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Sensor Subsystem Post Flight Analysis Report

MISSION 1208

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

BYE 15256-75

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SENSOR SUBSYSTEM

POST FLIGHT ANALYSIS REPORT

JUNE 1975

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PUBLICATION REVIEW

This report has been reviewed and is approved.

David F. Bergo

DAVID F. BERGANINI
Lt Colonel, USAF
PFA Chairman

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FOREWORD

This report was prepared for and by direction of the Director, Photo Reconnaissance Systems, Office of Development and Engineering. The final mission report is divided into two parts and this part constitutes Volume II. Volume I is entitled Performance Evaluation Team, Mission 1208, BYE 15336-74. This Volume II report also combines data from all black and white and color films utilized on 1208.

The preparation, collection, and reduction of the data in this report has been a joint effort of the members of the Post Flight Analysis (PFA) Team. Major contributors to this report include:

Section I	-	PFA Team
Section II	-	Sensor Subsystem Contractor
Section III	-	Sensor Subsystem Contractor and BRIDGEHEAD
Section IV	-	BRIDGEHEAD, AFSPPF, and NPIC
Section V	-	NPIC
Sections VI and VII	-	PFA Team

The majority of the raw data collection was accomplished at, and by, AFSPPF. The PFA Team is indebted for the excellent support received from Colonel Clark E. Davison, Commander, and his staff.

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SUMMARY

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SECTION 1

SUMMARY

1.1 BACKGROUND

Mission 1208 was launched from Vandenberg AFB, SLC-4E, at 1320 PST on 10 April 1974. Mission statistics, camera data, and RV recoveries are summarized in Tables 1-1 thru 1-3.

TABLE 1-1

MISSION STATISTICS

Mission Number - 1208
Launch Date - 10 April 1974
Launch Time (Z) - 2020
Satellite Vehicle - SV-8 (8008)
Sensor Subsystem - SN-011
Orbit Inclination (degrees) - 94.5
Initial Perigee (NM) - 85.6
Initial Apogee (NM) - 164.7
Argument of Perigee (degrees) - 141.4
Initial Period (minutes) - 89.0
Range of Photo Altitudes (NM)
1208-1, 84-104
1208-2, 84-101
1208-3, 82-106
1208-4, 82-108

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TABLE 1-2

CAMERA STATISTICS

Parameter	Forward Camera	Aft Camera
Camera Designation	A	B
Film	1414	1414/SO-255/FE-3916
Focal Length (inches)	59.9760	59.9890
Equivalent Filter Type	W-12*/W-2E3	W-12/W-2E3
Initial Focus Setting (microns)	68	25/55**
Supply Footage (feet)	108,981	101,088/2,588/3,036
Supply Spool No.	5077	5076
Supply Film Weight (lbs)	862	861
Optical Set Numbers	035	037
Initial Pneumatics (lbs)	35.4	
Estimated Remaining Pneumatics (lbs)	2.3	

*W-12 used throughout mission.

**Focus for SO-255 and FE-3916.

TABLE 1-3

RV RECOVERY STATISTICS

	RV-1	RV-2	RV-3	RV-4
Recovery Date	24 Apr 1974	22 May 1974	18 Jun 1974	24 Jul 1974
Recovery Time (Z)	2325	2208	2132	2031
Recovery Rev	228	581	1118	1701
Capacity Load (%)	95.9	97.6	84.6	95.3
Balance Status (%)	0	3.3	3.1	5.2

NOTE: RV-2 thru RV-4 were retrieved by aerial recovery. RV-1 was a successful water recovery.

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This report details the technical evaluation of the cameras employed on this flight and includes important aspects of the satellite vehicle performance, post recovery handling, and exploitation of the product. Although the product is evaluated principally with regard to 1414 Film, consideration of both the SO-255 Color and FE-3916 False Color Films is included.

This report is the consensus of the Post Flight Analysis (PFA) Team, which consists of representatives from the System Program Office (SPO), the Office of Development and Engineering (OD&E), the Sensor Subsystem Contractor (SSC), the National Photographic Interpretation Center (NPIC), the BRIDGEHEAD Processing Center, and the Air Force Special Projects Production Facility (AFSPPF).

The SV-8 Sensor Subsystem (SN-011) was tested extensively on the ground prior to launch during both the acceptance test phase at the SSC facility and during vehicle integration at the SVIC facility. The results of these tests are detailed in the following reports:

A. Flight Model (SN-011) Acceptance Team Report, BYE 15312-72, 15 December 1972.

B. SV-8 (SN-011) Flight Readiness Report, BYE 15250-74, February 1974.

1.2 CAMERA OPERATIONS AND PERFORMANCE

Mission 1208, the second of the Block II Systems, was a successful operation. The entire supply of film was utilized with over 215,000' of film being recovered. Of this amount, 2,588' were SO-255 Color Film, 3,036' were FE-3916 IR False Color Film, and the remainder was 1414 (black and white) Film. During the course of the mission, there were two anomalies that resulted in system malfunctions. Operational contingency modes that did not impact system performance were employed to bypass these anomalies.

This mission was the first to incorporate the Servo Inhibit Assembly, which inhibits the drive servos from dithering when the recycle profile is at pause. It also included, for the first time, the Metering Capstan settling time improvement which decreases the synchronization error in the first few degrees of photography. These design improvements performed well during the mission.

1.2.1 Camera Operation

Mission 1208 was the longest active photographic mission to date with RV-4 recovery on Day 106; other recoveries were on Days 15, 43, and 70. A Solo phase extended the vehicle life to Day 110.

Operational photography began on Rev 5, Op 4, and continued with no camera system malfunctions until Rev 980 when the system failed to execute two operations. The failure was determined to be a missing Forward Camera Take-up Builder Roller (BR) down verification interlock signal. Operations were resumed on Rev 996 with the system configured in SCC II with BR down verification interlock disabled (VIA-DIS). When transfer to RV-4 was made, VIA was re-enabled and operated satisfactorily for the remaining portion of the mission.

On Rev 1268, the system shut down due to a failure of the Aft Camera Take-up Integrator Servo

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to reset at TU brakes off. This failure necessitated eliminating nested operations when operations were resumed on Rev 1300. The system continued to operate normally for the rest of the mission.

For the first time in eight missions, it became necessary to actuate the pneumatic system operate valves to maintain the film path pressure above the ballooning criterion. The combination of short operations with corresponding small increases in path pressure, separated by long quiescent periods, caused the repeated occurrence of the low pressure condition.

Twelve engineering test objectives were established for Mission 1208 to acquire data for both short and long term assessment of on-orbit system performance.

1.2.2 Image Quality

Photographic image quality of Mission 1208 was Good with performance of the Aft Camera slightly better than that of the Forward Camera. The mean 2:1 contrast VEM resolution performance was 151 cycles/mm with peak resolution being 199 cycles/mm. Deployed CORN tribars read from 1.8' to 2.6' ground resolved distance in twelve acquisitions, format location and incident contrast being variable. Two acquisitions each of color and infrared film both read 3.2' and 5.6' respectively. The quality of Mission 1208 was comparable with previous missions.

VEM analysis showed that the optical field curvature was essentially flat with little or no platen tilt required. The on-orbit resolution (inferred from VEM) is comparable to the best performance in ground testing except for the Forward Camera in-track direction, which is approximately 15% low. There were no indications of McDonald's Arches (paragraph 3.4.3). Analysis of CORN line deployments shows no degradation in optical performance between ground and orbital performance.

1.2.3 Focus

Thru focus engineering tests showed the need to change focus (for 1414 Film) on the Forward Camera by +8 microns. The Aft Camera prelaunch setting was correct for orbital operation. The change was accomplished on Op 156 of RV-2. Focus for the Color Film, SO-255, was examined subjectively and was assessed to be near optimum.

1.2.4 Film Synchronization

The ground image motion compensation settings for 1414 Film were correct for the Forward Camera in-track and Aft Camera cross-track directions. Minor changes were made on-orbit to the Forward Camera cross-track and Aft Camera in-track directions of +.013 inch/second, and -.024 inch/second, respectively. These changes were made on Ops 160 (Aft) and 399 (Forward). The film synchronization for the SO-255 Color Film was subjectively judged to be adequate. The inherent low image quality of the IR False Color Film, FE-3916, rendered any smear slit evaluation of this film's synchronization impossible.

Image motion variability for Mission 1208 showed that it was within the SV design goal.

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1.2.5 Exposure

The new exposure algorithm used for Mission 1208 black and white film was successful; this algorithm includes a .06 log E reduction on the Aft Camera. The Color Film, SO-255, and IR False Color Film, FE-3916, were overexposed by about .10 log E. These films were flown on the Aft Camera and were intentionally not given the .06 log E reduction in exposure. Thus, it is recommended for future missions that SO-255 Color and FE-3916 IR False Color on the Aft Camera include this bias.

Frequent instances of dirty and/or melted snow in prim areas of interest indicate that snow bias techniques should be suspended on late spring and summer missions.

1.2.6 Engineering Tests

Twelve engineering tests were performed during the course of Mission 1208. Eleven of the twelve tests produced satisfactory results. The resolution of the IR False Color Film was too low to permit mensuration by smear slits. Therefore, film synchronization for FE-3916 IR False Color Film cannot be determined. Four of the tests required deployment of CORN targets (lines, tribars, gray scales, log periodic, and radiometric patches), while the remaining tests required only the acquisition of dense culture areas.

The only test not completed was the smear slit evaluation of film synchronization of SO-255 Color Film. However, subjective assessment of the smear slit imagery of operational and normal engineering color film showed the film synchronization to be near nominal.

1.3 PROCESSING AND REPRODUCTION SUMMARY

Defilming operations were normal except for 1208-3. Here, the Aft core locking pin was found bent; the bent pin was removed by drilling after normal removal techniques had failed.

Abnormally high base-plus-fog levels, on certain sections of 1208-1, were noted and then found to be associated with specific manufactured film rolls. After identification of these rolls, compensation was provided by special processing techniques for the remaining segments of 1208. Particulate matter wound in the Forward stack of RV-1 resulted in the puncture of four convolutions in Op 38 and another dimple and puncture in Op 1 IOR. Apparently, a foreign particle remained imbedded in the film (Op 1 IOR) until it transferred to a processor dryer roller and caused a base side film scratch that continued through Op 17. The process was interrupted in Op 18 IOR and the roller was cleaned before normal processing resumed.

Black and white reproduction of Geographic Area duplicate positives from RV-2, RV-3, and RV-4 was achieved using the ABCC printing method; this method provides additional contrast in shadow areas plus an in-line production capability for contrast changes. All 1208 Target Complex copies were reproduced at BRIDGEHEAD for the first time.

Processing of the 1208-4 color originals was accomplished without incident. The SO-255 color original

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was processed in the Grafton Processor, Specification E-26-8C, which was modified to provide a .10 log E increase in photographic speed.

Reproduction of the color originals was accomplished using additive Rainbow Printers. The color duplicates were printed onto Aerial Color Print Film SO-287, which had been preflashed to provide substantial improvements in sensitometric reproduction.

NPIC's evaluation of the Priority 1 and 2 duplicate copies of the 1414 Film Type shows their quality to be similar to recent 1200 Series missions. The color balance of the SO-287 color duplicate positives (CDPs) made from the SO-255 original positive has improved significantly over that of Mission 1207, due principally to flashing of the SO-287 Film. The resolution transfer of the CDP is still substantially poorer than the black and white green record DP. The low resolution of the FE-3916 IR False Color Film continues to be the limiting factor in the image quality of its duplicate copies.

1.4 EXPLOITATION SUITABILITY

The interpretability of the black and white acquisitions from Mission 1208 was typical of recent 1200 Series missions, with the majority of the targets read out by NPIC rated 4 on the National Imagery Interpretability Rating Scale (NIIRS). Analysis of the mission ratings shows that for the fogged 1414 Film there were fewer acquired targets (10%) rated 5 or 6, as compared to the unfogged film on RV-1. The processing modification made on subsequent RVs appears to have compensated for this degradation. The focus and OOAA adjustments made on RV-2 correlate with a significant improvement in the NIIRS ratings for this mission segment's photography.

The interpretation suitability of the CDPs was the best to date. The black and white DPs made from either the SO-255 Color Film or the FE-3916 IR False Color Film original positives are still preferred for their better resolution. The FE-3916 DPs were poor for military intelligence uses, but good for economic intelligence uses; e.g., wheat field yield estimates.

1.5 AEROSPACE VEHICLE SUMMARY

1.5.1 Mission Preflight Planning

Mission 1208 was the second of the Block II Satellite Vehicles and Panoramic Camera Systems. All four RCS tanks were installed and filled with 394 pounds of propellant; the Orbit Adjust Tank contained 3,200 pounds of propellant. Space Ground Link System (SGLS) transponders were General Dynamics and Cubic units; a backup UHF command receiver was added. The vehicle also carried the Quantic Horizon Sensor.

Mission 1208 orbit was designed to:

A. Maintain solar angle (Beta) within -8° to +30° for the planned 93 days.

B. Have orbit adjusts occur on a three-day cycle with every third orbit adjust having a positive and negative burn for close control of the argument of perigee.

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1.5.2 New Secondary Flight Objectives

During the mission, three new secondary flight objectives were defined:

A. Early Rev Search and Acquisition

The SV SGLS Transponder was commanded "ON" over specific RTS contacts to provide a test vehicle for another program's acquisition procedure testing.

B. S-pulse Suppression Tests

Use of the ECS/UHF command receiver required disabling SGLS-2 S-pulses. To accomplish this, octal correctors were developed and tested to verify proper operation.

C. Panoramic Camera Leak Delay Testing

A possible pneumatics leak was detected just prior to launch and HPIV-A was closed. The leak delay test was conducted to determine if the normal camera pneumatics configuration could be used safely.

1.5.3 Active Mission

The eighth 1200 Series Satellite Vehicle (SV-8) was placed into a nominal 85 x 150 NM orbit by the Titan III D Booster on 10 April 1974. Ascent events were all nominal and proper stabilization of the SV allowed initiation of deployment of the solar arrays at the first station contact. [redacted] The SSU Subsatellite (-Y) was properly ejected on Rev 13. Preflight mission planning envisioned a 60 day Mapping Camera mission, a 93 day Panoramic Camera mission, and a 3 day Solo operation. The Panoramic Camera operated throughout the mission. All RVs were successfully recovered on Days 15, 43, 70, and 106. The first RV was a water recovery while RV-2 thru RV-4 were aerially recovered. All the Panoramic Camera film was transported and recovered. All the Mapping Camera operations were normal and the entire film load, including 3414 Special Test Film, was transported into RV-5 and aerially recovered on Day 61.

1.5.4 Solo and Mission Termination

Limited Solo testing started after RV-5 recovery with the DBS redundant equipment testing and final turn off at Rev 1053.

Stellar Terrain testing started during the RV-4 segment; however, the failure of the Terrain Thermal Shutter emergency open function prevented the thermal evaluation test.

Quantic accomplished two maneuver experiments during this segment (1 Rev inertial hold and pitch maneuver) with SPO approval, and increased the amount and frequency of data collection. Redundant system performance tests and diagnostic tests on SGLS-2 were also accomplished.

Active Solo testing started after RV-4 recovery on Rev 1701 and continued until a successful SV deboost on Rev 1768, Day 110. All planned experiments were completed during the 4 days of Solo with emphasis placed on completing the Quantic testing that required extensive SV maneuvers.

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CAMERA OPERATIONS

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SECTION II

CAMERA OPERATIONS

2.1 INTRODUCTION

The Mission 1208 Satellite Vehicle was launched from VAFB, SLC-4E, at 1320 PST on 10 April 1974 using a Titan III D Booster Vehicle. The first Recovery Vehicle was successfully water retrieved and the remaining three recovery vehicles were successfully air retrieved within the predicted impact dispersions. Recoveries were on Days 15, 43, 70, and 106 respectively.

2.2 SUMMARY

During testing at the launch base, a leak was detected in the Forward Camera pneumatics and was determined to be between the high pressure isolation valve (HPIV) and the regulator. To prevent any loss of nitrogen gas during the mission, it was decided to operate with HPIV-A closed. With subsequently provided vendor data, the nitrogen gas leak was determined to be in the low pressure side of the regulator. Calculations, substantiated with on-orbit tests, showed that the magnitude of the leak would not cause any significant increase in gas usage rate. On Rev 563, HPIV-A was opened and the pneumatics system remained in its normal configuration for the remaining portion of the mission.

After insertion, the Sensor System (SS) was successfully uncaged. The constant velocity test on Rev 2 and the health check tests on Rev 4 were also accomplished successfully. Operational photography began on Rev 5, Op 4, and continued with no camera system malfunctions until Rev 980 when the system failed to execute two operations. The failure was determined to be a missing Forward Camera Take-up Builder Roller (BR) down verification interlock assembly (VIA) signal. Operations were resumed on Rev 996 with the system configured in SCC II with BR down VIA (disabled). When transfer to RV-4 was made, VIA was enabled and operated satisfactorily for the remaining portion of the mission.

On Rev 1268, the system shut down due to a failure of the Aft Camera Take-up Integrator Servo to reset at TU brakes off. This failure necessitated eliminating nested operations when operations were resumed on Rev 1300. The system continued to operate normally for the rest of the mission.

The Aft Camera Film Supply contained the following films: (1) a 2,588' segment of SO-255 Color Film and (2) a 3,036' segment of FE-3916 IR False Color Film. The operational intervals associated with the color films are presented in Table 2-1.

TABLE 2-1

COLOR FILM USAGE

Film Type	RV	Rev	Op	→ to →	Rev	Op	Footage
SO-255	4	1511	723		1596	747	2,588
FE-3916	4	1597	748		1684	774	3,036

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The active photographic mission was terminated with RV-4 recovery on Day 106 following depletion of both film supplies. A Solo phase of the mission extended the vehicle life to Day 110, at which time the vehicle was deboosted and re-entered.

2.3 ON-ORBIT OPERATIONS

2.3.1 Launch and Orbital Parameters

Appendix B presents a table of basic parameters including period, perigee, apogee, inclination, and argument of perigee. Figures B-1 and B-2 are provided for mission histories of beta angle, period, and perigee. Figure B-2 also shows the effects of the 43 orbit adjusts during the mission.

2.3.2 Mission Event History

The summary listing of all Sensor System photographic operations is presented in Appendix C. This listing primarily covers operational photography, but also includes SS and PFA engineering photography. The chronological description of these engineering operations plus other special events that occurred during Mission 1208 are given in the following paragraphs:

2.3.2.1 Ascent

Uncage (Seqs 204 and 205) and OB stow (Seqs 213 and 214) occurred in a normal manner following BV/SV separation. These events were verified from tape recorder playback at Rev 1 POGO.

2.3.2.2 Health Checks

Day 1 operations thru Rev 4 were designed to verify system health and confirm orbit operational readiness. An engineering operation designed as a baseline test was performed on Rev 8. The health check events were as follows:

A. Rev 1

An uncage verification check, Seq 215, was performed over POGO to confirm the uncage event.

B. Rev 2

A constant velocity run, Seq 208, was performed over KODI. This was the first attempt to transport film after launch. The Sensor System worked properly, and the film was correctly aligned within the film path. Steerers, tensions, and Take-up and Supply drive summed errors were well within limits.

C. Rev 4

The Sensor System health check, Seq 175, was performed over POGO. All Sensor System executed commands were functionally verified, including all tested bits of the variable commands. Focal plane position indicated 68 microns for the Forward Camera, and 25 microns for the Aft Camera.

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D. Rev 8

A scheduled engineering operation, Seq 209, was performed over COOK to provide characteristic telemetry data for comparison with data from any future identical functional check. In the event of an anomaly, the telemetry signatures of the two runs could then be equated and any suspected system degradation determined.

2.3.2.3 Engineering Tests

Twelve engineering tests were defined in the SV-8 Engineering Photography Plan. This series of tests was designed to acquire data for assessment of on-orbit camera, lens, and film performance. Table 2-2 presents a summary of the tests and their objectives.

TABLE 2-2

SUMMARY OF ENGINEERING TESTS

	Test	Objective	Status
1.	Thru Focus (1414)	Optimize focus.	Fully accomplished; confirmed focus (1414) was optimum in RV-2.
3.A	Smear Slits (1414)	Validate IMC settings.	Completed in RV-2.
3.B	Smear Slits (SO-255)	Evaluate smear slit for validating IMC settings with SO-255 Film.	No operations accomplished.
3.C	Smear Slits (FE-3916)	Evaluate smear slit for validating IMC settings with FE-3916.	Completed in RV-4.
4.	CORN Acquisitions (SO-255)	Evaluate and radiometrically calibrate SO-255.	Satisfactorily completed in RV-4.
5.	CORN Acquisitions (FE-3916)	Evaluate image quality of FE-3916.	Accomplished in RV-4.
6.	Lens MTF (1414)	Measure on-orbit lens MTF.	Completed in RV-3.
7.	Tucson Acquisition	Standard scene for quality assessment.	Satisfied in RV-1, RV-2, RV-3, and RV-4.
8.	Color Thru Focus (SO-255)	Optimize focus.	Completed in RV-4.
9.	Tribars for Resolution	Photo quality assessment.	Satisfied in RV-1, RV-2, RV-3, and RV-4. Acquisitions were in common with Test 7.
10.	Smear Versus Scan Angle (1414)	Assess smear as a function of scan angle location.	Fully accomplished. Completed in RV-3.

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TABLE 2-2 (CONT'D)

	Test	Objective	Status
12.	Dense Culture Acquisition (1414)	Photo/EM correlation.	Satisfied in RV-1, RV-2, RV-3, and RV-4.

2.3.2.4 Special Events

Table 2-3 lists the chronology of the health checks, engineering tests, and miscellaneous events accomplished during each of the four segments of the mission. The film footage used and the predicted and verified percentage of clear weather are provided where applicable.

TABLE 2-3

SUMMARY OF SPECIAL EVENTS

— Mission Segment 1208-1 —

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
0.8				Uncage/SCC 1 Sel		
0.8				Stow A/Stow B H PIV-A Close		
1				Uncage Verify		
2				Inhibited CV		102
4	1-3			SS Health Check		163
8	8			SS Engineering Test		63
14	13	1		1414 Thru Focus (-8, -16, -8, 0, +8, 0;)		
			75	Boston/Providence	90	54
16	14	1		1414 Thru Focus (+16,		
			95	+8, 0;) San Diego	90	29
56	42			PN Equalization		
81	54	1		1414 Thru Focus (-16,		
			85	-8, 0;) Sacramento	95	
			80	San Francisco	99	56
86	55			PN Equalization		
96	63	3A		1414 Smear Slits		
			70	Dallas/Ft Worth	99	81
97	64	3A		1414 Smear Slits		
			95	Los Angeles	99	
		10		1414 Smear Vs Scan		
			85	San Diego	99	124

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TABLE 2-3 (CONT'D)

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
129	84	7, 9, 12	95	Tucson With CORN Acquisition	99	
144	94	1	85	1414 Thru Focus (Fwd: -8, 0; Aft: +8, 0) Atlanta	99	27
				PN Equalization		
160	103	10	85	1414 Smear Vs Scan Baltimore	99	
			85	Washington	99	93
176	114	1	75	1414 Thru Focus (+16, +8, 0, -8, 0) New York	95	
		3A	75	1414 Smear Slits Philadelphia	95	121
184	115			PN Equalization		
225	130	1	80	1414 Thru Focus (+16, +8, 0, -8, -16) Detroit	99	34
225	131			Protective Wrap		108
				1208-1 Footage:		1,055
				Accumulated Footage:		1,055
				— Mission Segment 1208-2 —		
226				Transfer to TU-2, Prep I		
227				Complete Transfer, Prep II		63
248	139/141			PN Equalization		
281	156			PBF Fwd Set to 76 Per PFA Direction		
291				IT-Aft Set to -5 Steps Per PFA Direction		
313	165/166			PN Equalization		
338	175	12	70	Quality Variability Miami	75	38
356	187			PN Equalization		
428	224			PN Equalization		
435	228	10	70	1414 Smear Vs Scan New York	80	
		3A	70	1414 Smear Slits Philadelphia	30	144

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TABLE 2-3 (CONT'D)

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
451	234	3A		1414 Smear Slits		
			70	Boston	99	
			70	Providence	90	49
480				Leak Rate Test, 5 Sec		
493	254/256			PN Equalization		
496				Leak Rate Test, 180 Sec		
548	302	10		1414 Smear Vs Scan		
			65	Boston	99	
			65	Providence	99	
563				H PIVA Open		
566	311	3.1		1414 Lens MTF		
			95	Florence Lines	99	
		7,9,12	95	Tucson with CORN Acquisition	85	114
629	338	1		1414 Thru Focus (+12, +6, 0, -6, 0)		
			75	Boston	99	
			75	Providence	99	46
631	339	10		1414 Smear Vs Scan		
			75	Los Angeles	85	88
647	346	6.1		1414 Lens MTF		
			95	Luke With CORN Acquisition	99	52
				1208-2 Footage:		702
				Accumulated Footage:		1,757
				— Mission Segment 1208-3 —		
678				Transfer to TU-3, Prep I		
679				Complete Transfer, Prep II		63
696	372	12		Quality Variability		
			90	Sacramento/Bay Area	80	30
728	388	6.2		1414 Lens MTF		
			95	Kingman with CORN Acquisition	99	
		6.3		1414 Lens MTF		
			95	Quartzsite with CORN Acquisition	85	78

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TABLE 2-3 (CONT'D)

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
744	397	7,9,12	90	Tucson with CORN Acquisition	99	29
752				Fwd Cross-Track Set to +2 Steps Per PFA Direction		
888	456	10		1414 Smear Vs Scan Aft Mono, -37°		
			75	New York	85	83
980	491			ESD		
989				Fwd Mono Constant Velocity		
989				Aft Mono Constant Velocity		12
991				Fwd Mono CV Via Disabled		12
993				SCC-II Select Fwd Mono CV Via Enabled		
995				SCC Health Check Via Disabled		163
1003	502	6,1		1414 Lens MTF		
			95	Florence with CORN Acquisition	95	50
1020				Fwd Mono CV Via Enabled/Disabled		12
1092				PN Equalization		

1208-3 Footage: 437(Fwd)/478(Aft)

Accumulated Footage: 2,144(Fwd)/2,235(Aft)

— Mission Segment 1208-4 —

1115				Transfer to TU-4, Prep I Via ENA		
1116				Complete Transfer, Prep II		63
1181	620	7,9,12	99	Tucson with CORN Acquisition	99	29
1268	641			PN Equalization Aft ESD		
1277				PN Equalization		
1279				Aft Creep		
1283				Aft Creep		2
1287				Dither Test		

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TABLE 2-3 (CONT'D)

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
1295				Fwd CV Released for Fwd Mono Opn Aft Jog		64
1299				Aft Creep		7
1300				SS Engineering Released for Stereo Opn		66
1309	651	3A		1414 Smear Slits (-16, -8)		
			75	Baltimore	99	
			75	Washington	99	37
1461				PN Equalization		
1487	719	3A		1414 Smear Slits (+16, +8, 0)		
			65	New York	65	43
1501				Transfer to SO-255		
1528				PN Equalization		
1554	733	4, 12		SO-255 Color with CORN Acquisition		
			99	Livermore	99	37
1570	741	4		SO-255 Color with CORN Acquisition		
			95	Van Nuys		
		8		SO-255 Thru Focus (+14, 0, -14)		
			95	Los Angeles	99	67
1585	745	4, 8		SO-255 Color with CORN Acquisition Thru Focus (+14)		
			95	St. Louis	95	81
1596				Transfer to FE-3916		
1633	756	3C		FE-3916 Smear Slits		
			75	Philadelphia	95	31
1635	758	5		FE-3916 with CORN Acquisition		
			90	Stockton	99	29
1651				PN Equalization		
1656				PN Equalization		

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TABLE 2-3 (CONT'D)

Rev	Op Number	Test Number	Predicted Wx (%)	Event (location)	Verified Wx (%)	Footage
1667	764	5		FE-3916 with CORN Acquisition		
			65	Tucson	95	29
1667				PN Equalization		
1700				Prep II Constant Velocity		Depleted

1208-4 Footage: 596(Fwd)/605(Aft)

Accumulated Footage: 2,740(Fwd)/2,840(Aft)

2.3.2.5 Solo Phase

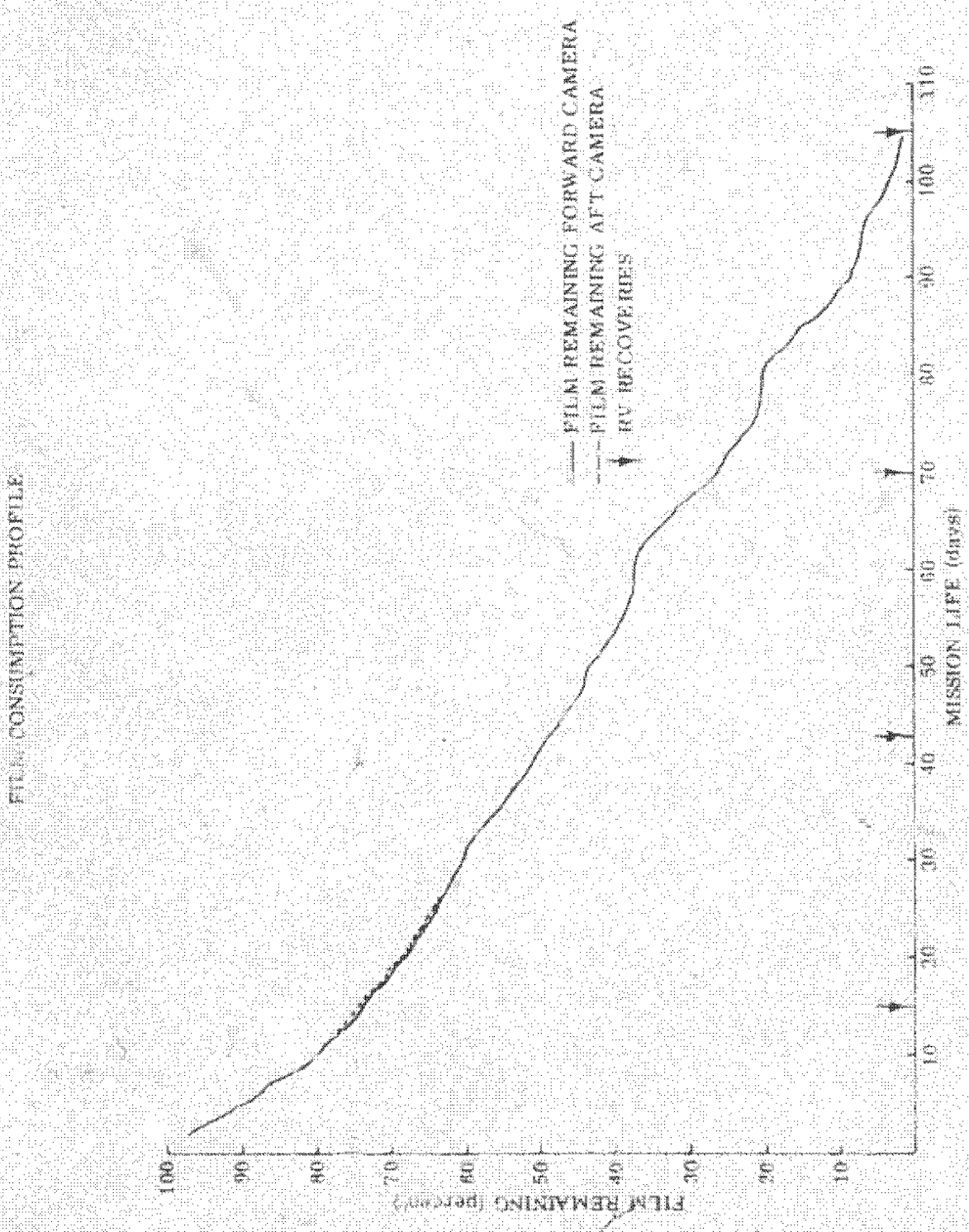
No Solo phase experiments were performed for the Panoramic Camera on Mission 1208.

2.3.3 Mission Expendables

The profile of film consumption over the life of the mission is shown in Figure 2-1. The film footages recovered in each of the four mission segments is shown in Table 2-4. The film footage used for engineering and other non-intelligence uses is summarized in Table 2-5. The distribution of film footage as a function of the various operating modes is presented in Figures 2-2 and 2-3. Figures 2-4 thru 2-13 present data and cumulative frequency distributions relative to solar elevation, vehicle altitude, latitude, slit steps (width), and Vx/h. Data on land mass coverage and fully framed targets versus scan sectors is given in Figures 2-14 and 2-15, respectively. Table 2-6 is a tabulation of the land mass by scan sector.

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TABLE 2-4

FILM USAGE SUMMARY

Segment	Rev Span	Camera	Recovered Footage
RV-1	Launch - 225	Forward	28,042
		Aft	28,111
RV-2	226 - 674	Forward	28,854
		Aft	27,758
RV-3	675 - 1116	Forward	25,258
		Aft	24,225
RV-4	1117 - 1700	Forward	26,827
		Aft	26,618

TABLE 2-5

NON-INTELLIGENCE FILM USAGE

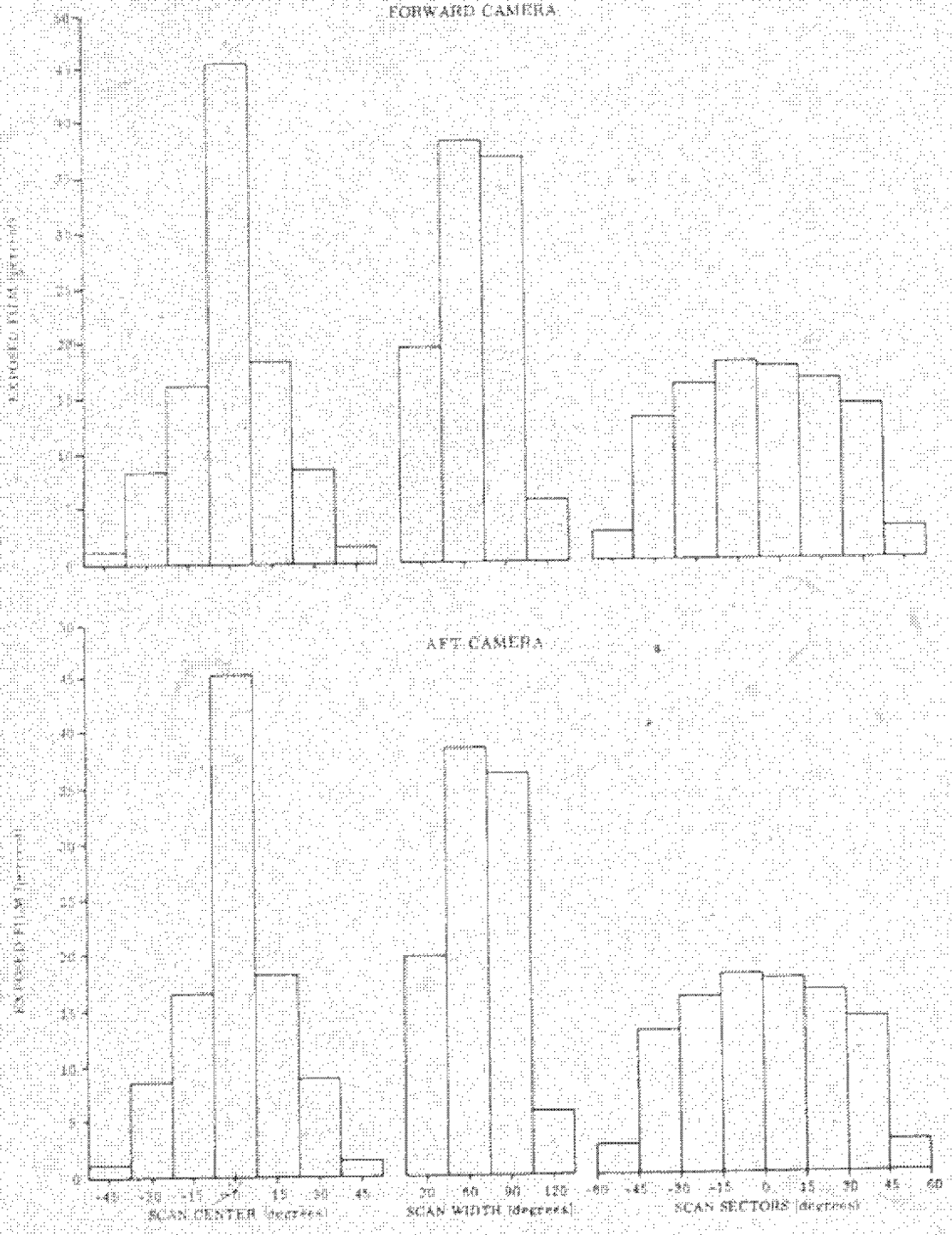
(feet)

Event	Forward Camera	Aft Camera
Pre-Launch	1,829	1,970
PFA Engineering		
RV-1	1,055	1,055
RV-2	702	702
RV-3	437	476
RV-4	596	605
Total Utilization	4,643	4,831
Film Recovered	108,981	106,712
Percentage of Non-Intelligence	4.26	4.53

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PHOTO FOOTAGE DISTRIBUTION VERSUS SCAN WIDTH/SCAN CENTER/SCAN SECTOR

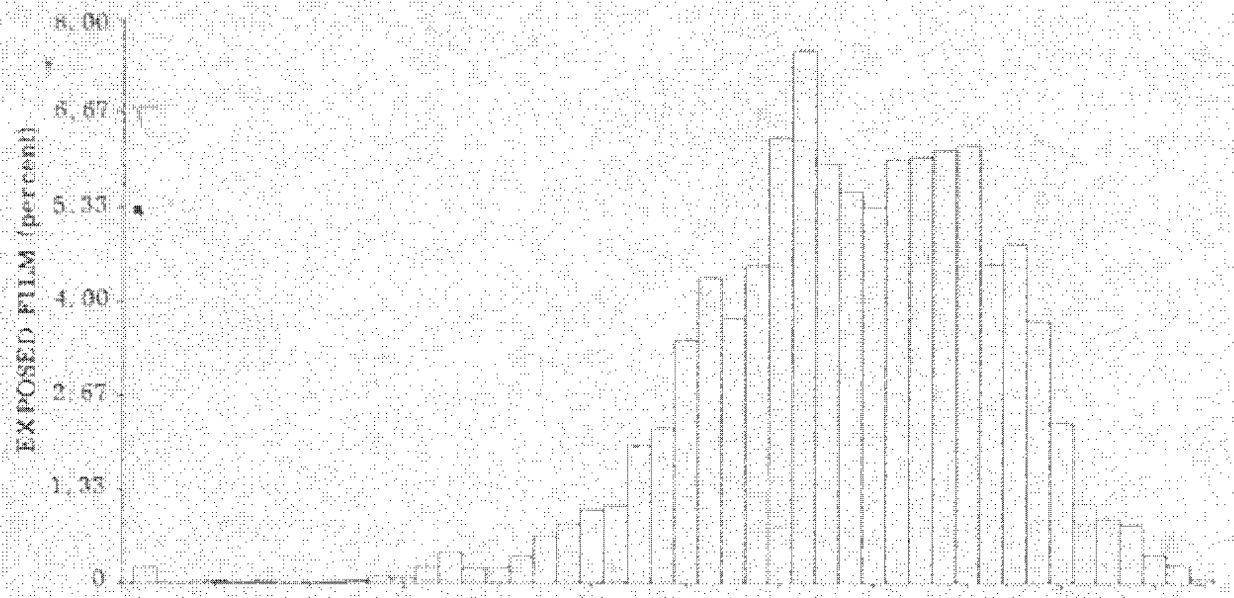


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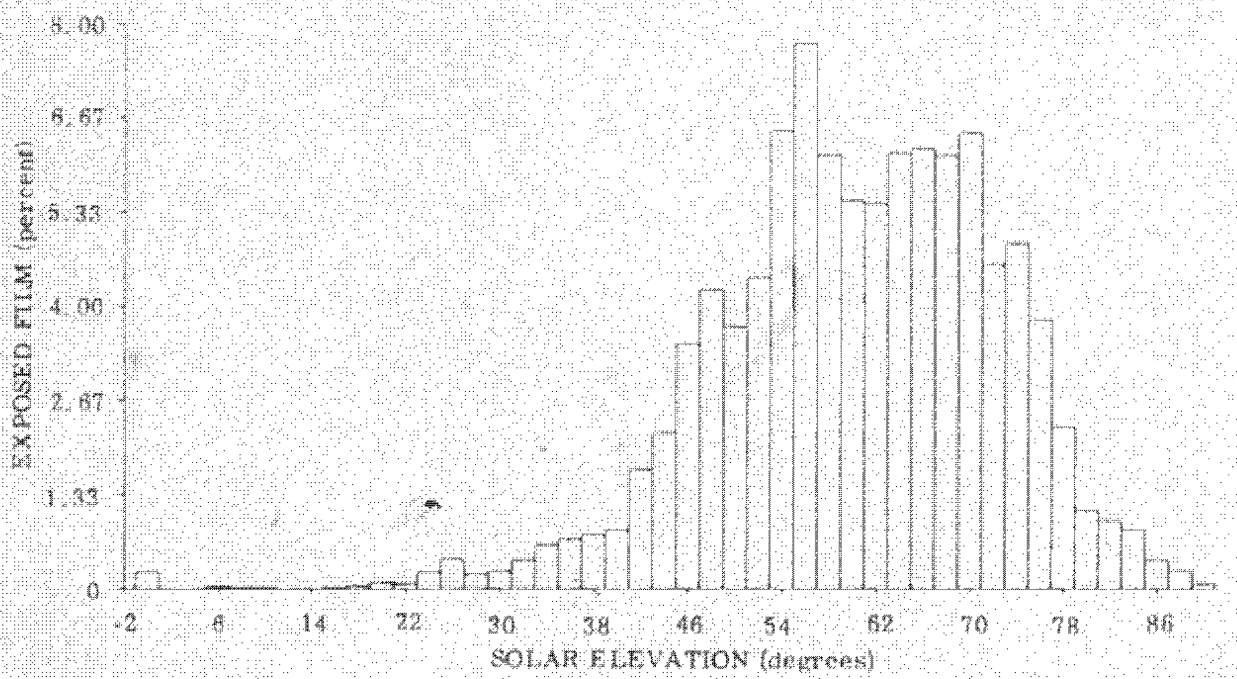
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PERCENTAGE OF EXPOSED FILM VERSUS SOLAR ELEVATION

