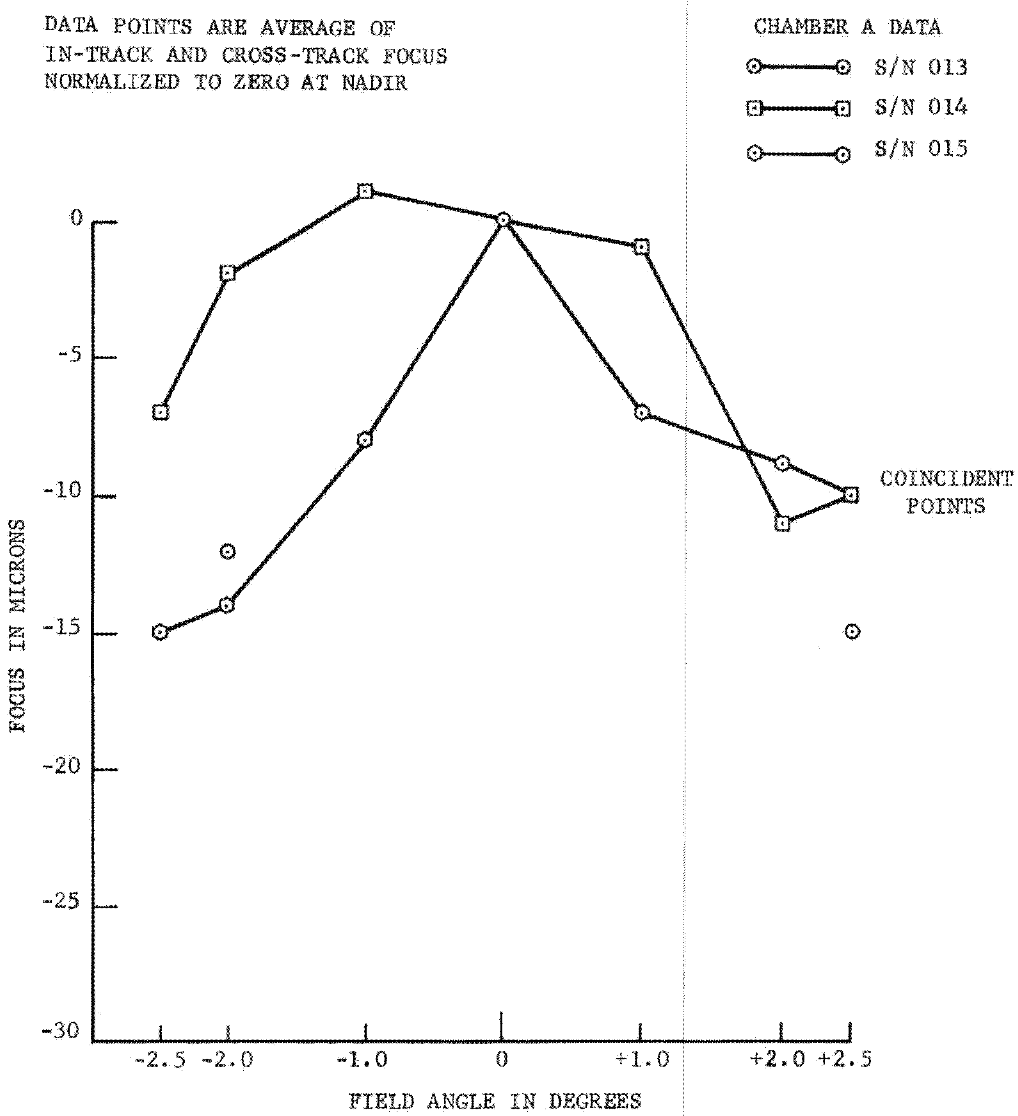


Figure 3-33. Chamber A Pitch Test, AFT Camera

SECTION 4

ELECTROMECHANICAL PERFORMANCE

Reviewing electromechanical acceptance data and its correlation to acceptance photo data confirms the system has demonstrated compliance with all performance requirements. No out-of-specification conditions exist.

4.1 EMERGENCY SHUTDOWN

Verification of controlled system shutdown to both internally and externally commanded ESDs was performed during assurance and acceptance testing. For all ESDs, the system shut down properly and the expected diagnostics were present.

4.2 RV TRANSFER

Functional tests verified normal operation with an AGE take-up sequentially cabled to each of the four RV locations in accordance with the test parameters of Table 2-1 (Format Test Matrix) of CEI Specification SI 621-0090-0001.

4.3 CAGING

Looper and Supply Assembly caging tests were performed during horizontal and vertical baseline testing. Acceptance testing, which is performed in the vertical position, consists of cage, uncage, cage and backup uncage sequences. All sequences were properly executed and all performance requirements were met. After completion of acceptance testing, the supply and loopers were caged and verified in preparation for delivery to the integrating contractor.

4.4 NEGATIVE CONSTANT VELOCITY TESTS

The NCVU operation in TU ONLY and SU ONLY was verified during assurance tests; the NCV mode was verified during vacuum acceptance tests. And, in all tests, the tracking and electromechanical performance was proper.

4.5 SCAN MODE

All scan centers and scan angle lengths were tested successfully during the horizontal baseline format tests. The off center scan tests and the operational mode verification tests, which were conducted in vacuum, also met all performance requirements. In each, evaluation of electromechanical data includes verification of phasing, shutter open and close time, and associated EM signals. Actual frame lengths are measured on the film exposed during the format tests.

4.6 START/STOP TIMES

All measured start/stop times as required by the CEI specification were within specification. For the Vx/h = 0.052 runs, the start/stop times range from 66 to 67 seconds thus meeting the CEI requirement of being less than 71 seconds.

4.7 SLIT WIDTH

The measurement of slit width versus slit command is within specification (See Table 4-1 for calibration of measured width and telemetered width versus commanded width.)

4.8 OPTICAL BAR SCALING

Optical bar velocity calibration was performed in both Blocks I and II of the SCC. The calibration (Table 4-2) shows that the actual velocities at all Vx/h commands tested tracked the theoretical value within one percent of the maximum commandable velocity (0.00054 rad/sec). At no time during system testing did the optical bars exceed the ± 1 percent velocity limit set in the SSTC limit check.