FORWARD CAMERA



AFT CAMERA



BYE 15256-75

FIGURE 2-4

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CUMULATIVE FREQUENCY DISTRIBUTION

SOLAR ELEVATION

FORWARD AND AFT CAMERAS

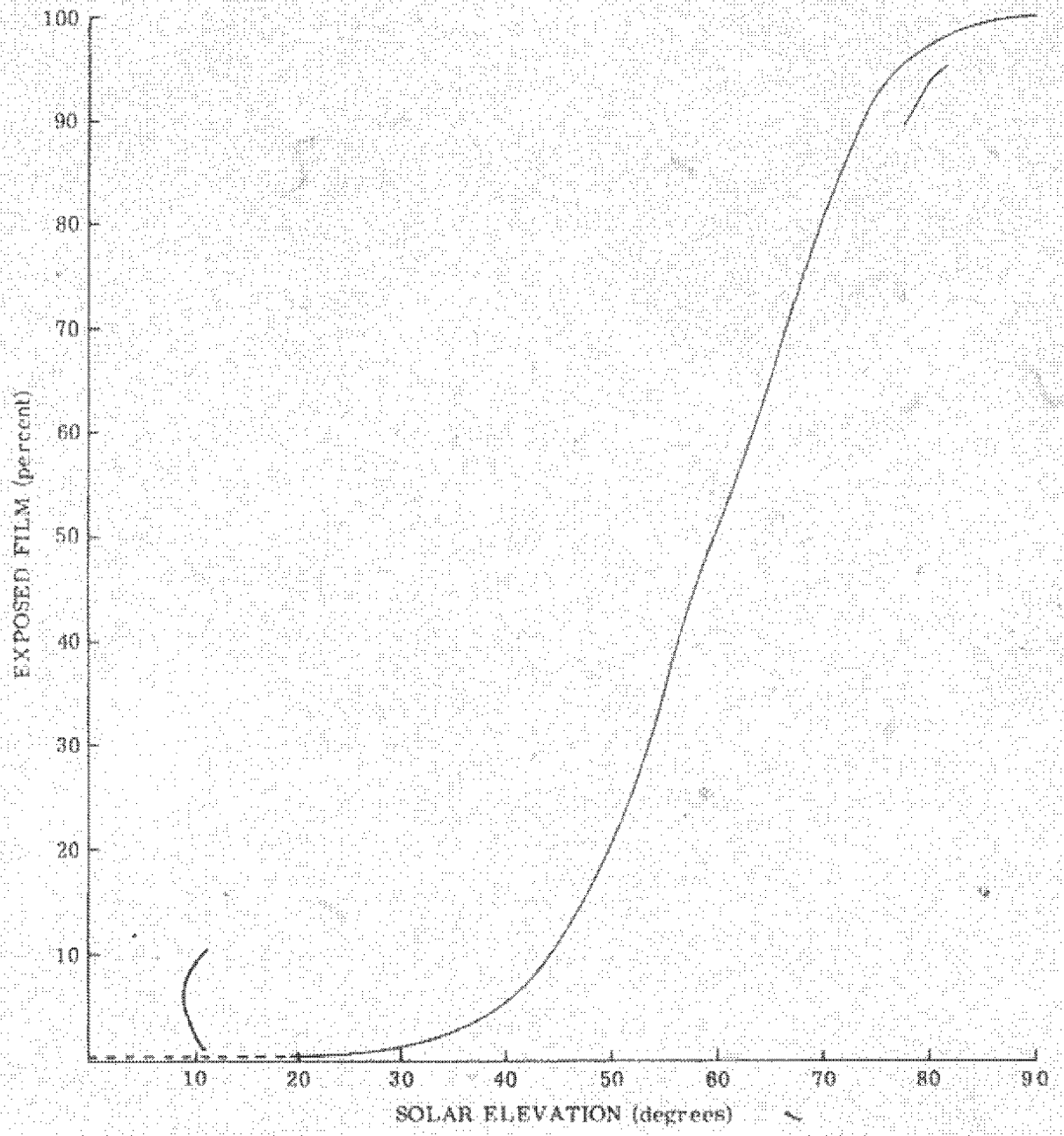


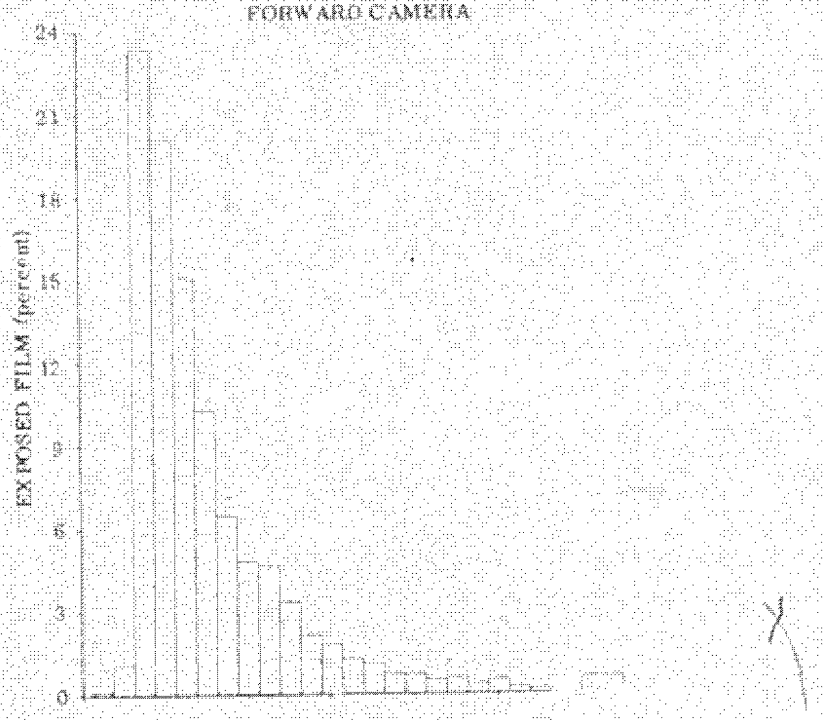
FIGURE 2-5

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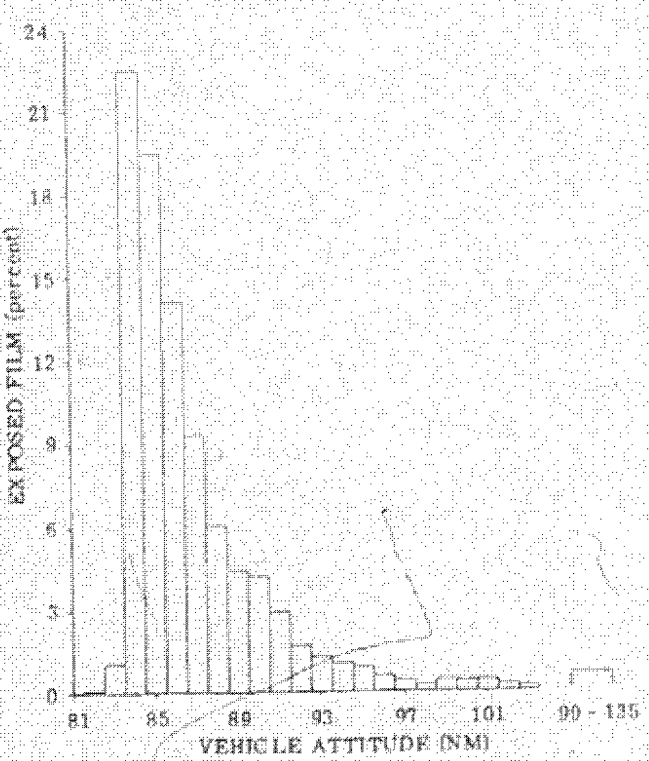
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PERCENTAGE OF EXPOSED FILM VERSUS VEHICLE ALTITUDE

FORWARD CAMERA



AFT CAMERA



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POST FLIGHT ANALYSIS REPORT
1208

CUMULATIVE FREQUENCY DISTRIBUTION

VEHICLE ALTITUDE

FORWARD AND AFT CAMERAS

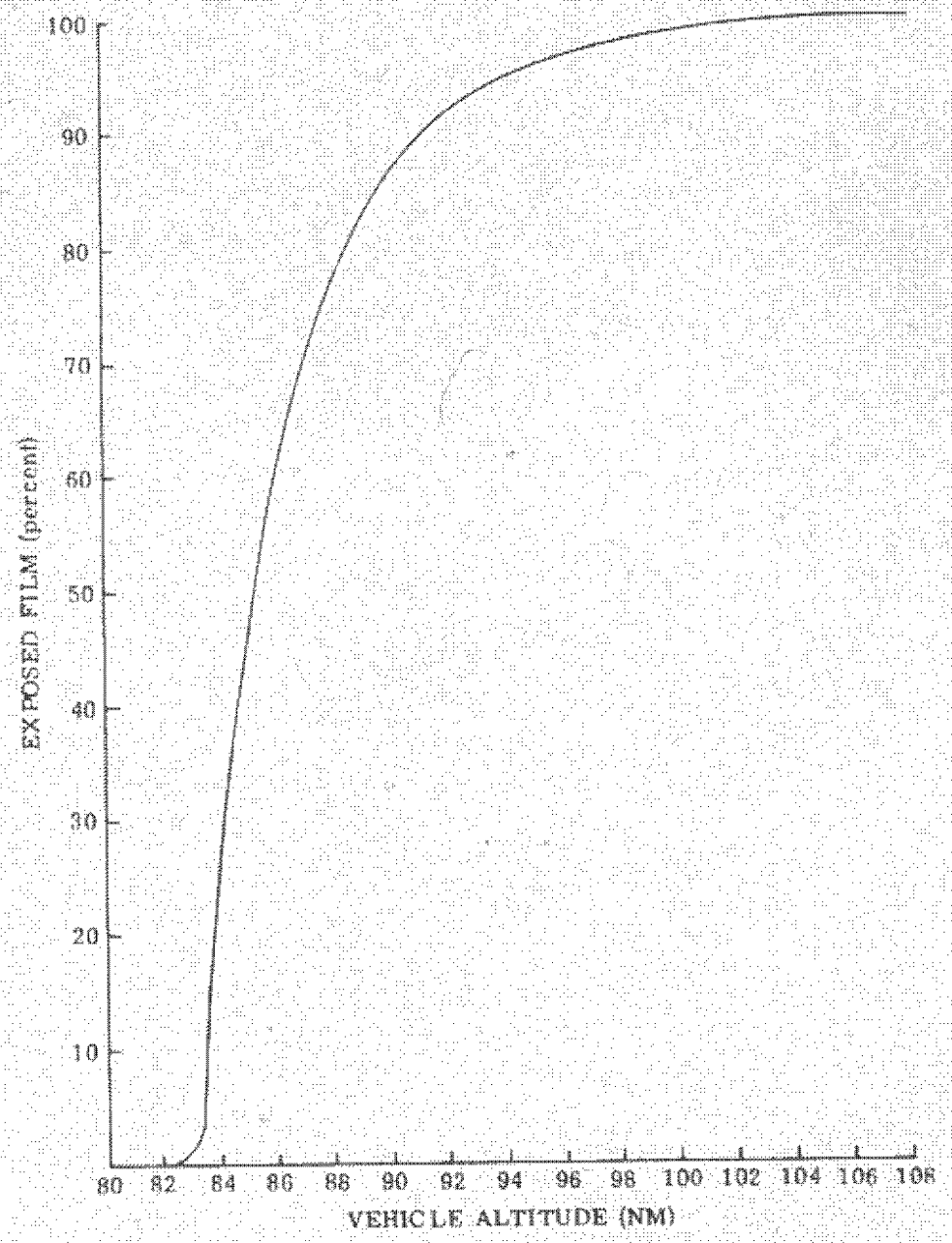
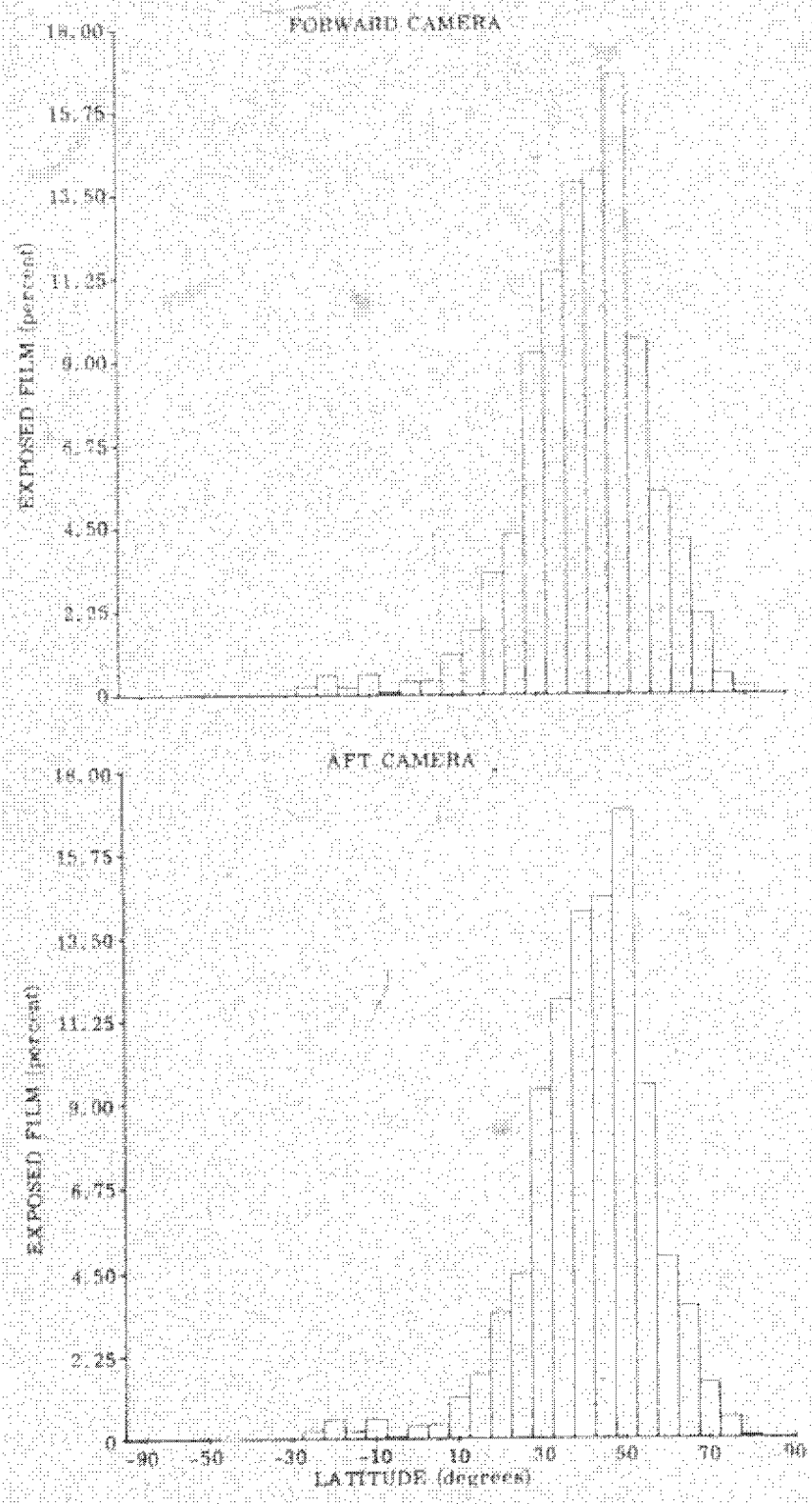


FIGURE 2-7

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PERCENTAGE OF EXPOSED FILM VERSUS LATITUDE



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~~TOP SECRET~~ - HEXAGON

FIGURE 2-8

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POST FLIGHT ANALYSIS REPORT
1208

CUMULATIVE FREQUENCY DISTRIBUTION

LATITUDE

FORWARD AND AFT CAMERAS

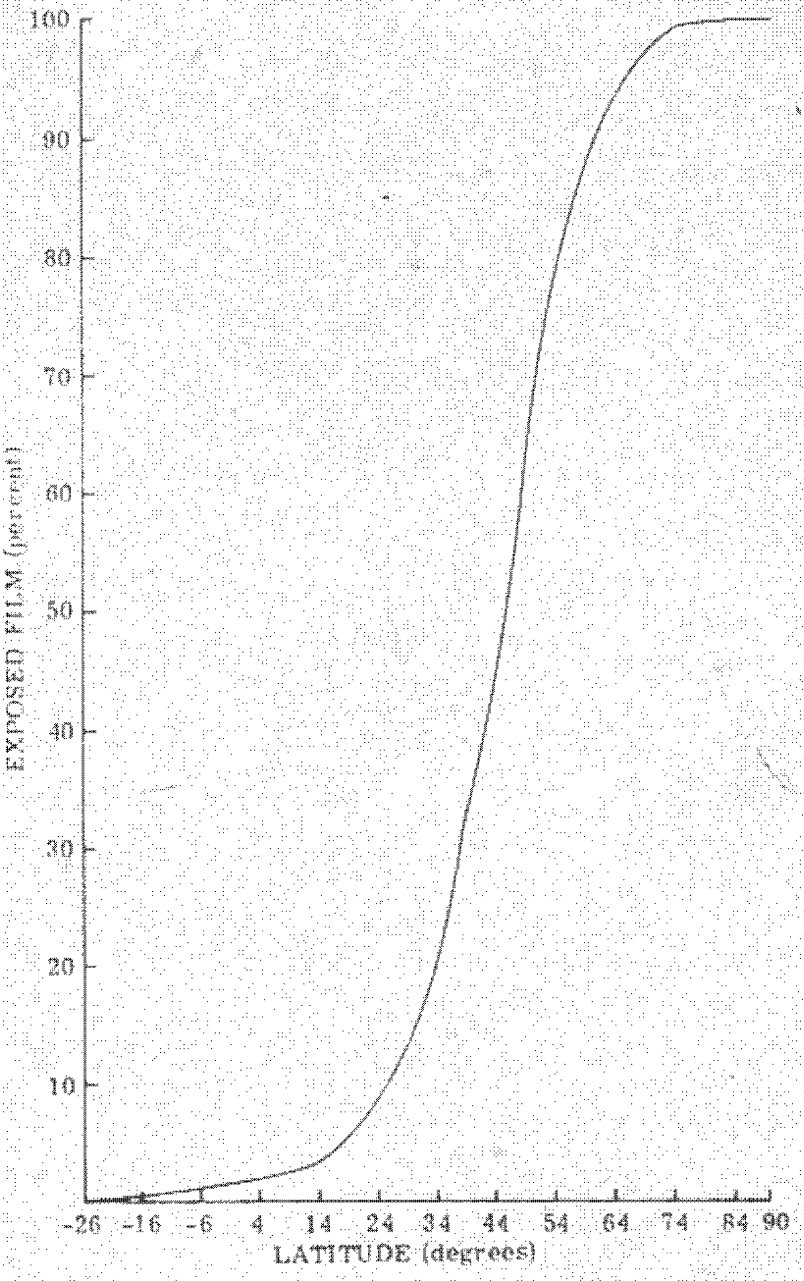


FIGURE 2-9

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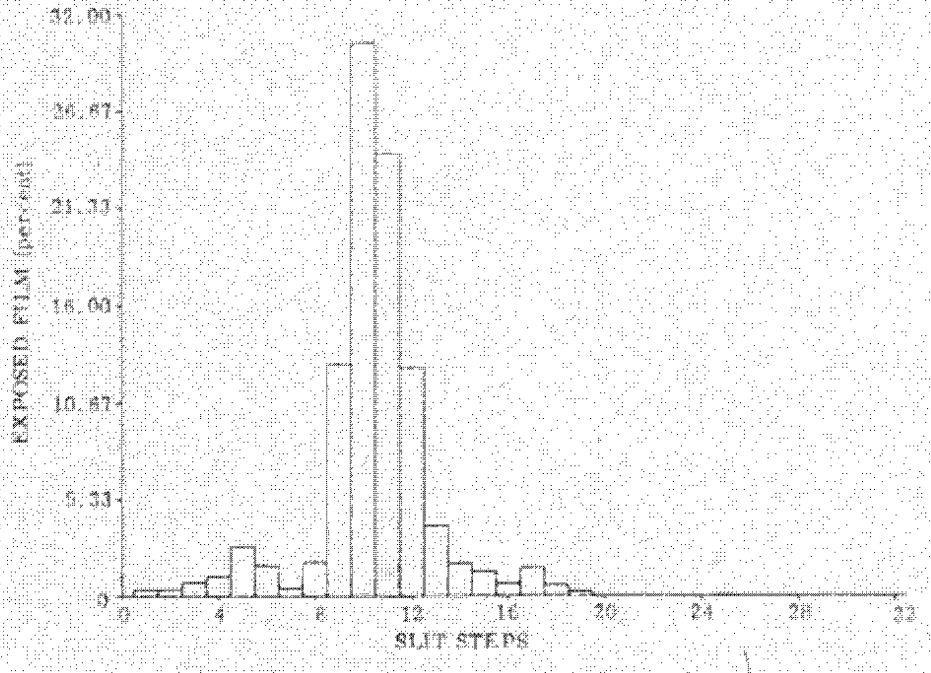
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PERCENTAGE OF EXPOSED FILM VERSUS SLIT STEPS

FORWARD CAMERA



AFT CAMERA

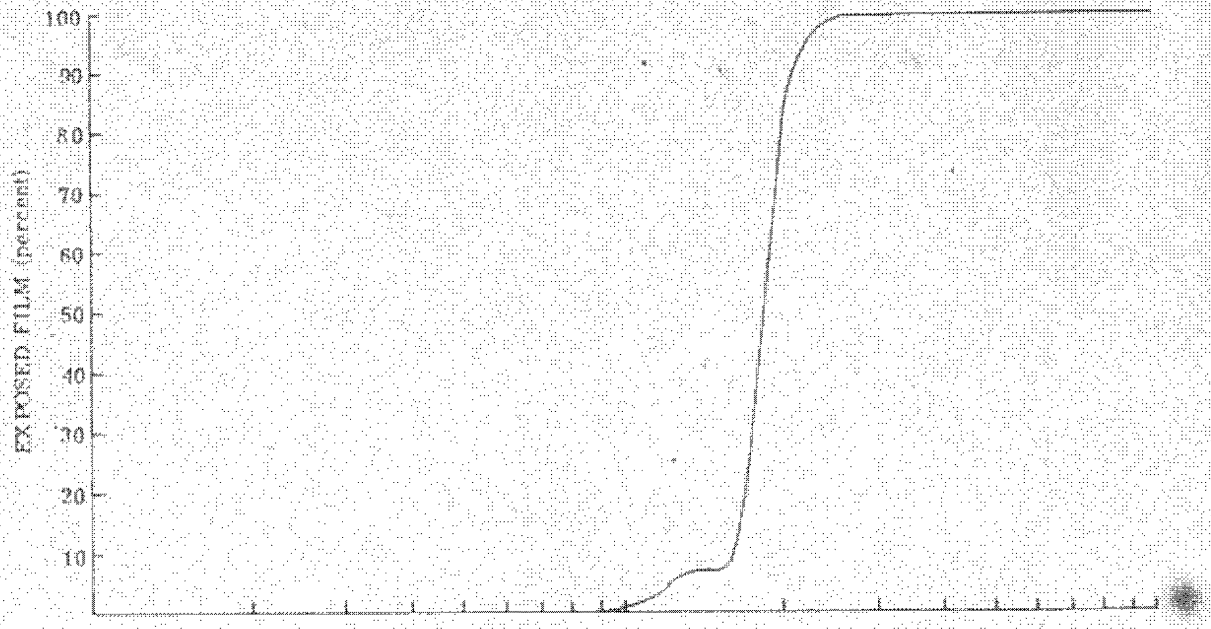


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CUMULATIVE FREQUENCY DISTRIBUTION SLIT WIDTH

FORWARD CAMERA



AFT CAMERA

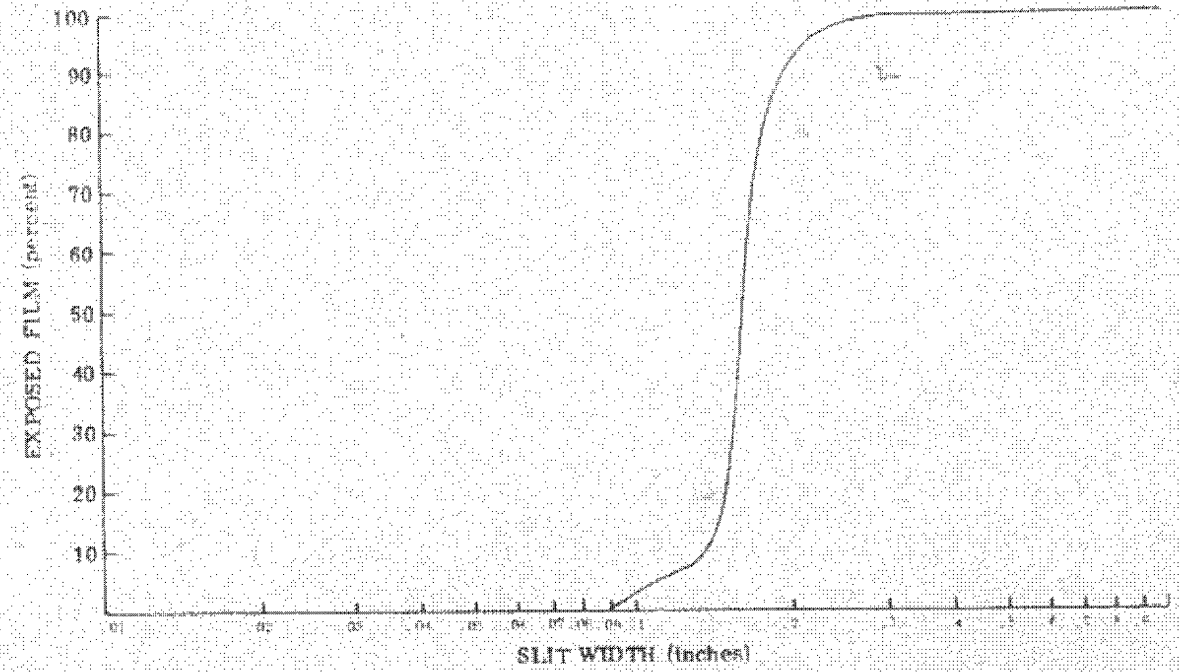


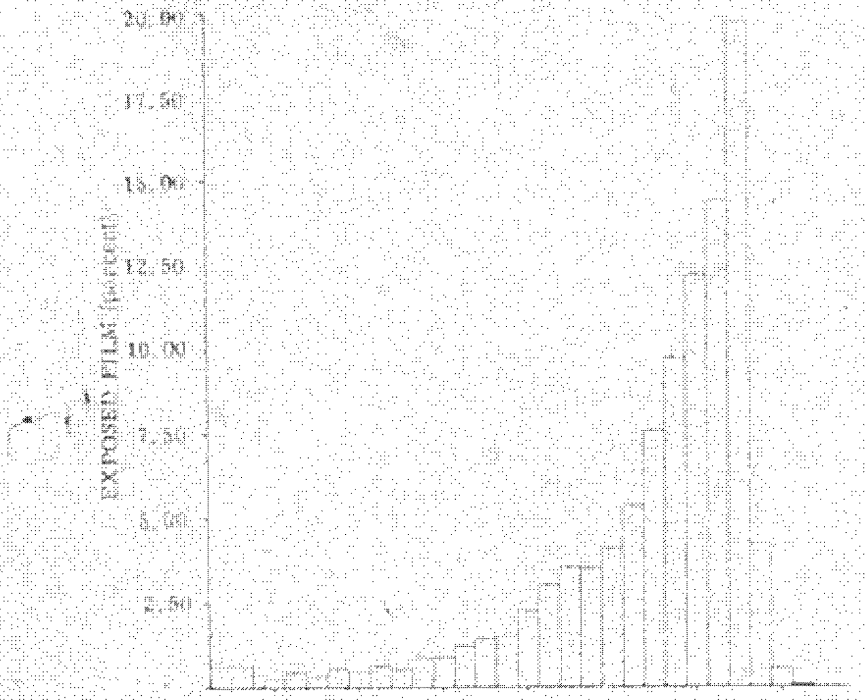
FIGURE 2-11

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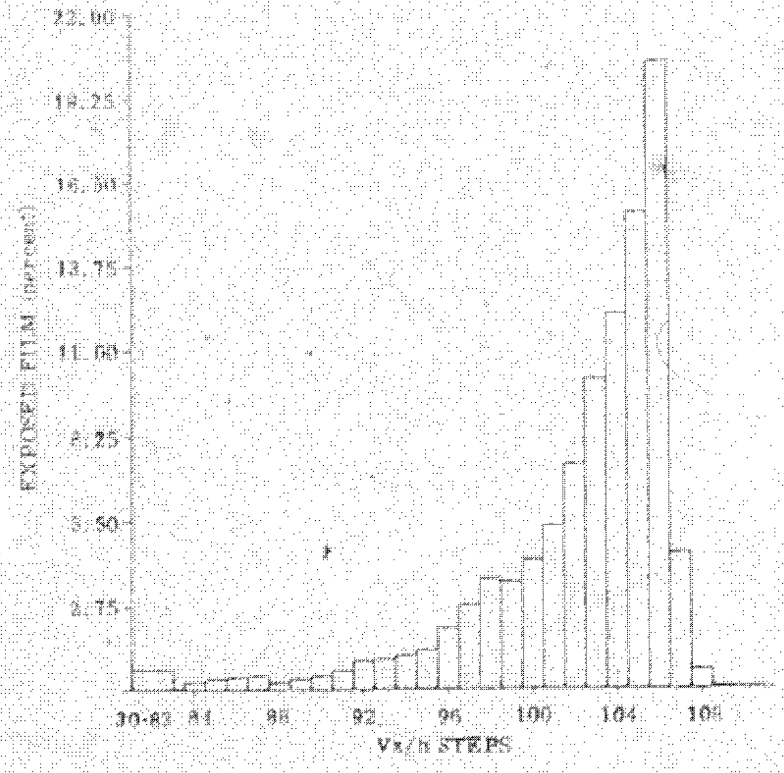
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PERCENTAGE OF EXPOSED FILM VERSUS Vx/h STEPS

FORWARD CAMERA



AFT CAMERA



BYE 15258-75

~~TOP SECRET~~ HEXAGON

FIGURE 2-12

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CUMULATIVE FREQUENCY DISTRIBUTION
Vx/h

FORWARD AND AFT CAMERAS

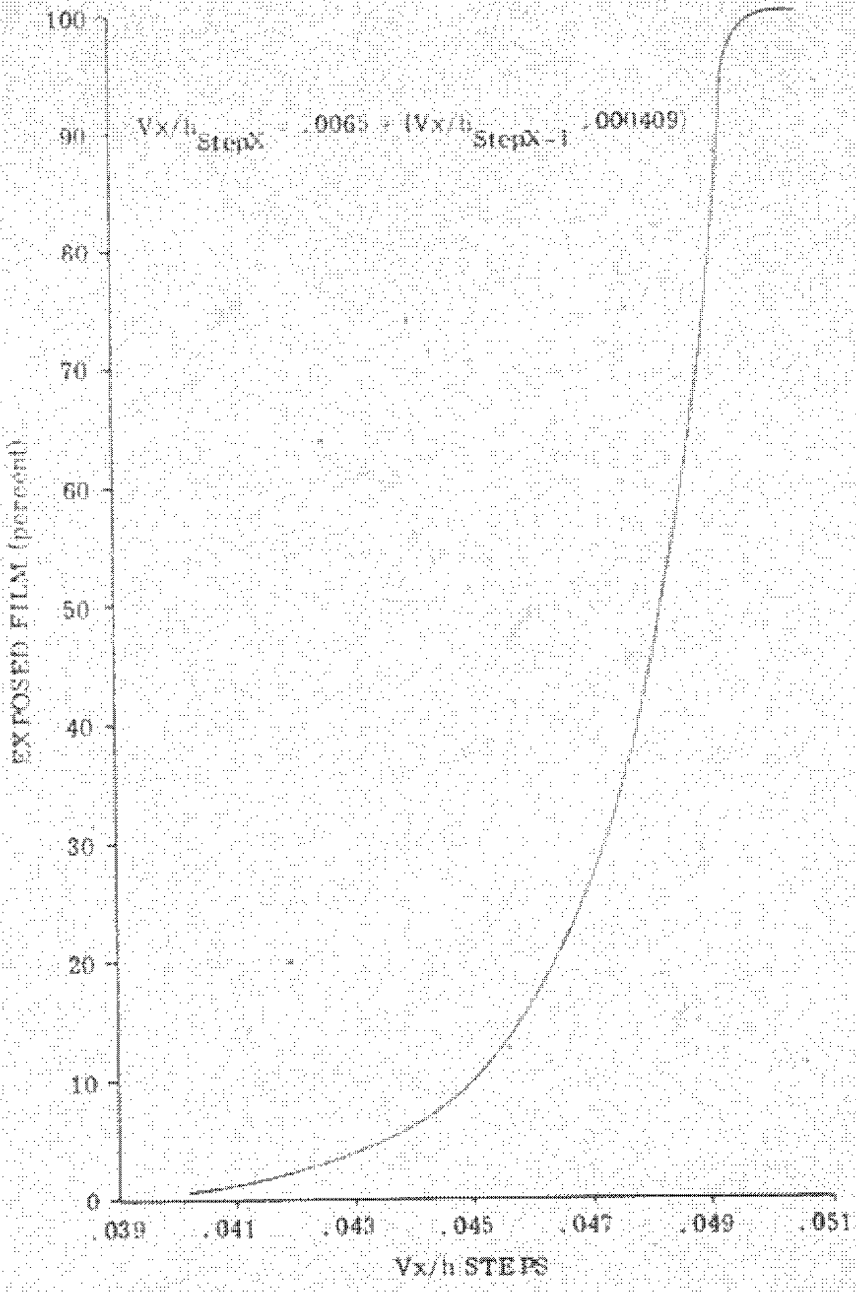


FIGURE 2-13

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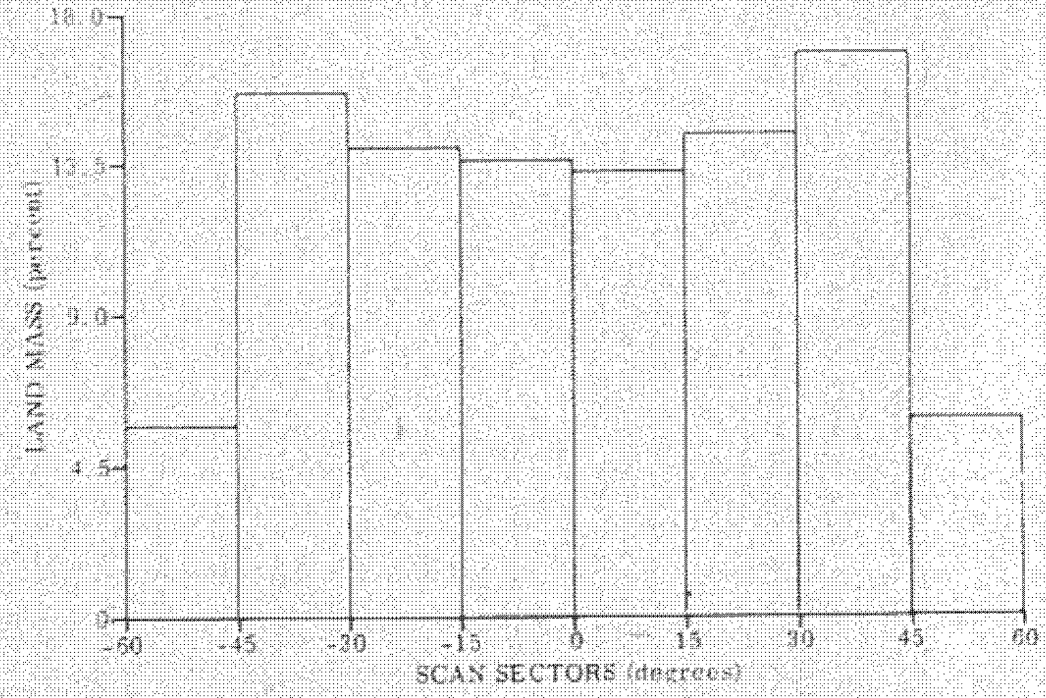
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DISTRIBUTION OF LAND MASS COVERAGE AS A FUNCTION OF SCAN SECTORS

FORWARD CAMERA



AFT CAMERA



BYE 15256-75

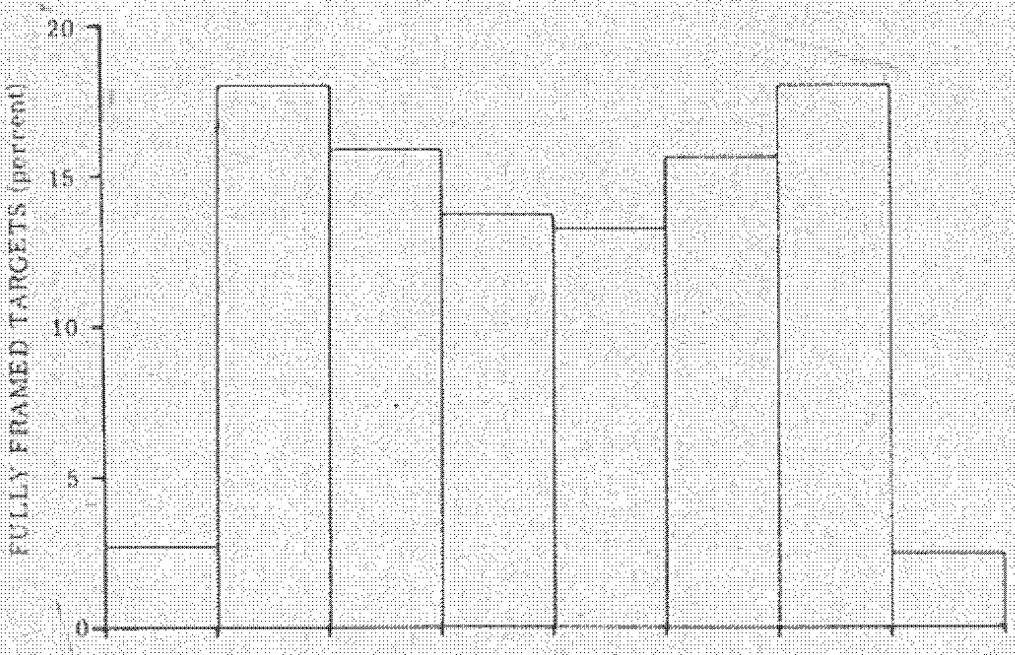
FIGURE 2-14

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DISTRIBUTION OF FULLY FRAMED TARGETS VERSUS SCAN SECTORS

FORWARD CAMERA



AFT CAMERA

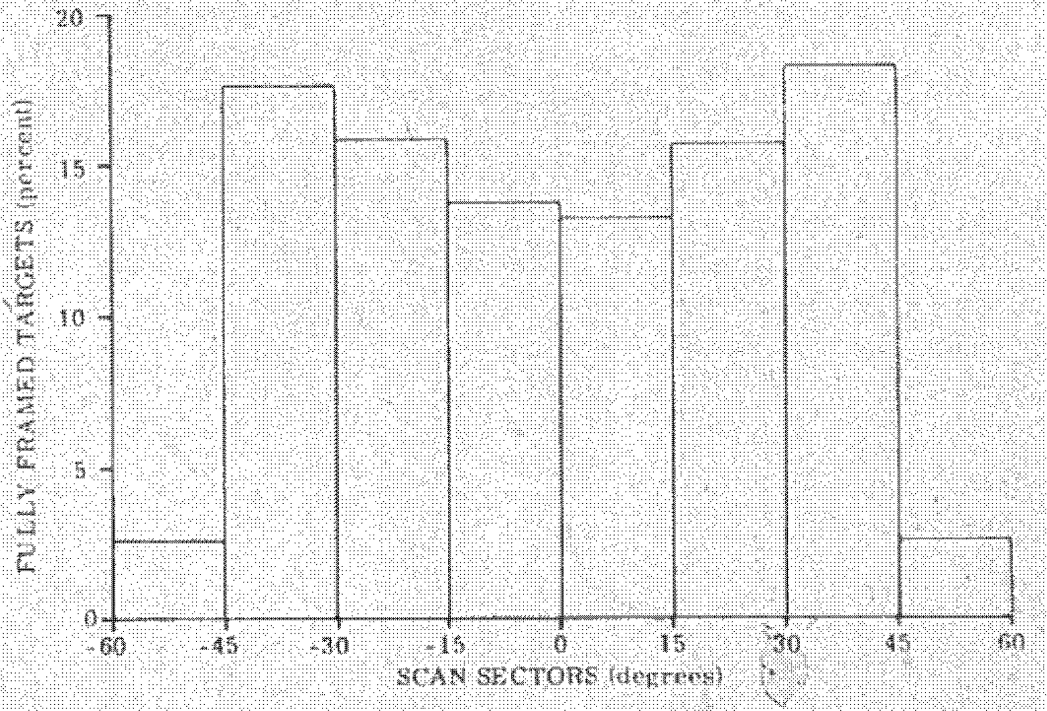


FIGURE 2-15

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TABLE 2-6

DISTRIBUTION OF LAND MASS COVERAGE BY SCAN SECTORS

Scan Sector (degrees)	Land Mass (%)
-60 to -45	5.5
-45 to -30	15.5
-30 to -15	14.5
-15 to 0	14.3
0 to 15	13.7
15 to 30	13.5
30 to 45	17.0
45 to 60	6.0

2.4 SENSOR SUBSYSTEM ANOMALIES

2.4.1 Loss of Take-up Builder Roller Down Verify Signal

2.4.1.1 Introduction and Summary

The camera film transport system failed to start up on 10 June 1974 during Rev 980 on planned Op 491 which was the second of three operations planned for this revolution. The previous operation executed properly and unexecuted Op 491 was normal through the start-up of the optical bars; however, the system failed to move film at film transports on. During start-up, the seal door and pneumatics on verifications were normal; during shutdown the optical bars stowed at the proper time. Since the commands for planned Op 492 had also been loaded, the system tried to execute this next operation but experienced the same phenomenon as that of Op 491.

This phenomenon was caused by the lack of a Forward Camera Builder Roller down verify signal. The anomaly analysis and the on-orbit engineering tests were accomplished in slightly less than one day. Mission operations were resumed on 11 June 1974 and Op 491 was executed with the Forward Camera verification interlock disabled. The remainder of this mission segment (RV-3) was completed in this mode, with no recurrence of the problem. Normal interlock verification was implemented in RV-4. Tests were conducted on the Take-up after its recovery in an effort to determine the details of the malfunction; however, the problem was intermittent and could not be reproduced during this testing. Therefore, it was not possible to further define the cause of failure.

2.4.1.2 Analysis and On-Orbit Testing

It was determined from telemetry of planned Op 491 that the seal door did not close at the film transports off command but remained open until camera power off, indicating a malfunction in the verification interlock. Normally at film transports off the supply velocity generator produces an "end VP"

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signal, which is necessary for the closing of the seal door. No velocity profile was generated here and therefore no "end VP" reached the seal door logic. The fact that the seal door did close at camera power off precludes the possibility that mechanical failure prevented closing of the door.

The film transport interlock system will not allow film transport to start unless signals are present indicating that the seal doors are open, the pneumatics are on, and the Take-up Builder Rollers are down. In this case, the discrete verifications indicated that the pneumatics were on and that the seal door was open. Therefore, the possible failure modes were either no builder roller down verify or a failure in the sequencer interlock logic. Since there is no builder roller down verify telemetry signal, on-orbit tests were run to isolate the cause of the malfunction.

Monoscopic constant velocity runs were attempted on each camera with the verification interlocks enabled. Failure of the Forward Camera to run and normal operation of the Aft Camera isolated the problem to the Forward Camera. The Forward Camera was operated with the verification interlock disabled; it then ran properly. This further isolated the problem to the lack of a builder roller down verify. To assure that the problem was not with the verify circuitry contained within the SCC box, the system was switched to the redundant SCC system and another Forward Camera monoscopic run attempted (with SCC II and VIA enabled). Failure of this run to execute confirmed that the problem was not in the SCC. During Rev 1020, an engineering test run was made with the verification interlock enabled and the system ran properly. Therefore, the problem was either intermittent or had gone away. No further on-orbit testing was performed.

2.4.1.3 Conclusions

Upon receipt of the Take-up at the processing facility, a visual inspection was made of the builder roller and the verify microswitch. The use of infrared photography and viewing aids allowed this inspection to be done prior to the despooling of the film so as to avoid caging of the builder roller prior to the inspection. The condition of the builder roller was found to be normal. To minimize any effect on the areas of the Take-up in question, the builder roller was caged electrically instead of mechanically which is the normal method. After despooling, extensive electromechanical testing was done in an attempt to isolate the cause of failure. Again, to minimize the chance of disturbing the Take-up, a number of these tests were conducted before the Take-up was removed from the RV and other tests were performed immediately after removal. This testing was extensive, however, it was not possible to reproduce the malfunction and therefore no further isolation of the cause was possible.

Malfunction of the builder roller down microswitch is the most probable cause with the possibility that the failure was elsewhere in the builder roller verify circuitry.

2.4.2 Tension Integrator Reset Failure

2.4.2.1 Introduction and Summary

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During the start-up of an operation planned for Rev 1268, a low tension condition caused an emergency shutdown on the Aft Camera. The under-tension condition was due to a decreased Take-up linear film velocity with respect to the Supply. The Take-up control system alters the film velocity command through tension feedback to compensate for tension offsets in the system. The integral portion of the feedback caused the decreased Take-up film velocity.

Integration of a tension offset begins when power is applied to the camera. The compensation, however, is only applicable when the film transports are on. Because there is normally a small tension sensor offset at camera power on and a time delay between power on and film transports on, the integrator output at the time of film transports on can be substantial. This integrator output must be reset to zero and is automatically pulsed upon application of Take-up brake release power. It was the combination of the loss of this reset signal and an unusually long time between camera power on and film transport on that resulted in a decreased Take-up velocity large enough to cause an ESD.

In this particular case, the time between camera power on and film transports on was in excess of 120 seconds as opposed to a normal maximum of approximately 20 seconds. The long time was commanded to allow the film path to pressurize before moving film, see paragraph 2.5.6.1. Although the offset at camera power on was small, the integrator output at film transports on was saturated. The failure to reset this saturated integrator output with brake release power caused the undertension ESD.

2.4.2.2 Data and Analysis

The data available from telemetry included the summed error and the adaptive tachometer output, but not the integrator output. The integrator output is available only from operations occurring over telemetry stations (telemetry Mode B) and this particular operation employed telemetry Mode C. Without the integrator output telemetry, the reset failure could not readily be determined.

Analysis of subsequent engineering operations run for diagnostic purposes in telemetry Mode B revealed the reset failure. The first engineering operation run also had an emergency shutdown during start-up, but the cause was an overtension condition. The overtension condition also was caused by the reset failure. Even though the integration time was more nominal, a large undertension condition existed and the integrator output at film transports on sped up the Take-up to compensate for the undertension condition. Without the reset, the Take-up overcompensated by taking up film much too fast and caused the overtension emergency shutdown.

Another engineering operation was designed to move just the right amount of film so that the system would be shut down with the tension near nominal. After this operation was successfully run, normal operations continued with the time between camera power on and film transports on constrained to a maximum of seventeen seconds. This constraint was based on analysis indicating that with tension between 2.2 and 2.8 pounds and the integration time no greater than 17 seconds, the Take-up would

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recover from any integrator compensation present at brake release. The remainder of Take-up four operations were executed without incident.

2.4.2.3 Conclusions

In postflight functional testing of the Take-up electronics, the reset signal anomaly was repeated. The fault was isolated to the brake control section, which contains the relay triggered by brake power for the integrator reset, see Figure 2-16. Further testing at the component level isolated the problem to a faulty relay. The relay was damaged either during initial assembly or rework, otherwise a manufacturing defect might have caused failure of the glass metal seal of one of its terminals.

2.4.3 Plus Density Markings

2.4.3.1 Description

Small plus-density marks were found on processed film from both the Forward and Aft Cameras. These appear to be the same as the plus density or "black spots" that were first observed on film from Mission 1207. As on 1207, they appear individually and also in closely spaced groups, are of medium to high density, and range in size up to about 24 microns.

2.4.3.2 Status of Investigation

Presently, the cause of this anomaly is not known. Its investigation is still underway and to date, the following has been revealed:

A. The marks occur only on 1414 Film. They were not observed on either SO-255 Color or FE-3916 IR False Color.

B. They have been observed on flight film and Chamber A-2 film. This means that they have been observed only on film that has passed through the camera system and has been dual gamma processed. Testing done by the film manufacturer has failed to produce them.

C. When the spots occur, their distribution is not uniform across the minor axis of the film. In most cases, the center of the film is most severely affected; the film near one edge has significantly less marking and the other edge is essentially clean.

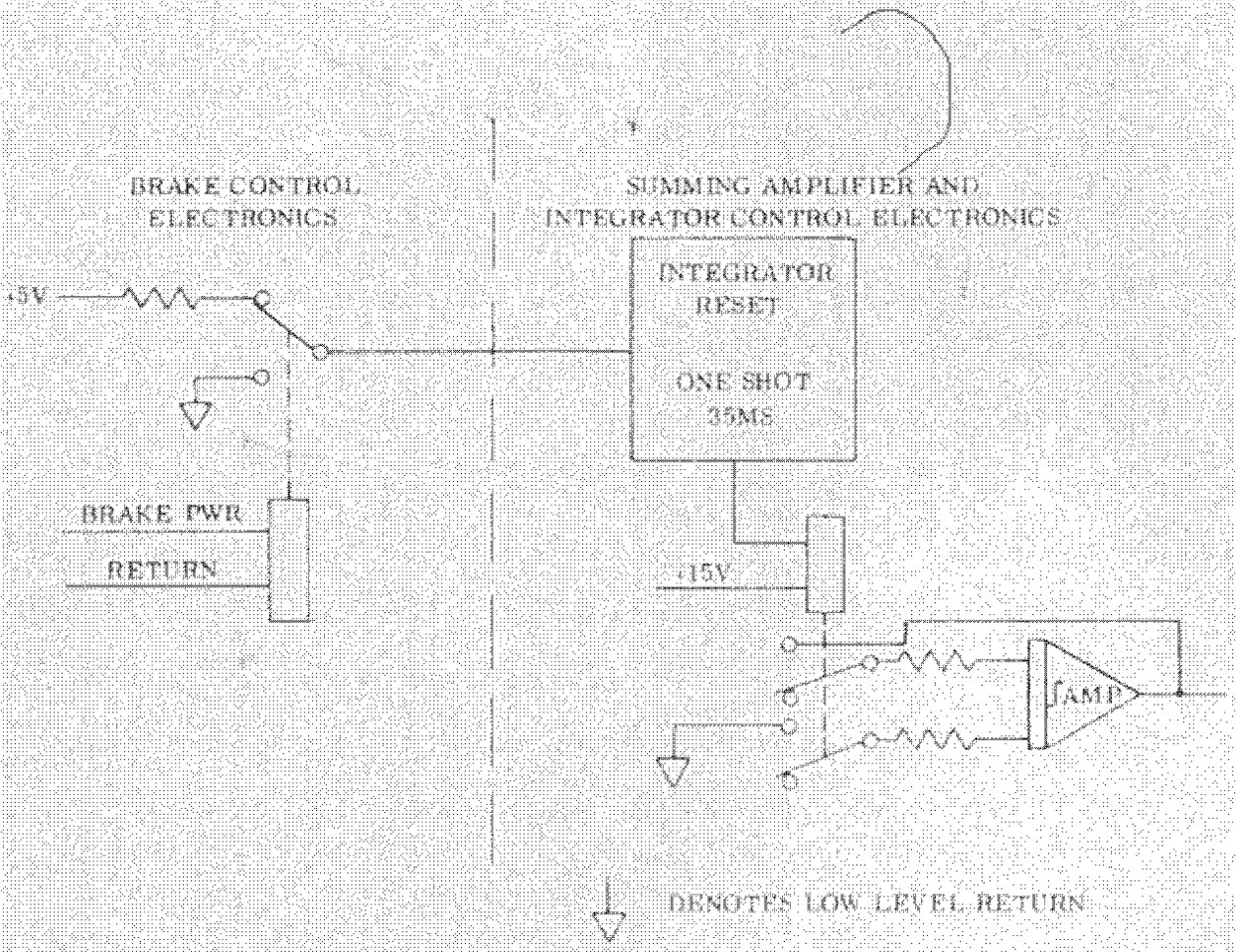
D. The anomaly does not continue throughout the mission. In general, it is either quite severe or does not appear on the film. One case has been found in which the film condition changes abruptly from clean to very severe marking across a manufacturing splice.

E. Cases have been found wherein a spot or a group of spots repeats, suggesting specks of dirt lodged on rollers as a cause. In most cases, no such repeat pattern was observable and when it did occur the interval between spot groups did not always correspond to the circumference of a known camera

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INTEGRATOR RESET SIGNAL FLOW



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FIGURE 2-16

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roller.

F. The markings do not appear to be electrostatic.

2.4.3.3 Recommendations

At this time, the cause of the plus density marks is not known. Work is continuing to determine the cause and to eliminate this anomaly on future missions. The need to eliminate these marks is emphasized by reports of cases in which the marks hindered the photo interpreter's readout, see paragraph 5.5.

2.4.4 Edge Damage and Splice in Op 562

2.4.4.1 Description

Prior to despooling of RV-3, a film protrusion was noted on the inboard side of the Forward Take-up stack. After processing, the protrusion was found to correspond to a section of film in Frame 052 of Op 562, which had severe edge damage on the tilted side. The damage extended approximately 1' on each side of manufacturing splice No. 51, and was severe enough so that the splice stress relief cut-out was missing on the damaged side, see Figure 2-17.

Measurement revealed that the two sections of film joined by this splice were inclined to each other at an angle of approximately .2° and were offset approximately .4mm. Two sections of film joined at an angle would be expected to protrude on the obtuse side of the angle as shown in Figure 2-18. This was, in fact, the edge that protruded from the stack and had experienced severe damage. Splice No. 51 under tension is illustrated in Figure 2-19.

2.4.4.2 Telemetry Data

Excursions occurred in both the summed error and the carriage position signals of the Supply steerer when the splice passed the steerer. At the time that it passed the metering capstan, a transient occurred in the metering capstan summed error. Both the Take-up steerer carriage position and the Take-up steerer summed error showed excursions when the splice passed the Take-up steerer. However, this occurred during start-up of the next operation at a time when excursions in these two signals are not abnormal. It is therefore not possible to ascertain if these two excursions were due solely to the passage of the splice.

During spooling of the Supply, the film is under ten pounds of tension and during passage through the camera, it is under 2.5 pounds of tension. The stress across the width of the film will not be uniform due to the angle between the two sections of film. Calculation has shown that the entire tension loading would have been carried by a small section of film on the undamaged edge of the web, refer to Figure 2-19. Approximately 1" would be under stress during spooling and a little more than 1/2" during passage through the camera. In both cases, the damaged edge of the film would not have experienced tension. This lack of tension of the damaged edge probably prevented tearing of the film web.

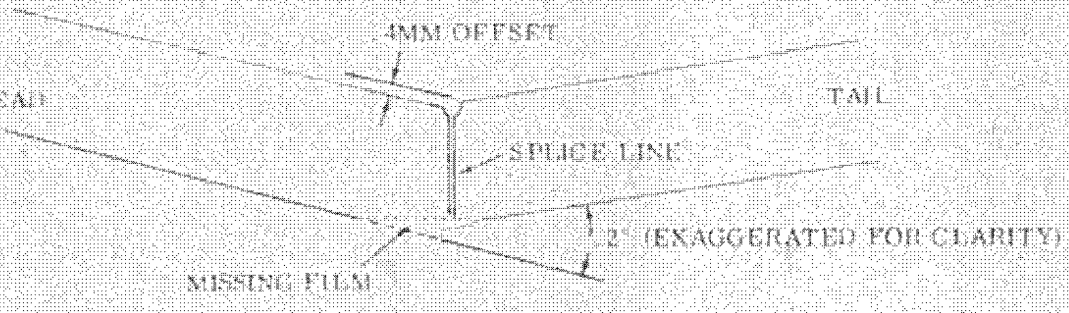
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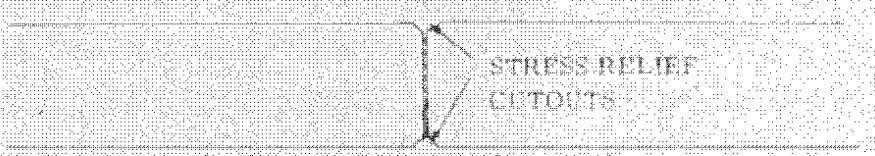
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SPLICE NO. 51 COMPARED TO A NORMAL SPLICE

—SPLICE NO. 51—



—NORMAL SPLICE—



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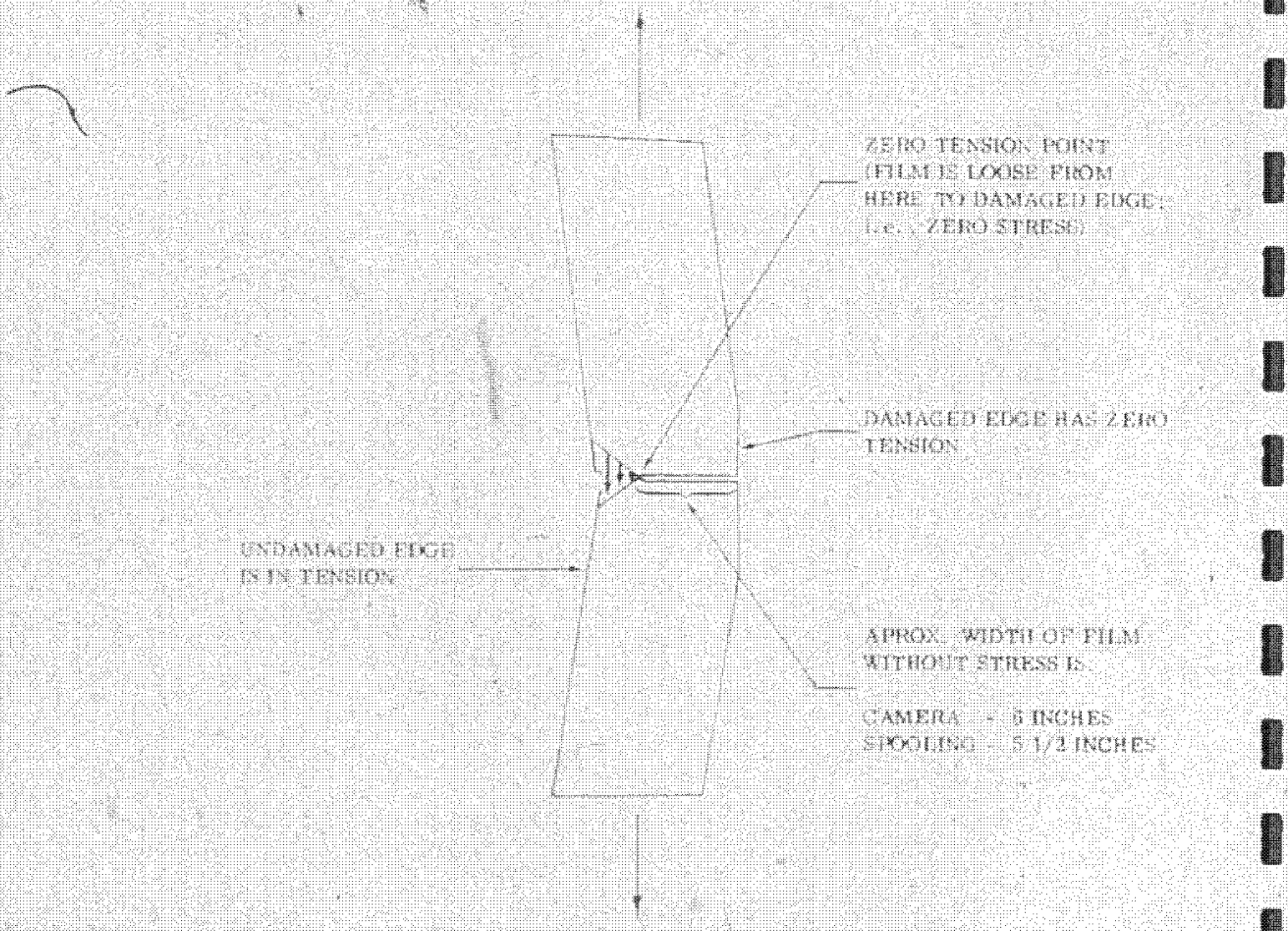
FIGURE 2-17

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SPLICE NO. 81 UNDER TENSION



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2.4.4.3 Conclusion

The edge damage is associated with the abnormal splice, but it has not been possible to establish when it occurred. It is unlikely that it occurred at the time that the splice was made. Most probably it resulted from rubbing the protruding edge of film either during make up of the supply or during passage of the film through the camera.

Such splices greatly increase the possibility of edge rubbing. This rubbing could result in edge damage such as occurred in this case or cause a catastrophic film web tear.

A new splice-making and inspection device is currently being installed to allow the operator to view the completed splice. This device employs an infrared vidicon system. The IR false color film, however, cannot be inspected via this technique.

2.4.5 Film Punctures

Two cases of puncturing were found on the 1208 Mission film. In the first case, a small puncture occurred in the interop space prior to Op 1. A scratch on the base side of the film originated at this puncture and continued through Op 17. A dimple in the stack was detected during the despooling, which correlated with the start of the scratch. It is suspected that a foreign particle was ingested into the Take-up stack resulting in the puncture and dimple and that the particle was carried by the film into the processor where it lodged on a roller causing the scratch. Cleaning the processor eliminated the scratch.

The other case of puncturing produced four 1/8" diameter holes in Op 36, Frames 018, 019, 022, and in the interframe space between Frames 020 and 021. These locations correspond to four layers of film on the Take-up. A number of pressure marks associated with these holes also occurred on the film layers, which were directly under and directly on top of the punctured film. This puncturing was caused by the ingestion of a 1" piece of wire into the Take-up stack during orbital operation.

2.4.6 Pneumatics Leak

During the launch countdown, on Day R-1, the Forward Camera regulated pressure was observed to decay at an abnormally high rate from 2,46 to 1,28 psi in 300 seconds. On the basis of this decay rate and the immediately available design data, it was concluded that a leak had developed on the high pressure side of the regulator and was of sufficient magnitude to be unacceptable for flight operation; i.e., the continuous loss of gas would severely shorten the mission.

The system was configured in a contingency mode by isolating the leak from the high pressure gas supply. The Forward side high pressure isolation valve (HPIV-A) was commanded to the closed position following the uncage and OB stow sequences which were executed on Rev 0. The only disadvantage to this configuration was a reduction in system reliability as a result of the loss of parallel redundancy in the gas supply.

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Subsequent analysis indicated that the leak was on the low pressure side of the regulator and was of negligible magnitude. The total loss from the system during its mission was estimated to be less than .03 lbs mass.

As a precaution, on-orbit tests were performed to verify that the leak was in the low pressure stage. The tests were conducted by momentarily opening the HPIV-A and monitoring the regulated pressure decay rate following valve closure. As a result of the analysis and tests, the HPIV-A was opened on Rev 563 and left open for the remainder of the mission.

2.4.7 Take-Up 1208-2 Brake Failure

During the despooling of the second mission segment, it was discovered that the Forward Camera Take-up brake was inoperative. There was a minimal impact on post recovery operations due to the brake failure, see paragraph 4.2.2. The failure occurred either during or after recovery since brake performance was normal throughout on-orbit operation.

The end bulkhead on the Forward Camera side of the Take-up was removed and it was found that the brake band retainer was fractured at the point where the first rivet attaches the brake band to the retainer. The failure was due to a tear cut of the material between the first rivet and the edge of the brake band retainer. The failure was attributed to a suddenly applied load since in the worst operation condition forces experienced are only 14% of the minimum force required to fracture a brake band retainer.

A similar failure occured on Mission 1205. Block II incorporated a new brake override design which employs a spring to permit core motion upon being subjected to suddenly applied loads. This new design has not been incorporated into Block II recycled Take-ups which was the case for Mission Segment 1208-2. There are two more Block I recycled Take-ups planned for use in the program, one each on Mission 1209 and 1210. All other Take-ups will have the new brake override design. No corrective action is recommended since such a failure has a low probability and has a minimal impact on post recovery operation.

2.5 OPERATIONS AND PERFORMANCE

2.5.1 Command and Control

The Sensor System performance with respect to the Command and Control Subsystem was nominal throughout the mission. All commands were properly received and executed.

2.5.2 Sensor System Control

The Sensor System control was accomplished on SCC I until Rev 993 when an engineering test was run on SCC II to isolate the cause of the ESD on Rev 980, see paragraph 2.4.1. The remainder of RV-3 was run with the verification interlock circuitry disabled on SCC II. When transfer to RV-4 was made, the verification interlock circuitry was re-enabled and the mission successfully completed in that configuration with SCC II.

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2.5.3 Optical Bar Performance

The optical bars performed properly throughout the mission. Variations between commanded and actual OB velocities were no different than those noted during preflight systems test and were less than specification limit of .00054 radian/second.

2.5.4 Tracking

Edge damage associated with a splice in Op 562 was the only tracking anomaly that occurred during Mission 1208, see paragraph 2.4.4.

Examination of the SVT index dots on the 1414 Film showed that both cameras experienced small tracking shifts between ground testing and orbital operation. The Forward Camera shifted downward (direction of untitled edge) approximately .4mm and the Aft shifted upward approximately .3mm. Prior to launch, the tracking of both cameras was .1mm below nominal; therefore, after launch the Forward Camera was low by .5mm and the Aft high by .2mm. Figure 2-20 shows the measured mean distance from film edge to the SVT dot for horizontal preshipment testing and for each RV. It can be seen from this figure that the Forward Camera tracking showed a gradual upward shift during the mission so that by RV-4 it was tracking only .2mm low. The Aft Camera tracking position for 1414 Film remained constant during the mission. The 2,600' of SO-255 Color Film and 3,000' of FE-3916 IR False Color Film were located at the end of the Aft Supply. Both of these films tracked .3mm lower than the 1414 Film. Table 2-7 shows the maximum excursions of the measured SVT dots for Chamber A-1 and for each RV.

TABLE 2-7

SVT DOT TRACKING DATA, MAXIMUM EXCURSIONS

(Peak-to-Peak)

Camera	Pre-Launch (Chamber A-1)	RV-1 1414	RV-2 1414	RV-3 1414	RV-4 1414	RV-4 SO-255	RV-4 FE-3916
Forward	0.2	0.7	0.8	0.8	0.7	-	-
Aft	1.3	0.6	0.9	0.9	0.7	0.4	0.6

2.5.5 Instrumentation

All instrumentation operated normally through the mission. The system provided consistent and accurate data for analysis of anomaly conditions and for the routine verification of the camera status.

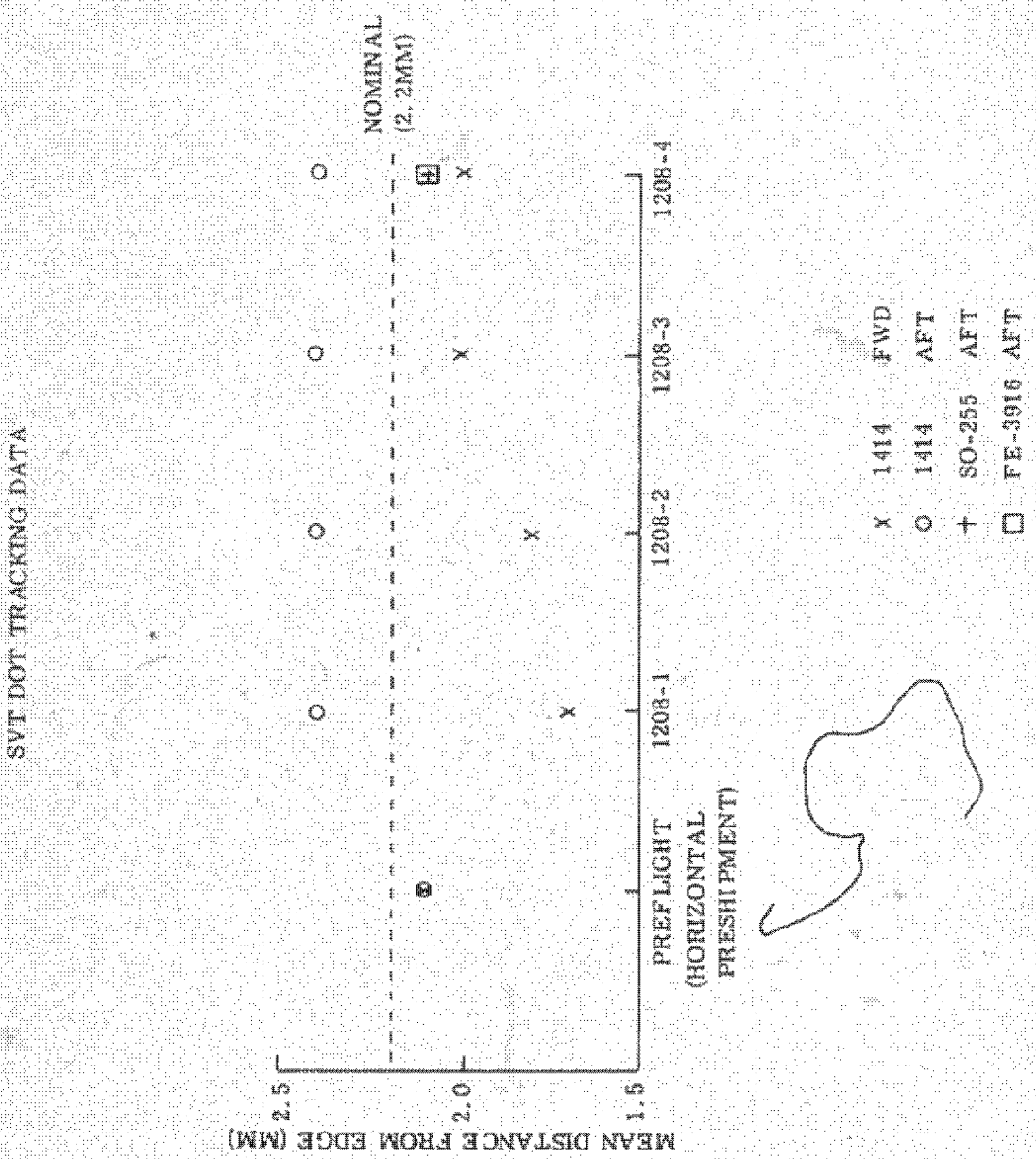
2.5.6 Pneumatics

The pneumatic system nitrogen reserve status for Mission 1208 is presented in Table 2-8.

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FIGURE 2-20

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TABLE 2-8

PNEUMATIC SYSTEM NITROGEN RESERVE STATUS

	Tank A			Tank B			
	Press (PSI)	Temp (°F)	Mass (lbs)	Press (PSI)	Temp (°F)	Mass (lbs)	Total (lbs)
Lift-off	3,388	69	17.8	3,374	68	17.7	35.5
End of Primary Mission	196	69	1.1	210	67	1.2	2.3

The computed PNT use rate was a constant .023 lbs/minute throughout the mission. The pneumatics consumption history is graphically presented in Figure 2-21. A small pneumatics leak had been detected during the launch countdown, which did not materially affect the use rate, see paragraph 2.4.6.

2.5.6.1 Path Pressurization

For the first time in eight missions, it became necessary to actuate the pneumatic system operate valves to maintain the film path pressure above the ballooning criterion. The initial repressurization occurred after transfer to TU-4 and was repeated as required for the remainder of the mission. Although the path leak rate was within specification requirements, the combination of short operations with corresponding small increases in path pressure, separated by long quiescent periods, caused the repeated occurrence of the low pressure condition. To minimize the additional gas usage, a procedure was used wherein the path was repressurized by an increase of approximately .1 PSI when the path pressure had decayed to the ballooning pressure limit.

2.5.7 On-Orbit Thermal Performance

The data reported in the following subparagraphs describe the thermal environment for Mission 1208. Thermal control for SV-8 can be generally summarized by stating that all SS temperatures were within design limits throughout the mission.

2.5.7.1 TCA Environment

Table 2-9 is a summary of temperature levels, spatial distributions, and temporal variations over a typical orbital revolution in terms of the thermal ICD (1420316A) requirements. Figure 2-22 shows the corresponding orbital profiles of the ICD parameters.

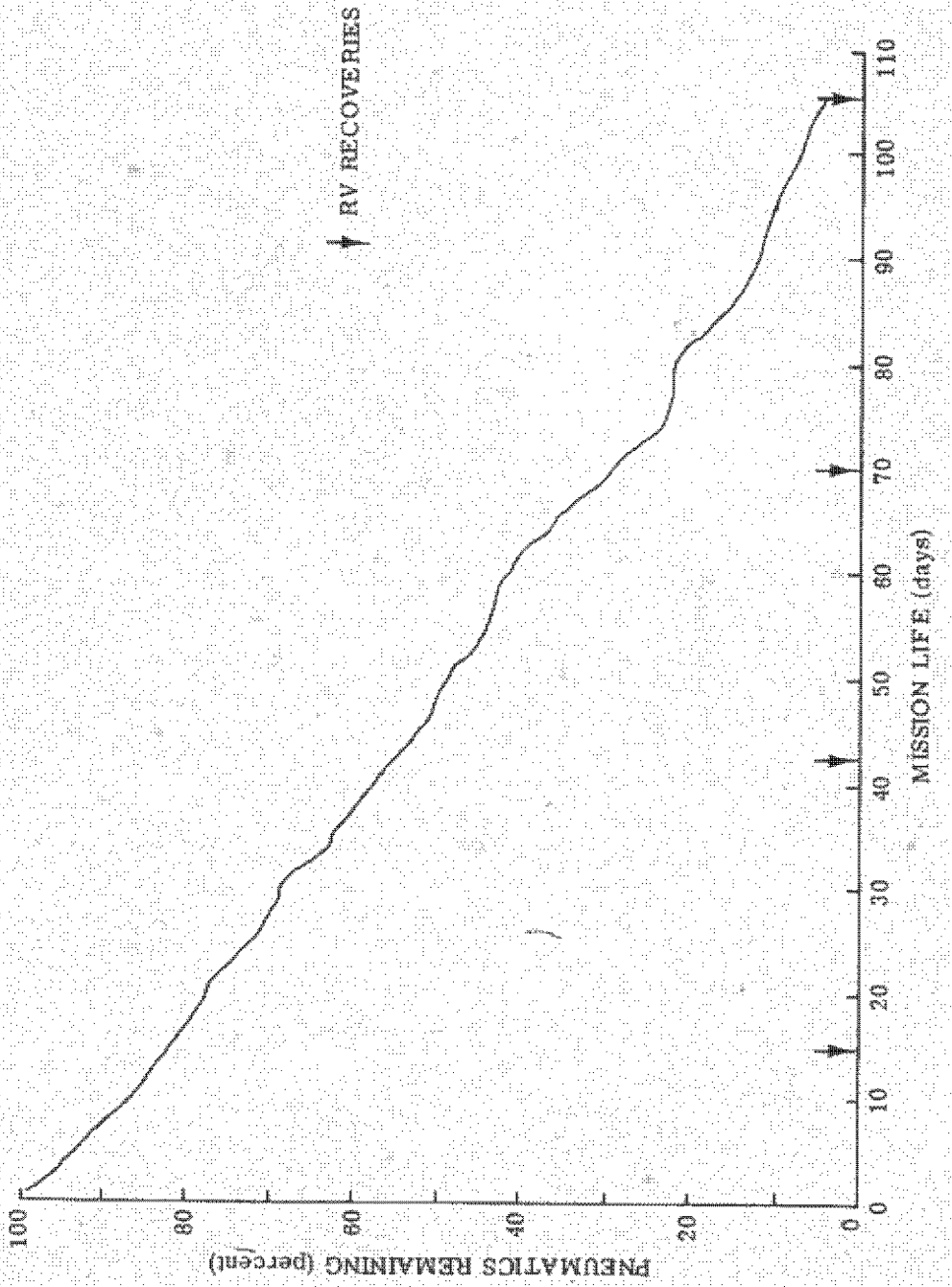
2.5.7.2 Optical Bar Temperatures

T_{ref} is the average temperature indicated by four thermistors in the film path. T_{ref} was 67 ± 1° F throughout the mission. The equilibrium temperature levels for the A and B Optical Bars were approximately 66° F and 65° F respectively. Figure 2-23 shows an orbital profile of the OB temperatures in the stowed position.

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ESTIMATED PNEUMATICS SUPPLY VERSUS MISSION LIFE



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FIGURE 2-21

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TABLE 2-9

REV 861 TCA COMPARTMENT TEMPERATURES

Description	Designated Zone	Max Allowable	Flight Value
Temperature Level Index ($\bar{T}_{TCA}$)		70 ± 21	67
Zone I Mean Temperature		NA	67
Zone II Mean Temperature		NA	65
Zone III Mean Temperature	Not Applicable	NA	66
Zone IV Mean Temperature		NA	69
Forward Bulkhead		NA	68
Middle Bulkhead		NA	69
Variation of Mean Temperature Between Designated Zones	I to IV	9	2
	II to III	6	1
	I to II	4	2
	III to IV	4	3
	Bulkhead to Bulkhead	6	1
Spatial Variation of Time-Average Temperature (Measurements at Locations within Designated Zone)	I	11	5
	II	9	2
	III	9	1
	IV	11	1
	Forward Bulkhead	5	2
	Middle Bulkhead	17	6
Temporal Variation (Peak to Valley) of Temperature (Measurement at any one Location within Designated Zone)	I	46	17
	II	20	1
	III	20	1
	IV	46	17
	Forward Bulkhead	26	4
	Middle Bulkhead	57	16

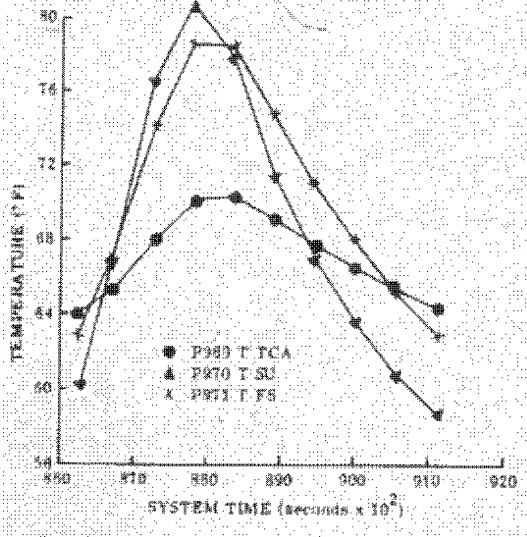
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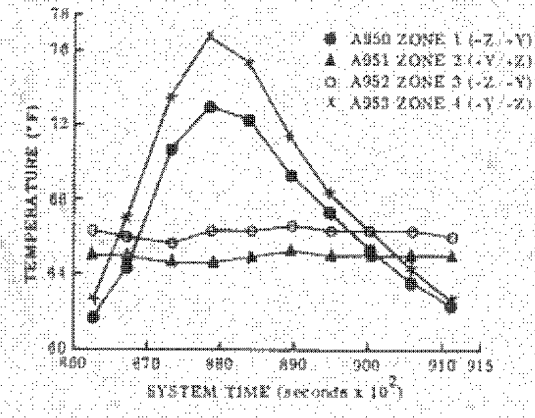
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SATELLITE BASIC ASSEMBLY TEMPERATURE DATA, REV 861

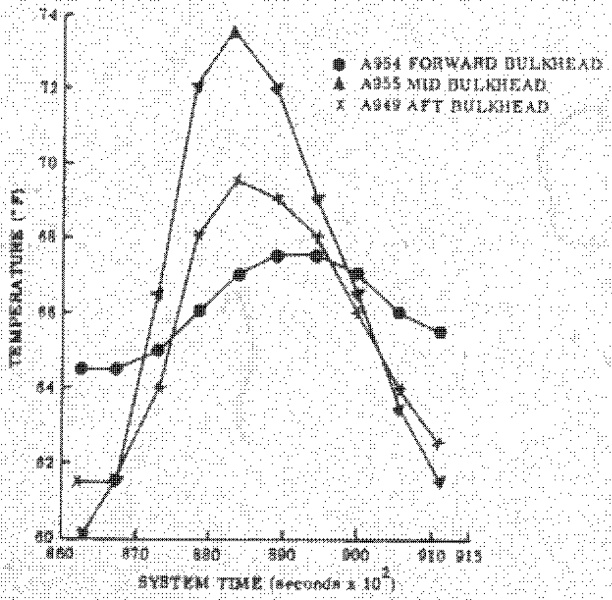
MID-SECTION
(Fourth Power Spatial Averages)



TCA ZONES 1-4
(First Power Spatial Averages)



MID-SECTION BULKHEAD
(First Power Spatial Averages)



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~~TOP SECRET~~ HEXAGON

FIGURE 2-22

Handle via Byeman
Control Only

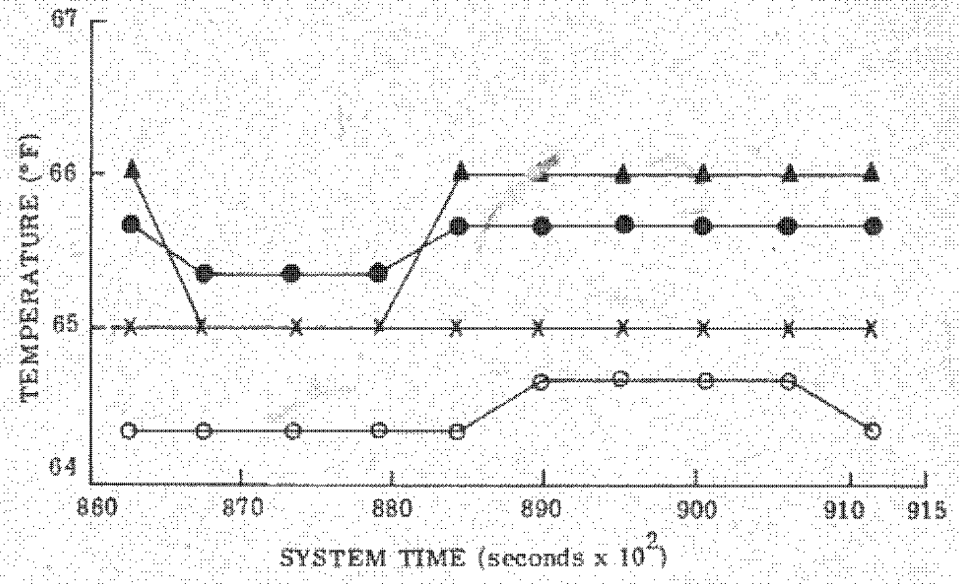
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SENSOR SUBSYSTEM TEMPERATURE DATA, REV 861.3

(Optical Bar and Corrector Plate)



●	P910	FWD	SIDE	OB
▲	P240	FWD	SIDE	CP
○	P920	AFT	SIDE	OB
X	P238	AFT	SIDE	CP

FIGURE 2-23

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2.6 'TUNITY FOR MISSION 1208

The 'TUNITY MOD-2 software for Mission 1208 performed all of its functions normally except for one software problem. In Message 350, Rev 123, Op 3, a desert polygon bias was applied where no desert polygon had been defined. This caused the operation to be underexposed. A change was made to 'TAPWRP and corrected the problem. The change was incorporated on the Flight Auxiliary Master.