4.9 FINE PATH PERFORMANCE

The following parameters, evaluated to monitor the performance of the fine film path, were within specification during the acceptance runs delineated by the CEI specification:

TABLE 4-1

SLIT WIDTH CALIBRATION, S/N 015

FWD			AFT		
SLIT COMMAND (DECIMAL)	SLIT DIAGNOSTIC (COUNTS)	MEASURED SLIT WIDTH (INCHES)	SLIT DIAGNOSTIC (COUNTS)	MEASURED SLIT WIDTH (INCHES)	EXPECTED SLIT WIDTH (INCHES)
0	1	0.079	--	--	0.080
1	9	0.084	9	0.086	0.086
2	18	0.094	17	0.095	0.093
4	33	0.107	33	0.111	0.109
8	66	0.149	67	0.155	0.150
16	131	0.281	129	0.283	0.280
24	193	0.522	193	0.523	0.525
31	249	0.901	249	0.904	0.910
28	227	0.726	227	0.734	0.719
20	162	0.388	161	0.390	0.384
16	129	0.278	129	0.285	0.280
12	97	0.205	96	0.204	0.205
0	1	0.079	2	0.083	0.080

TABLE 4-2

OB SERVO CALIBRATION

FWD CAMERA

CMD IN COUNT	CMD VX/H CE101XS (RAD/SEC)	ACTUAL VX/H (RAD/SEC) (OB ENCODER)	ERROR FROM THEORETICAL
39	0.01799	0.01812	+0.00012
49	0.02208	0.02220	+0.00011
59	0.02617	0.02630	+0.00012
69	0.03026	0.03039	+0.00011
79	0.03435	0.03447	+0.00011
89	0.03844	0.03857	+0.00011
99	0.04253	0.04266	+0.00011
109	0.04662	0.04674	+0.00010
119	0.05071	0.05085	+0.00012
127	0.05398	0.05413	+0.00013

AFT CAMERA

CMD IN COUNT	CMD VX/H CE101XS (RAD/SEC)	ACTUAL VX/H (RAD/SEC) (OB ENCODER)	ERROR FROM THEORETICAL
39	0.01799	0.01811	+0.00011
49	0.02208	0.02220	+0.00011
59	0.02617	0.02630	+0.00012
69	0.03026	0.03039	+0.00011
79	0.03435	0.03447	+0.00011
89	0.03844	0.03859	+0.00011
99	0.04253	0.04266	+0.00011
109	0.04662	0.04674	+0.00010
119	0.05071	0.05085	+0.00012
127	0.05398	0.05413	+0.00013

Phase Lock Error + ΔP_f (Theoretical)
Fine Tension
OB Summed Error
Metering Capstan Summed Error
Photo Mode Error (PME)
Skew Angle Modification (ψ)
Metering Capstan Tachometer
ΔP_f (Theoretical) − ΔP_f
Film to Bar Sync (FBS)

The limit checks and the percentage of samples within the limits for the metering capstan summed error and the film-to-bar synchronization signals are shown in Table 4-3.

The metering capstan summed error has been evaluated by comparing each CEI-required run to a particular reference run. At each temperature, a reference run is designated for each different Vx/h. A small percentage of metering capstan summed error samples during P Mode are examined to determine the mean and two-sigma for the run, e.g. at Vx/h = 0.052, the program examines 15 samples at each of the three collimator positions or 45 out of 636 (about seven percent) and calculates the mean and two-sigma. A delta of 0.04 inch/sec is added to establish the acceptance window for all the other samples of the reference run and all the P-Mode samples of any other Vx/h = 0.052 run at the same temperature. As can be seen from Table 4-3, all the runs have greater than 99 percent of the samples falling within the reference window.

4.10 FOCUS

Focus for the fwd and aft cameras was calibrated at nadir. Shown at temperatures of 47°F, 70°F and 93°F are three point calibrations (Figures 4-1 and 4-2) between the focal plane position as read from the telemetry diagnostic and the corresponding focal plane command. Theoretically, this is a one for one linear relationship resulting in a straight line of 45 degree slope, as shown. Actual data measurements are plotted with (+).

In addition, at each of the three commanded focal plane positions, the film line targets were examined and the average (in-track and cross-track) point of best focus determined. As expected, for this relationship, a horizontal line plot should result because moving the physical focal plane should not affect

~~Hx TOP SECRET~~

TABLE 4-3

LIMIT CHECKS AND SAMPLE PERCENTAGES, METERING CAPSTAN SUMMED ERROR AND FILM-TO-BAR SYNCHRONIZATION SIGNALS

CEI SPECIFICATION			TESTS											
PARA.	NAME	REQUIREMENT	70° VAC				47° VAC				93° VAC			
			RUN	SIDE	$2\sigma + \delta$ IN./SEC	% IN SPEC	RUN	SIDE	$2\sigma + \delta$ IN./SEC	% IN SPEC	RUN	SIDE	$2\sigma + \delta$ IN./SEC	% IN SPEC
2.11	MC SUMMED ERROR	WITHIN $\pm 2\sigma + \delta$ TOLERANCE 96% OF THE TIME	101	FWD AFT	0.083 0.076	100 99.9	111	FWD AFT	0.088 0.088	99.8 100	115	FWD AFT	0.088 0.080	99.9 100
			105*	FWD AFT	0.083 0.076	99.9 99.9	112*	FWD AFT	0.088 0.088	99.8 100	116*	FWD AFT	0.088 0.080	99.9 99.9
			106*	FWD AFT	0.079 0.082	100 100	113*	FWD AFT	0.079 0.078	99.9 100	117*	FWD AFT	0.086 0.081	100 100
		*WITH RESPECT TO REF RUNS {0.052, 0.044, 0.036	107*	FWD AFT	0.076 0.075	100 100	114*	FWD AFT	0.081 0.075	99.9 100	118*	FWD AFT	0.087 0.081	100 99.9
			109	FWD AFT	0.083 0.076	99.9 100								
			110	FWD AFT	0.083 0.076	100 100								
			108	FWD AFT	0.083 0.076	99.9 99.8								
	FILM TO BAR SYNC	WITHIN ± 0.08 IN./SEC 96% OF THE TIME	101	FWD AFT		100 99.9	111	FWD AFT		99.8 99.9	115	FWD AFT		99.9 99.9
			105	FWD AFT		99.9 99.9	112	FWD AFT		100 99.8	116	FWD AFT		99.8 99.9
			106	FWD AFT	FWD & AFT	100 100	113	FWD AFT	FWD & AFT	99.9 99.9	117	FWD AFT	FWD & AFT	100 100
			107	FWD AFT	±0.08	100 100	114	FWD AFT	±0.08	100 100	118	FWD AFT	±0.08	100 100
			109	FWD AFT		100 99.9								
			110	FWD AFT		100 99.9								
			108	FWD AFT		99.9 99.8								

~~Hx TOP SECRET~~

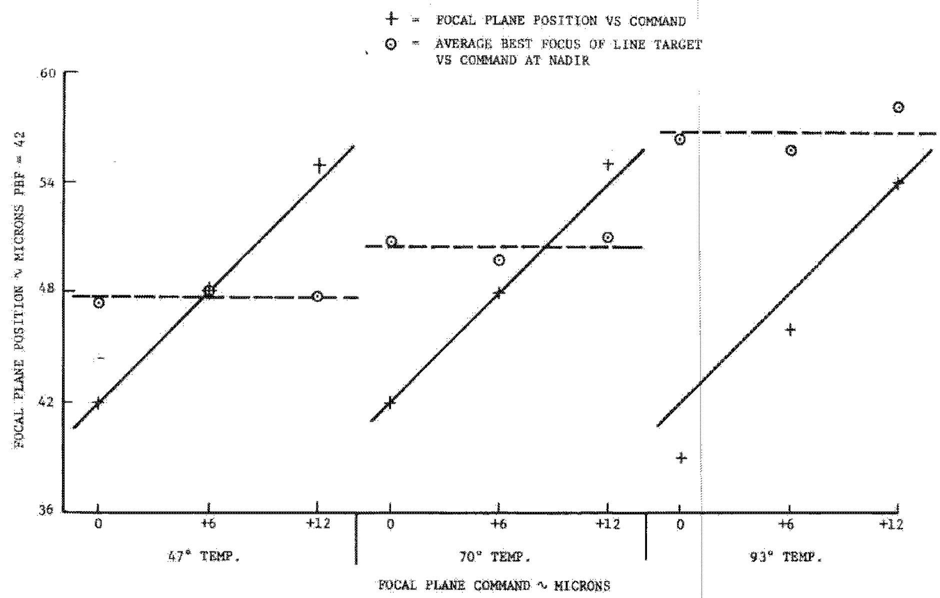


Figure 4-1. Focus Calibration, FWD Camera (CEI 111, 101, 115)

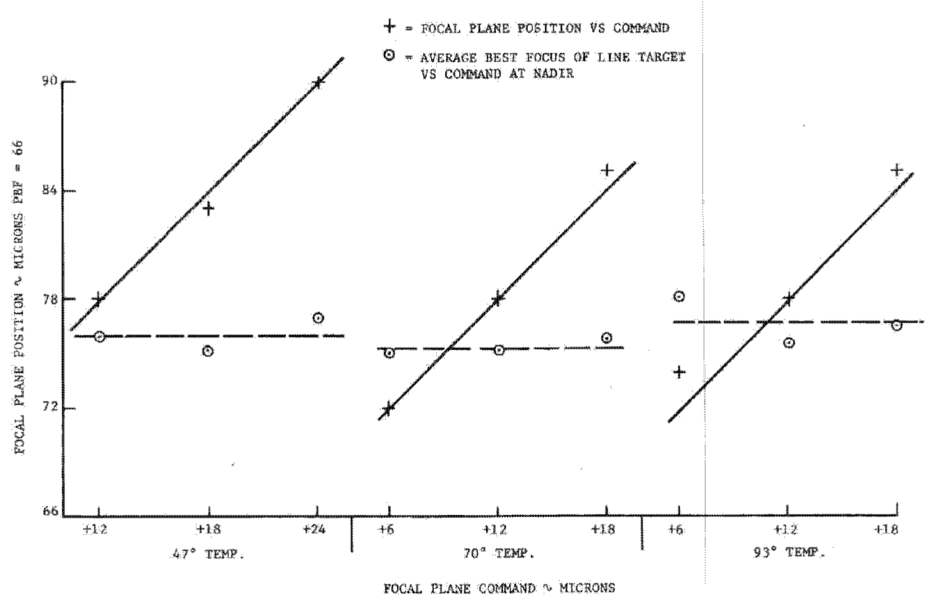


Figure 4-2. Focus Calibration, AFT Camera (CEI 111, 101, 115)

or move the true focal plane, i.e. point of best focus. Actual data measurements are plotted with (⊙) and the average of these three data points results in the horizontal dashed line.

4.11 POWER CONSUMPTION

The peak and average wattages during startup, photo and shut down were within the specified ICD limits (See Table 4-4 tabulation of the percentage of the corresponding ICD value for each wattage.)

TABLE 4-4

POWER CONSUMPTION
(Values in Percentage of Equivalent ICD Values)

	CEI Run					
	108		112		116	
	Peak	Average	Peak	Average	Peak	Average
Start	75	46	55	53	54	51
Operate	65	54	61	60	61	58
Stop	57	49	53	57	59	55

4.12 DRIVE AND METERING CAPSTAN FREQUENCY SPECTRA

Data obtained during a single frame of CEI run 105, an 00AA calibration run, are plotted in Figures 4-3 and 4-4 (Fourier spectra for all three capstan summed errors of both cameras) and Figures 4-5 and 4-6 (time based correlations of each signal with film-to-bar synchronization). The sample frame was taken with both skew and velocity commands set at zero; CEI run 105 was with a RADX of 0.052 with IMC enabled.

The Fourier plot of the metering capstan summed error for the FWD camera shows the three typically predominant frequencies. The lowest of these (∿63 Hz) represents a once-per-revolution disturbance emanating from the metering capstan; the highest (∿126 Hz) represents the metering capstan's true twice-per-revolution disturbance. The middle frequency (∿104 Hz) represents a once-per-revolution disturbance caused by a 0.6-inch roller in the platen assembly. None of these frequency components, however, represents a potential performance problem.