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CAMERA PERFORMANCE

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SECTION III

CAMERA PERFORMANCE

3.1 INTRODUCTION

Camera system performance for Mission 1208 was assessed for focus, resolution, image motion compensation, and exposure. The first three quality indicators were analyzed by the SSC using visual edge matching, smear slits, and CORN targets; the fourth was analyzed by BRIDGEHEAD using microdensitometry. In this section, comparisons are given, where possible, between ground testing and on-orbit performance. A summary of the results of the analyses is presented below:

A. The Forward Camera required a focus change of +8 microns. The Aft Camera's ground setting was correct.

B. Two corrections were required to optimize the camera's image motion compensations. The Forward Camera's film speed was changed to correct a cross-track error of .013 inch/second and the Aft Camera's skew angle was changed by 30 arc-seconds to correct an in-track error of .024 inch/second.

C. Twelve CORN tribar targets were acquired on 1414 Film. The average geometric mean was 2.1'; the adjusted readings for an equivalent 2.1 contrast was 2.6 feet. Two targets were acquired on SO-255 Color Film averaging 3.2' (as read), and two on FE-3916 IR False Color Film producing 5.6 feet. Equivalent 2:1 contrast corrected values for SO-255 and FE-3916 have not been established.

D. Randomly sampled VEM resolution (2:1 contrast) from operational target complexes showed an average geometric mean of 150 cycles/mm. These complexes were distributed over the 120° format during the entire mission.

E. Examination of the major axis VEM data showed no existence of format-related image quality dependance.

F. Optical field curvature and platen tilt were nominal.

G. Quality variability at nadir was comparable between ground tests and orbital operations.

H. Mean smear as a function of scan angle was less than .02 inch/second within ±45° of scan nadir.

I. Smear variability was within the SV design goal. The change from ground test to on-orbit operation was approximately .026 inch/second and was partly attributable to measurement uncertainty in the smear slit technique and to errors not encountered during ground tests.

J. Exposure for 1414 Film was optimum, with the Aft Camera containing a two count bias (~.06 log E). Both the SO-255 and FE-3916 Films were overexposed by .10 log E.

K. Frequent instances of dirty and/or melted snow in prime areas of interest indicate that snow bias techniques should be suspended for late spring and early summer missions.

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3.2 ON-ORBIT FOCUS ANALYSIS

3.2.1 1414 Film

Effective on Op 156, the Forward Camera focus was changed by +8 microns from its launch position of 68 to a new nominal of 76 microns; no adjustment of the Aft Camera's focus position was required. These decisions were based upon analysis of thru focus engineering photography using visual edge matching (VEM) and subjective assessment of image quality. The thru focus tests were executed during RV-1 and RV-2 and discontinued thereafter.

3.2.1.1 Analysis Procedure

A total of six 1414 thru focus operations were performed on both cameras during RV-1, and a single operation in RV-2. These operations, summarized in Table 3-1, constitute Engineering Test 1. The Test 1 requirement was acquisition of cloud-free culture across the entire minor axis within ±20° of scan nadir, with platen offsets of 0, ±8 and ±16 microns from each camera's nominal focus position at launch.

During the RV-2 acquisitions, the camera offsets were made in 6 micron steps. Using these engineering operations, minor axis profiles were generated using VEM at each of the platen offsets. This was done for both in-track and cross-track directions, by a single reader/matrix combination for each camera to optimize the data's consistency. The minor axis was sampled at seven locations, each 1/2" wide, centered at 0°, ±1.0°, ±2.0°, and ±2.5° of field. From each cell seven in-track and cross-track edges were matched to constitute a single average data point. A minimum of two frames at each platen offset was used, and the data was averaged to better characterize each camera's thru focus performance.

3.2.1.2 Data Analysis, Forward Camera

The VEM data collected from the thru focus operations (Table 3-2 and Figure 3-1) shows that peak performance is between the launch nominal and +8 microns. The profiles of the remaining offsets show a marked decrease in quality levels. The nominal and +8 micron positions peaked at about 170 cycles/mm in-track; the -16 micron position dropped to about 136 cycles/mm. This fall off in quality, however, is asymmetrical with respect to the nominal setting of 68 microns, the image quality decreasing more rapidly with platen offsets in the minus direction. The average resolution across the field for the -16 micron position is 22% lower than the levels at nominal and +8 microns, while only a 4% loss is seen at the +16 micron platen position, see Table 3-2. The differences between the nominal and +8 micron profiles are related to field position: +8 microns is slightly better on the positive side of field than nominal, and nominal is marginally better on the minus field side.

Where the VEM data indicated no clear choice, the subjective evaluation of the thru focus imagery showed a marked preference for +8 microns over the other platen positions tested. The subjective assessments were based on comparison of image quality of visual edge matched thru focus

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TABLE 3-1

SUMMARY OF TEST 1 THRU FOCUS OPERATIONS FROM 1208

OP		Scan Mode (degrees)	Frames	Location	Plates Offsets (microns)	Weather	Culture	Utility	Comments
13		30/0	14	Boston	0, -8, -18	Partial Cloud Cover	Good	Poor	Snow Cover
14		30/0	5	San Diego	0, -8, -16	Clear	Fair	Good	
	RV-1	54	14	Sacramento San Francisco	0, -8, -16	Clear	Excellent	Excellent	
84		30, 45	14	Atlanta	0, -8*	Clear	Fair	Fair	
114		60/0	10	New York	0, -8, -18	Clear	Excellent	Fair	
130		20, 30	7	Detroit	0, -8, -16**	Clear	Fair	Not Useful	Culture Acquired Beyond 30° Scan Angle
	RV-2	335	11	Boston	0, -6, -12	Clear	Good	Fair	

NOTES: 1. The asterisk (*) indicates that the Forward Camera platen offset was -8 microns and the Aft Camera platen offset was +8 microns.

2. The asterisks (**) indicate that only the Forward Camera platen offset was -16 microns.

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TABLE 3-2

1208-1 MINOR AXIS THRU FOCUS SUMMARY

(cycles/mm)

Relative Defocus (microns)	Field Angle (degrees) -2.5	-2.0	-1.0	0.0	1.0	2.0	2.5	Mean	Direction
— FORWARD CAMERA —									
-16*	135	136	136	136	130	128	127	133	
-8	149	152	156	158	152	146	144	151	
0	158	161	167	172	164	157	151	161	In-Track
8	156	160	164	171	173	161	153	163	
16	148	156	160	165	160	155	148	156	
-16*	121	135	136	132	121	121	115	126	
-8	142	150	152	156	146	139	135	146	
0	153	157	161	166	160	153	146	157	Cross-Track
8	144	149	157	162	163	154	147	154	
16	143	146	151	158	154	147	141	149	
-16	128	136	136	134	126	125	121	130	
-8	146	151	154	157	149	143	140	149	
0	156	159	164	169	162	155	149	159	Geometric Mean
8	150	155	161	167	168	158	150	159	
16	146	151	156	162	157	151	145	153	
— AFT CAMERA —									
-16	153	173	168	165	167	168	158	165	
-8	168	173	169	171	173	169	162	169	
0	180	183	187	185	183	173	165	179	In-Track
8	168	177	182	182	179	167	168	175	
16	149	165	168	176	173	165	158	165	
-16	157	157	161	163	158	163	147	158	
-8	167	168	169	167	168	158	155	165	
0	168	170	174	176	176	170	164	161	Cross-Track
8	158	165	174	174	165	163	152	164	
16	120	144	151	165	165	138	141	146	
-16	155	165	165	164	163	164	153	162	
-8	168	171	169	169	171	164	159	167	
0	174	177	181	181	180	172	165	175	Geometric Mean
8	163	171	178	178	172	165	160	170	
16	135	155	160	171	169	153	150	156	

NOTE: The asterisk (*) denotes that there was one frame only.

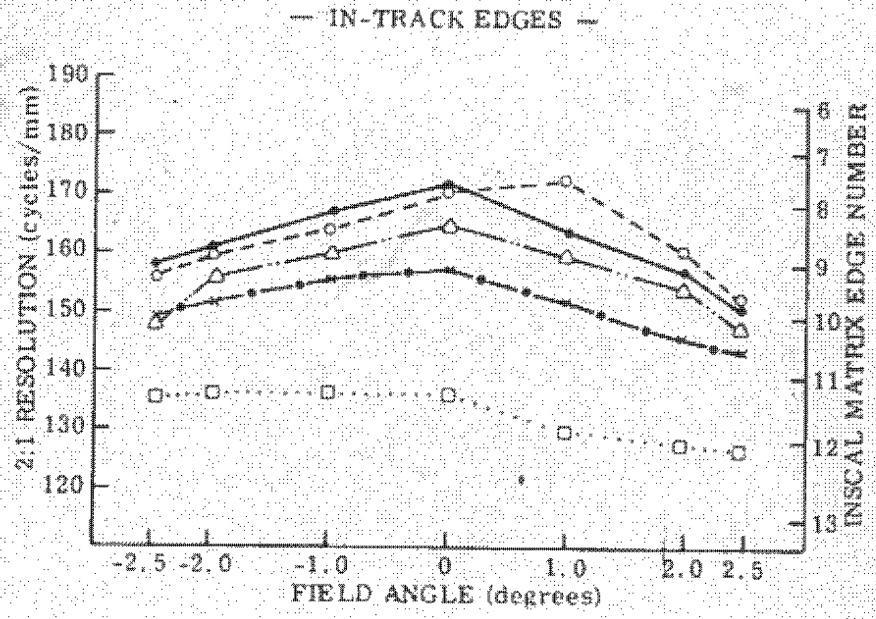
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FORWARD CAMERA THRU FOCUS MINOR AXIS PROFILES 1208-1



PLATEN POSITION
(microns)
+16
+8
0
-8
-16

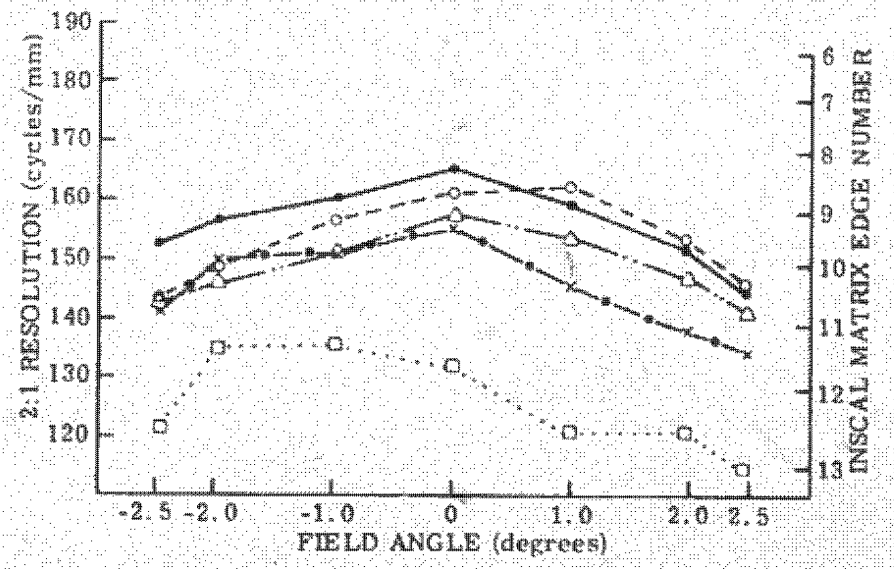


FIGURE 3-1

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operations. In all the comparisons made between platen positions, the +8 microns position consistently exhibited the best image quality. These assessments did agree with the VEM data with respect to the asymmetry of thru focus. Based on the strong subjective preference for the +8 micron position and the VEM data which indicated some improvement with a plus direction platen offset, the +8 micron change was made.

3.2.1.3 Data Analysis, Aft Camera

The VEM data, summarized in Table 3-2, shows that the analysis of the Aft Camera thru focus operations was similar to that performed on the Forward Camera. Minor axis profiles generated from this data, presented in Figure 3-2, show that the nominal platen position gives the best performance across the field for the five positions measured; i.e., 179 cycles/mm in-track and 171 cycles/mm cross-track.

Unlike the Forward Camera data, the Aft Camera's thru focus curves are fairly symmetrical about the nominal position. As the data in Table 3-2 indicates, the performance of the Aft Camera is somewhat better than that of the Forward. The VEM data, therefore, indicated that no change in platen position was required for the Aft Camera.

Subjective evaluation of the thru focus photography did not yield a clear conclusion as to which platen position gave the best imagery over the range of +8 to -8 microns. This is consistent with the VEM data showing only a 4% change in average resolution across the field for similar changes in platen position. As a result of these tests, no change was made for the Aft Camera.

3.2.1.4 RV-2 Focus Reverification

During RV-2, a single thru focus operation was performed with platen offsets of ±6 microns and nominal. Again, minor axis profiles were obtained by VEM measurements of the photography. Because only one operation was performed, it was not always possible to get more than a single frame at each platen offset. The data is given in Table 3-3 for both the Forward and Aft Cameras. These measurements are at a different resolution level and contain more scatter than the RV-1 measurements; but, this could be due to differences existing between VEM readers.

The Aft Camera nominal shown in Figure 3-3 still appears to be best. The Forward Camera data given in Figure 3-4, however, is inconsistent in that there is an apparent inversion between ±6 and nominal focus setting. The ±6 positions are about equal, leading to the conclusion that the nominal set of data is suspect and that the RV-1 change was adequate. Also, subjective assessments of this photography and imagery from denied areas taken during RV-2 at the new settings indicate a general improvement in quality from that seen in RV-1.

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TABLE 3-3

1208-2 MINOR AXIS THRU FOCUS SUMMARY

(cycles/mm)

— FORWARD CAMERA —

Relative Defocus (microns)	Field Angle (degrees) -2.5	-2.0	-1.0	0.0	1.0	2.0	2.5	Mean	Direction
-6	152	165	171	180	174	164	145	164	
0	181	165	178	183	172	163	148	170	In-Track
6	180	182	183	180	172	168	150	174	
-6	144	158	163	169	169	152	137	156	
0	143	149	165	168	152	146	138	151	Cross-Track
6	156	156	167	172	172	156	149	161	

— AFT CAMERA —

-6	139	138	158	151	146	144	151	148	
0	140	144	160	153	146	151	139	148	In-Track
6	155	152	153	142	169	165	138	153	
-6	136	141	149	132	141	147	139	141	
0	131	139	148	144	146	138	139	141	Cross-Track
6	127	127	120	134	149	135	124	131	

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AFT CAMERA MINOR AXIS PROFILES 1208-1

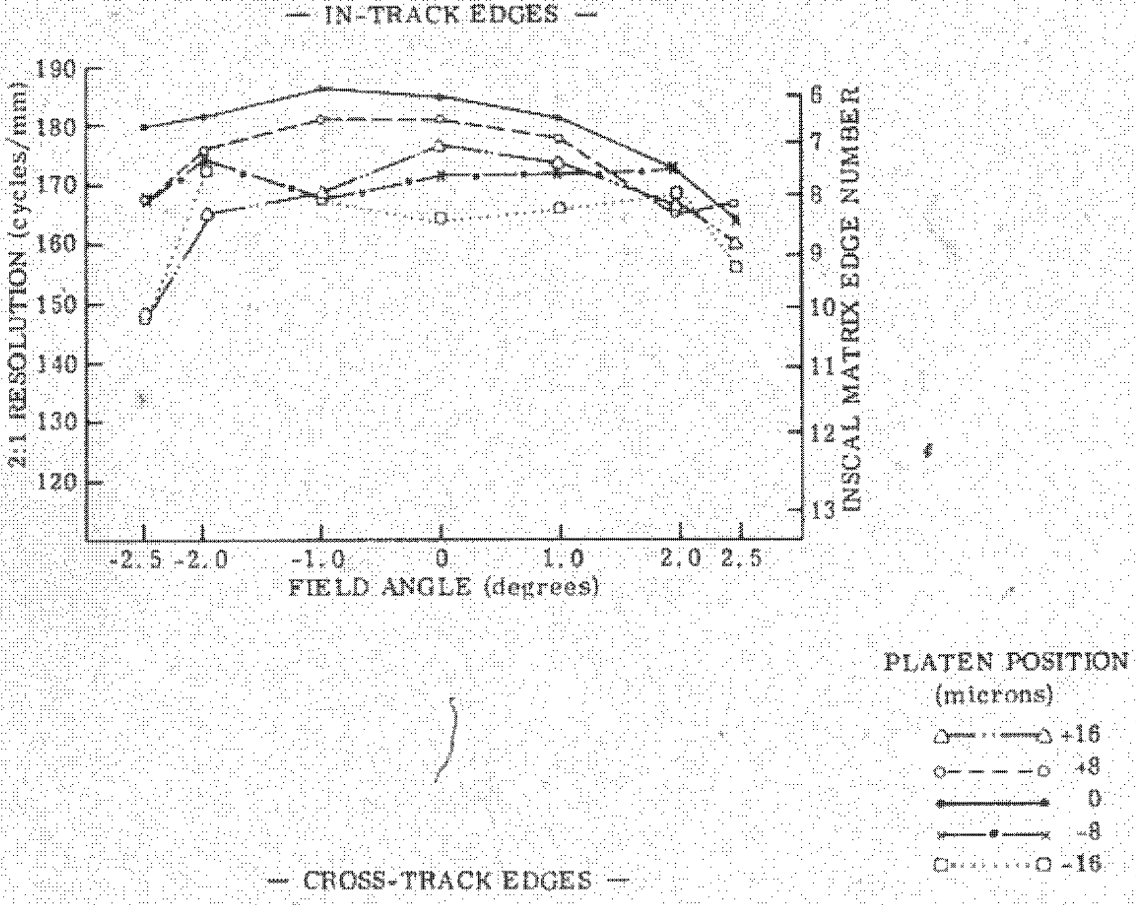


FIGURE 3-2

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AFT CAMERA FOCUS VERIFICATION 1208-2

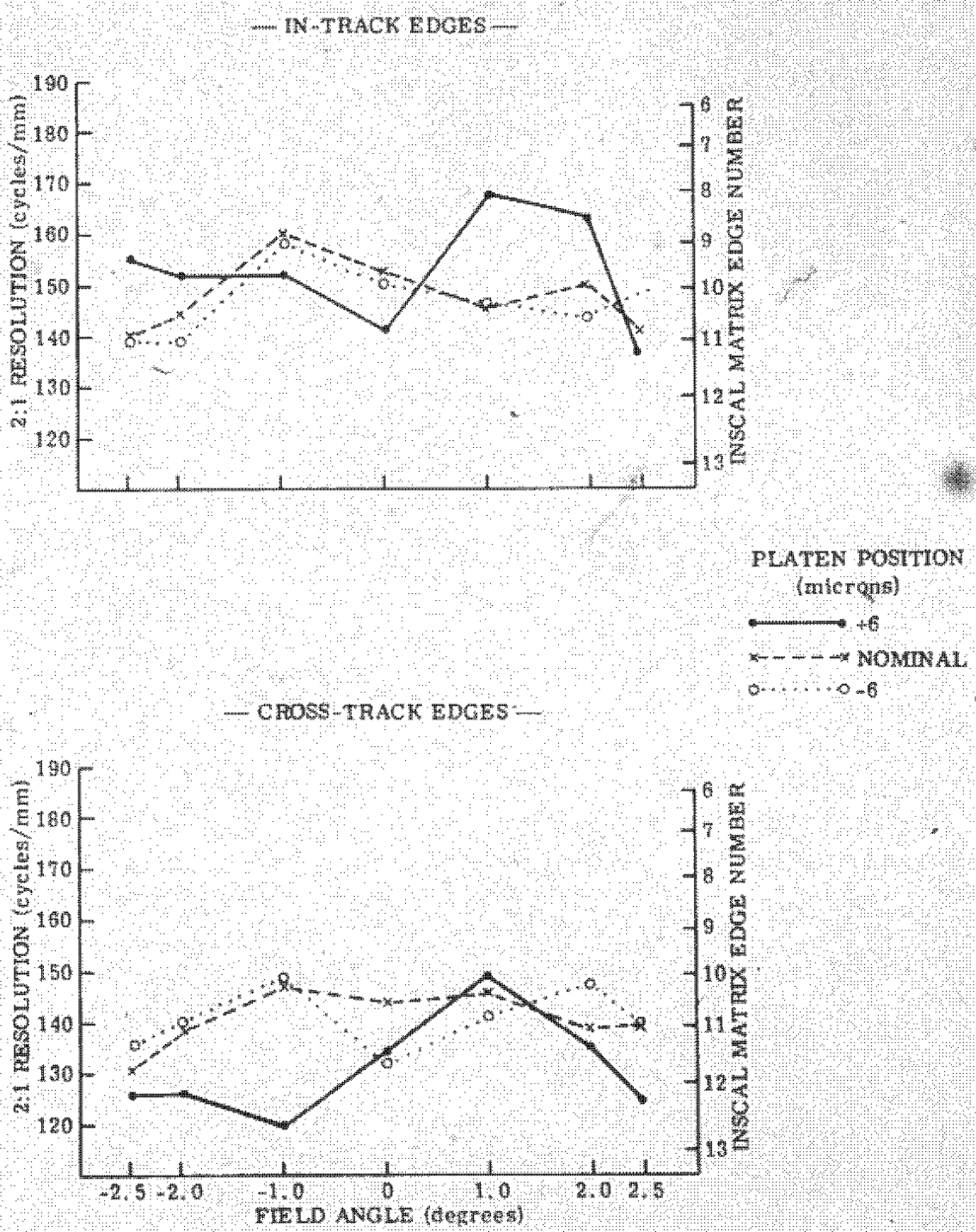


FIGURE 3-3

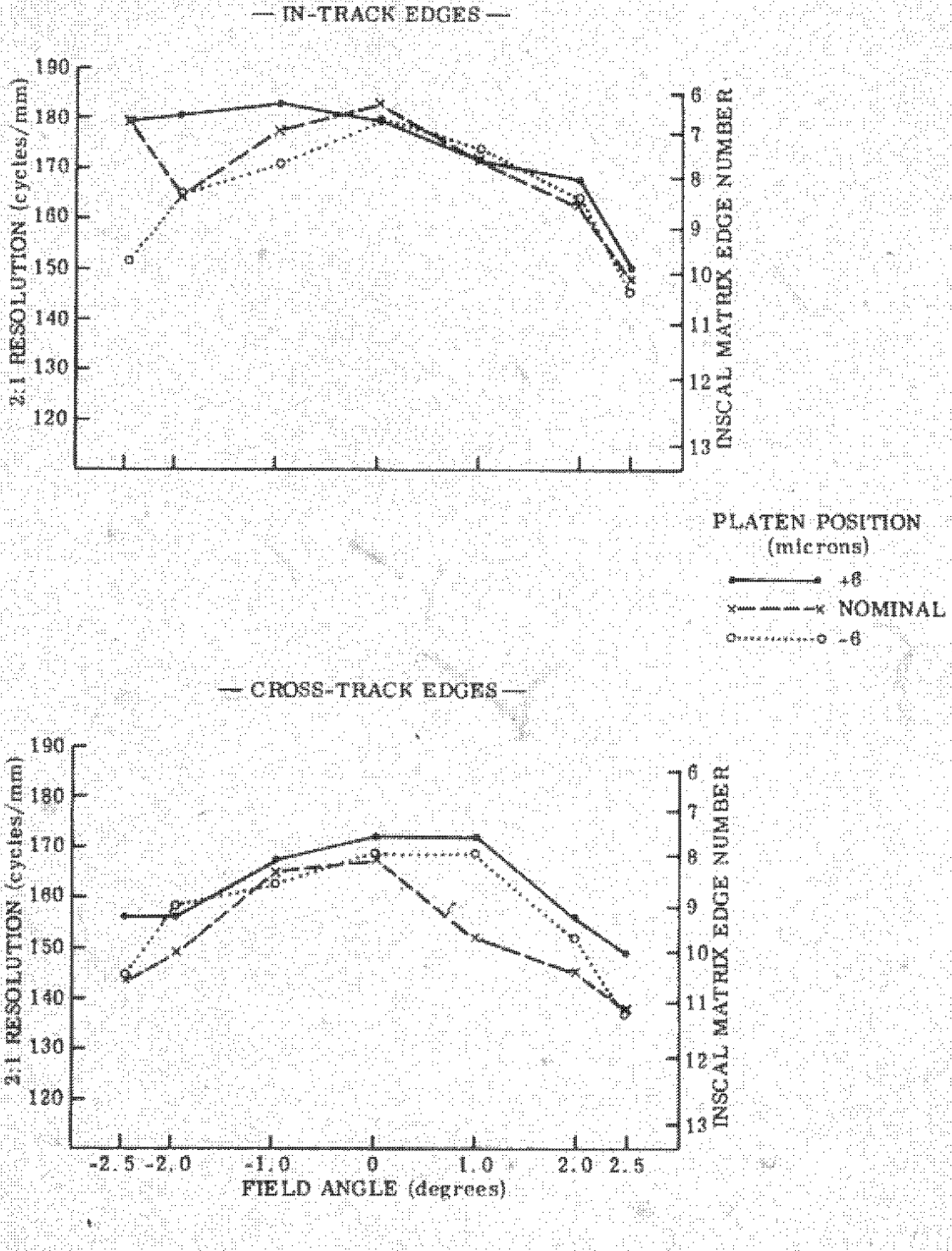
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3.2.2 SO-255 Color Film

Acquisitions with SO-255 Color Film (2,588' on Aft Camera film stack) occurred during RV-4, starting with Op 723. At this time, the filter was changed from W-12 to W-2E and a focus adjustment of +30 microns (25 microns to 55 microns) was made in the camera's platen position to accommodate the color film transition. Two thru focus tests (Engineering Test 8) were performed over a range of ±14 microns about the nominal platen position, see Table 3-4. Useful acquisitions totaled four frames at the nominal 55 micron position, one at the 41 micron position, and two at the 69 micron platen position. Subjective analysis indicated that focus was set near optimum.

TABLE 3-4

SUMMARY SO-255 THRU FOCUS TESTS

Op	Frames	Platen Position (microns)	Offset (microns)
741	1 - 4	55	0
	5	Transition	
	6	55	0
	7	Transition	
	8	41	14
	9	55	0
745	1 - 3	55	0
	4	Transition	
	5 - 6	69	14

3.3 ON-ORBIT IMAGE MOTION COMPENSATION

Film-to-image velocity registration on-orbit is evaluated by measuring displacements in the smear slit imagery on the edge of the format. The smear slits are designed to amplify the primary slit smear by approximately a factor of four. Measurable displacements are generated by commands to the On-Orbit Adjust Assembly (OOAA) to change the film speed. The speed changes by factors of $.015\left(\frac{Vx/h}{.054}\right)$ and $.010\left(\frac{Vx/h}{.054}\right)$ inch/second per command step in the cross-track and in-track directions respectively.

The measured displacements are compared to predicted displacements to determine if any synchronization error exists in the camera. The method involves a linear regression of the data points taken at positive and negative film velocity biases. The regression analysis yields a zero smear command step estimate of the on-orbit adjust assembly. If, with 90% confidence, the command step being used is more than one step away from optimum, a change in film speed is recommended. Before implementing the

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change, a second check of the smear slit imagery is made on frames without film velocity biases. If the regression analysis has indicated that the command step being used is not the zero smear intercept, the smear slit imagery should indicate the smear since it is amplified by approximately a factor of four. When this check confirms the regression analysis, the command step change is implemented.

3.3.1 Test 3A, Smear Slit Indication of Optimum OOAA Settings, 1414 Film

Test 3A was conducted, as in Missions 1206 and 1207, by inducing known positive and negative OOAA biases in the in-track and cross-track directions (approximately ±.2 inch/second) simultaneously. The measured and predicted displacements of the double image pairs were tabulated and linear regression analysis performed. For the first mission segment, three operations were acquired (Ops 63, 64, and 103) and 91 and 80 samples were measured for the Forward and Aft Cameras, respectively. Results are presented in Table 3-5.

TABLE 3-5

TEST 3A LINEAR REGRESSION ANALYSIS FOR RV-1 DATA

Camera	Direction	Intercept (inch/second)	90% Confidence Interval (inch/second)	2σ Error (inch/second)	Number of Samples
Forward	In-Track	-.007	±.004	±.047	91
	Cross-Track	-.013	±.007	±.077	91
Aft	In-Track	.024	±.008	±.062	80
	Cross-Track	.004	±.006	±.067	80

The Forward Camera in the in-track direction indicated a mean error of -.007 inch/second and the Aft Camera in the cross-track direction, +.004 inch/second; hence, no OOAA correction was required. The Forward Camera in the cross-track direction indicated a mean error of -.013 inch/second (one OOAA command step), with an uncertainty of ±.007 at a 90% confidence interval. The decision was made to collect more data during the second mission segment to build a larger data base prior to implementing such a small correction. The Aft Camera in the in-track direction indicated a mean error of +.024 inch/second with an uncertainty in the mean of ±.008 for a 90% confidence interval. A -3 OOAA command step change was implemented, effective on Op 160. Additionally, subjective analysis of unbiased smear slit imagery clearly indicated the in-track error.

On the second mission segment, two additional Test 3A engineering exercises (Ops 228 and 234) were accomplished to verify the Aft Camera in-track adjustment implemented based on the data collected during the first segment and to evaluate the Forward Camera in the cross-track direction. During the

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second mission segment, an additional 91 and 93 data points were collected for the Forward and Aft Cameras, respectively. The data is given in Table 3-6.

TABLE 3-6

TEST 3A LINEAR REGRESSION ANALYSIS FOR RV-2 DATA

Camera	Direction	Intercept (inch/second)	90% Confidence Interval (inch/second)	2σ Error (inch/second)	Number of Samples
Forward	In-Track	-.002	±.005	±.052	92
	Cross-Track	-.013	±.009	±.097	91
Aft	In-Track	-.008*	±.005	±.054	93
	Cross-Track	0	±.008	±.090	93

NOTE: The asterisk (*) indicates that an OOAA correction equivalent to -.024 inch/second was made between the acquisition of RV-1 and RV-2 Test 3A data.

The data reconfirmed that the Forward Camera in-track and Aft Camera cross-track OOAA settings were proper and agreed with the first mission segment results to within .001 inch/second. The Aft Camera in-track data confirmed the three command step change made on Op 160. The Forward Camera data in the cross-track direction repeated the -.013 inch/second velocity error observed in the first segment data; a +1 command step change (equivalent to +.013 inch/second) was implemented effective with Op 399.

While the third mission segment was in process, a more rigorous analysis of Test 3A was performed. All data collected during the first and second mission segments were combined into a common data base, biasing the first segment Aft in-track data by the -.024 inch/second adjustment implemented between the data sets. Linear regression analysis was performed and 2σ values computed for each of the four cases (Forward and Aft, in-track and cross-track directions). Data points whose difference between the fitted line and the data point exceeded the computed 2σ value were rejected, resulting in rejection of approximately 4% of the data. The regression analysis was then repeated on the new data set; the results, shown in Table 3-7, confirmed the conclusions and OOAA changes. Interestingly, the 2σ rejection criteria, which was meant to reject "flyers" in the data, yielded the same results as the entire data base without any exclusions.

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TABLE 3-7

TEST 3A LINEAR REGRESSION ANALYSIS FOR RV-1 AND RV-2 DATA COMBINED

Camera	Direction	Intercept (inch/second)		Number of Samples	
		All Data	2σ Rejection	All Data	2σ Rejection
Forward	In-Track	-.004	-.003	183	175
	Cross-Track	-.011*	-.013**	182	174
Aft	In-Track	-.005**	-.004*	173	166
	Cross-Track	.002	.001	173	163

NOTES: 1. The asterisk (*) indicates that this mean was corrected in RV-3, Op 399, by a .013 inch/second OOAA command change.

2. The asterisks (**) indicate that the data includes the biasing of RV-1 data by the OOAA correction (-.024 inch/second) made between RV-1 and RV-2.

3.3.2 Test 3B, Smear Slit Indication of Optimum OOAA Settings, SO-255 Film

Test 3B on the Aft Camera for SO-255 Film was planned for Mission 1208. However, due to a combination of bad weather and lack of suitable culture while in the color film segment, no data was acquired for this test. Instead, subjective assessment of smear slit imagery was performed using a Los Angeles acquisition near nadir (Frames 004, 005, and 006 of Op 741) with nominal OOAA settings. The evaluation method and results were as follows. Smear slit imagery was evaluated between ±15° to ±25° of scan on the titled and untitled side of the format. At these scan angles, the orbital fixed known errors produce displacements of approximately 5 microns in both in-track and cross-track directions, with the sign of the error a function of titled versus untitled and positive versus negative scan angle in the format. Subjective assessment indicated that essentially the only mean errors detected were due to orbital fixed known errors and that any cross-track mean error, if present, could be no greater than ±.02 inch/second. The conclusion is that the OOAA settings for the Aft Camera for SO-255 Film were adequate.

3.3.3 Test 3C, Smear Slit Indication of Optimum OOAA Settings, FE-3916 Film

Test 3C was performed for the first time on Mission 1208 to assess the adequacy of the OOAA on the Aft Camera for the IR False Color Film (FE-3916). One operation was executed (Op 756) acquiring Philadelphia at +10° of scan in good weather. The test was performed in a manner similar to Test 3A by inducing large OOAA biases simultaneously in the in-track and cross-track directions (approximately ±.2 inch/second). The inherent low resolution of this film negated any possible image motion assessment, either objectively or subjectively. The double images, although theoretically separated by values varying from 15 to 30 microns, were of such poor quality that they were indistinguishable. It is recommended that this test not be repeated on future missions and that the OOAA setting selected for the SO-255 Color

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Film continue to be used for the FE-3916 IR False Color Film.

3.4 SYSTEM RESOLUTION PERFORMANCE

Three different assessments were made of Mission 1208 camera resolution performance. The first is a direct methodology of acquiring CORN tribar targets. Results are only suggestive, however, due to small sample size and an unvalidated contrast normalization procedure. The second is the VEM resolution data generated and highly controlled for inputs to calculations of Mission Evaluation Score (MES). This, in effect, provides a random format sampling for a reasonably realistic average performance characterization; and, although only a small number of edges were selected for any given formal position, it does serve as a good base for mission-to-mission comparison. Third, the largest data baseline, is the VEM resolution profiles along the major axis (image quality as a function of scan angle) for each of the available scan modes.

3.4.1 CORN Tribar Acquisitions

As with previous missions, CORN tribar targets were acquired to fulfill the Mission 1208 engineering plan. For this mission, the flight stack contained three film types; 1414 black and white, SO-255 Color, and FE-3916 IR False Color; the tribars were to be acquired on each segment as part of a different test.

Parameters for each test differed only in number of acquisitions required. Two acquisitions each on SO-255 and FE-3916 were required (both film types on the Aft Camera) and one per segment with 1414. Each was to be a confirmed clear weather acquisition at nominal focus and exposure and, if possible, be within ±20° of nadir but not outside of ±30 degrees. For the Forward Camera, there were eight mobile CORN tribar acquisitions, all on 1414 Film. Of the eight acquisitions with the Aft Camera, four were on 1414 Film and two each on SO-255 and FE-3916 Films.

The data and acquisition parameters for this mission (see Table 3-8) include the GRD and camera resolving power for both the actual target contrast and the target contrast adjusted to 2:1 at the camera aperture. The resolution values are variable but consistent with other performance indicators. Some general conclusions can be made from this data:

A. The Aft Camera quality was superior to the Forward Camera.

B. Neither of the color films has the resolution capability of 1414.

C. SO-255 has greater resolution than FE-3916.

The actual tribar contrast varied from 2.01:1 to 7.16:1 thus illustrating the dynamic effects of local weather on acquisition conditions. To meaningfully compare resolution values at such extremes, they are all adjusted to 2:1 contrast. The normalization method consisted of multiplying the appropriate optics MTF by the applicable linear Smear Transfer Function representing the orbital fixed known velocity error, which is generally less than one micron of smear.

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TABLE 3-8

1208 MOBILE CORN TRIBAR DATA

— FORWARD CAMERA —

— AFT CAMERA —

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Determination of actual tribar contrast at the entrance pupil via microdensitometry of the gray scales and representative microsensitometric conversion was achieved by a new procedure developed at BRIDGEHEAD. (This procedure is reported in PFA Technical Report No. 7, "Microdensity Correction for CORN Target Contrast Estimation", TCS 363508-73).

The combined optics and smear transfer function is shifted along the modulation axis until it intersects the film TM curve (the curve is adjusted for the actual tribar contrast) at the spatial frequency equal to the read resolution. The TM curve is readjusted for the equivalent 2:1 contrast tribar with the new MTF/TM intersection point. This now represents the 2:1 adjusted tribar resolution. Thus, the tribar normalization procedure requires as inputs: (1) the optics MTF, (2) the smear MTF, (3) the film TM curve, and (4) the actual tribar contrast at the entrance pupil. The 2:1 tribar normalization procedure is more strongly dependent on accurate knowledge of the actual tribar contrast at the entrance pupil than it is on knowledge of the optics or smear MTFs.

3.4.2 Random Format Resolution (VEM/MES)

Visual edge matching was performed by three readers on 40 random access in-track and cross-track edges for each camera per mission segment on predetermined denied area target complexes. The resultant data serves primarily as input to the Mission Evaluation Score. This approach offers a characterization of system performance as a function of camera, direction, and mission segment; it provides a method of comparison between missions using the same operational target complexes.

The distribution of matches made is mapped onto a single 120° frame format, pooling data from both cameras. See Figure 3-5. In the figure, the numerals indicate the field scan angle locations of the edge data as well as the number of samples taken at each sampled position. The sample size varied from one to eight edge matches at a given location. Note from the figure that the VEM/MES data distribution is nearly uniform.