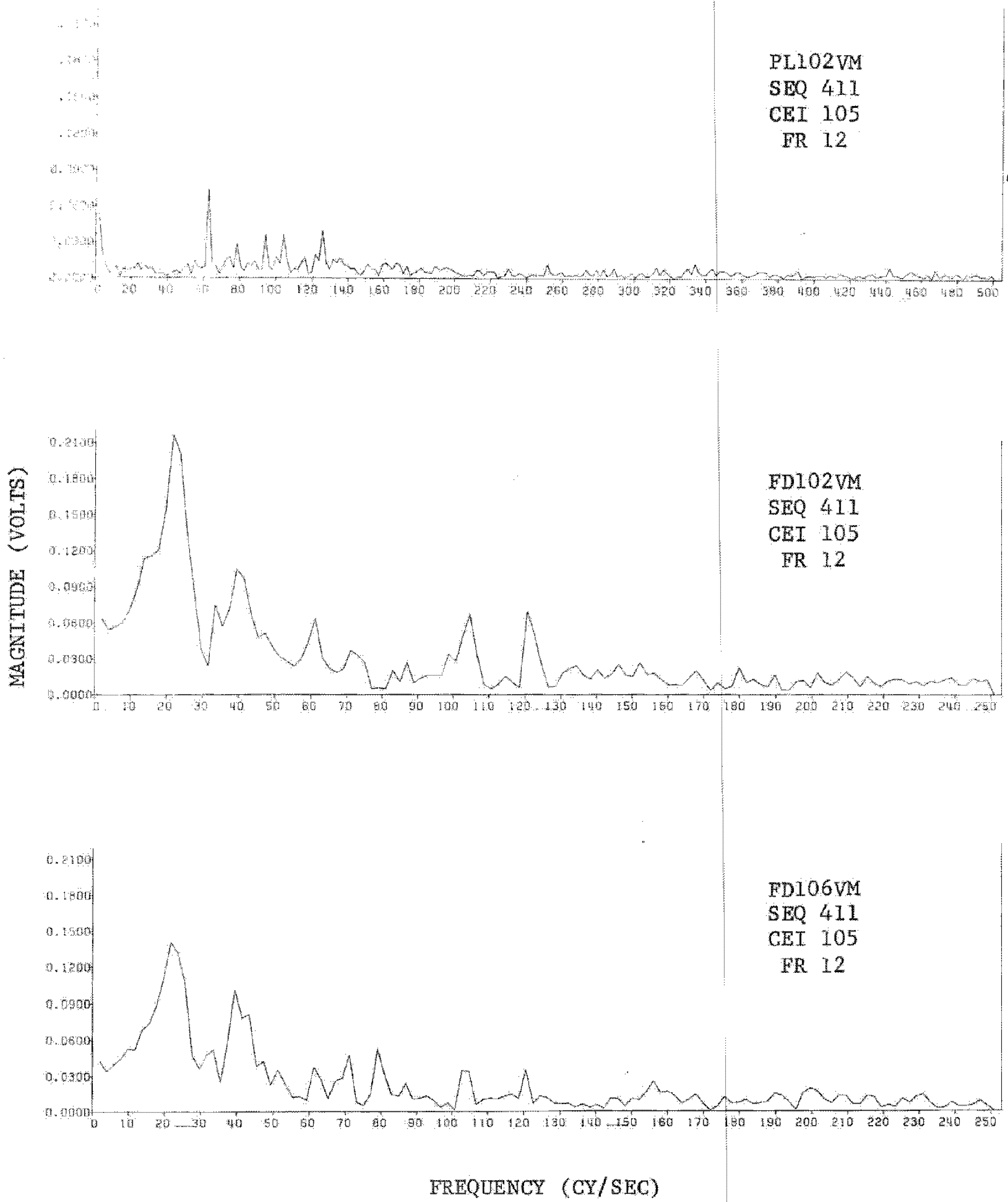


Figure 4-3. Metering Capstan, Input Film Drive and Output Film Drive Summed Errors, Frequency Spectra FWD Camera

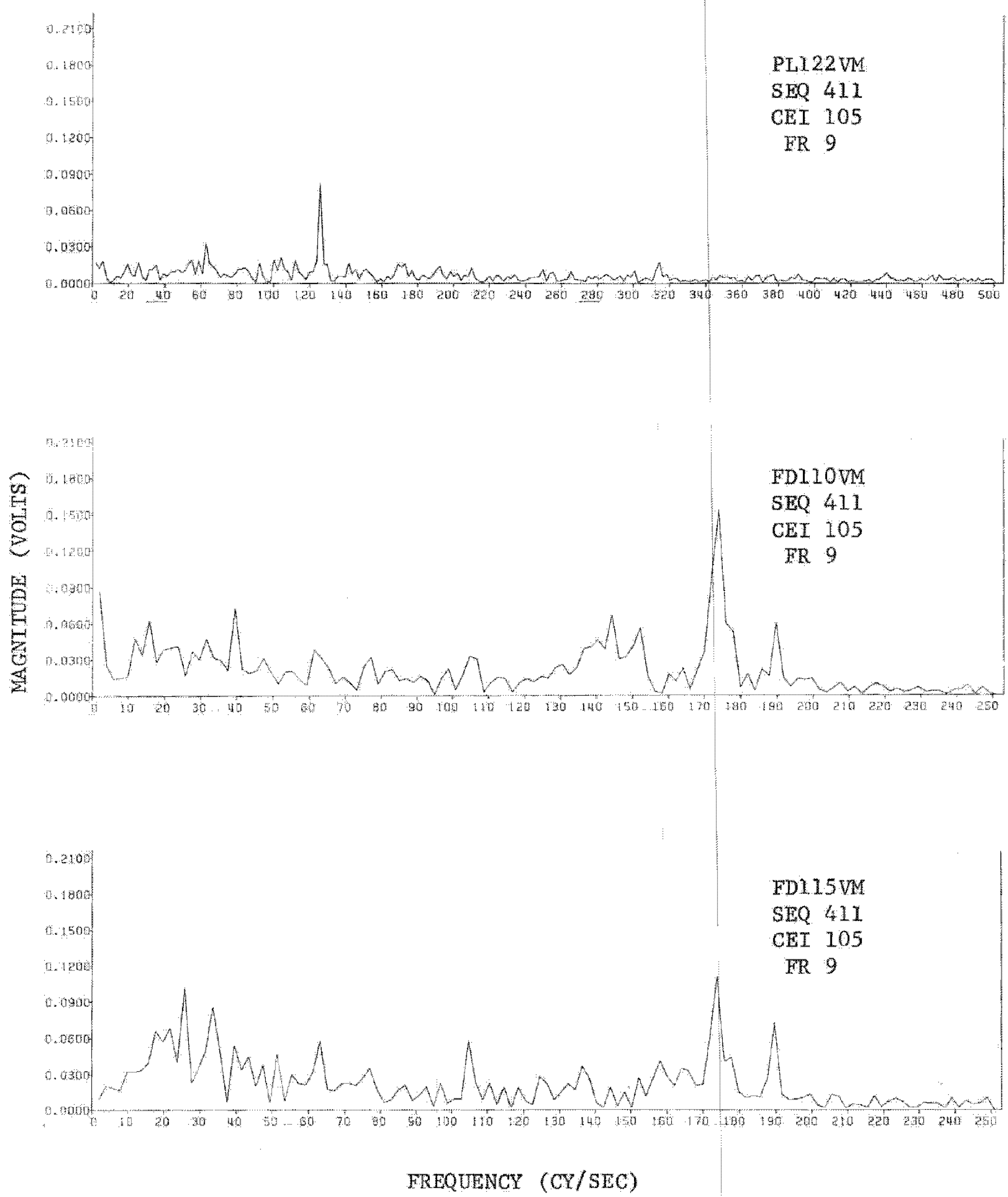


Figure 4-4. Metering Capstan, Input Film Drive and Output Film Drive Summed Errors, Frequency Spectra AFT Camera