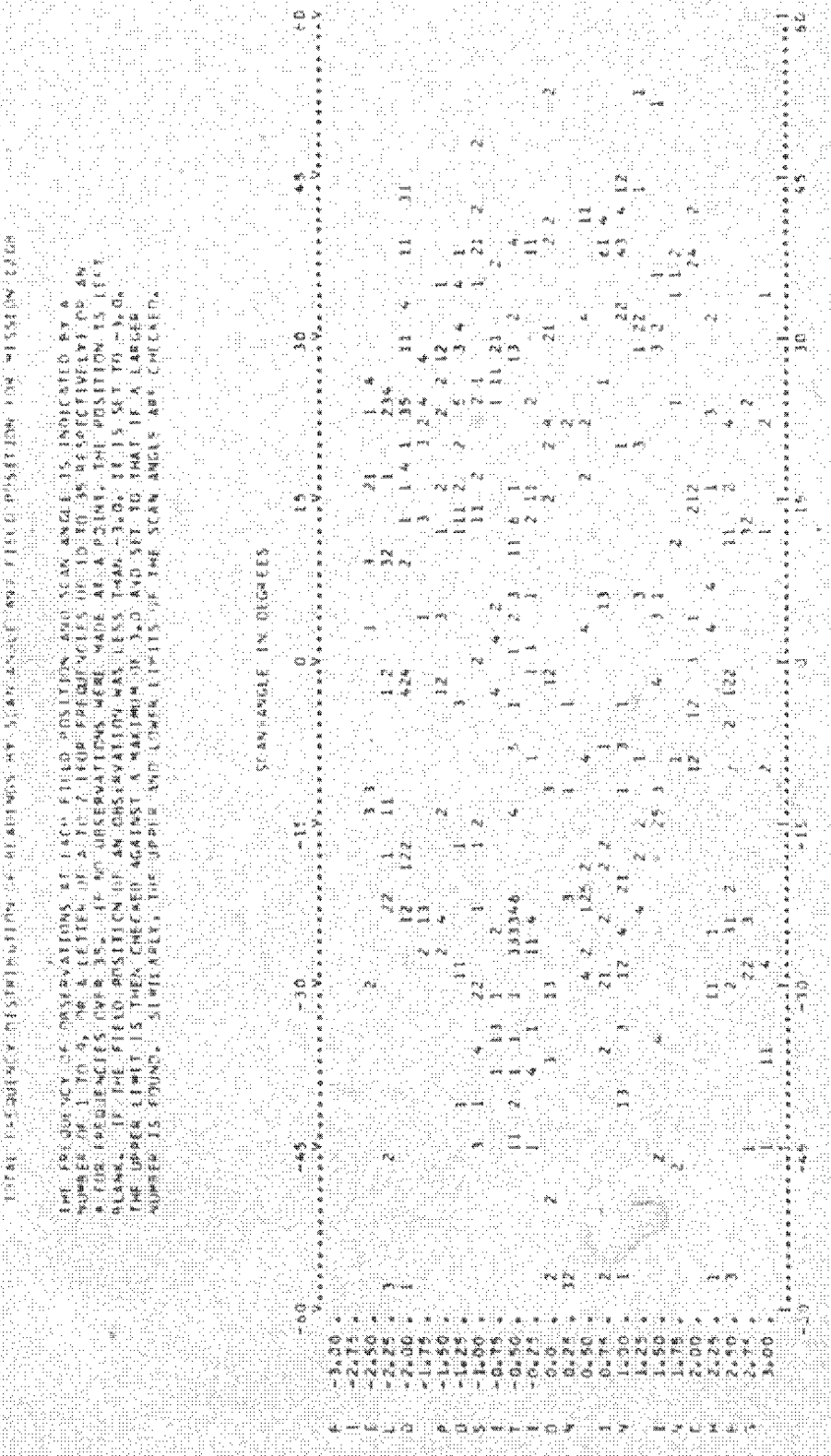
The data for Mission 1208 in terms of equivalent 2:1 contrast VEM resolution is tabulated in terms of mean values together with their respective 95% confidence limits, see Table 3-9. The data is presented as in-track, cross-track and geometric mean for the individual mission segments. Several observations are immediately apparent: (1) the in-track resolution is consistently higher (as anticipated) than cross-track resolution, (2) the mission averages for the two cameras are comparable, and (3) neither camera indicated any performance degradation with time.

Segments of the film stacks for both Forward and Aft Cameras exhibited anomalies (e.g., high base plus fog, different gamma and a lower maximum density). However, a processing adjustment after RV-1 corrected for these anomalies. The VEM/MES for 1208-1 determined the sharpness and contrast for each complex edge. Table 3-10 lists contrast levels and edge sharpness of the affected and non-affected film material. Note that the contrast level obtained for each camera, in either case, is approximately the

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DISTRIBUTION OF VEM/MES DATA



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TABLE 3-9

VEM/MES RESOLUTION SUMMARY

(cycles/mm)

Mission Segment		Forward Camera			Aft Camera		
		In-Track	Cross-Track	Geometric Mean	In-Track	Cross-Track	Geometric Mean
1208-1	(1)	150	137	144	156	142	149
	(2)	154	143	148	161	147	154
	(3)	158	150	153	166	152	158
1208-2	(1)	154	134	145	158	140	149
	(2)	159	142	150	163	147	154
	(3)	165	148	155	168	154	159
1208-3	(1)	152	137	145	152	146	149
	(2)	156	143	149	158	153	155
	(3)	161	150	154	165	159	161
1208-4	(1)	142	128	135	151	139	145
	(2)	151	138	144	158	146	152
	(3)	159	148	152	166	154	159
Mission Averages	(1)	150	134	142	154	142	148
	(2)	155	142	148	160	148	154
	(3)	161	149	154	166	155	159

NOTE: The numbers in parentheses denote: (1) Lower 95% confidence limit on the mean; (2) Mean; (3) Upper 95% confidence limit on the mean.

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same and not biased toward a lower contrast by a base plus fog buildup.

TABLE 3-10

MEAN CONTRAST AND EDGE SHARPNESS VALUES FOR 1208-1

Camera	Status	Contrast	Edge Sharpness
Forward	Affected	3.7	2.21 ± .44
	Non-Affected	3.8	2.16 ± .55
Aft	Affected	3.6	2.02 ± .56
	Non-Affected	3.4	1.95 ± .47

An analysis was performed to determine if there was any significant difference between these sets of means on a per camera basis. The test hypothesis assumed was that no difference existed between population means. A variance ratio test; i.e., F Ratio Test ($V^2 = S_2^2/S_1^2$), was conducted where S_2^2 is the variance between sets and S_1^2 is the variance within sets. For this test, at a 95% probability, if the ratio is calculated to be less than 4.1, then we should not reject the test hypothesis. The ratio for the Forward Camera was determined to be .1 and for the Aft Camera, it was .2. Therefore, no significant difference exists between the affected and non-affected material for RV-1.

For RVs 2, 3, and 4, the non-affected film material was processed normally (19DN) while the affected film material was specially processed (26DN). An investigation was conducted to determine if any significant difference existed for the VEM/MES between the two types of processing. The geometric mean of the in-track and cross-track edge sharpness values were pooled (per camera) for RVs 2, 3, and 4, and the mean and standard deviation estimates were determined, see Table 3-11.

TABLE 3-11

COMBINED EDGE SHARPNESS VALUES AND TYPES OF PROCESSING

(RVs 2, 3, and 4)

Camera	Type of Processing	Edge Sharpness Mean	Standard Deviation	Number of Observations
Forward	26DN	2.14	.51	37
	19DN	2.15	.63	83
Aft	26DN	2.02	.60	71
	19DN	1.87	.47	49

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The test hypothesis assumed was that no significant difference existed between the population means of the two processing types. The variance ratio test was conducted to test this hypothesis. For this test, at a 95% probability, if the ratio is calculated to be less than 3.9, then the test hypothesis should not be rejected. The ratio for the Forward Camera was determined to be .01 and the Aft was 2.18. Therefore, no significant difference exists between sharpness values resulting from materials processed in two different processes.

In Table 3-12 on page 3-23, Mission 1208 VEM/MES data is compared on an RV basis to VEM resolution means and standard deviations of previous missions. In Figure 3-6, a direct comparison of mission means, bounded by their 95% confidence levels for Missions 1203 thru 1208 is shown. A statistical analysis was performed to determine the truth of the hypothesis that all mission means belong to the same population; the previously described variance ratio test was used to test the hypothesis. For this test, at a 95% probability, if the ratio calculated is less than 1.80 then we should not reject the hypothesis. The ratio for all missions (1203 thru 1208) was determined to be 20.4; therefore, we reject the hypothesis that all the mission means are equivalent. The ratio was again calculated for these missions but excluding 1205 data and found to be 6.45. Again, the hypothesis that these means are equivalent must be rejected.

The population means of all missions, considering both Forward and Aft Cameras, were pooled into three separate groups. The first set contained Mission 1205 Forward and Aft Camera means; the second set consisted of Forward Camera mission means from 1203, 1204, 1206, 1207, and Aft Camera mission means from 1206, 1207, 1208; the third set consisted of mission means from the Forward Camera on 1208 and the Aft Camera on 1203 and 1204. For these three sets of data, the ratio at 95% probability should be less than 3.9, 2.11, and 3.01, respectively; the ratio for these was determined to be 1.65, 2.09, and .15, respectively. The conclusion, therefore, is that no significant difference exists within each set; however, significant differences do exist when all data is pooled.

The variance test used here was extremely sensitive due to the large mission sample size (160 observations) with the result that a 5.5 cycles/mm difference in the means was significant. Note that this slight difference in the mean at these resolution levels represents less than a .1' change in ground resolved distance (GRD). From the statistical viewpoint, a .1' GRD difference is significant; however, from a practical viewpoint, this difference is not significant.

In summary, random format 2:1 contrast VEM resolution analysis indicated that:

A. Sampling has been uniformly distributed over the full format.

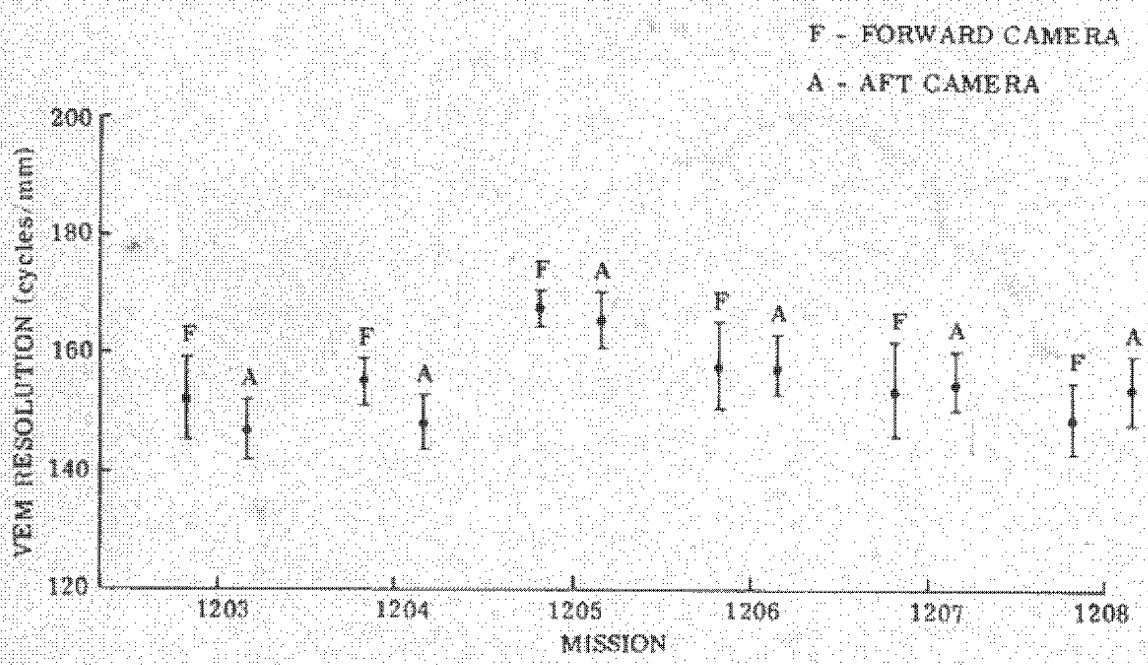
B. In-track resolution is slightly better than cross-track resolution.

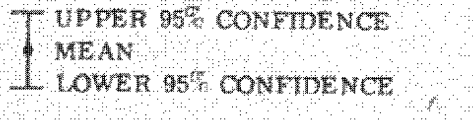
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MISSION AVERAGE GEOMETRIC MEAN VEM RESOLUTION





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C. The two cameras have comparable performance.

D. The overall average resolution for Mission 1208 at 151 cycles/mm is comparable to previous missions except for 1205.

TABLE 3-12

HISTORICAL COMPARISON OF MEAN RESOLUTION LEVELS AND SIGMAS AT 2:1 CONTRAST

(cycles/mm)

— Forward Camera —

	Mission											
	1208		1207		1206		1205		1204		1203	
Mission Segment	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
RV-1	148	15	159	13	159	26	162	8	167	13	156	16
RV-2	150	15	156	18	159	18	159	8	159	15	148	30
RV-3	149	15	152	16	158	21	153	8	153	16	149	17
RV-4	144	25	146	26	152	16	140	9	140	18	153	20
Average	148	18	153	19	157	20	167	8	155	16	152	21
— Aft Camera —												
RV-1	153	13	161	16	154	17	164	13	161	12	147	20
RV-2	154	15	151	17	160	17	168	12	141	25	145	14
RV-3	155	17	152	16	155	13	168	15	145	21	149	20
RV-4	152	22	155	17	160	14	161	27	143	22	146	21
Average	153	17	154	16	157	15	165	18	148	20	147	19

NOTE: $\bar{X}$ values are geometric means of in-track and cross-track measurements.

3.4.3 Major Axis Quality Profiles

3.4.3.1 Introduction

Visual Edge Matching was used to characterize the image quality of Mission 1208 photography along the major axis (the center line of scan). Quality profiles along the format's major axis have in the past shown a fall off in image quality away from scan center regardless of the absolute scan angles involved; this is illustrated in Figure 3-7 which shows a set of major axis profiles taken from Mission 1203. The image quality fall off shown in this figure is one of the most severe examples seen to date. This relationship of image quality to format position has been referred to as the "Arches" phenomenon. This apparent problem has not been consistent from mission-to-mission, varying both in the degree of fall off and in the scan modes affected.

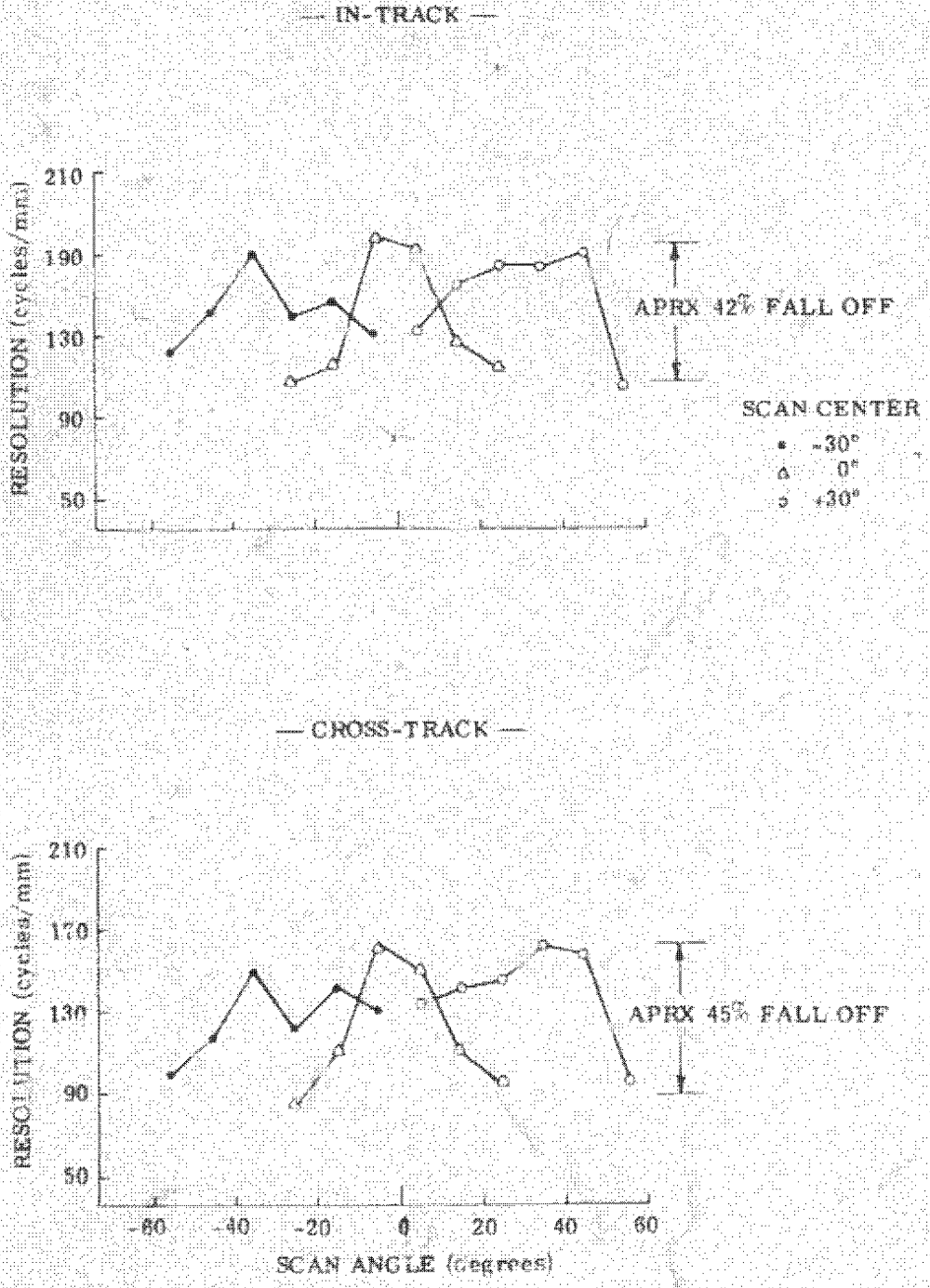
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"ARCHES" PHENOMENON FROM MISSION 1203

(Aft Camera, 60° Scans)



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FIGURE 3-7

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Results of the 1208 measurements generally show a uniform performance level with scan angle. No tendency exists in the 1208 data for a resolution fall off away from scan center as has been indicated in earlier 1200 Series missions. The measured geometric mean (in-track and cross-track) of both cameras was about 154 cycles/mm along the center line of scan.

3.4.3.2 Analysis Procedures

A new data collection procedure was used for the evaluation of this mission's major axis quality profiles. It differed from past methods in two ways: (1) the film to be measured is chipped from the mission DPs to remove any format bias that could exist, and (2) the VEM readings are spread out over a longer period of time to lessen reader fatigue. These method changes are due to the results of tests conducted on 1207 photography. The 1207 test consisted of excising film chips from those areas used for the initial major axis measurements. These film chips were then evaluated by the same VEM readers who had conducted the first set of measurements. The major axis profiles generated from this data exhibited two significant differences from the original measurements:

A. Where the original profiles had shown a large variation in image quality between various scan modes, the new measurements showed very small differences.

B. Where the first set of data had shown several cases of "Arches", only one of the remeasured profiles showed an "Arching" tendency, and the percent fall off from format center to format end was only 11% versus 26% with the old method.

Also, discussions with AFSPPF personnel indicated a preference for the new evaluation technique because of the ease of handling and lower levels of fatigue.

Major axis profiles were obtained for eight of the sixteen possible combinations of scan length and scan center used during this mission. Each profile is composed of a series of VEM measurements made from film chips taken at 15° increments along the major axis of the format. The size of the film chip included an area of ±1° in scan by ±1° in field. Table 3-13 gives the scan angle locations measured in each of the tested scan modes.

Each profile data point is the average of eighteen VEM readings; i.e., nine edge matches by each of two readers. The nine readings per reader per scan angle sampled were made from three film chips with each chip taken from a separate frame to avoid any bias that could result from single frame sampling.

Past major axis measurements sampled nearly every combination of scan length and center used during respective missions. The decision not to do this for 1208 was made to reduce the amount of VEM measurements taken. This, however, in no way reduces the chance of detecting the "Arches" if they exist. A summary by mission, camera, and scan mode of all the measured examples of "Arches" to date is given in Table 3-14. In every mission where some tendency towards "Arches" has occurred,

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the data collection and analysis procedures used in evaluation of 1208 photography would have been effective in detecting them. The scan angles (modes) selected from Mission 1208 are noted in Table 3-14.

TABLE 3-13

LOCATION OF CELLS FOR VEM FILM CHIPS

(degrees)

Scan Angle (degrees)	Scan Center (degrees)	Format Locations				
120	0	-45	-30	0	30	45
90	0	-45	-30	0	30	45
60	30			0	30	45
60	0		-30	0	30	
60	-30	-45	-30	0		
30	30				15 30	45
30	0			-15 0	15	
30	-30	-45	-30	-15		

3.4.3.3 Data Analysis

Major axis data for each of the Forward Camera scan modes measured indicates that of the eight modes analyzed, only the 120° scan shows a symmetrical loss in image quality and this occurs only at ±45° of scan. In general, the other profiles are flat. Figure 3-8 presents the Forward Camera major axis profiles; data collection areas within the scans are shown and not necessarily the whole scan; e.g., the 60° scan profiles.

The 60° plots do show an image quality decrease for the start of frame side of the 0° scan center case; however, no significant quality decrease is measured at the end of frame. The lack of a data point at 0° of scan for the 60° scan centered at -30° is due to an inability to locate culture that would be usable for VEM analysis.

The resolution range for the scan modes measured for the Forward and Aft Cameras is given in Table 3-15. This table compares the maximum resolution, regardless of format position, to the minimum for each of the measured cases.

The data for Aft Camera profiles along the major axis, like that of the Forward Camera, is mostly flat with the exception of the 120° and 90° data. The 120° data does show a decrease in quality away from center, but this loss is only 13% at ±45° of scan. The 90° data is not flat, but sloped with a peak at about -30° of scan. Figure 3-9 presents the Aft Camera profiles; data collection areas within the scans are shown and not necessarily the whole scan.

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TABLE 3-14

"ARCHES" SUMMARY BY MISSIONS

Scan Angle (degrees)	Scan Center (degrees)	Forward Camera 1203	1204	1205	1206	1207	Aft Camera 1203	1204	1205	1206	1207
120°	0	A			A		A	A	A	A	A
90	-15		A			A			A		
90°	0		A		A			A	A		
90	15		A						A		
60°	-30					A					
60	-15				A		A	A	A		
60°	0			A		A					
60	15				A		A	A	A		
60°	30	A									
-30	-45										
30	-30		A		A					A	A
30	-15		A		A					A	A
30°	0		A							A	A
30	15		A		A					A	A
30°	30		A		A					A	A
30	45										

NOTES: 1. The letter "A" denotes data which shows a tendency towards "Arches".

2. The asterisk (*) indicates scan modes selected for analysis in Mission 1208.

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FORWARD CAMERA MAJOR AXIS PROFILES

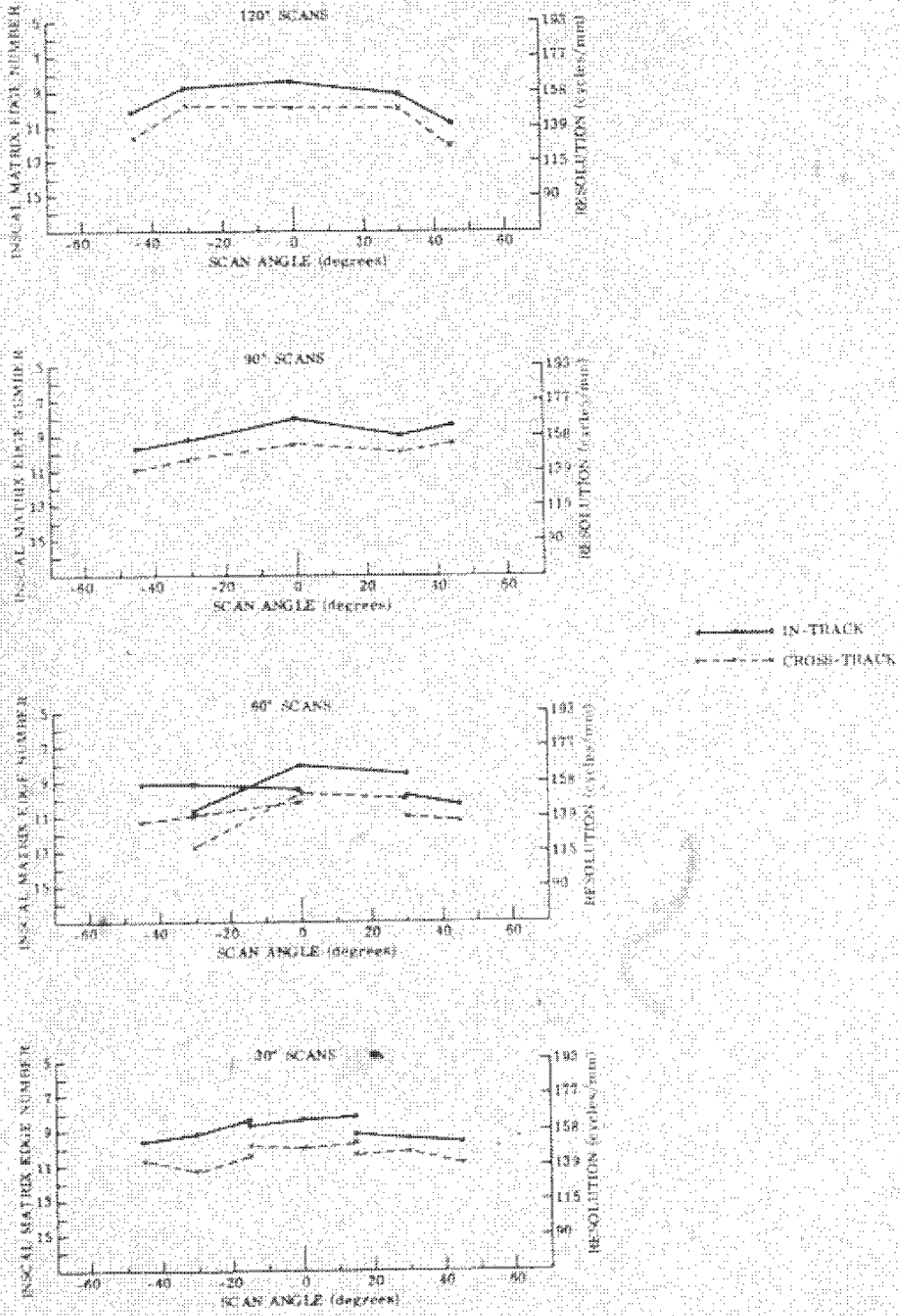


FIGURE 3-8

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TABLE 3-15

RESOLUTION RANGE MEASURED BY VEM FOR EACH SCAN ANGLE

(cycles/mm)

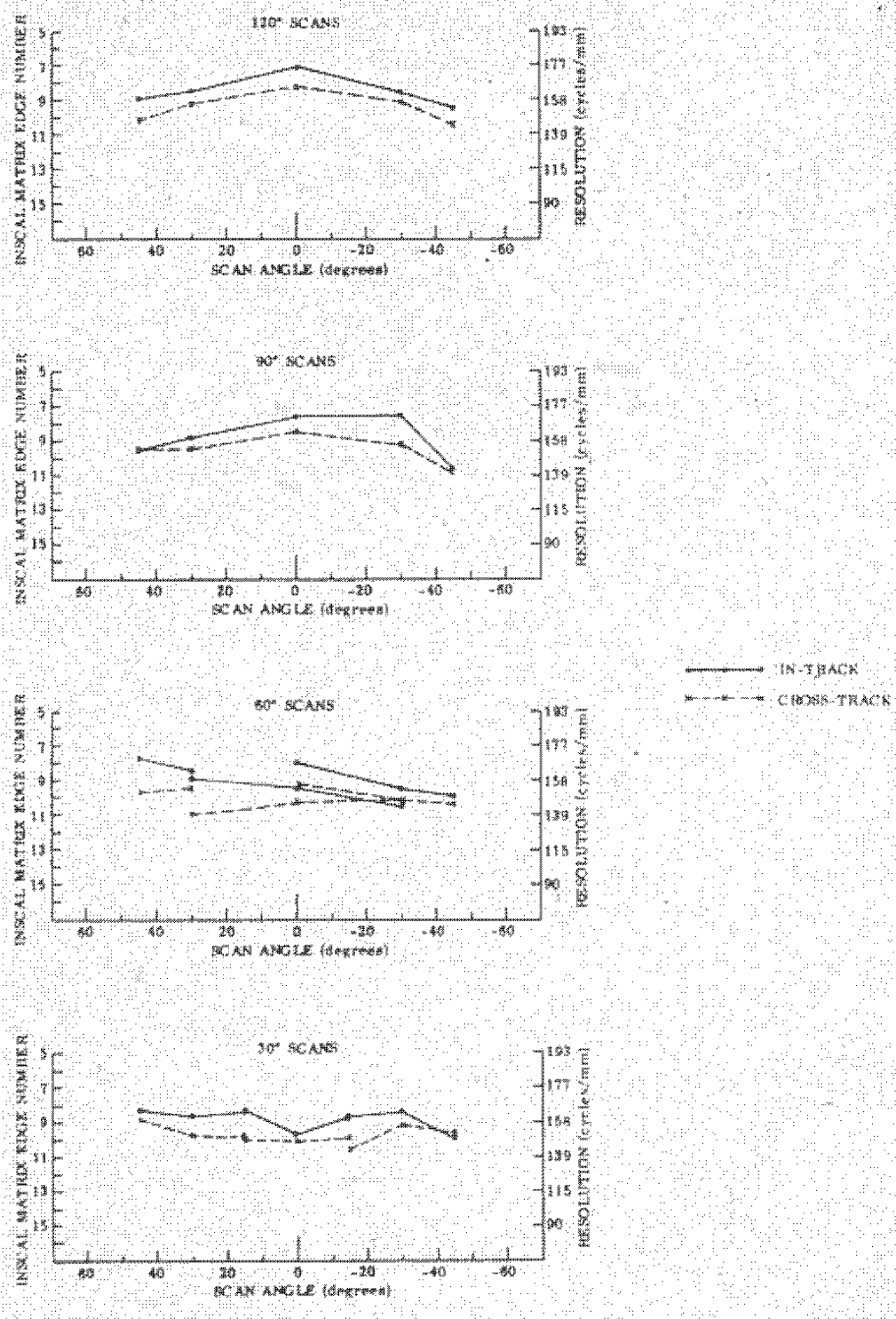
Scan Angle (degrees)	Scan Center (degrees)	Forward Camera						Aft Camera					
		In-Track			Cross-Track			In-Track			Cross-Track		
		Max	Min	%	Max	Min	%	Max	Min	%	Max	Min	%
120	0	164	139	15	151	124	18	175	152	13	165	144	13
90	0	166	149	10	154	139	10	170	140	18	164	140	15
60	30	150	145	3	139	137	1	164	161	2	155	151	3
60	0	168	141	16	168	141	16	159	144	9	147	139	5
60	-30	156	154	1	156	154	1	168	150	11	155	145	6
30	30	156	152	2.5	146	140	4	165	162	2	160	149	7
30	0	166	162	2	151	149	1	166	151	9	151	149	1
30	-30	165	152	8	165	152	8	164	149	9	156	142	9

NOTE: $\% = \frac{\text{Max} - \text{Min}}{\text{Max}} \times 100$

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AFT CAMERA MAJOR AXIS PROFILES



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FIGURE 3-9

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Composite profile plots for each camera were obtained by combining the data collected for each of the scan modes measured. The composite performance for each camera is essentially flat with both cameras exhibiting only an 8% variation in performance within ±45° of scan. Maximum and minimum geometric mean resolution values, for both cameras, are 159 cycles/mm and 146 cycles/mm, respectively. See Figure 3-10.

3.4.3.4 Conclusions and Recommendations

The data shows there was no overall difference in performance level between the various scan modes used during Mission 1208. Further, no case can be made for the dependence of image quality on format location or the existence of "Arches" in this mission. Given the fact that this is the first time since Mission 1203 where no apparent "Arching" has occurred and that this corresponds to the first use of a different measurement technique, some question is raised concerning the validity of past data.

3.5 LABORATORY VERSUS ORBITAL PERFORMANCE

Ground testing in environmental test Chambers A and A-2 reveals several aspects of camera performance: resolution, optical field curvature, platen tilt, quality variability, and image motion. On-orbit, the engineering tests designed to fine-tune the focus setting and image motion compensation yield a data base that allows a comparison of operational versus laboratory performance of the Sensor Subsystem.

3.5.1 Resolution

Measurements of 2:1 contrast resolution are made both prior to launch and on-orbit. The prelaunch measurements are made from tribar targets imaged in Chamber A-2 on the original negative 1414 Film. A complete description of the methods used and results obtained is given in the SV-8 Flight Readiness Report (BYE 15250-74).

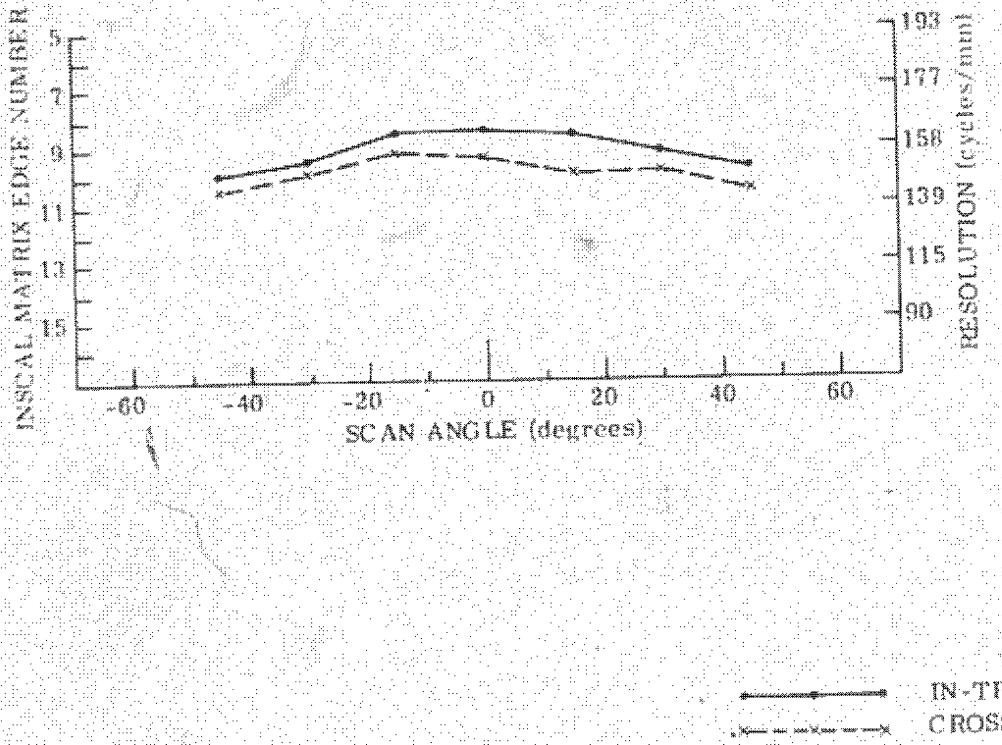
The on-orbit resolution measurements are made on the SO-192 duplicate positives using visual edge matching as discussed in paragraph 3.2 of this report. VEM resolution values are in terms of equivalent 2:1 contrast resolution values obtained through a laboratory derived calibration curve. A comparison of on-orbit to ground test resolution is made by comparing the laboratory resolution profiles across the field with the VEM derived minor axis profile at the optimum on-orbit platen position.

Chamber A-2 results showed pronounced field curvature in both cameras of SV-8 whereas the analysis of on-orbit data indicated an almost perfectly flat field in both cases. However, for the purpose of comparison, it was assumed that both fields are flat and the on-orbit data was compared to the peak resolution values obtained at each field position in Chamber A-2 testing. Furthermore, the collimator system interaction across the field has been under investigation for some time and, for this analysis, it was decided to accept the flat field response, thereby establishing stringent expectations for the Sensor System's on-orbit performance. Results are presented in paragraph 3.5.2.

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COMPOSITE MAJOR AXIS PROFILES



NOTE: For both cameras, the geometric mean high point and low point on the profiles are 159 and 146 cycles/mm, respectively, with a percentage difference of 8 percent.

FIGURE 3-10

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A comparison of resolution values from chamber tests and operational data is given in Table 3-16. The Forward Camera in-track performance is 15% lower on-orbit than in the laboratory and the cross-track 4% lower, while the Aft Camera in-track performance is 9% lower and the cross-track higher by 2 percent. It is concluded that both cameras performed essentially the same on-orbit as during the Chamber A-2 test cycle.

The OOAA settings in RV-1, however, were incorrect for the Forward Camera cross-track and the Aft Camera in-track direction by -.013 and +.024 inch/second, respectively. Therefore, these performances are understandably depressed. The result is that only the Forward Camera in-track performance is low but within the generally accepted 15% resolution measurement error budget.

3.5.2 Optical Field Curvature

The effective field curvature in mission photography is determined by using VEM minor axis profile data generated by Engineering Test No. 1, focus series frames. At each field position of interest, smoothed curves representing the best estimate of thru focus response are drawn from the available data points, see Figures 3-11 and 3-12. The apparent PBFs are selected from these curves. Normalizing to the 0° position, these PBFs define the final estimate of on-orbit field curvature for each camera, see Figure 3-13. The final assessment of on-orbit field curvature is not as precise as it could be because of the limited thru focus samples; this limitation is the result of acquisition conditions and film consumption. The on-orbit data for Mission 1208 indicates a flat field and little if any platen tilt for either camera.

The on-orbit estimate of field curvature shows very good agreement with Chamber D determined field curvature. However, the preflight test measurements in Chamber A-2 indicate about 25 microns of effective field curvature which is in poor agreement with the on-orbit estimate. The reason for this discrepancy is not presently known; however, a 20 micron field curvature could be found by VEM on operational photography.

3.5.3 Quality Variability

Previous mission reports have dealt with quality variability by comparing the coefficient of dispersion for the VEM/MES ($\sigma/\bar{R}$, the ratio of the standard deviation to the average resolution) to the tribar readings made during flight readiness testing. These results appeared to be relatively constant for all previous missions; i.e. . .14 for on-orbit and .08 for laboratory testing. Although it was anticipated that some increased variability would take place on-orbit, since laboratory testing does not include all camera and vehicle known errors, the magnitude of actual change was surprisingly large. To resolve this peculiarity, a more in-depth examination of the comparison was attempted.

The VEM/MES measurements shown in paragraph 3.4.2 are made randomly over the entire format. Therefore, this data includes fixed known image motion errors whose magnitude vary both in-track and cross-track as a function of format position. Because these fixed known errors are not present during

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TABLE 3-16

2:1 CONTRAST MEASURED RESOLUTION COMPARISON BEFORE AND AFTER LAUNCH

(cycles/mm)

— In-Track —

	Forward Camera			Aft Camera		
Field Angle (degrees)	Lab Tribar Test	Orbit VEM	Difference (%)	Lab Tribar Test	Orbit VEM	Difference (%)
-2.5	203	156	-23	191	180	-6
-2.0	198	160	-19	199	183	-8
-1.0	214	164	-23	186	187	1
0.0	181	171	-6	202	185	-8
1.0	167	173	4	206	183	-11
2.0	192	161	-16	189	173	-8
2.5	181	153	-15	204	165	-19
Average	191	163	-15	197	179	-9

— Cross-Track —

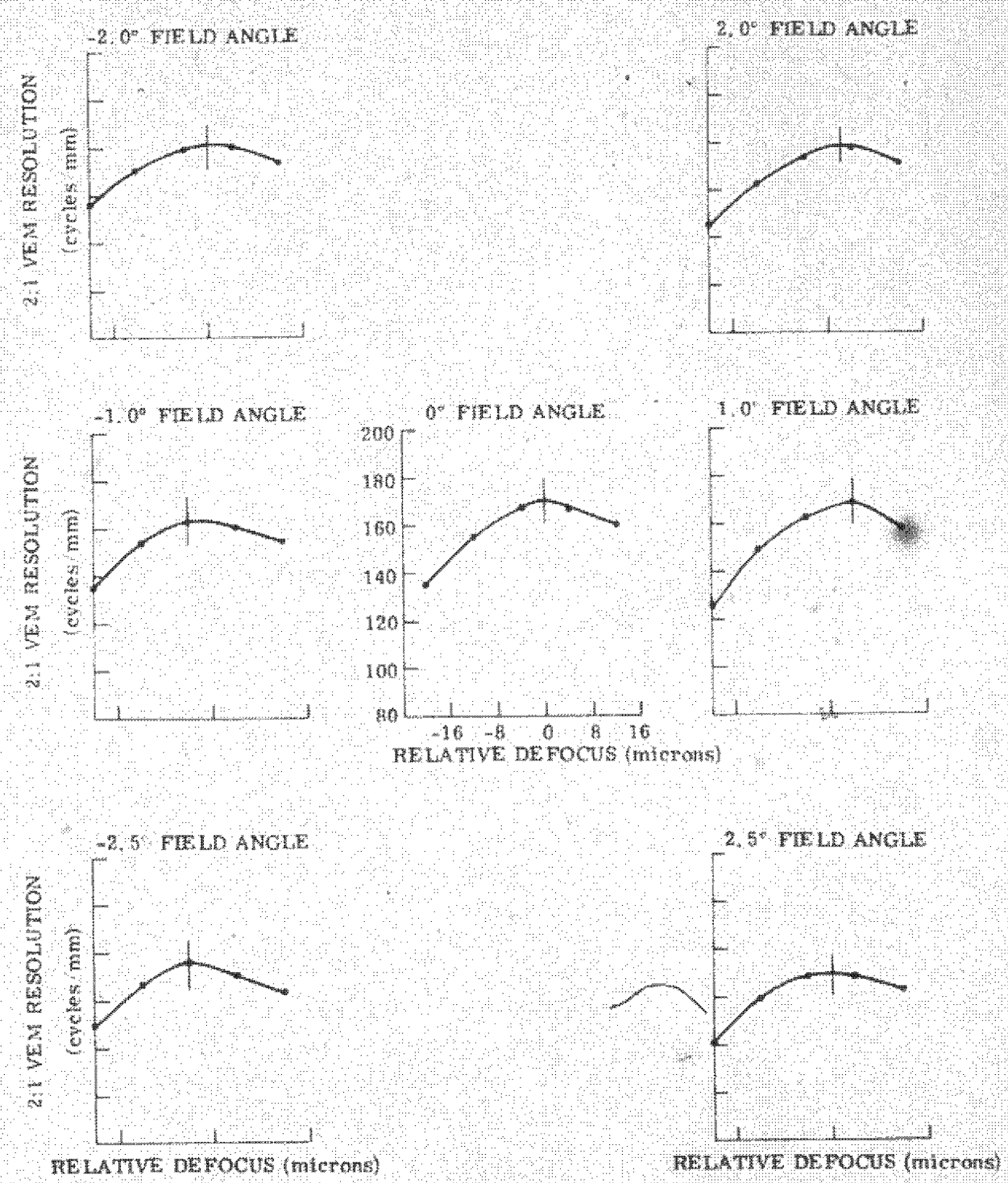
-2.5	169	144	-15	164	168	2
-2.0	167	149	-11	173	170	-2
-1.0	181	157	-13	158	174	10
0.0	165	162	-2	170	176	4
1.0	142	163	15	176	176	0
2.0	154	154	0	169	170	1
2.5	151	147	-3	169	164	-3
Average	161	154	-4	168	171	2

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1208-1 FORWARD CAMERA ON-ORBIT THRU FOCUS GEOMETRIC MEAN RESOLUTION AS A FUNCTION OF FIELD ANGLE



NOTE: The vertical line (|) designates relative defocus as measured from 0° field angle.

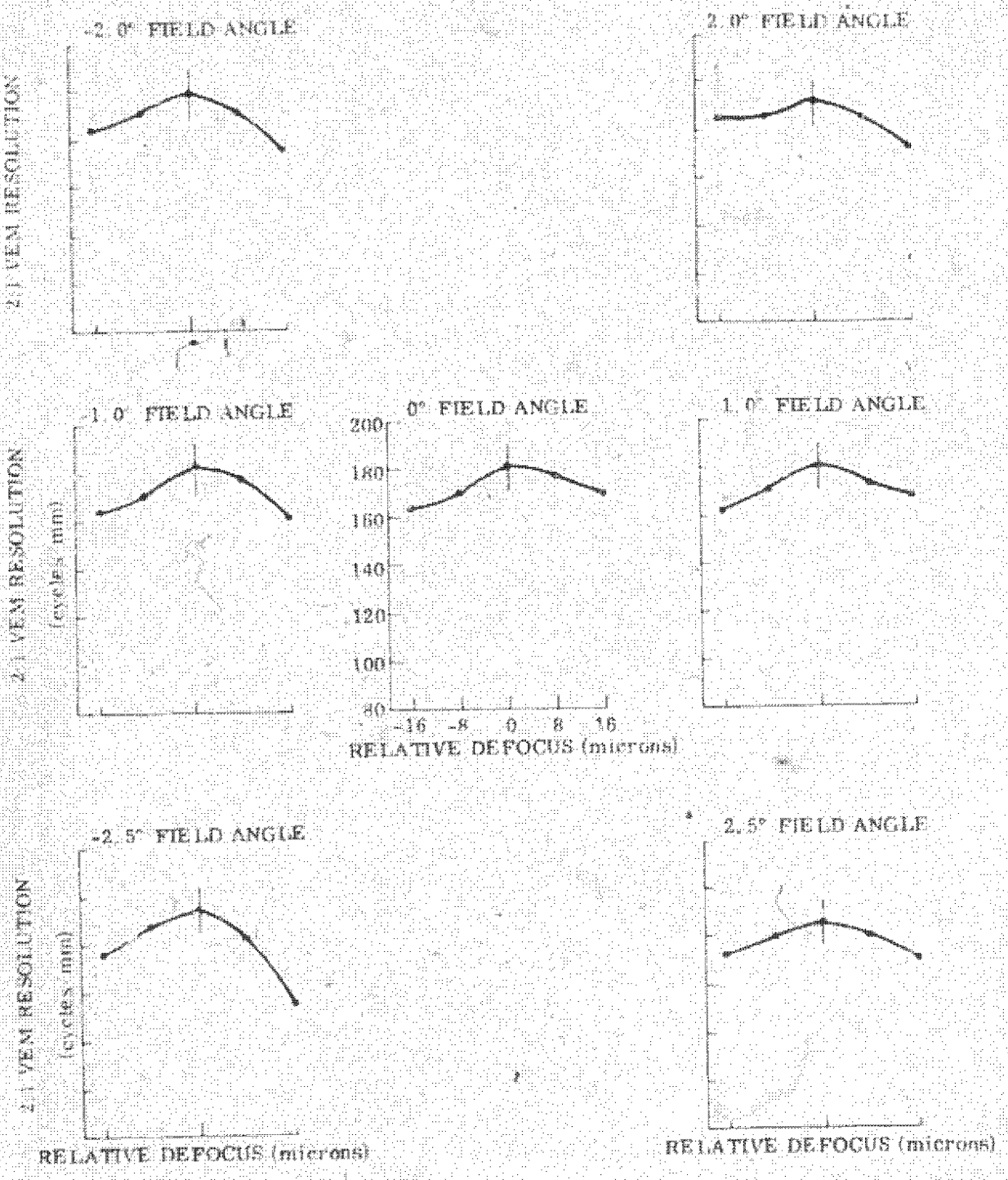
FIGURE 3-11

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1208-1 AFT CAMERA ON-ORBIT THRU FOCUS GEOMETRIC MEAN RESOLUTION AS A FUNCTION OF FIELD ANGLE



NOTE: The vertical line (|) designates relative defocus as measured from 0° field angle.

FIGURE 3-12

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laboratory tribar testing, the comparison of VEM/MES to laboratory tribar testing is tenuous if format location is not taken into consideration.

For Mission 1208, the VEM/MES data was restricted to within ±1° of field angle and ±10° of scan center. For these scan and field angles, there should be no fixed known orbital image motion errors. Table 3-17 presents results obtained from a direct comparison of on-orbit with laboratory (Chamber A-2) data at nadir. Due to the nature of VEM/MES data collection, operational sample sizes are smaller than those from lab test but sufficiently large to give a good indication of the variability.

The data shows that the quality variability between laboratory and on-orbit photography at nadir is comparable. This is consistent with a priori knowledge and image motion results shown in paragraph 3.5.3.

TABLE 3-17

ON-ORBIT VERSUS CHAMBER QUALITY VARIABILITY

(σ R Values)

	Chamber A-2			On-Orbit		
Camera	IT	XT	Sample Size	IT	XT	Sample Size
Forward	.11	.11	19	.08	.10	10
Aft	.10	.11	19	.08	.09	10

3.5.4 Smear As A Function of Scan Angle (Test 10)

3.5.4.1 General

The objective of Test 10 is to assess smear as a function of scan angle, and correlate on-orbit measured velocity errors with chamber ground test sync-flash derived errors at the four discrete collimator locations in the panoramic format. To accomplish this on Mission 1208, photography was acquired at scan angles within ±20° of nadir and from ±30° to ±50° of scan with known OOAA biases (approximately ±.2 inch second from nominal orbital settings). The displacement between double image pairs is measured and compared to the theoretically predicted displacement, the difference being the resultant error. The Test 3A data is processed identically to and merged with the Test 10 data to obtain the data points within ±20° of nadir. The Aft Camera in-track data prior to Op 160 is adjusted to reflect the -3 command step change implemented to the camera effective on that operation, while the Forward Camera cross-track data prior to Op 390 is adjusted to reflect the +1 command step change. A total of nine operations were performed for Tests 3A and 10.

In the Test 10, velocity error is a function of scan angle and each data point is the average of three repeated measurements of the same object in the in-track and cross-track directions, see Figures

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3-14 and 3-15. For the Forward Camera, approximately 340 objects were measured from eight operations, while the Aft Camera data was obtained from nine operations and consists of approximately 290 objects. Included in Figures 3-14 and 3-15 is the ground test predicted on-orbit velocity error at each of the four discrete collimator locations. Ground test data points are the algebraic sum of the most current Chamber A and A-2 sync-flash indicated velocity errors, which include gravity induced image motion, reticle rotation, and OOAA adjustments prior to launch. That is, they represent the predicted on-orbit performance and are directly comparable to the on-orbit smear slit derived mean values. A positive value is indicative of film that is moving too fast relative to the image or that the skew angle is too large. The data plotted in Figures 3-14 and 3-15 was segmented into three scan groups of approximately 0° to ±15°, 35° to 50°, and -35° to -50 degrees. For each scan group, the mean and 2σ error were computed and are tabulated in Table 3-18.

TABLE 3-18

ON-ORBIT MEAN SMEAR AND VARIABILITY AS A FUNCTION OF SCAN

Scan Angle (degrees)		Forward Camera		Aft Camera	
		In-Track	Cross-Track	In-Track	Cross-Track
-50 to -35	Mean	-.011	-.014	-.004	-.009
	2σ	±.050	±.072	±.044	±.060
-15 to 15	Mean	-.004	.002	-.004	.003
	2σ	±.056	±.088	±.058	±.082
35 to 50	Mean	.003	.013	-.022	.004
	2σ	±.046	±.066	±.054	±.066
Overall Average	Mean	-.004	0	-.010	-.001
	2σ	±.050	±.076	±.052	±.070

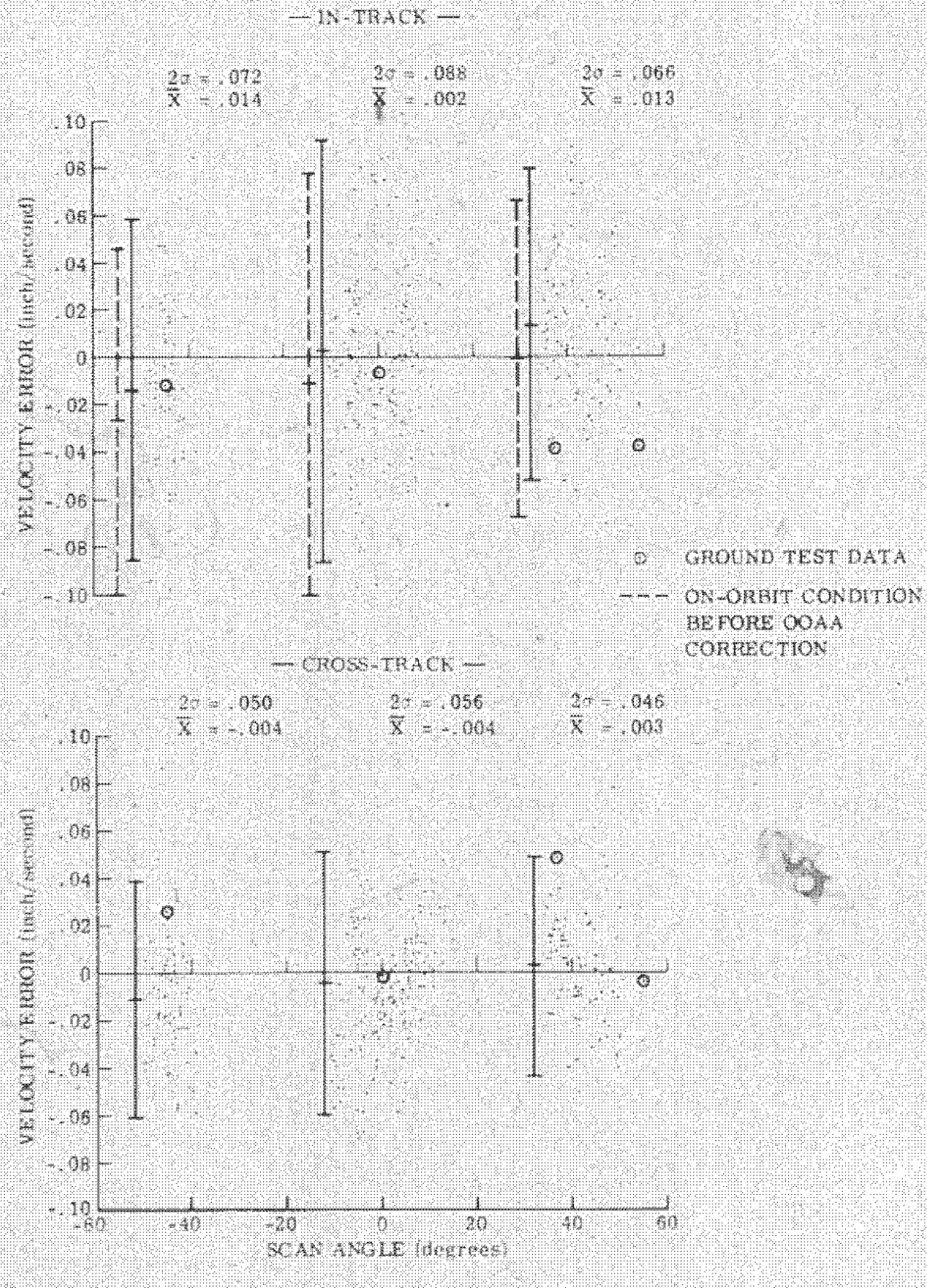
3.5.4.2 On-Orbit Results

Orbital results of smear as a function of scan for Missions 1207 and 1208, are presented in Figure 3-16. Note that at the start of scan portion of the frame on both cameras the results are consistent and in general indicate no appreciable scan dependent mean error (with the exception of Mission 1208 on the Aft Camera in the in-track direction). At the end of scan portion of the frame, the Forward Camera cross-track and Aft Camera in-track are significantly different between the two missions.

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TEST 10 FORWARD CAMERA



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FIGURE 3-14

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TEST 10 AFT CAMERA

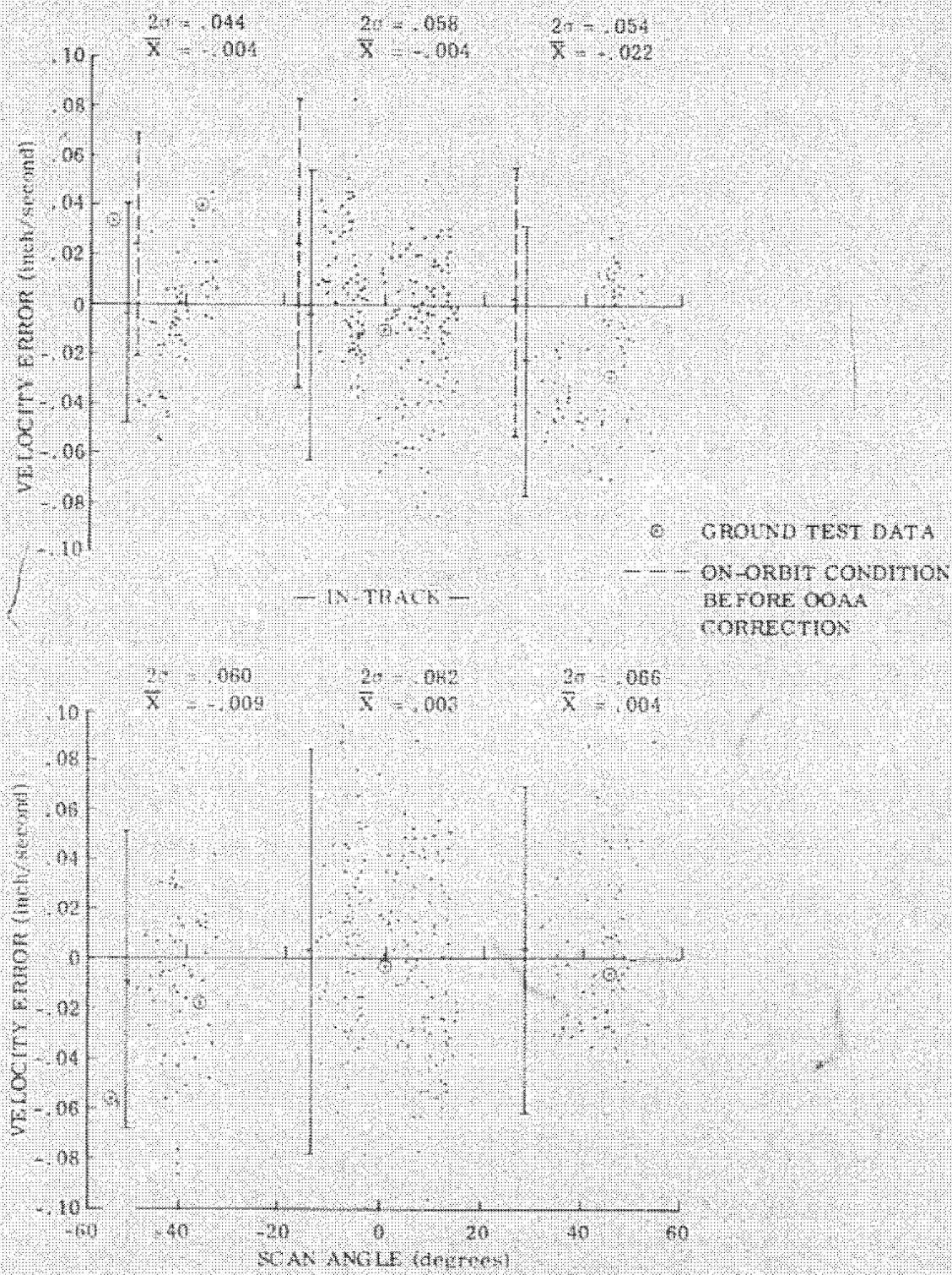
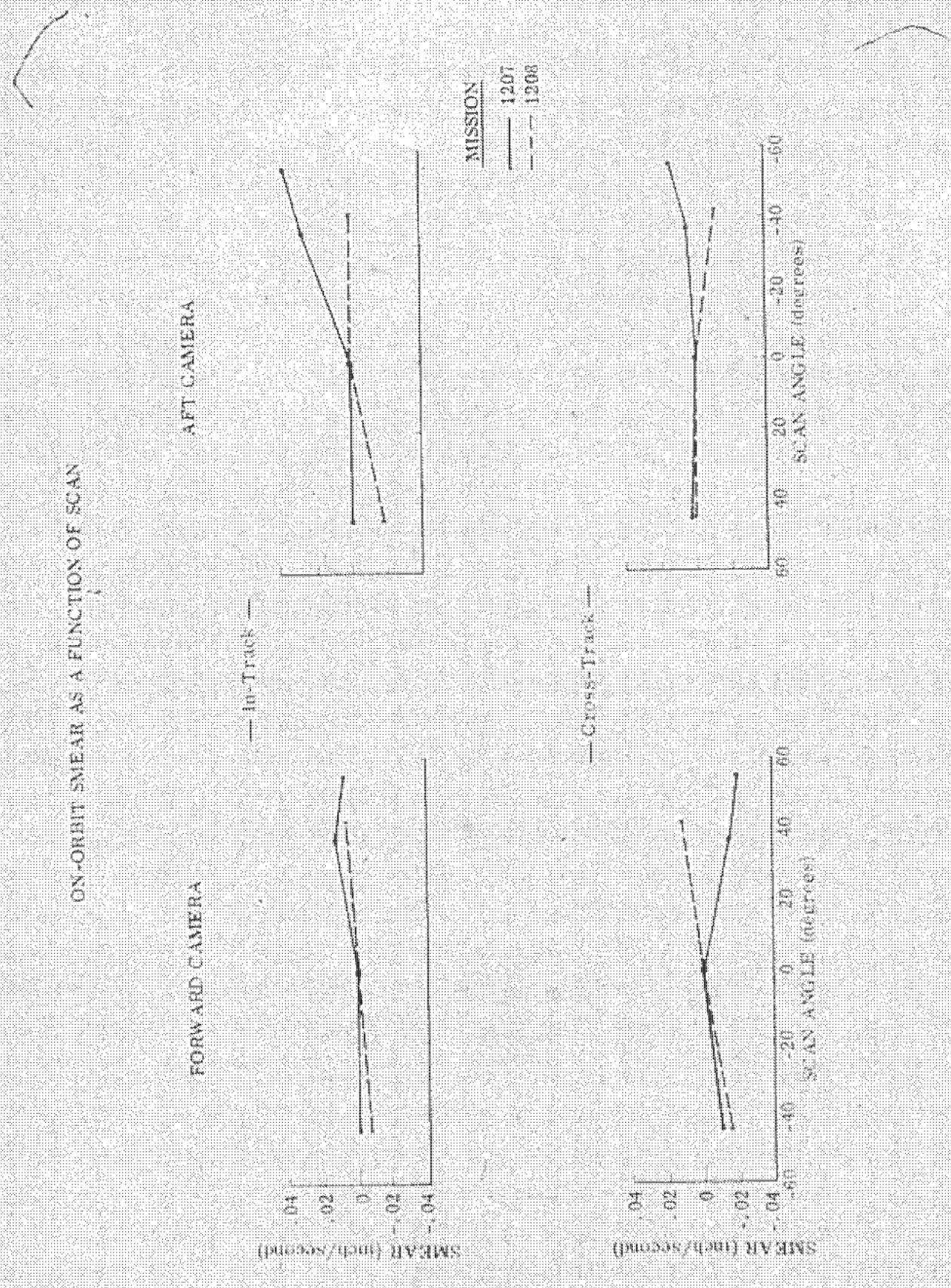


FIGURE 3-15

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FIGURE 3-16

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The correlation of orbital results with the collimator sync-flash measured mean errors is given in Table 3-19. Differences between ground test and orbital mean velocity errors emerge from this data. The conclusions are that the Forward Camera in-track and the Aft Camera cross-track component velocities are being accurately set for orbit based on the 0° collimator. In the Forward Camera cross-track direction, the setting may be too slow by .01 inch/second, and the Aft in-track too fast by .03 inch/second. Additional data will be acquired on Mission 1209 to establish a larger historical data base for judging these conclusions.

TABLE 3-19

COLLIMATOR VERSUS ORBITAL CORRELATION OF SMEAR

(inch/second)

		Collimator (degrees)			
Camera	Direction	+45	0	+37	+55
Forward	In-Track	.03	0	.03	-.01
	Cross-Track	.01	.01	**	**
Aft	In-Track	-.03*	-.03	**	**
	Cross-Track	-.01	0	**	**

NOTES: 1. The results are based upon data from Missions 1207 and 1208; collimator minus orbital velocity errors. Values are all approximate.

2. The asterisk (*) denotes inclusion of pre-OOAA correction.

3. The asterisks (**) indicate that values are indeterminable.

3.5.4.3 Camera Variability

The ground test sync-flash derived values of velocity error variability for SV-8 are obtained from the most current Chamber A-2 tests and are the average of Vx/h of .052 and Vx/h .044, see Table 3-20. The average values of the two sigma error across the format are used for comparisons to the orbital data. Table 3-18 on page 3-39 contains the computed values of the two sigma error as a function of scan; note that in all four directions (both cameras in each direction) the two sigma value is larger near the zero scan than at either the positive or negative high scan angles, and that at the end of the scan portion of the format, it is less than either start of scan or zero scan.

A comparison was made between the variability measured during ground test, the anticipated on-orbit values, the measured on-orbit values, and the on-orbit budget values, see Table 3-21. The anticipated values for on-orbit variability were obtained by combining the most current ground test measured data with the anticipated on-orbit errors due to random and fixed unknown error sources. The

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TABLE 3-20

GROUND TEST SMEAR VARIABILITY TWO SIGMA

(inch/second)

		Collimator (degrees)			
Camera	Direction	0	55	37	Average
Forward	In-Track	.034	.027	.035	.032
	Cross-Track	.026	.035	.050	.045
Aft	In-Track	.026	.011	.032	.023
	Cross-Track	.061	.032	.058	.050

NOTE: These values are the average of test data with Vx/h of .052 and Vx/h of .044 and from the Chamber A-2 test box-in and post vacuum test box-out.

TABLE 3-21

COMPARISON OF OVERALL SMEAR VARIABILITY TWO SIGMA

(inch/second)

			On-Orbit		
Camera	Direction	Ground Test	Anticipated	Measured	Budgeted Values
Forward	In-Track	.032	.038	.050	.047
	Cross-Track	.045	.047	.076	.071
Aft	In-Track	.023	.031	.052	.047
	Cross-Track	.050	.052	.070	.071

NOTE: Definitions:

1. Ground Test = Most current chamber measured values (from Table 3-15).
2. Anticipated On-Orbit = RSS of ground test value plus anticipated additional on-orbit random plus fixed unknown errors.
3. Measured On-Orbit = Smear slit derived errors.
4. Budgeted Values = RSS of 32 budgeted fixed unknown plus random errors (ground test plus orbital).

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budgeted values for five first-order contributors to on-orbit smear were used (vehicle yaw error; roll, pitch, and yaw rate errors; and Vx/h command errors), which account for 80% of the on-orbit error (external to the sensor).

As with Mission 1207, the measured on-orbit values are very nearly equal to the budgeted values. In comparing orbital versus ground test variability for Missions 1207 and 1208, it was noted that the four cameras for a given direction (in-track or cross-track) differ very little, see Table 3-22. The overall average for variability measured by ground test in the in-track direction is approximately .026 inch/second, and the cross-track .044 inch/second. The orbital data indicates that on the average, both the in-track and cross-track measured values are expected to increase .026 inch/second in both directions from their ground test values. A portion of the .026 inch/second increase is budgeted as measurement error which is probably no greater than .01 inch/second. The .01 inch/second is based on laboratory results from ten readers, and the decrease in the two sigma values (approximately .01 inch/second) when accepted data rejection techniques are used. This leaves an increase between ground test and orbital variability of approximately .016 inch/second, which is equal to the anticipated fixed unknown plus random errors.

3.5.5 Line/Lens MTF

3.5.5.1 Background, Summary

For the three previous 1200 Series missions, line targets were deployed and acquired for measuring the MTFs of the optics on-orbit and comparing these to test chamber measured MTFs. This was done as an experiment to determine if a difference exists between the optical performance on-orbit and the optical performance in ground testing (Mission 1205, 1206, and 1207 PFA Report references are TCS 363510-73, and TCS 363515-73, and TCS 363505-74, respectively.).

Results of the line/lens experiment for Mission 1208 (paragraph 3.5.5.2) are nearly opposite to the results obtained on Mission 1206. The Chamber A-2 line/lens MTFs are lower than the orbital line/lens MTFs, while the Chamber D derived MTFs show very good agreement with the orbital MTFs at all field angles.

It is most likely that the limits of accuracy and precision, as related to present procedures, have been reached in the total line/lens analysis technique. Analyses of results must therefore be tempered and should not be construed as conclusive indications of real differences between orbital and preflight optical performance.

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TABLE 3-22

MISSIONS 1207 AND 1208 GROUND TEST AND
ORBITAL VARIABILITY TWO SIGMA
(inch/second)

		Ground Test		Measured On-Orbit		Orbit Ground Test	
Camera	Direction	1207	1208	1207	1208	1207	1208
Forward	In-Track	.022	.032	.044	.050	.022	.018
	Cross-Track	.045	.045	.060	.076	.015	.031
Aft	In-Track	.026	.023	.062	.052	.034	.020
	Cross-Track	.035	.050	.074	.070	.039	.020
Overall Avg	In-Track	.026		.052		.026	
	Cross-Track	.044		.070		.026	

3.5.5.2 Line/Lens Procedure, Mission 1208

The approach used on Mission 1208 was similar to that used on Mission 1206, with one important exception. In addition to lines acquired at the nominal film platen position, lines were acquired at +8 microns from the nominal position to obtain a more accurate estimate of the effective optics/film orbital field curvature.

The North South CORN line array, consisting of 16 pairs of in-track and cross-track lines (each line being 8" x 75") across the field format, was deployed. The arrays were acquired within ±10° of nadir at nominal focus (after B-831 RV-1 corrections) and OOAA-settings with a .6 millisecond exposure time which resulted in less than 1 micron of smear for all lines acquired. Also, no lines were acquired on those frames and for those scan angles where the roller set anomaly exists.

In the Mission 1208 operationally acquired line data (Table 3-23) the "number of useful lines" is less than the total number of lines successfully acquired; i.e., 206 versus 294, see Table 3-23. This is due to the fact that only lines acquired at certain field angles are comparable to test chamber lines; thus, operational lines acquired in the following seven field cells were used:

Operational Line Field Cell (degrees)			Comparable Chamber A-2 Line Field Angle (degrees)
-2.8	→	-2.3	-2.5
-2.2	→	-1.8	-2.0
-1.2	→	-1.4	-1.0
-.3	→	.3	0.0
.8	→	1.2	1.0
1.8	→	2.2	2.0
2.3	→	2.8	2.5

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The operational lines on the original negative were traced on two PDS Microdensitometers, 10x 99 μm slit, at AFSPPF and processed through the PFALINES Computer Program. Each line was processed twice; i.e., both with and without the non-linear process diffusion model option. This option, recently added to PFALINES, theoretically accounts for and removes adjacency effects[1] inherent in dual gamma film processing. However, the chamber lines are ordinarily processed through FOCMO, which does not incorporate the diffusion model. FOCMO output would therefore not be directly comparable to operational lines which have been computer processed with the diffusion model. Apparently, a fairly constant difference in terms of output MTFs exists between operational lines processed with and without the diffusion model. For lines acquired in any one field cell (same camera and direction) the same "best" CORN line is identified in the PFALINES output, either with or without use of the diffusion model option.

TABLE 3-22

CORN LINES ACQUIRED DURING MISSION 1208
FOR LINE/LENS EXPERIMENT

Op	Frames	Forward Platen Position (microns)	Number of Useful Lines IT	Number of Useful Lines XT	Aft Platen Position (microns)	Number of Useful Lines IT	Number of Useful Lines XT
311	4,5,6						
346	10,11,12	76 (nominal)	20	29	25 (nominal)	39	34
502	10,11,12						
388	10,11,12	84 (+8)	13	12	33 (+8)	12	13
388	20,21,22	68 (-8)	6	0	17 (-8)	10	9

The PFALINES version without the diffusion model used as inputs the assumed combined 1414 Film/PDS Microdensitometer MTF and the "small scale sensitometric assumption", see Figure 3-17. This combination uses the macro process D log E curve with a straight line extension at the maximum gamma point. The algorithm converts the line trace, density versus distance, to effective exposure versus distance by means of the straight line extended D log E curve. Then, it Fourier transforms this line profile with noise smoothing and divides out the film/microdensitometer MTF and known target line frequency spectrum (a sinc function). The result is printed out as the optics MTF.

3.5.5.3 Results

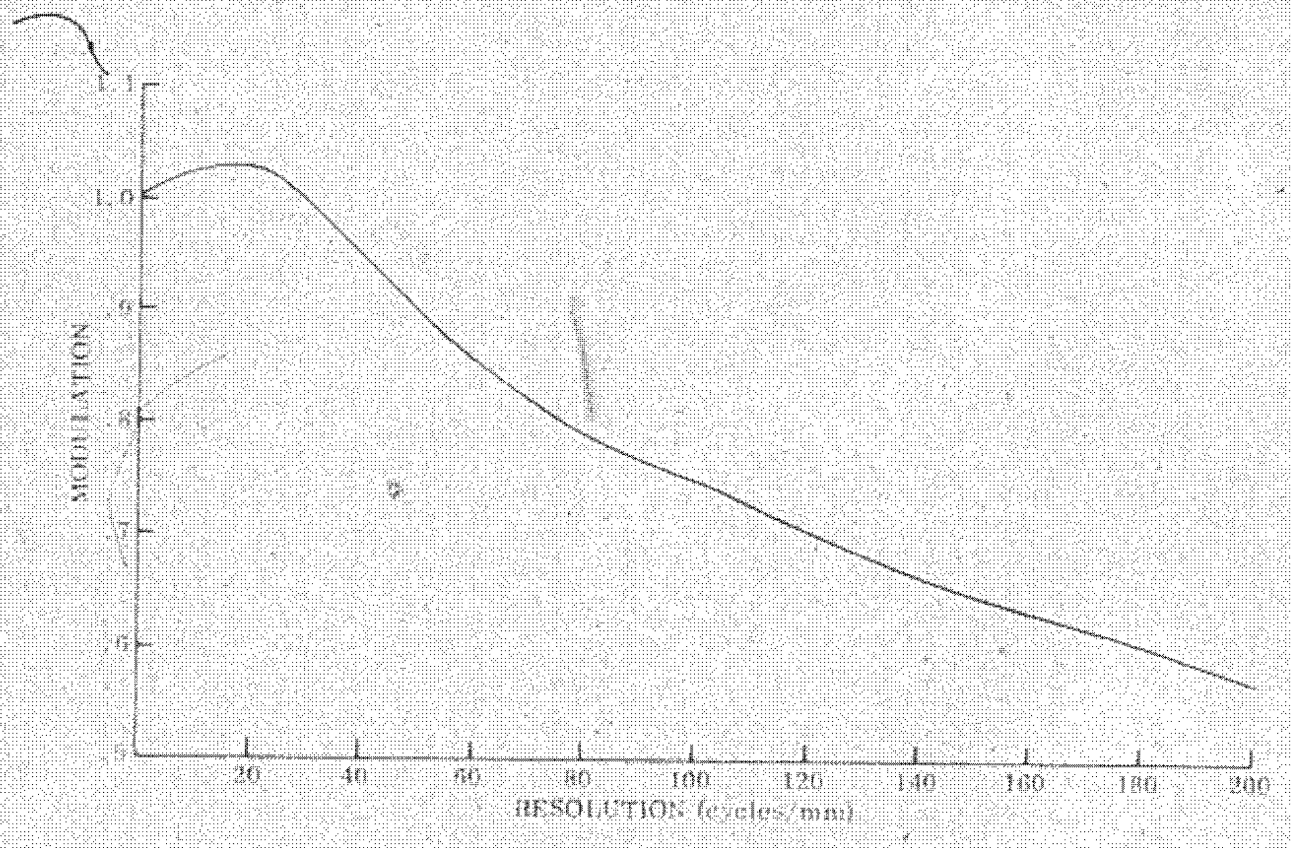
In deciding which operational lines to use in comparison with test chamber lines, operational lines were chosen only from the nominal positions where more than twice as many lines were

[1] Ehn, Stievitch, J. Opt. Soc. AM, May 1974, pg. 667.

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COMBINED 1414 FILM, PDS MICRODENSITOMETER MTF



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FIGURE 3-17

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acquired than at either of the other two positions. Furthermore, some of the +8 micron platen position line orientations were inaccurate; i.e., not strictly scan or flight. Resolution versus field angle plots for Forward and Aft Cameras, flight and scan directions, of all successfully acquired lines at nominal platen positions are presented in Figures 3-16 and 3-19. This data is derived from PFALINES without the diffusion model option. Resolution values in this computer program are determined by intersecting the calculated optics MTF with a 2:1 contrast adjusted, film threshold modulation (TM) curve.

Note in these figures the significant spread in resolution values, and thus in PFALINES derived optics MTFs, at any given field angle. This spread is due to microdensitometer tracing variability (such as misalignment or defocus), film grain noise effects, and real differences in camera system quality from line image to line image (within and between frames). In addition, two thirds of the lines at nominal platen position were special dual gamma processed in 26DN.

The reason for using the special 26DN process was to compensate for a high log level anomaly occurring on some of the film footage (further discussed in paragraph 4). Over the density range covered by the lines (.4 → 1.7) and with the previously mentioned D log E straight line extrapolation, the D log E curve for special processing is almost identical to the D log E curve with normal processing. Some preliminary experimental evidence, however, suggests that the adjacency effects are different between the two dual gamma viscous developer types. This may contribute to the variability in results from PFALINES for a given field angle, camera, and direction.

The operational lines chosen for comparison to test chamber lines yield the highest MTF/TM resolution in a given field cell (indicated by circled data points in Figures 3-18 and 3-19), except where the highest resolution line is felt to be a spurious data point (e.g., Aft Camera, scan, -2°). A possible cause for this spurious data is incompletely filtered grain noise which can sometimes make a measured MTF greater than it should be.

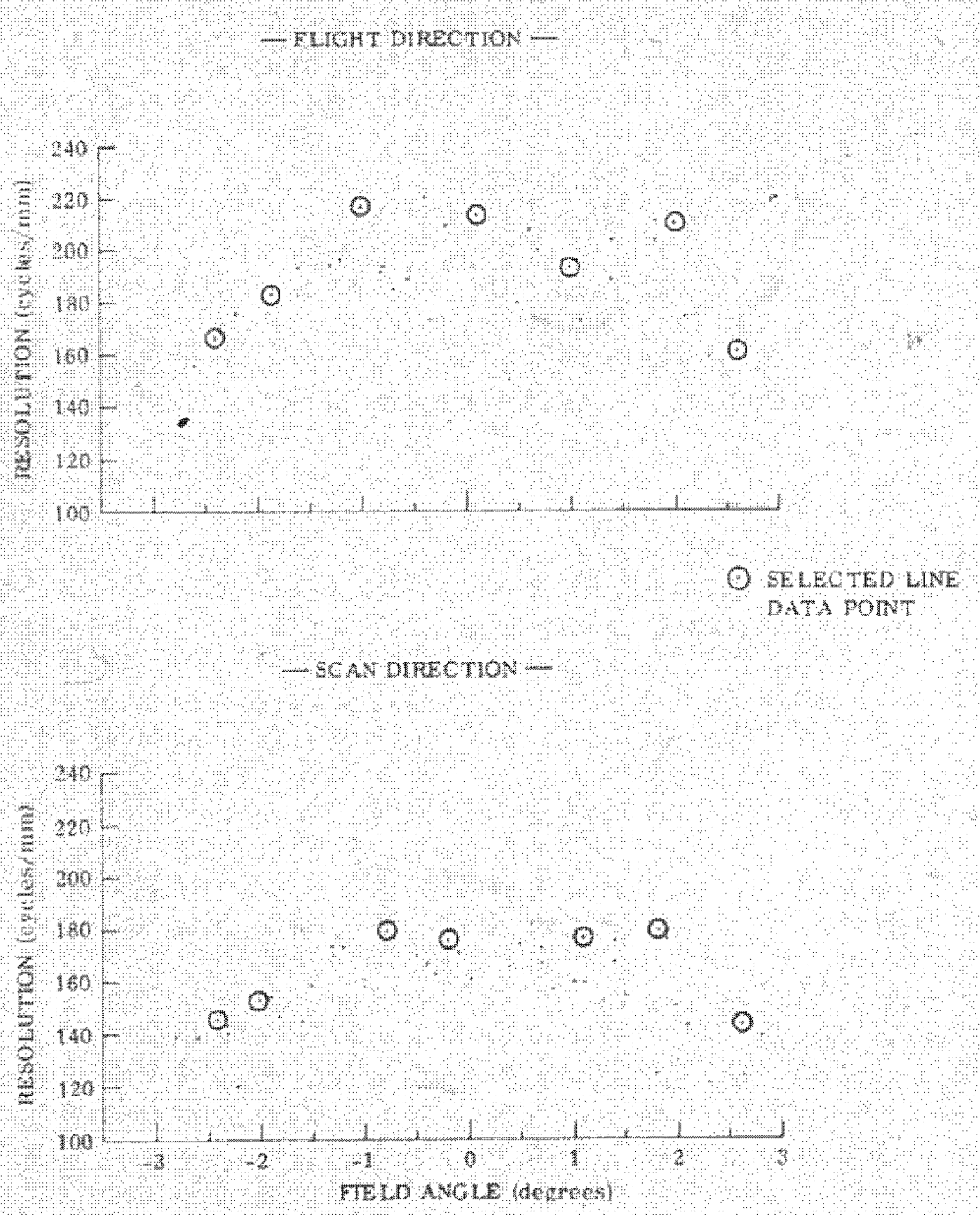
The assumption is made that the line derived MTFs corresponding to the circled data points in the figures are the most representative of the measured orbital lens MTFs available. It remains then to determine the amount of camera system defocus present when each of these lines was acquired using effective optics/platen tilt/film field curvature information. The line data acquired at +8 μm platen position is useful for this purpose. For both cameras in both directions in the +2.5° field, the MTF/TM resolution at the -8μm platen position is higher than the MTF/TM resolution at nominal platen. In the 0° and 1° fields, the nominal platen resolution is higher; a mixture of resolution peaks occurs in the +2.0° field. The +8μm platen position yields lower resolution values at all field angles.