TE 0515

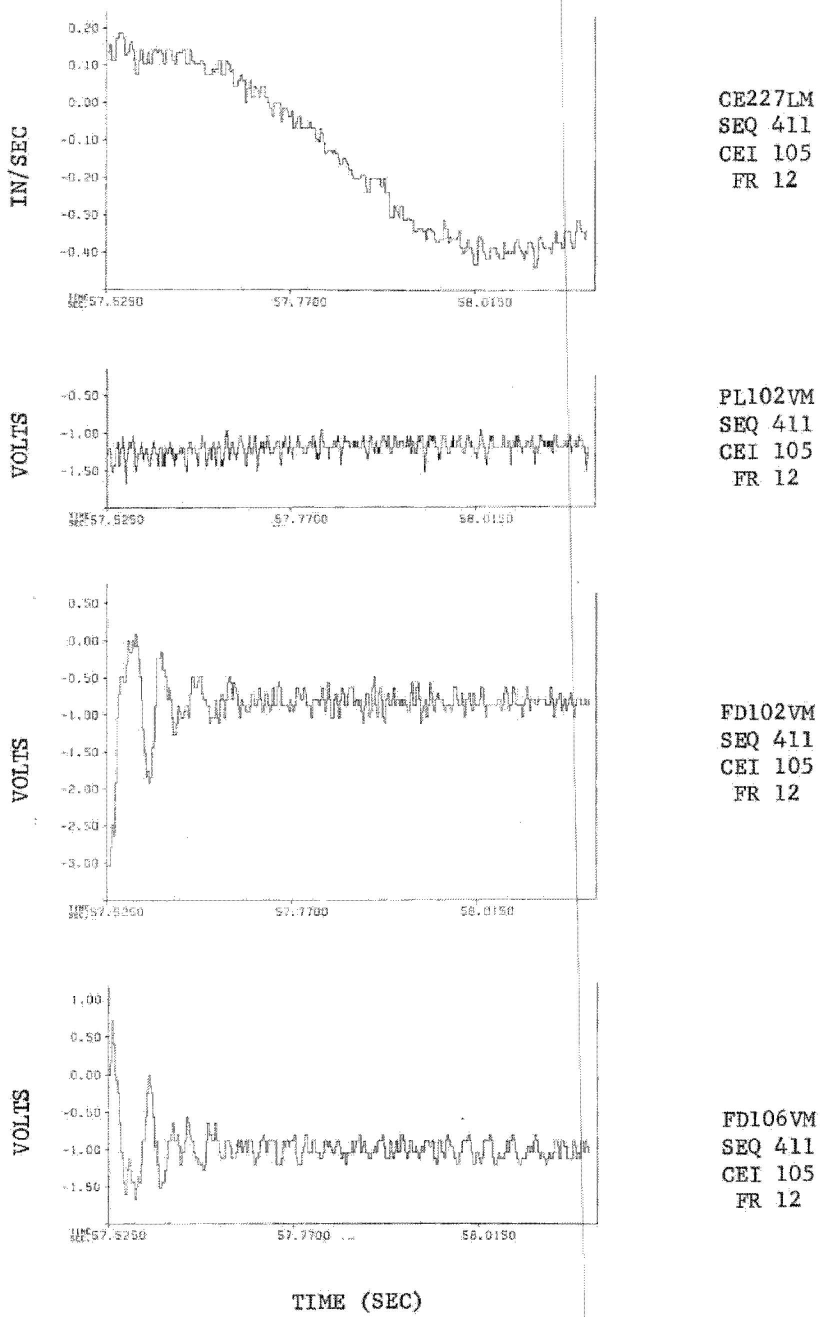
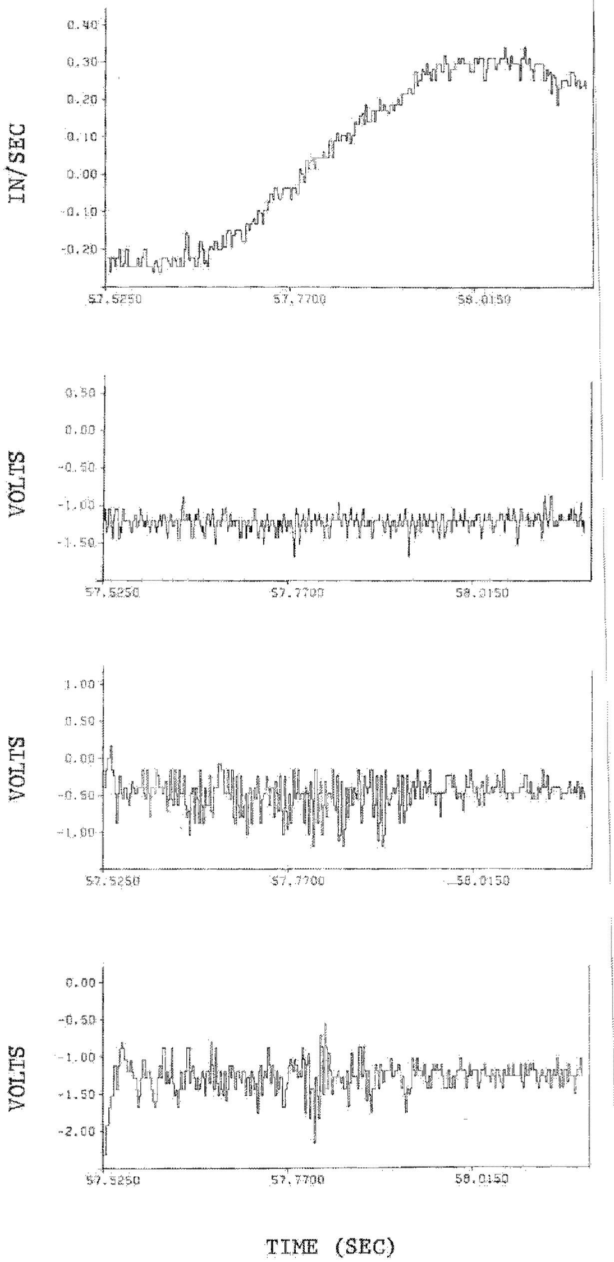


Figure 4-5. Film-to-Bar Synchronization and Metering Capstan, Input Film Drive, Output Film Drive Summed Errors, FWD Camera

TE 0515



CE228LM
SEQ 411
CEI 105
FR 9

PL122VM
SEQ 411
CEI 105
FR 9

FD110VM
SEQ 411
CEI 105
FR 9

FD115VM
SEQ 411
CEI 105
FR 9

Figure 4-6. Film-to-Bar Synchronization and Metering Capstan, Input Film Drive, Output Film Drive Summed Errors, AFT Camera

SECTION 5

OPERATIONAL DATA

5.1 TEST/SOFTWARE PARAMETERS

The parametric values unique to S/N 015 (Table 5-1) are provided as information for use in future testing and software preparation.

TABLE 5-1

S/N 015 PARAMETRIC VALUES

Parameter	FWD Camera	AFT Camera	Units
1. Design Stereo Angle	10°±1	10°±1	Degrees, Min.
2. Field of View	5.73	5.73	Degrees
3. Theoretical Focal Length Shift (Vac to Air)	30	23	Microns
4. Flange Focal Length	4.7798	4.7793	Inches
5. Back Focal Length	0.9966	1.0015	Inches
6. Metering Capstan Diam.	0.99825	0.99820	Inches
7. OB Stow Angle	178	178	Degrees
8. Commandable Focal Step	2.14	1.98	Microns/ Step Command
9. ψ Offset CAB	40 Lag	25 Lead	Arc-Sec
10. 00AA Skew Fixed Board Value	-110 001011	+150 101111	Arc-Sec Bit Pattern
11. 00AA Skew Variable Board Value	0 000000	0 000000	Arc-Sec Bit Pattern
12. 00AA Skew Test Point Voltage	0.855	-1.001	Volts

TABLE 5-1 (Cont'd)

Parameters	FWD Camera	AFT Camera	Units
13. Disable Velocity Correction	-0.0627	+0.0132	In/Sec@ Vx/h = 0.054
Resistance	502	100	Ohms
14. OOAA Velocity Fixed Board Value	0.1021	-0.0292	In/Sec@ Vx/h = 0.054
	000111	000010	Bit Pattern
15. OOAA Velocity Variable Board Value	0	0	In/Sec@ Vx/h = 0.054
	000000	000000	Bit Pattern
16. OOAA Velocity Test Point Voltage	0.798	0.228	Volts@ Vx/h = 0.052
17. F & E Trim Resistors	R_1 = 0	R_4 = 910K	Ohms
	R_2 = 0	R_5 = 0	Ohms
	R_3 = 1 MEG	R_6 = 0	Ohms
18. Steerer Trim Resistors			
ART	249	102	Ohms
FEV	280	280	Ohms
19. Pneumatic Tank Volume	3850	3850	Cubic Inches

5.2 OPERATING CONSTRAINTS

There are no unique operating constraints relating to operation of S/N 015, other than those listed in the HSSOP document. Testing done prior to 26 September 1974 was conducted under the constraints of the HSSOP document, Revision AS, and PM-1428, Revision G.