In spite of the smaller sample size and mis-orientation of the +8μm platen lines, these results strongly indicate that the effective field curvature, operant during line acquisitions, was enough

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RESOLUTION VERSUS FIELD ANGLE OF SELECTED OPERATIONAL LINES, FORWARD CAMERA



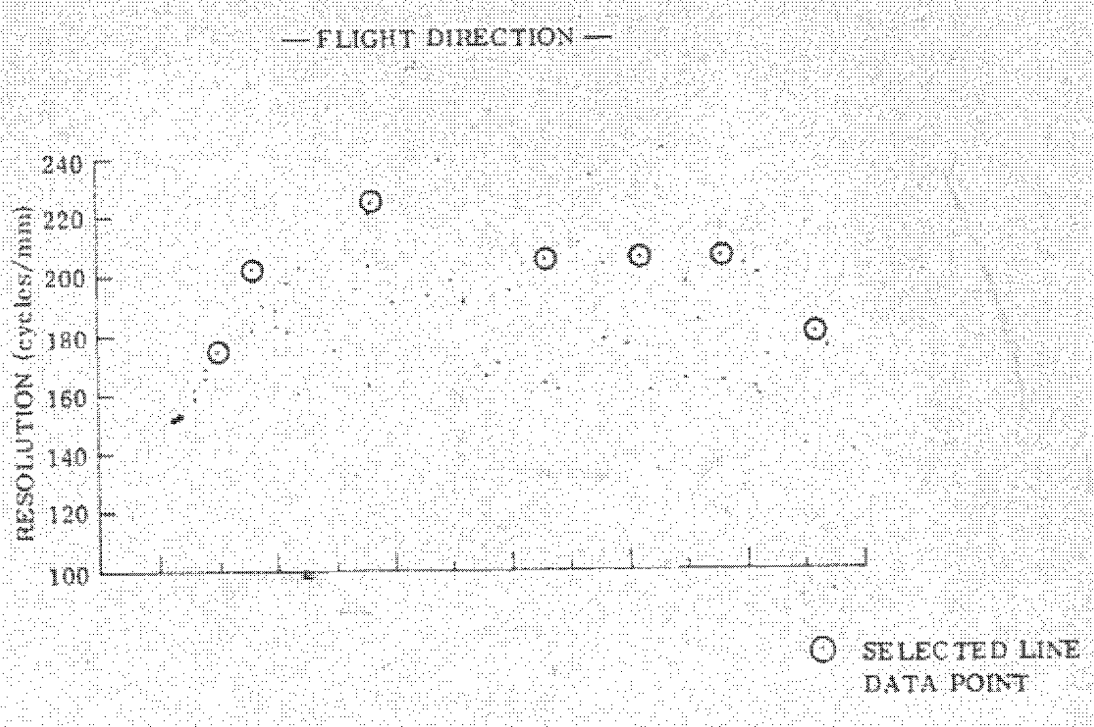
NOTE: Platen position is 76 nominal

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RESOLUTION VERSUS FIELD ANGLE OF SELECTED OPERATIONAL LINES, AFT CAMERA



NOTE: Platen position is 25 nominal

FIGURE 3-19

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to defocus the ±2.5° field positions by more than -4 microns for nominal platen position acquisitions. This observation, coupled with the better performance observed between ±1.0° field angle for nominal platen position and the knowledge of field curvatures derived from Chamber D, Chamber A-2, and on-orbit results (refer to Figure 3-13), lead to the synthesis of an effective field curvature presented in Figure 3-20. This field curvature was used in this analysis for both cameras in both directions. With a nominal platen position selected for overall best performance across the field format, lines at the various field angles are assumed to have been acquired with the defocus indicated in Table 3-24.

TABLE 3-24

DEFOCUS AT LINE ACQUISITION FOR VARIOUS FIELD ANGLES

Field Angle (degrees)	Amount of Defocus (microns)
±2.5	-6
±2.0	-2
±1.0	+2
0	+4

Refering to Figure 3-20, note that the field curvature is symmetrical about the 0° field and in general falls approximately midway between Chamber D and Chamber A-2 derived field curvatures given in Figure 3-13.

With the field curvature and line data available, the first comparison that can be made is between the line derived orbital optics MTFs and the polychromatic MTFs derived from test Chamber D. The monochromatic MTFs derived from measured interferograms taken in Chamber D are combined with optical design data, a spectral weighting function, and a gravity release factor; this combination was made to achieve polychromatic optics MTFs (PMTF) for the various directions and field angles applicable to orbital performance. Figures 3-21 thru 3-24 show a comparison between the Chamber D PMTFs and orbital optics MTFs for both cameras and directions at ±2.5°, ±2.0°, ±1.0°, and 0.0° field angles. The Chamber D PMTFs are those corresponding to the amounts of defocus given in Table 3-24.

A perusal of Figures 3-21 thru 3-24 shows very close agreement between the line derived orbital optics MTFs and the test Chamber D interferometrically derived optics PMTFs. These comparisons are shown on an expanded scale as modulation at 140 cycles/mm versus field angle in Figures 3-25 and 3-26. Note from these two figures that the Chamber D PMTF modulation is always somewhat higher than the operational MTF at ±2.5°, in both flight and scan directions. This could indicate a slightly greater defocus condition existing at ±2.5° than the -6 microns assumed. The closer agreement on the Aft side could be due to the individual behavior of the PDS Microdensitometer used to trace the Forward and Aft

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EFFECTIVE OPTICS/PLATEN TILT/FILM FIELD CURVATURE

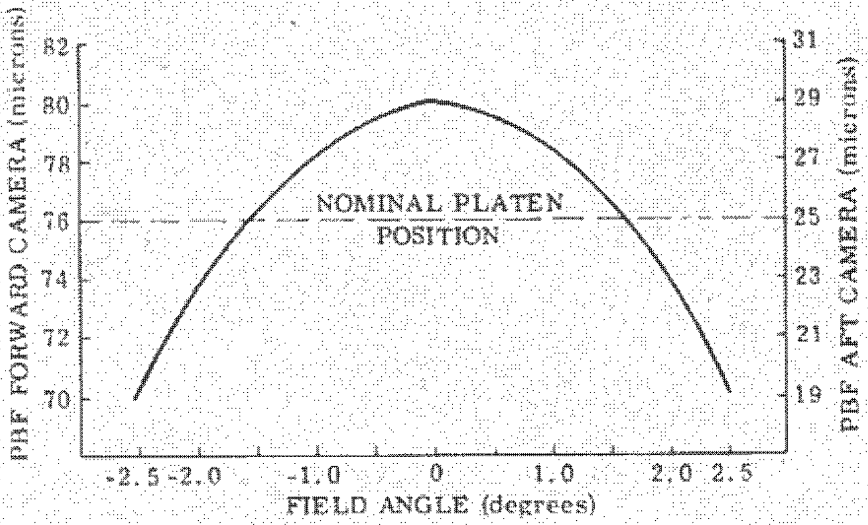


FIGURE 3-20

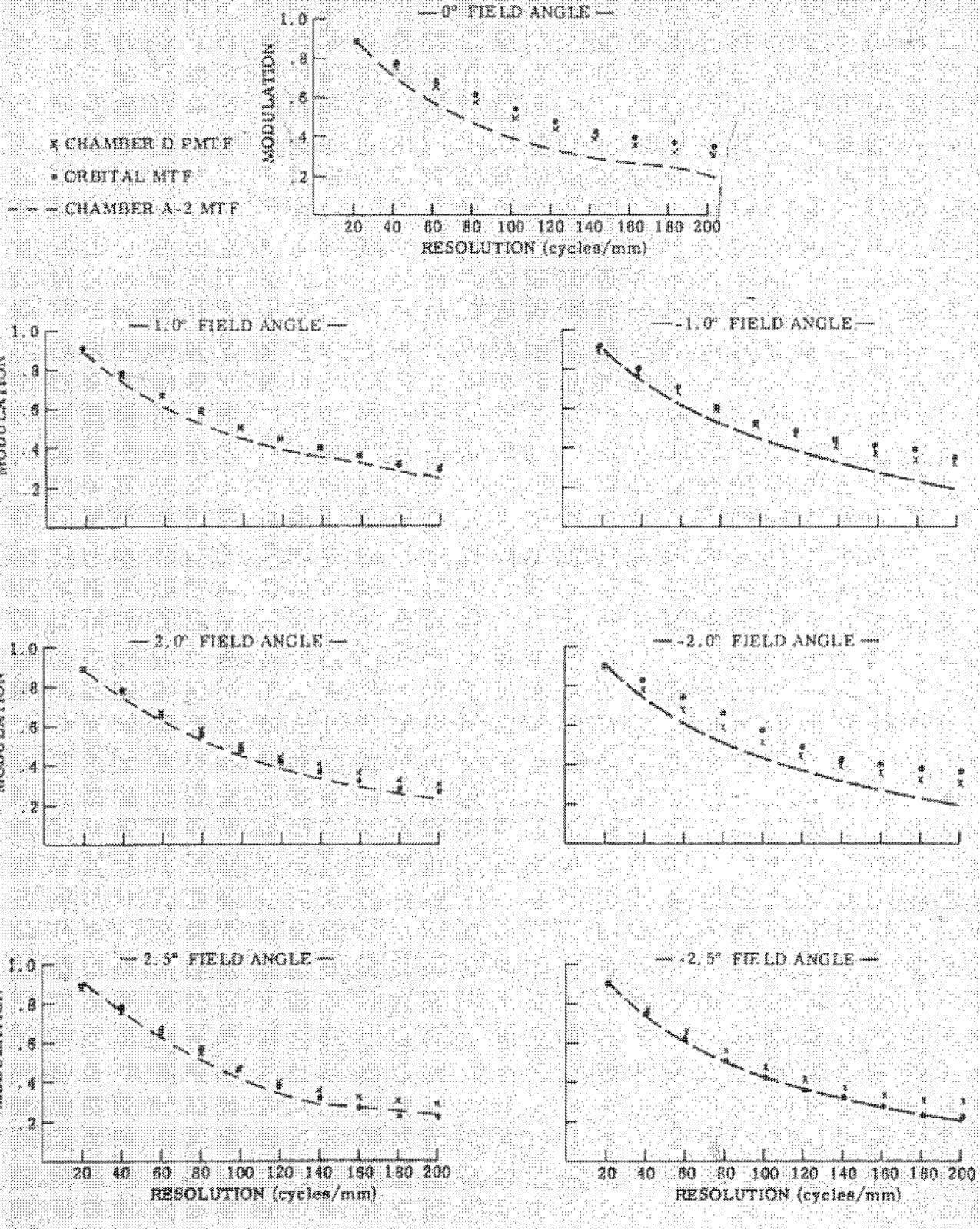
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COMPARISON CHAMBER PMTFs/MTFs AND ORBITAL MTFs

AFT CAMERA, SCAN DIRECTION



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FIGURE 3-21

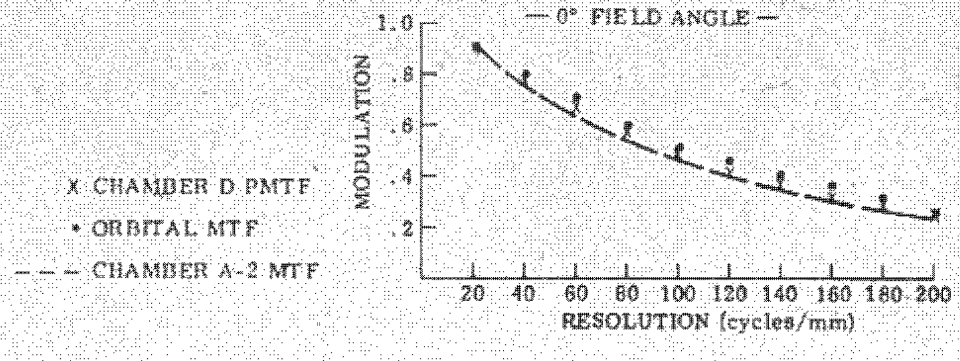
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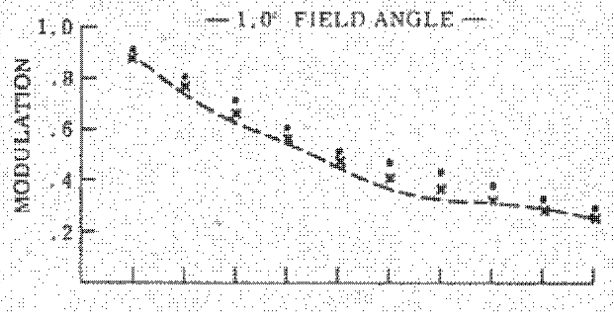
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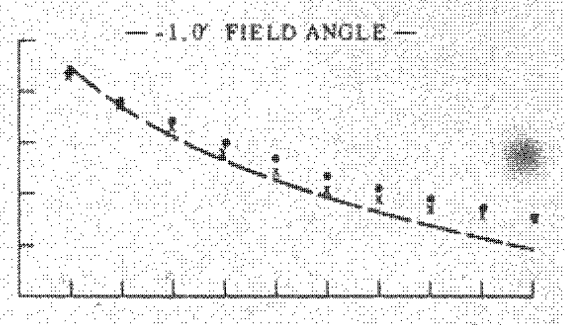
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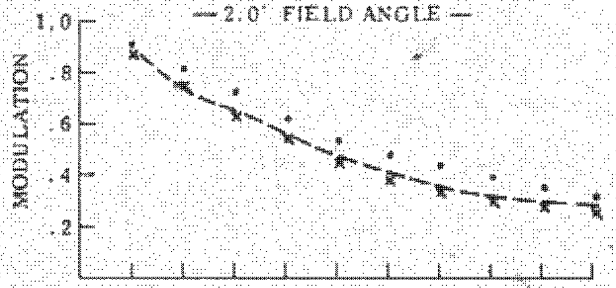
COMPARISON CHAMBER PMTFs/MTFs AND ORBITAL MTFs

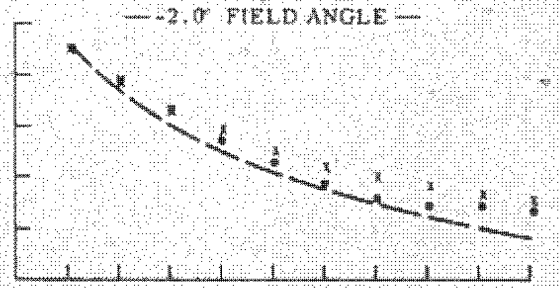
FORWARD CAMERA, SCAN DIRECTION

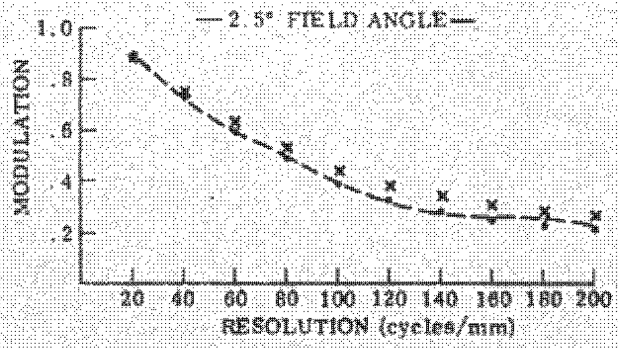












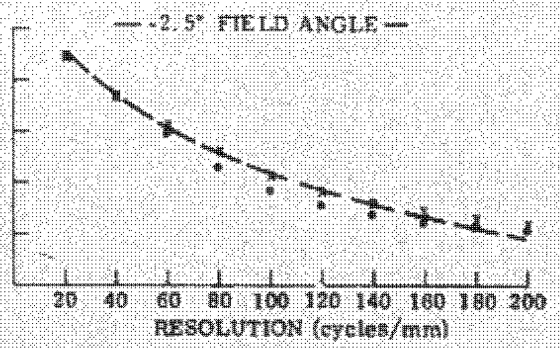


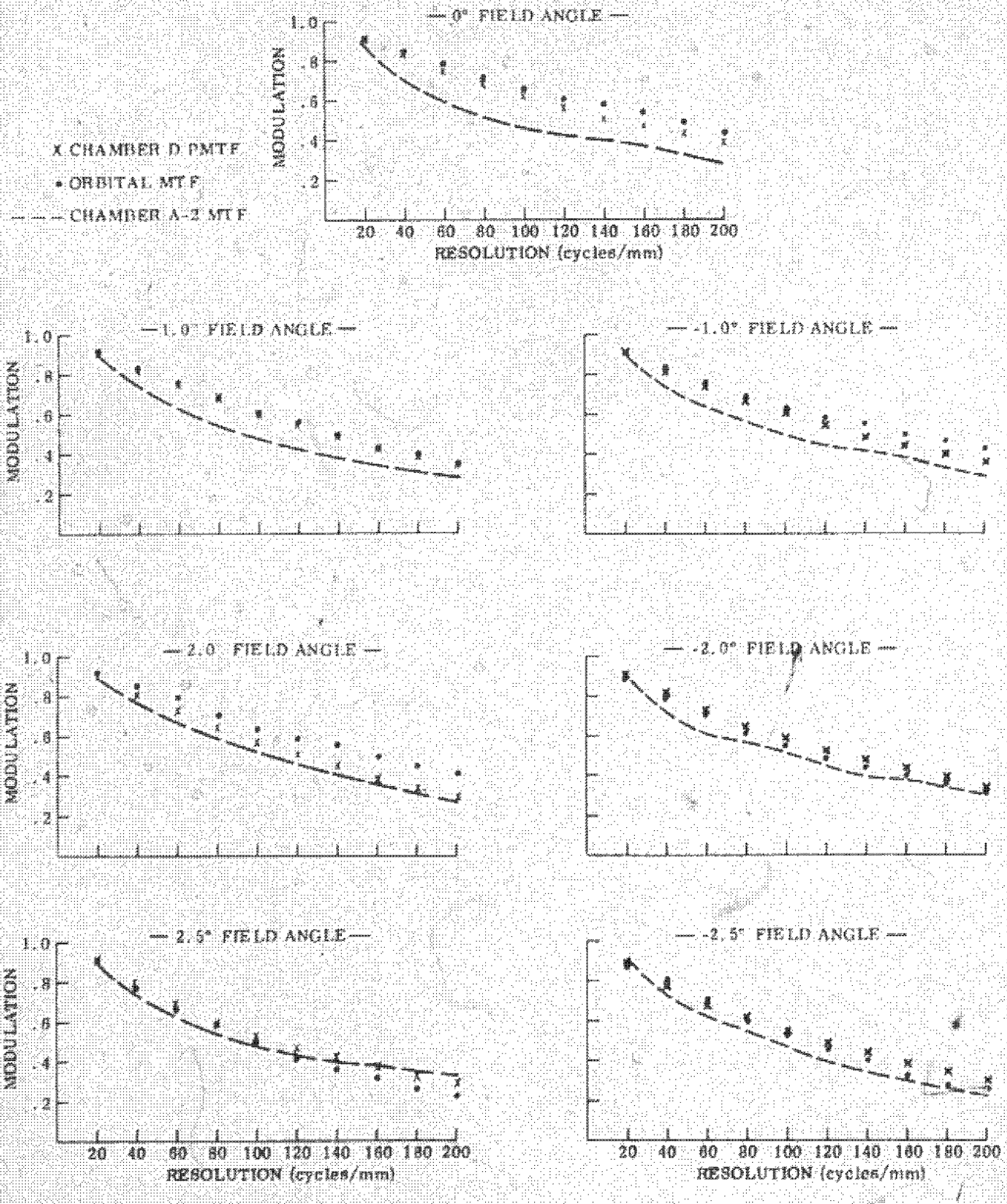
FIGURE 3-22

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COMPARISON CHAMBER PMTSs/MTFs AND ORBITAL MTFs

FORWARD CAMERA, FLIGHT DIRECTION



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FIGURE 3-23

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COMPARISON CHAMBER PMTSs/MTFs AND ORBITAL MTFs

AFT CAMERA, FLIGHT DIRECTION

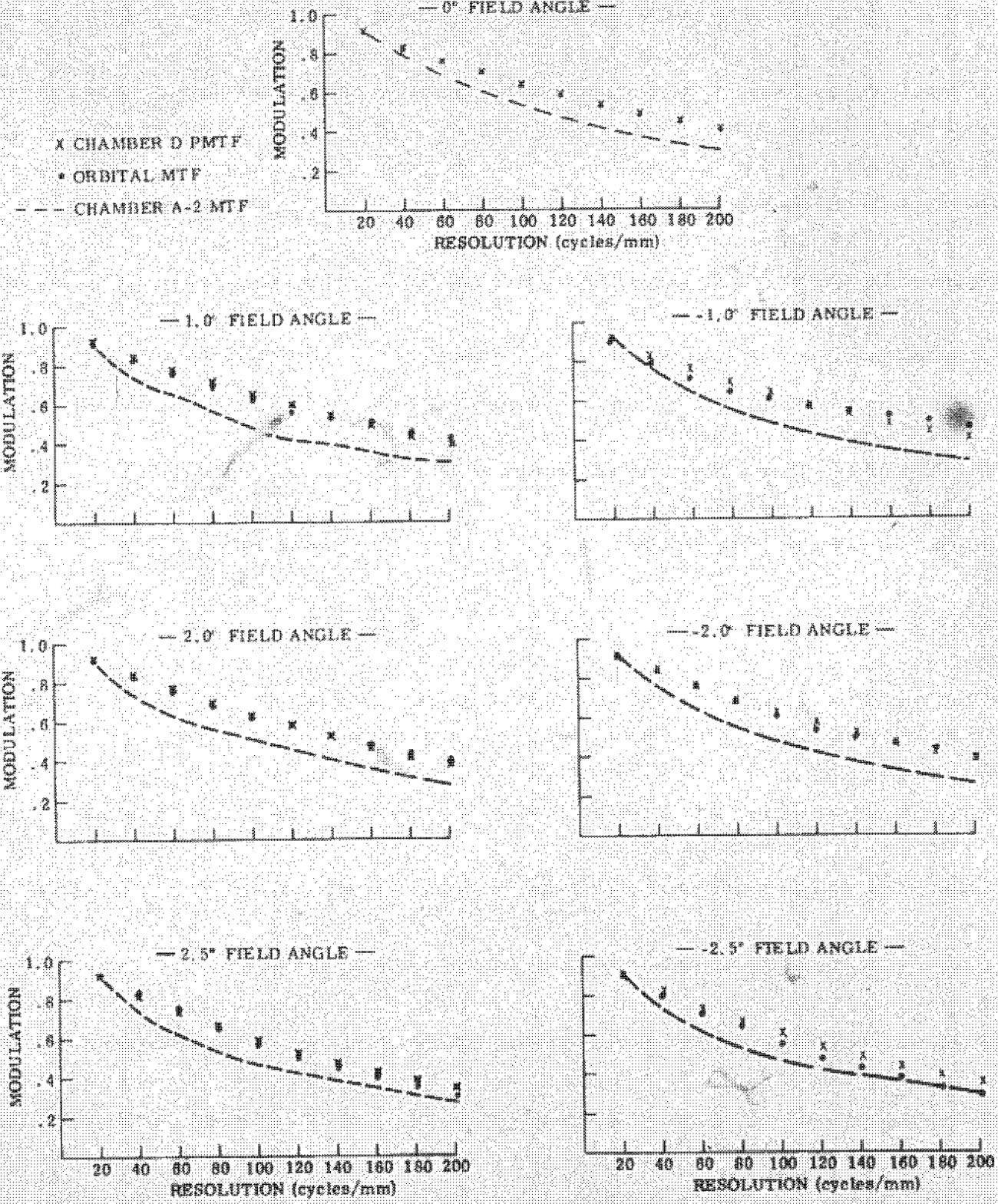
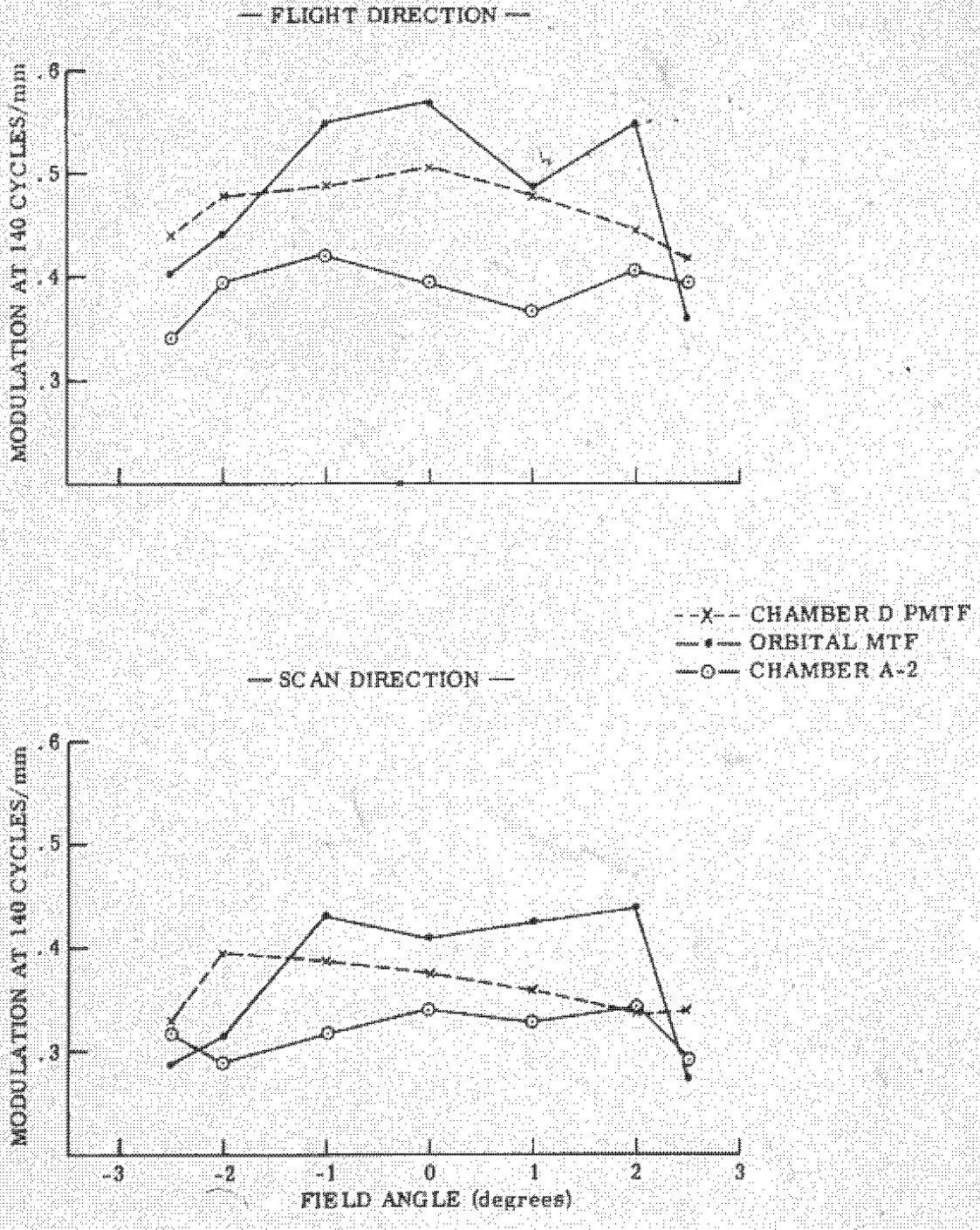


FIGURE 3-24

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EXPANDED COMPARISON OF CHAMBER PMTFs/MTFs
AND ORBITAL MTFs FOR FORWARD CAMERA



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EXPANDED COMPARISON OF CHAMBER PMTFs/MTFs
AND ORBITAL MTFs FOR AFT CAMERA

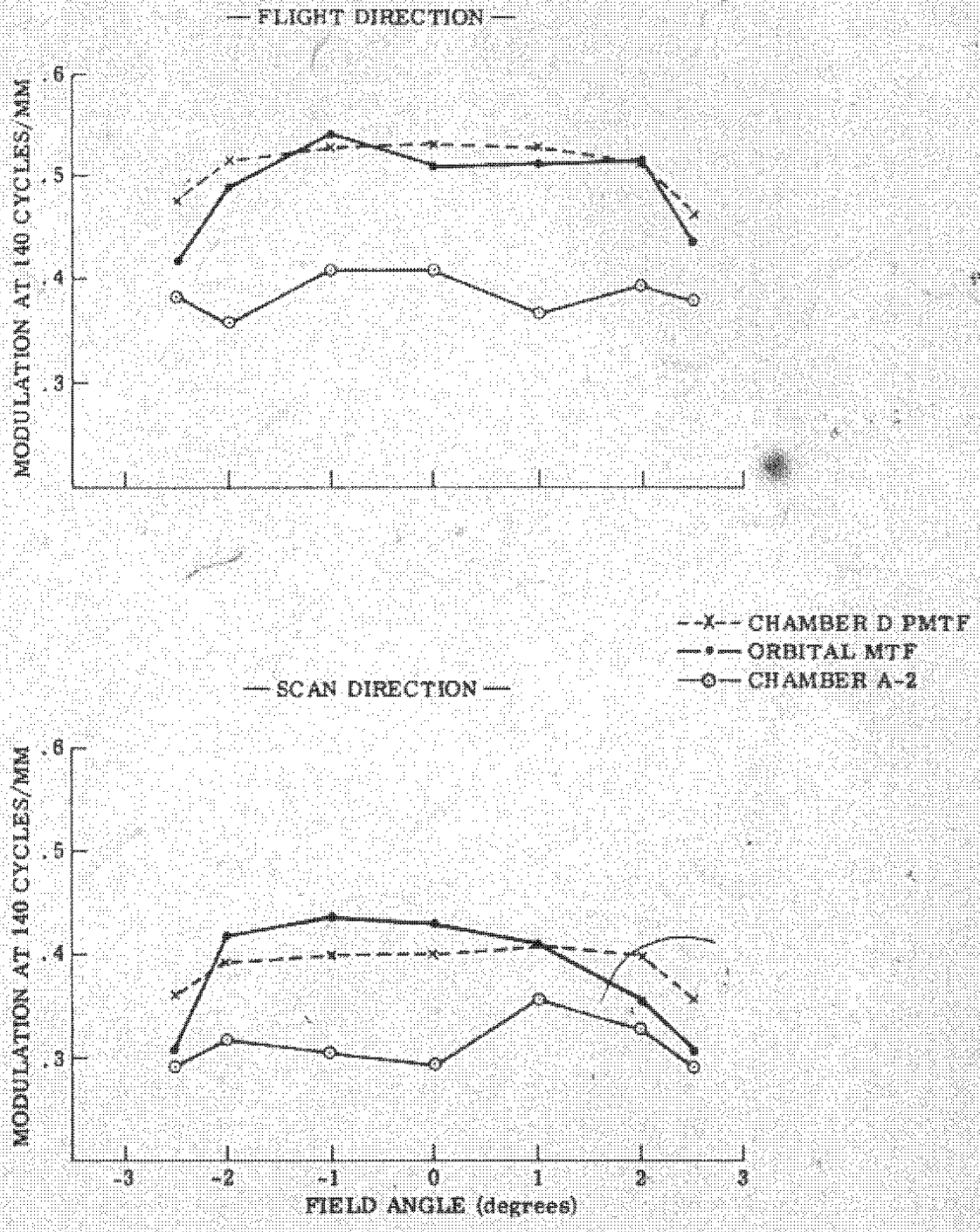


FIGURE 3-26

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CORN lines. Although the two microdensitometer MTFs may be slightly different, only one film/microdensitometer MTF was used for all line computer processing. This was acceptable because the errors in the experimental determination of this MTF would mask the much smaller, real differences between performance of the two microdensitometers.

Chamber A-2 line derived optics MTFs were compared with those of operational lines and Chamber D derived MTFs. The test Chamber A-2 tilted 33 line array target was used in conjunction with a vehicle pitch test sequence and the test film was dual gamma processed. For each of the seven field angles ($+2.5°$, $\pm 2.0°$, $\pm 1.0°$, $0.0°$) approximately 10 frames were acquired at a given platen position.

The two best frames for each camera/field angle/direction combination were selected from the original FOCMO runs, then these frames were retraced at AFSPPF. The better frame of the two retraced for each combination was then selected, and the best line derived MTF of the 33 possibilities was identified for that frame. Finally, in agreement with the assumed field curvature given in Figure 3-20, the actual line derived MTF used was identified. This was done by backtracking from the best line an appropriate amount and using the fact that a 2 micron focus change exists between adjacent lines in the 33 line tilted target. Note that once the best frame is chosen, the actual platen position is irrelevant since it is only assumed that the best line in the best frame corresponds to zero microns defocus.

The FOCMO Program is similar to PFALINES and uses the same basic input parameters; i.e., the film/microdensitometer MTF of Figure 3-17 and the straight line extension D log E curve. However, to be certain that the two programs produced equivalent results, the same test case was run through both of them, see Figure 3-27. Note that the FOCMO Program gives slightly lower results than the PFALINES Program. The selected Chamber A-2 line derived optics MTFs processed through FOCMO were therefore multiplied by a frequency dependent factor which was the ratio of the two curves in the figure in order to compensate for this small difference in the two programs.

Evidently, from the data presented in Figures 3-21 thru 3-26, the Chamber A-2 optics MTFs are, in general, significantly lower than both the operational MTFs and Chamber D optics MTFs. Some of the line targets used were retraced a third time to check a possible microdensitometer problem but these retraces were essentially the same as the second traces.

The results of the Mission 1208 experiment are nearly opposite the results of the Mission 1206 line lens experiment, with regard to the relative positions of the orbital versus Chamber A-2 MTF curves. However, it would be no more correct to conclude from Mission 1208 results that orbital optics performance is better than ground test performance, than it would have been to conclude the converse from Mission 1206 results. What is evident is that the analysis technique has been stretched to its limit of accuracy and has been found lacking.

In view of this, it can be concluded that there is no valid experimental evidence or known

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TEST CASE COMPARISON OF PFALINES AND FOCMO OUTPUT

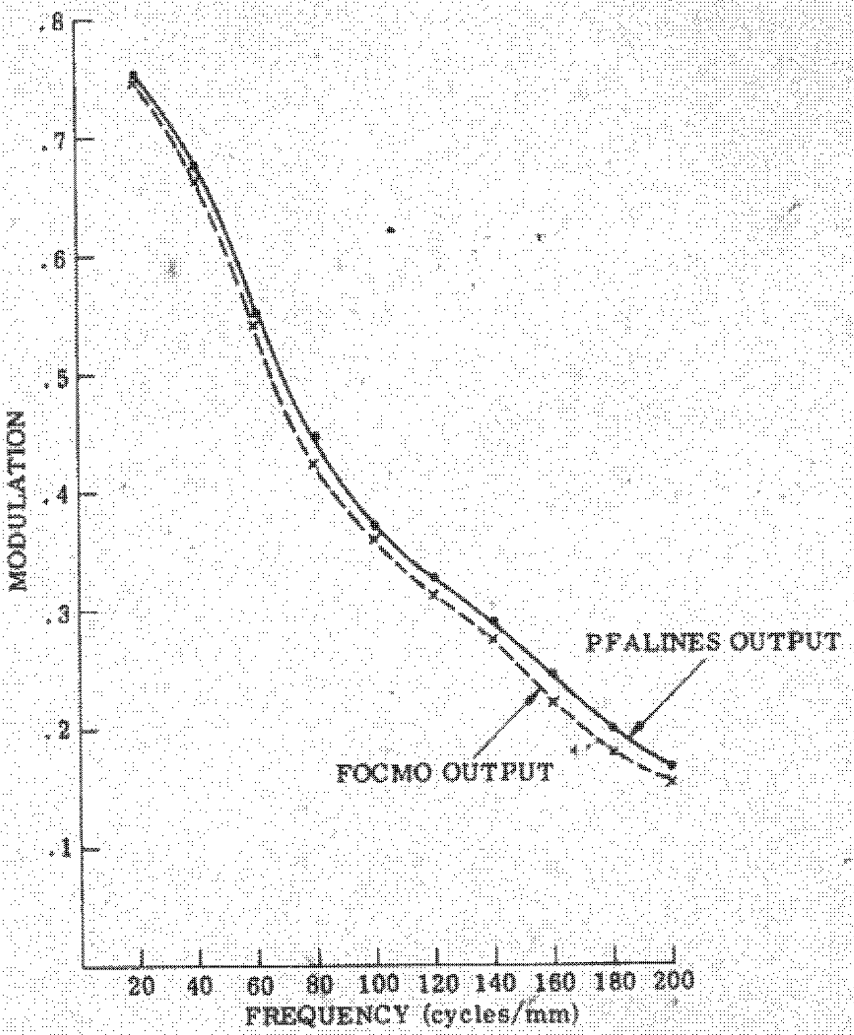


FIGURE 3-27

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theoretical evidence to support the hypothesis that orbital optics performance is significantly different from preflight ground test chamber performance. Existing differences most likely can be attributed to inaccuracies, limitations, or unaccountable variables in the total analysis technique.

3.6 EXPOSURE

3.6.1 Summary

Microdensitometer and subjective analysis performed on Mission 1208 black and white film indicated good exposure with both cameras. No change in the present exposure algorithm is recommended for subsequent missions. The present algorithm includes a .06 log E reduction bias for the Aft Camera.

The SO-255 Color and FE-3916 Infrared False Color Films were determined to be .10 log E overexposed by microdensitometer measurement. The overexposure on the SO-255 was substantiated by subjective assessment. In consideration of the measured overexposure on both films, the two-count Aft Camera bias (.06 log E decrease), used only for 1414 black and white Film on 1208, should be extended to color films on subsequent missions.

Frequent instances of dirty and/or melted snow in prime areas of photointerpreter interest indicated that snow bias techniques should be suspended on late spring and summer missions.

Limited analysis of sand surround urban area imagery confirmed use of the -.15 log E sand bias employed in 1208. However, it may be necessary to modify boundaries of the desert polygon since many frames requiring a reduction of exposure did not receive it.

Microdensitometry and subsequent analysis of tribars deployed in the Soviet desert (Tyuratam) suggest that the reflectance, contrast, and largest bar size are similar to those of CORN displays.

3.6.2 Exposure Recommendation

3.6.2.1 Basic KSCOPE Black and White

The basic exposure recommendation for both Forward and Aft Cameras was computed for 1414 with a Wratten 12 equivalent Filter using the radiometric acquisition model, KALEIDOSCOPE (KSCOPE). The recommended exposure time versus solar altitude curve is shown in Figure 3-28. They are based on acquiring a typical vegetation surround urban/industrial scene at a mean density of 1.1 (formerly 1.0).

3.6.2.2 Basic KSCOPE, Color

The basic exposure recommendation for SO-255 Color Film (Aft Camera only) was computed based on use of a Wratten 2E and Wratten 3 and a .10 log E faster process which was implemented for the first time on this mission. The recommendation for FE-3916 IR False Color Film (Aft Camera only) was generated for a Wratten 12 equivalent Filter. The recommendations for both films were based on a mean scene density of 1.5 in their respective green sensitive layers, see Figure 3-29.

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EXPOSURE RECOMMENDATION 1414 FILM
(Wratten 12 Filter)

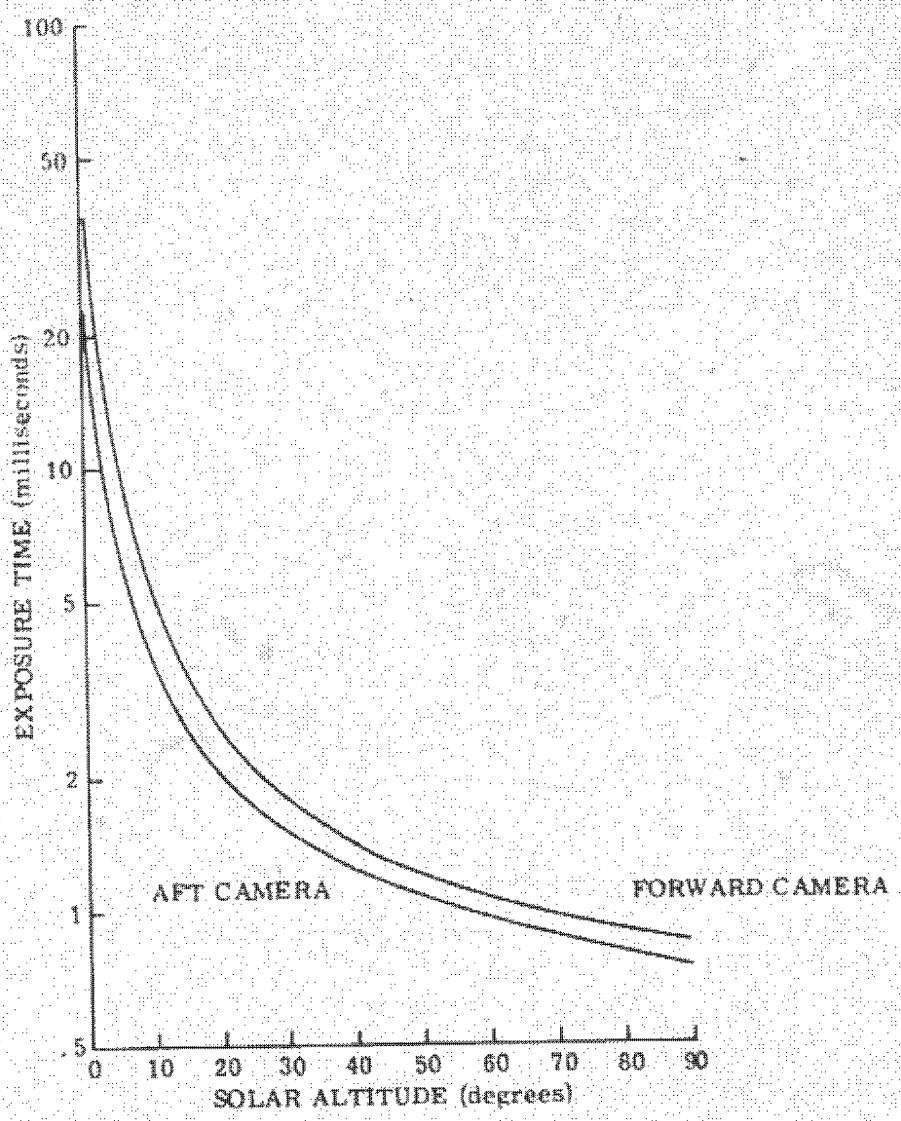


FIGURE 3-28

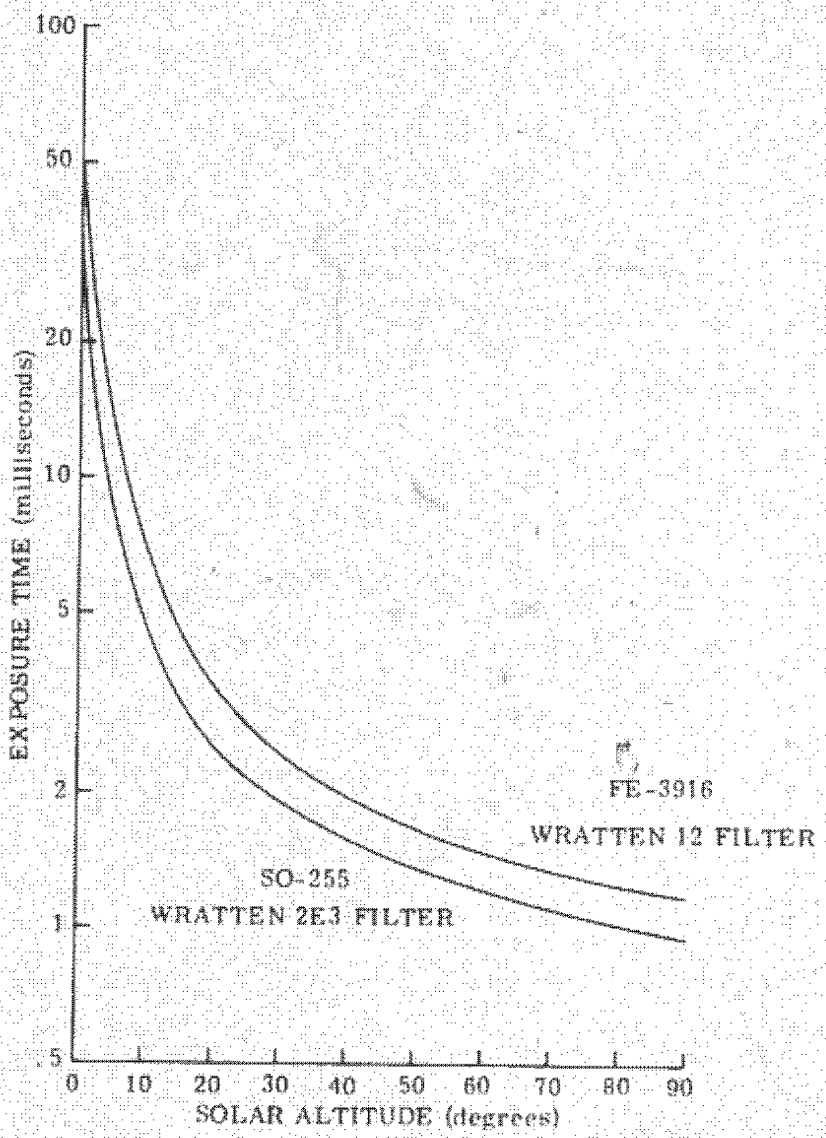
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EXPOSURE RECOMMENDATION SO-255 AND FE-3916 FILM

AFT CAMERA



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~~TOP SECRET~~ - HEXAGON

FIGURE 3-29

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3.6.2.3 Special Exposure Bias, Snow

The initial 1208 snow bias was the 3-step snow depth dependent bias used in Mission 1207. A bias modification was implemented on Op 399 for the duration of the mission. The snow bias as a function of snow depth is shown in Table 3-25.