5.3 MASS PROPERTIES

Compliance with the mass properties ICD requirements is shown in Table 5-2. The total weight and products and moments of inertia for an empty and full midsection are tabulated in Figures 5-1 and 5-2. Figure 5-3 illustrates the coordinate axes and notation system.

5.4 ICD COMPLIANCE

S/N 015 meets all applicable ICD requirements.

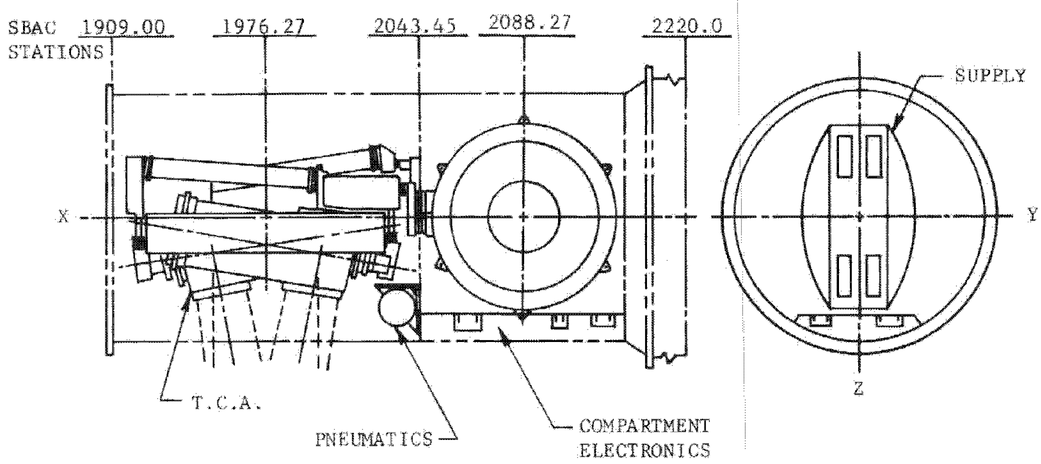
TABLE 5-2

ICD 1420313B SS/SBA MASS PROPERTIES		
WEIGHT REQUIREMENT OF SS MIDSECTION S/N 015/SV-12: total integrated SS shall not exceed 7190 lb (Block II, SV-11 and SV-12)		
COMPLIANCE:		WEIGHT (LBS)
SS MIDSECTION*		3978
FORWARD SECTION FOR SV-012		
S/N 015 FAK	311.6	
**RV POSITION - 1/SN 030A	230.9***	
- 2/SN 027A	230.9	
- 3/SN 022A	231.4	
- 4/SN 025A	235.7	
		1240.50
MATERIAL (FLIGHT LOAD - NOM. WT)		1850
GAS (FLIGHT LOAD)		68
WEIGHT UNDER ICD LIMIT OF 7190 LB BY 54 LB		7136.50

*Final predicted wt. as shipped less material and gas (includes SU caging pin, fences and decontamination control)

**Predicted RV/TU assignments

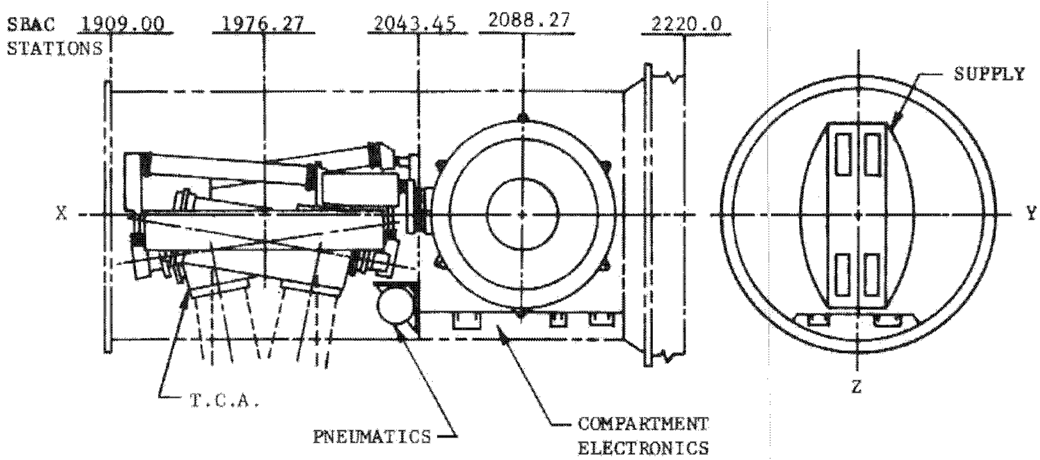
***To be verified by MWC



SUMMARY

PARAMETER		VALUE	
WEIGHT	=	3978.0	LBS
X BAR	=	2020.3	INCHES
Y BAR	=	0.7	INCHES
Z BAR	=	8.7	INCHES
IXO: ROLL MOMENT OF INERTIA	=	677.4	SLUG FT^2
IYO: PITCH MOMENT OF INERTIA	=	3404.9	SLUG FT^2
IZO: YAW MOMENT OF INERTIA	=	3473.5	SLUG FT^2
IXY: PRODUCT OF INERTIA	=	-29.2	SLUG FT^2
IXZ: PRODUCT OF INERTIA	=	35.7	SLUG FT^2
IYZ: PRODUCT OF INERTIA	=	-28.9	SLUG FT^2

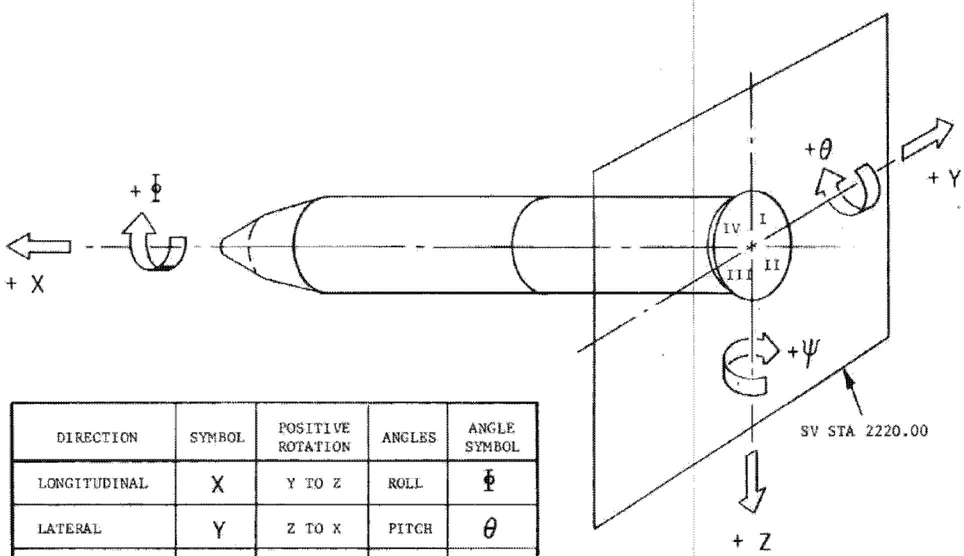
Figure 5-1. Total Weight, Products and Moments of Inertia, SS, MS Empty.



SUMMARY

PARAMETER		VALUE	
WEIGHT	=	5896.0	LBS
X BAR	=	2041.6	INCHES
Y BAR	=	0.5	INCHES
Z BAR	=	6.5	INCHES
IXO: ROLL MOMENT OF INERTIA	=	886.8	SLUG FT^2
IYO: PITCH MOMENT OF INERTIA	=	4971.5	SLUG FT^2
IZO: YAW MOMENT OF INERTIA	=	4901.9	SLUG FT^2
IXY: PRODUCT OF INERTIA	=	-42.4	SLUG FT^2
IXZ: PRODUCT OF INERTIA	=	-130.3	SLUG FT^2
IYZ: PRODUCT OF INERTIA	=	-28.4	SLUG FT^2

Figure 5-2. Total Weight, Products and Moments of Inertia, SS, Full Chute.



DIRECTION	SYMBOL	POSITIVE ROTATION	ANGLES	ANGLE SYMBOL
LONGITUDINAL	X	Y TO Z	ROLL	Φ
LATERAL	Y	Z TO X	PITCH	θ
VERTICAL	Z	X TO Y	YAW	ψ

Figure 5-3. Coordinate Axes and Notation System.

SECTION 6

SENSOR SUBSYSTEM ON-ORBIT PERFORMANCE PREDICTION

The object of the on-orbit performance prediction computation is to predict the camera system's resolution capability on orbit, based on Chamber A measurements, Chamber D measurements or budgeted values of errors where applicable. The Performance Prediction Program (PERF) is designed to create, for each location considered in the photographic format, 500 samples whose statistics represent actual system performance. For each sample, the amounts of defocus, in-track smear, and cross-track smear are determined by means of a random number generator. In-track and cross-track resolutions are computed by intersecting the resulting transfer functions with the film AIM (Aerial Image Modulation) curve.

The average values of the resulting geometrical mean resolutions for the two cameras at 47°F, 70°F, and 93°F at nine locations in the photographic format are shown in Tables 6-1 through 6-6. The major data inputs to PERF were as follows:

a. Image Motion Errors

1. Mechanization Errors - Chamber A sync-flash measurements
2. Vehicle Induced Errors - budget
3. Residual Errors - computed fixed knowns

b. Defocus Errors

1. Dynamic Defocus - Chamber A line target measurements
2. Thermal Defocus - Chamber A line target measurements
3. Flight Focus Calibration - budget

c. Optical Quality

1. Polychromatic Optical Transfer Function - computed from Chamber D measurements at each temperature

2. Optical Quality Factor for thermal and dynamic effects - budget

d. Target Characteristics

1. Brightness - 600 ft - lamberts

2. Contrast - 2:1 at camera entrance pupil

TABLE 6-1

FWD CAMERA 47°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	133	149	134
0°	184	185	182
+2.5°	139	152	137

TABLE 6-2

FWD CAMERA 70°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	140	163	140
0°	187	192	183
+2.5°	148	162	147

TABLE 6-3

FWD CAMERA 93°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	157	163	146
0°	191	178	179
+2.5°	149	163	152

TABLE 6-4

AFT CAMERA 47°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	135	153	140
0°	175	186	185
+2.5°	132	151	131

TABLE 6-5

AFT CAMERA 70°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	141	161	140
0°	180	188	185
+2.5°	136	156	141

TABLE 6-6

AFT CAMERA 93°F PERFORMANCE PREDICTION

Field Angle	Scan Angle		
	-45°	0°	+45°
-2.5°	146	156	133
0°	183	188	181
+2.5°	139	168	155

APPENDIX A

INDENTURED PARTS LIST
S/N 015 AS-SHIPPED CONFIGURATION

Indent	Title	Drawing No.	Configuration	Serial No.
1	Midsection Assembly	621-0090	150	5012
2	F Stack & SU Assembly	621-1392	025	5106
3	SU Assembly	621-0386	096	5206
4	Structure No. 1	621-5703	003	029
4	Bulkhead No. 2	621-0353	090	5306
5	Motor No. 3 (A)	645-0697	004	023
5	Motor No. 3 (B)	645-0697	004	022
5	Encoder No. 5 (A)	621-0661	004	5025
5	Encoder No. 5 (B)	621-0661	004	5019
5	SU Relief Valve Pneu.	645-6561	003	0017
5	SU Servo 6A1 (A)	621-0896	001	1021
5	SU Servo 6A1 (B)	621-0896	001	1023
5	F.E.V.	621-0385	103	5406
6	Edge Sensor 5A2 (A)	651-0024	002	5094
6	Edge Sensor 5A2 (B)	651-0024	002	5086
4	Structure No. 3	621-5704	003	030
2	Pneumatics Assembly	621-6326	001	5017
2	Midsection Structure GFE			
2	Two Camera Assembly	621-5264	047	5006

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
3	Frame Assembly	621-0192	019	5013
4	Frame	621-0190	002	5015
3	OB & Cntrwt (A)	621-5177	001	5036
4	OB Assembly (A)	621-5182	006	5005
5	MCB Box 1A6 (A)	621-5021	002	5013
5	Turret Assembly (IC Filter)	621-5067	006	5005
5	Motor No. 1 (A)	621-0554	003	1113
5	Encoder No. 1 (A)	621-0601	012	5060
3	OB & Cntrwt (B)	621-5177	001	5043
4	OB Assembly (B)	621-5182	006	5012
5	MCB Box 1A6 (B)	621-5021	002	5012
5	Turret Assy (IC Filter)	621-5067	005	5012
5	Motor No. 1 (B)	621-0554	004	1103
5	Encoder No. 1 (B)	621-0601	012	5061
3	Platen Assy (A)	621-0248	107	5110
4	Focal Plane Tilt Dr Assy (A)	621-0226	023	5312
5	FPEE (A) 2A10	645-0791	004	5030
4	MC Assembly (A)	621-0228	015	5309
5	Motor No. 5 (A)	645-0941	003	5119
5	Encoder No. 2 (A)	645-7525	002	5034
5	Thermal Comp (A) 2A8	651-0020	002	5015
4	S & S Assembly (A)	621-0249	053	5208

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
4	Prewire (A)	621-4906	012	5302
5	BME (A) 2A2	651-0026	004	5023
5	P Mode (A) 2A4	651-0019	002	5021
4	Tension Sensor (A)	621-2143	019	5212
4	Tension Sensor (A)	621-2144	019	5210
4	Encoder No. 4 (A)	645-7526	003	5030
4	P Mode (A) 2A11 Atten.	621-3464	003	5034
4	LSFS (A)	621-0289	008	029
5	OH Elec. 2A9 (A)	645-0331	006	5034
4	Motor No. 6 (A)	621-0553	010	6110
3	Platen Assy (B)	621-0248	107	5112
4	Focal Plane Tilt Dr Assy (B)	621-0226	023	5309
5	FPEE (B) 2A10	645-0791	003	5023
4	MC Assembly (B)	621-0228	015	5313
5	Motor No. 5 (B)	645-0941	003	7002
5	Encoder No. 2 (B)	645-7525	002	5035
5	Thermal Comp (B) 2A8	651-0020	002	5025
4	S & S Assembly (B)	621-0249	053	5011
4	Prewire (B)	621-4906	012	5301
5	BME (B) 2A2	651-0026	004	5018
5	P Mode (B) 2A4	651-0019	002	5025
4	Tension Sensor (B)	621-2143	019	5014

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
4	Tension Sensor (B)	621-2144	019	5212
4	Encoder No. 4 (B)	645-7526	003	5032
4	P Mode (B) 2A11 Atten.	621-3464	003	5038
4	LSFS (B)	621-0289	008	023
5	OH Elec 2A9 (B)	645-0331	006	5030
4	Motor No. 6 (B)	621-0553	010	6113
3	"F" Drive Assembly (A)	621-5300	005	5205
4	"D" Bar Assembly (A)	621-0204	026	5016
4	HSG Frame Assembly (A)	621-0330	008	5006
4	Roller Drive (A)	621-0331	012	5305
5	Motor No. 4 (A)	645-0931	001	5017
5	Encoder No. 3 (A)	621-0631	013	5062
4	Roller Drive (A)	621-1355	007	5306
5	Motor No. 4 (C)	645-0931	001	4109
5	Encoder No. 3 (C)	621-0631	013	5065
4	FDB (A) 4A4	621-5022	001	5012
3	"F" Drive Assembly (B)	621-5300	005	5212
4	"D" Bar Assembly (B)	621-0204	026	5302
4	HSG Frame Assembly (B)	621-0330	008	5009
4	Roller Drive (B)	621-0331	012	5312
5	Motor No. 4 (B)	645-0931	001	4108
5	Encoder No. 3 (B)	621-0631	013	5063

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
4	Roller Drive (B)	621-1355	007	5305
5	Motor No. 4 (D)	645-0931	001	4124
5	Encoder No. 3 (D)	621-0631	013	5069
4	FDB (B) 4A4	621-5022	001	5010
3	LO Assembly (A)	621-0337	062	5206
4	Lin Xducer Assembly	621-0172	014	1006
5	Amp Det 4A1 (A)	651-0021	001	5028
4	Base & Upright	621-0349	010	5014
4	Carriage Assembly	621-0400	009	5309
4	LPR Diag. 4A3 (A)	651-0023	001	5027
4	Course T.S. Preamp 4A2 (A)	651-0022	001	5049
4	Course T.S. Preamp 4A2 (B)	651-0022	001	5060
3	LO Assembly (B)	621-0338	064	5206
4	Lin Xducer Assembly	621-0173	014	1007
5	Amp Det 4A1 (B)	651-0021	001	5016
4	Base & Upright	621-0344	011	5013
4	Carriage Assembly	621-0400	009	5310
4	LPR Diag. 4A3 (B)	651-0023	001	5028
4	Course T.S. Preamp 4A2 (C)	651-0022	001	5042
4	Course T.S. Preamp 4A2 (D)	651-0022	001	5057
3	TCA Electronics			
4	OB Servo 1A1 (A)	621-0876	007	1034

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
4	OB Servo 1A1 (B)	621-0876	007	1025
4	MOD Comp (A) 1A2	621-0877	003	1030
4	MOD Comp (B) 1A2	621-0877	004	1029
4	O^2A^2 1A7	621-5882	003	5006
4	PL Servo 2A1 (A)	621-0878	008	1026
4	PL Servo 2A1 (B)	621-0878	008	1023
4	MC Servo 2A3 (A)	621-0872	013	1027
4	MC Servo 2A3 (B)	621-0872	013	1031
4	ID Servo 3A1-1 (A)	621-0882	010	1026
4	S.I.A. (A)	621-6578	002	5011
4	ID Servo 3A1-1 (B)	621-0882	010	1018
4	OD Servo 3A1-2 (A)	621-3410	009	1032
4	OD Servo 3A1-2 (B)	621-3410	009	1028
4	Flash 500 Hz 3A3 (A)	645-0875	002	5023
4	Flash 500 Hz 3A3 (B)	645-0875	002	5027
4	Flash 40 Hz 3A4 (A)	645-0900	003	5025
4	Flash 40 Hz 3A4 (B)	645-0900	003	5006
4	DCB (ICF) 3A5	621-5023	001	5001
4	Art Steer 5A1 (A)	621-0875	006	5084
4	Art Steer 5A1 (B)	621-0875	004	5060
4	S.I.A. (B)	621-6578	002	5012
3	AFT Articulator (A)	621-0333	028	5206

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
4	Act. Mech Art	621-0341	025	5306
5	Edge Sensor 5A2	651-0024	002	5077
3	AFT Articulator (B)	621-0334	026	5026
4	Act. Mech Art	621-0350	023	5306
5	Edge Sensor 5A2	651-0024	002	5093
3	Crossover (A)	621-0392	024	5108
3	Crossover (B)	621-0393	025	5107
3	FWD Enclos.	621-2116	012	LT/107
3	AFT Enclos.	621-0399	010	LT/112
3	Frame Articulator (A)	621-0335	011	5104
3	Frame Articulator (B)	621-0336	015	5106
3	MS to TCA Tang. Link	621-0164	006	LT/115
3	MS to TCA Tang. Link	621-6233	001	LT/109
3	Pitch Restraint	621-3494	002	LT/112 & 115
2	Compartment Electronics			
3	STR P.S. 5A3	651-0025	002	5009
3	SU Servo 6A2 (A)	621-0871	004	1020
3	SU Servo 6A2 (B)	621-0871	004	1024
3	UCC 8A1	621-0881	004	5018
3	F & E/SPS 12A1	645-0144	005	5013
3	SCC 13A1	621-0880	010	1013
3	SESD 13A2	621-6334	001	5106

APPENDIX A (Cont'd)

Indent	Title	Drawing No.	Configuration	Serial No.
3	PDS 14A1	621-0894	013	5022
3	SIRC 14A2	621-4886	004	5015
3	ISC/CU 15A1	645-0501	010	5010
3	DLF 16A1	645-5650	009	5017
3	MFA 17A1	645-7423	011	5004
3	N.C.V.U.	621-6136	002	5002