TABLE 3-25

SNOW BIAS AS A FUNCTION OF SNOW DEPTH

Snow Depth (inches)	Exposure Bias (nominal) Ops 1 - 398	After Ops 399
Less than 1	0	0
1 - 4	-.13 log E	-.13 log E
4 - 10	-.26 log E	-.13 log E
More than 10	-.36 log E	-.26 log E

3.6.2.4 Special Exposure Bias, Sand

A sand bias of -.15 log E was applied to all frames whose total format fell within the coordinates of one of seven desert polygons. Five of these polygons are in the Middle East, one is in the Soviet Union, and one is in the Southwestern United States.

3.6.3 General Description of Analysis

3.6.3.1 Microdensitometry

Most of the urban area microdensitometry in support of the basic exposure evaluation of 1208 was done on the GAF-650 Microdensitometer using a 15.3 micron aperture. Some 1414 material on 1208-3 was scanned on the PDS-100 Microdensitometer with a comparable aperture. The latter was used only after its density measurements were found comparable to those of the GAF in crossover tests. Calibration of both units was achieved with a step tablet of known macrodensities.

Microdensitometry done in support of the CORN target contrast analysis and the Tyuratam tribar contrast analysis was performed on the Mann-Data Microdensitometer using apertures of 5 microns and 1 micron, respectively.

3.6.3.2 Frame Selection

Acquisition frames of urban/industrial areas were selected by the exposure evaluation team for general exposure analysis. However, selection of some frames was initiated by the PFA Team when an apparent exposure anomaly requiring investigation was noted. The number of urban area images evaluated in the categories of film type, camera, and terrain type is shown in Table 3-26. These numbers do not necessarily indicate quantities of frames evaluated although in most instances only one area per

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frame was analyzed.

TABLE 3-26

1208 ACQUISITION EVALUATION BREAKDOWN
(Number of Images)

Film	Camera	Vegetation Surround	Snow Surround	Sand Surround
1414	Forward	30	4	2
	Aft	17	5	0
SO-255	Forward	N/A	N/A	N/A
	Aft	6	N/A	N/A
FE-3916	Forward	N/A	N/A	N/A
	Aft	3	N/A	N/A

3.6.3.3 Log E Analysis

Using density distributions generated from urban scene microdensitometer traces, each acquisition's exposure was rated by the log E deviation ("Total Delta Log E") of its mean density from the aim criteria. This aim is 1.1 density for 1414 and 1.5 density for SO-255 and FE-3916 green layer Status A. Any log E deviation from the aim can be considered caused by two factors. The first is deviation from recommended exposure called "Camera Delta Log E." This may be due to either slit granularity and/or an applied exposure bias. The second factor is a possible error in the exposure algorithm. This error is called "Algorithm Delta Log E" and is the arithmetic difference between "Total Delta Log E" and "Camera Delta Log E." A positive value of "Algorithm Delta Log E" is interpreted as creating overexposure while a negative value signifies an algorithm creating underexposure.

3.6.4 General Exposure Analysis

3.6.4.1 Evaluation of the Basic Recommendation for Black and White Film

Objective evaluation of the exposure of 1414 was made from raster scan data of 44 vegetation surround urban/industrial acquisitions from Mission 1208. Since two process chemistries were used on 1414, 19DN and 26DN, the exposure was analyzed relative to each process separately.

Density profiles of each scanned acquisition are plotted by mission part and process for RVs 1 thru 3; no 1414 urban areas were scanned on RV-4, see Figures 3-30 thru 3-34. In addition to giving the 95% maximum density, the mean density, and the 5% minimum density of each measured scene density distribution, these profiles permit determination of "Total Delta Log E" from the process curve which appears to the right of the density profile and is typical for that process and mission part.

With the exception of the many acquisitions degraded by clouds and haze, the general exposure of the mission was rated good both subjectively and objectively, see Table 3-27. Furthermore, no

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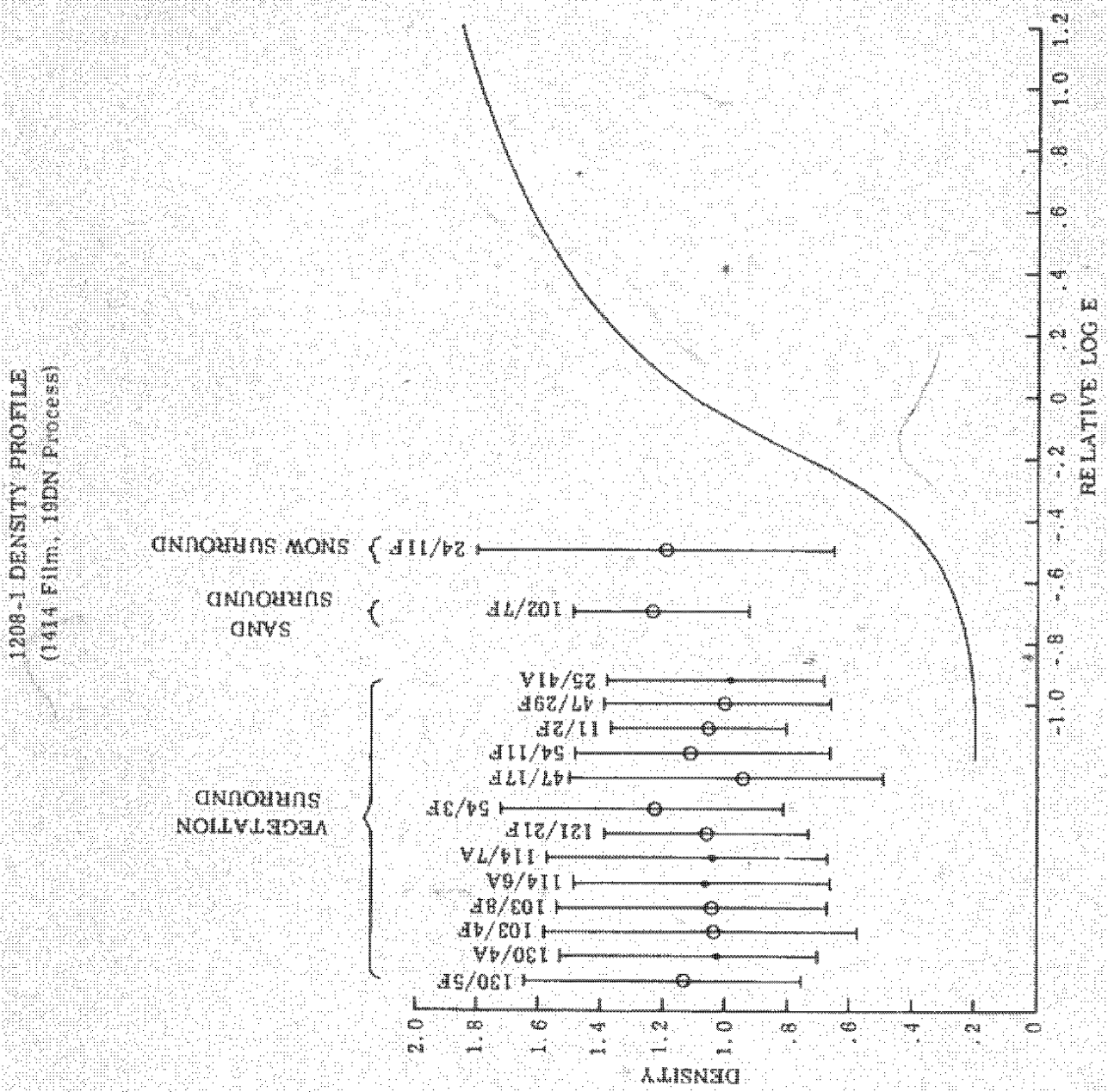


FIGURE 3-30

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FIGURE 3-32

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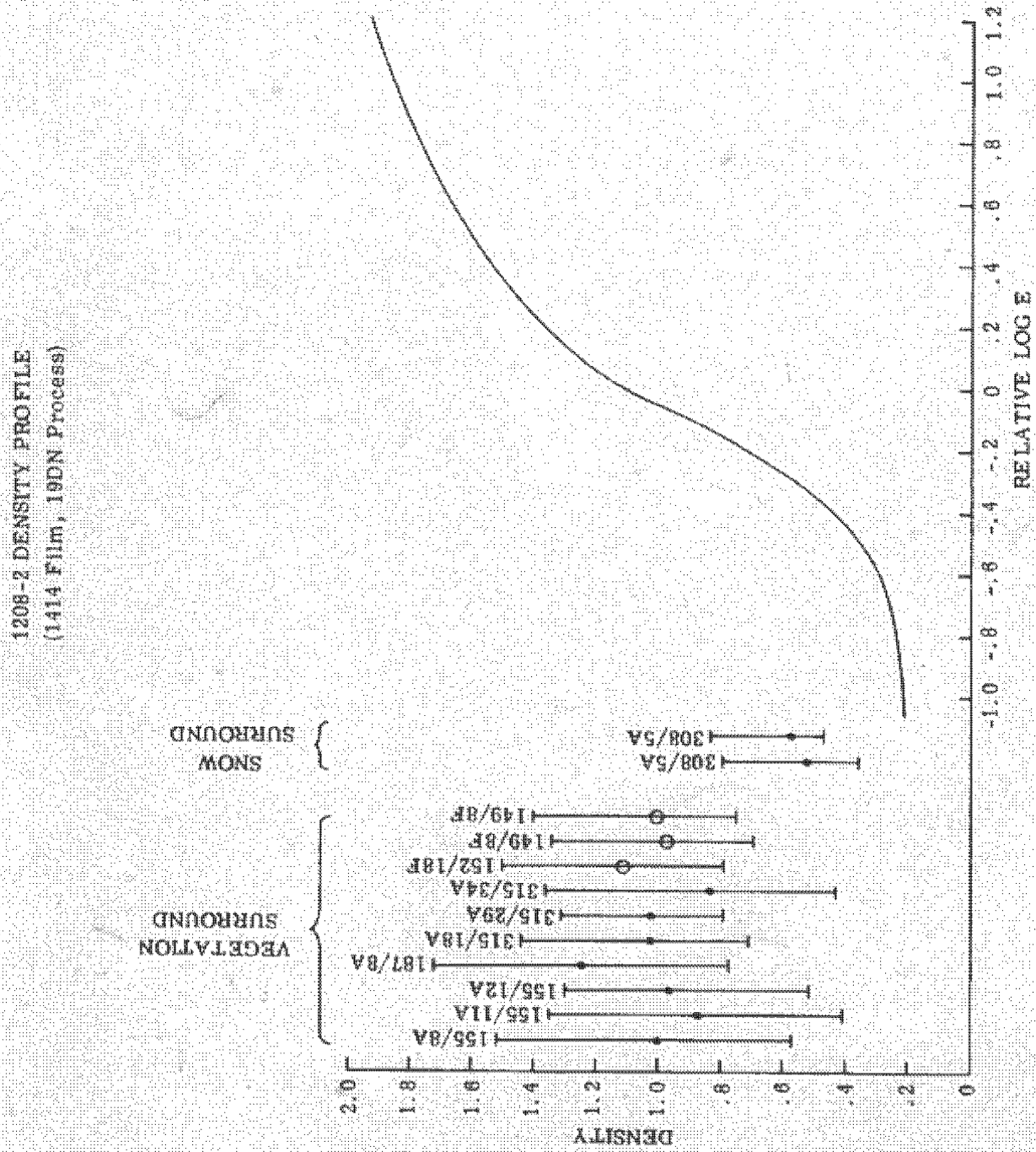


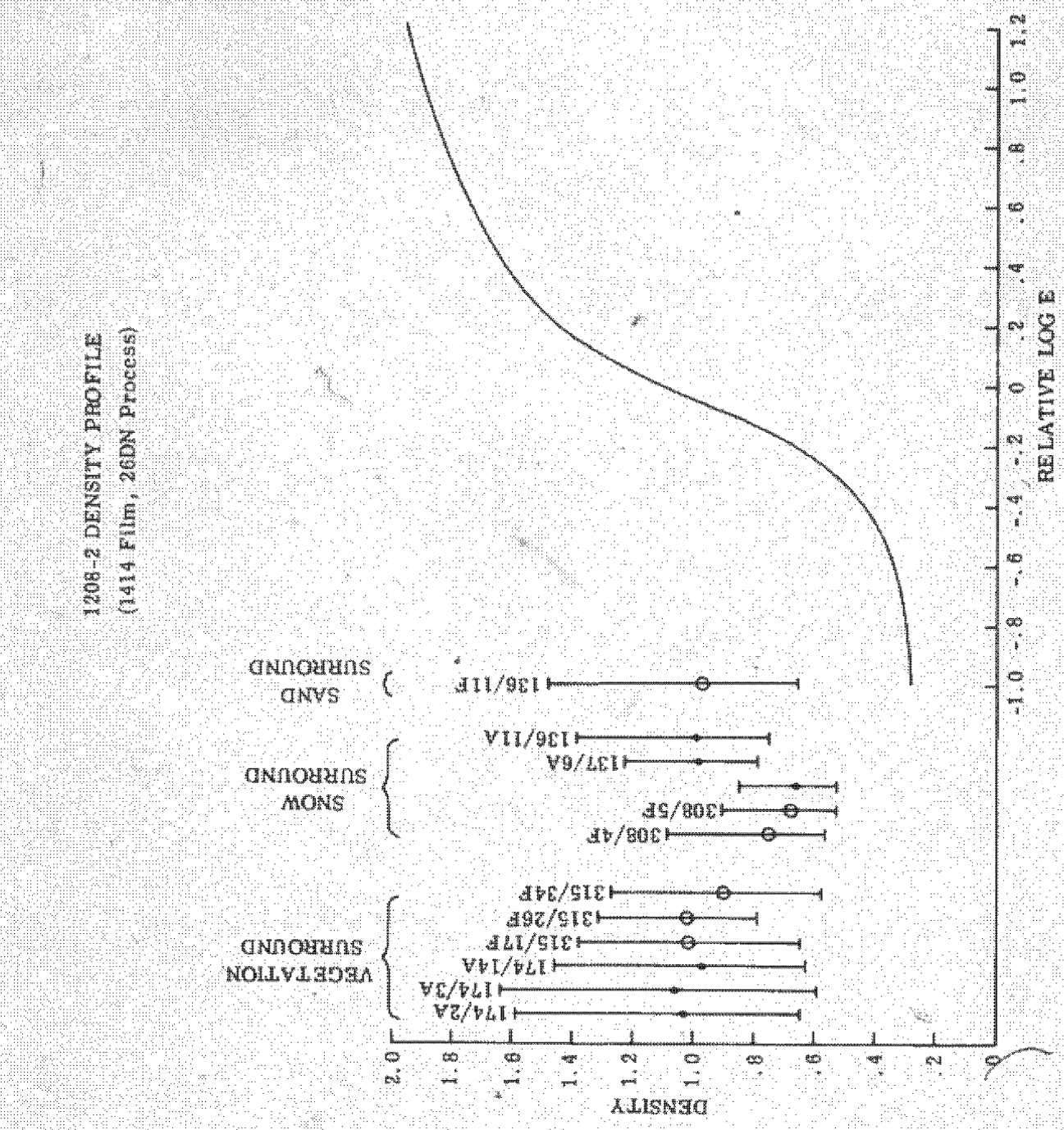
FIGURE 3-31

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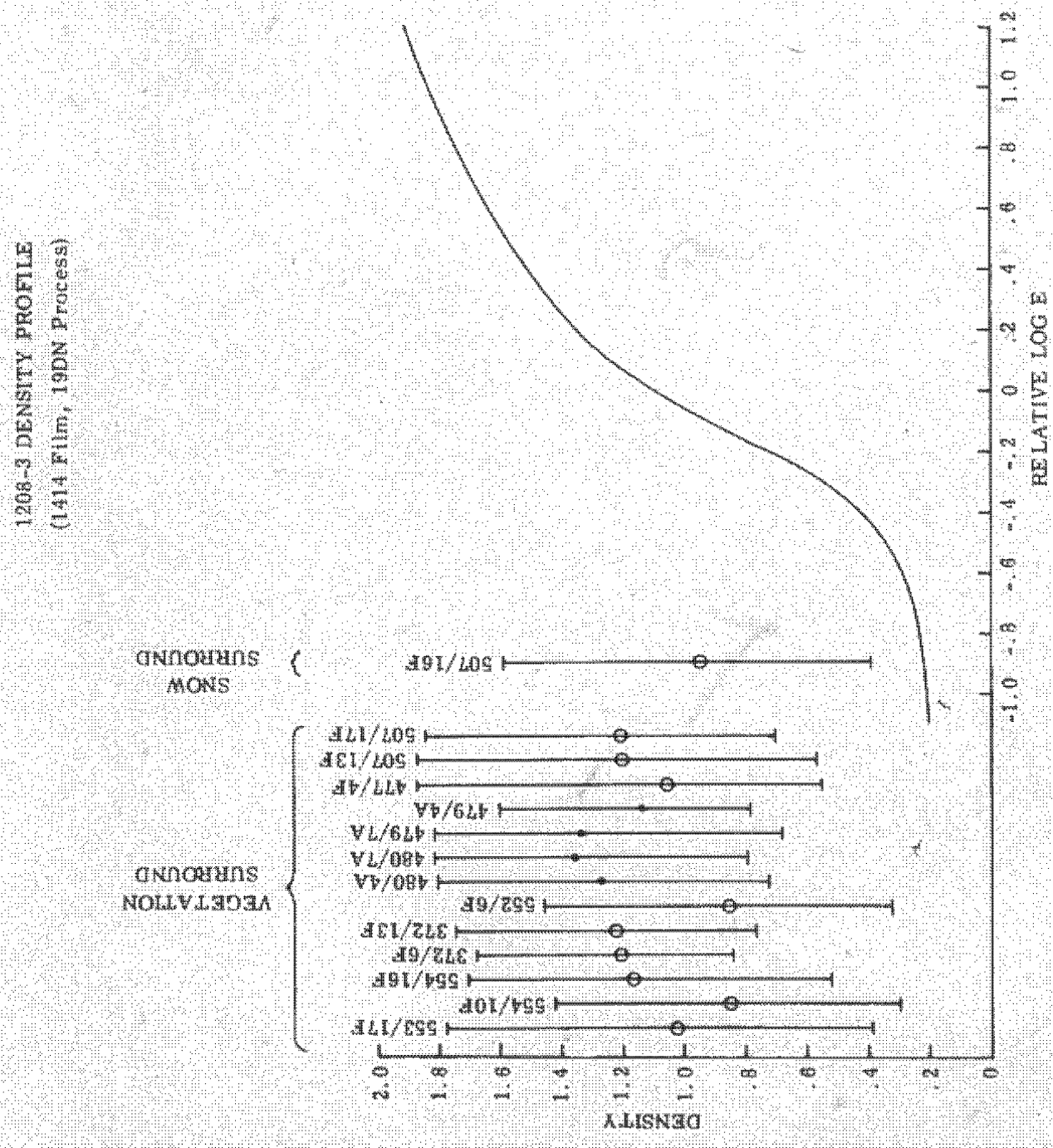
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FIGURE 3-33

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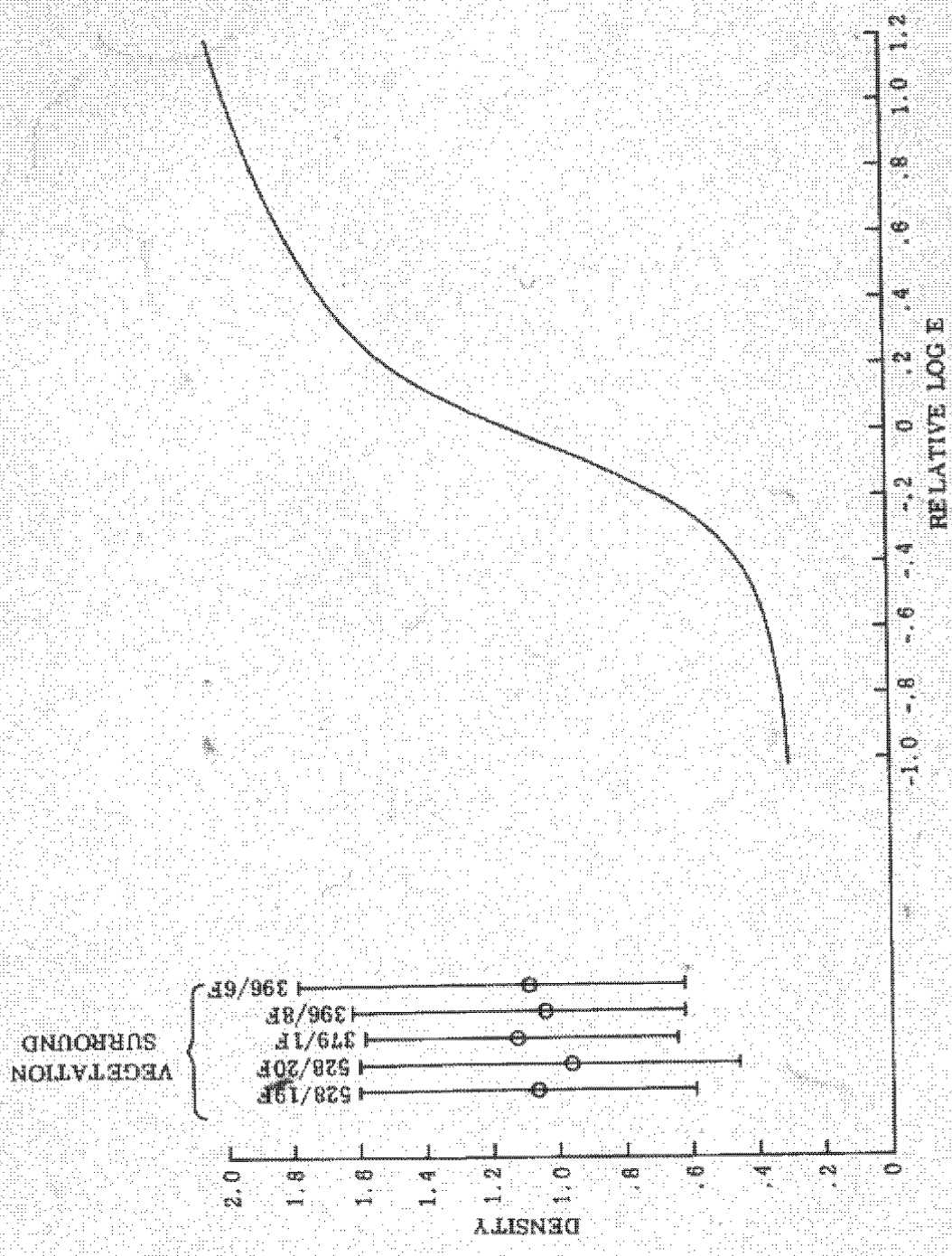


FIGURE 3-34

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TABLE 3-27

URBAN SCENE MEAN EXPOSURE ERRORS FOR 1414 FILM

Type Surround	Camera	Process	Number	Total	Δ Log E Error Camera	Δ Log E Error Algorithm
Vegetation*	Forward	19DN	22	-.02	-.01	-.01
		26DN	8	-.03	-.02	-.01
	Aft	19DN	11	-.04	.00	-.04
		26DN	3	-.04	-.01	-.03
Snow	Forward (Prior to Op 399)	19DN	1	.06	-.14	.20
		26DN	2	-.17	-.25	.08
	Aft (Prior to Op 399)	19DN	2	-.30	-.25	-.05
		26DN	3	-.10	-.29	.19
	Forward (After Op 399)	19DN	1	-.07	-.32	.25
Sand	Forward	19DN	1	.10	.02	.08
		26DN	1	-.06	-.17	.11

NOTE: The asterisk (*) indicates that there were five urban areas scanned which were considered typical and hence deleted from the analysis.

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significant difference could be found between the mean exposures of the Forward and Aft Cameras or between the two processes; note the vegetation surround data in the table. The insignificant algorithm error indicates that no change in the basic algorithm should be required on future missions. This algorithm includes a two-count bias (-.06 log E) on the Aft Camera, implemented during Mission 1207.

3.6.4.2 Evaluation of Special Exposure for Black and White Film

A. Snow Bias

The three-step snow bias, found to be very effective in the winter mission of 1207, was generally ineffective in Mission 1208. Many instances of dirty and melted snow around targets of interest were observed on acquisitions which had been given a snow bias. This resulted in underexposure of some frames to a maximum of -.30 log E, see Table 3-28 on page 3-76. Although the snow bias was reduced in Op 399, subsequent observations resulted in the conclusion that snow biasing should be eliminated completely from future late spring and summer missions; i.e., after April.

B. Sand Bias

The two sand surround acquisitions were evaluated. One had the proper sand bias and was properly exposed. The other received no bias and was overexposed by one half-stop. Photointerpreter evaluation of sand surround areas outside the present desert polygons would benefit from a sand bias.

3.6.4.3 Evaluation of Exposure and Basic Recommendation for Color Film

A. SO-255 (Aft Camera Only)

Six vegetation surround urban areas were scanned from the SO-255 Color Film. Their density profiles are given in Figure 3-35. All six showed overexposure with the mean being +.10 log E from correct exposure which yields 1.5 density. This agreed with subjective appraisals of the imagery.

The two-count Aft Camera bias (exposure decrease of .06 log E) given to the 1414 record was not applied to the color acquisitions on this mission. The observed overexposure indicates that this decrease should be applied to all Aft imagery, in addition to SO-255 exposure recommendations, in the future.

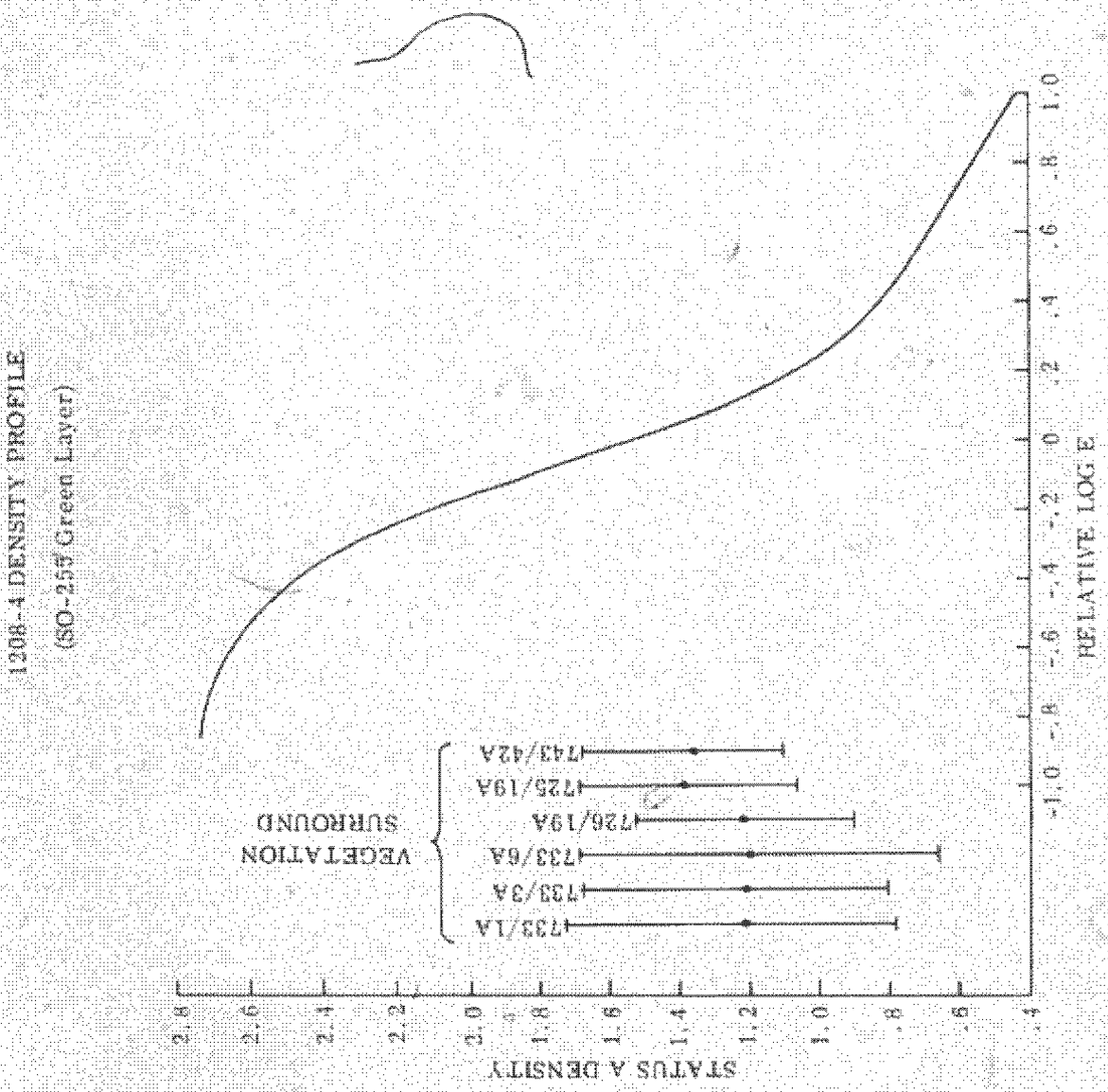
B. FE-3916 (Aft Camera Only)

The FE-3916 IR False Color Film was found to be approximately one-third stop overexposed relative to the objective criteria assigned, refer to Table 3-28. This was based on a sampling of three urban areas considered to be representative of the imagery. The FE-3916 density profile is given in Figure 3-36. Unlike SO-255, however, the subjective rating of FE-3916 exposure was stated as "correctly exposed." This may indicate lower observer sensitivity to less than optimal exposure of a false color film. Nevertheless, it is concluded that a two-count Aft Camera bias should be applied for future missions using this material.

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FIGURE 3-35

HEXAGON

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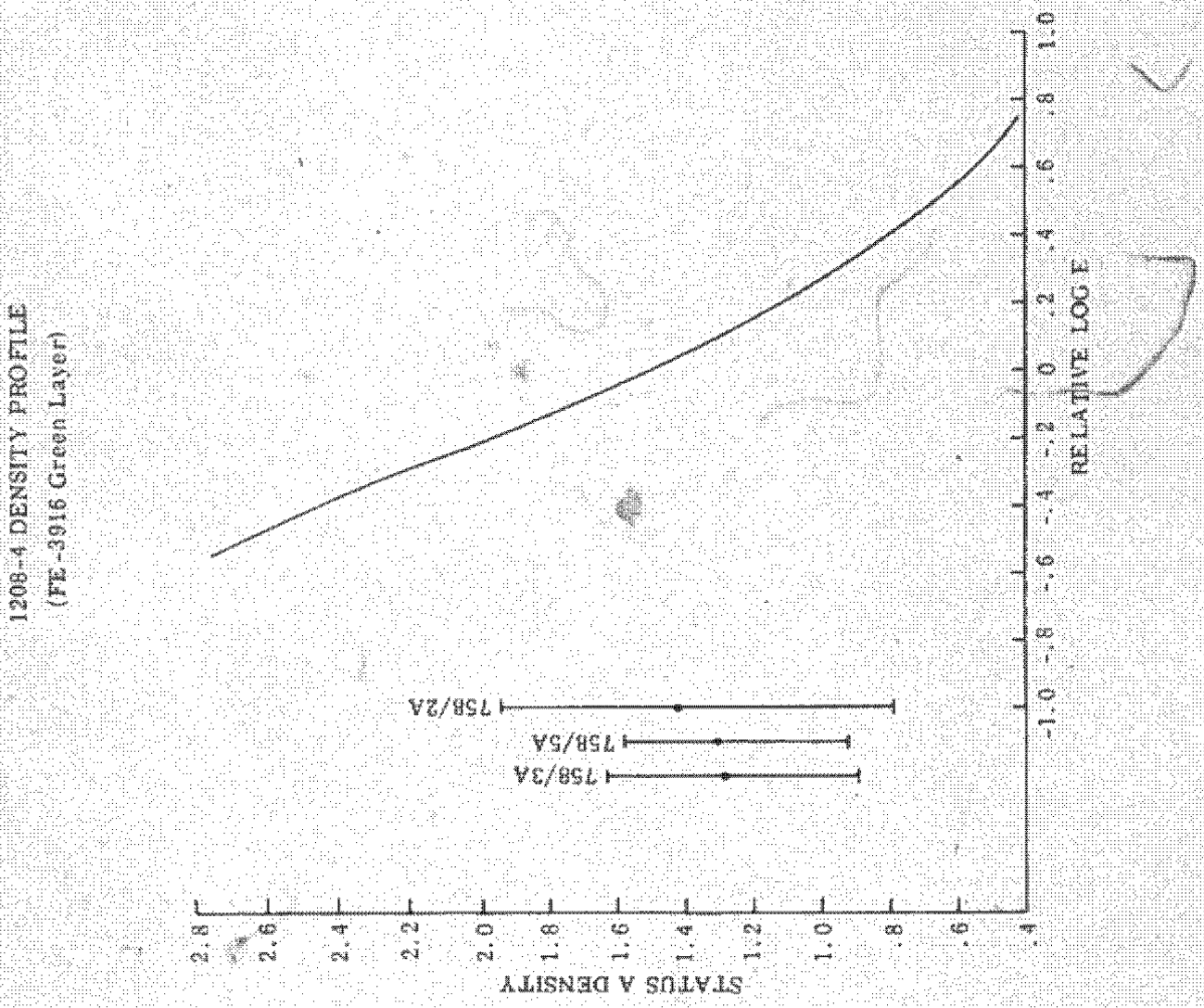


FIGURE 3-36

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TABLE 3-28

COLOR FILM URBAN SCENE MEAN EXPOSURE ERRORS

Type Surround	Camera	Film	Number	Total	Log E Error	
					Camera	Algorithm
Vegetation	Aft	SO-255	6	.10	0	.10
Vegetation	Aft	FE-3916	3	.08	.02	.06

3.6.4.4 Evaluation of Special Exposure Biases for Color Film

No microdensitometry was accomplished for snow or sand surround urban areas on SO-255 Color or FE-3916 IR False Color Film, but observation of areas with light surrounds indicated that the same special biases would appear to apply to color materials as for black and white films.

3.6.5 Special Analyses

3.6.5.1 CORN Target Contrast Analysis

The CORN Target contrast analysis was undertaken to establish the film plane contrast of the CORN display tribars. The tribar images are too small to scan accurately, so the contrast of the tribars, which have nominally 7% and 33% reflectance, was extracted from interpolation of gray scale density data converted to exposure data.

The actual scanning of the five-step gray scale patches was performed with the Mann-Data Microdensitometer using a five micron spot. The recorded microdensities versus their nominal reflectances were then plotted. Microdensities for nominal reflectances of tribar background and bars were then converted to macrodensities, using an empirically derived relationship which is discussed in PFA Special Report No. 7, TCS 363508-73. After conversion to relative exposure values, contrast was then calculated.

Table 3-29 gives the estimated macro contrasts of all Mission 1208 tribars on 1414 Films. Lack of a contrast value indicates that the computed contrast was unreasonably high as a result of inherent errors in the analysis.

3.6.5.2 Tyuratam Tribar Contrast Determination

An approximate determination of ground contrast was made for tribar displays in the Soviet desert at Tyuratam. Unlike the analysis for CORN targets, microdensitometer tracing had to be done across the Tyuratam bars themselves, with an acknowledged loss in accuracy in the microdensity determination, and then a conversion was made from micro to macrodensities. The traces were made with the Mann-Data Microdensitometer using a one micron spot.

The tribars were displayed in groups of four. The tribars were oriented in a different direction at 45° intervals. The tracing was done over each of the four largest tribars and average microdensities were determined for bars, backgrounds, and terrains. The size of the largest tribars was

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TABLE 3-29

IMAGE PLANE CONTRAST OF TRIBAR RESOLUTION TARGETS
AS ESTIMATED FROM FIVE-STEP GRAY SCALES

Mission Segment	Process	Camera	Op	Frame	Measured Contrast
1208-1	19DN	Forward	84	004	2.88
1208-1	19DN	Aft	84	004	3.09
1208-2	26DN	Forward	311	012	2.46
1208-2	19DN	Aft	311	012	2.54
1208-3	26DN	Forward	397	003	2.57
1208-3	26DN	Aft	397	003	2.29
1208-4	19DN	Forward	620	003	3.12
1208-4	26DN	Aft	620	004	2.01
1208-4	26DN	Forward	741	004	-
1208-4	26DN	Forward	745	003	3.34
1208-4	26DN	Forward	758	003	-
1208-4	26DN	Forward	764	003	4.47

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found to be approximately 5 1/2" in bar width as determined from microdensitometer traces. Using the micro to macrodensity conversion employed in paragraph 3.6.5.1, the contrasts were computed and are presented in Table 3-30.

TABLE 3-30

FILM PLANE CONTRASTS OF TYURATAM TRIBARS

Camera	Op	Frame	Measured Contrast
Aft	701	006	2.63
Aft	721	009	2.46
Forward	721	008	2.40
Aft	600	007	2.24
Forward	701	006	2.40
Forward	600	006	2.19
		Average	2.40

The average reflectance of 15.2% for CORN displays was assumed for the Tyuratam tribars as well as an average atmospheric attenuation C factor of 8.0. Use of the following relationships gives an estimated ground contrast (R_B/R_{BK}) of 3.84.

$$\frac{R_B + C}{R_{BK} + C} = FPC \qquad \sqrt{R_B \times R_{BK}} = 15.2$$

where:

R_B = Bar reflectance (%)

R_{BK} = Background reflectance (%)

C = Atmospheric attenuation factor

FPC = Film plane contrast

It would thus appear that the Tyuratam tribar characteristics are similar to those of CORN units; i.e., R_B and R_{BK} are approximately 30% and 8%, respectively.

3.6.6 Conclusions/Recommendations

A. Exposure of 1414 Film, in both Forward and Aft units was within .04 log E of the aim criteria. The basic 1414 exposure algorithm, including the two-count exposure bias of -.06 log E, should be

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maintained for future missions.

B. Evaluation of imagery from SO-255 Color and FE-3916 IR False Color Film, used in the Aft Camera only, indicated overexposure by approximately 1/3 stop (.10 log E for SO-255, .08 log E for FE-3916). The two-count Aft unit exposure bias, given only to 1414 on 1208, should be extended to these films on future missions.

C. Melted and/or dirty snow in areas of PI interest caused an apparent breakdown in the present snow bias routine. It is recommended that the snow bias be eliminated from late spring and summer missions, specifically April and thereafter.

D. Sand surround acquisitions indicated that the -.15 log E sand bias was correct. Boundaries of the present desert polygon should be revaluated.

E. Microdensitometry of Tyuratam tribar displays indicates that their contrast, reflectances, and largest bar size are quite similar to CORN tribars.

3.7 RADIATION MONITORING PACKETS (RMPs)

Radiation monitoring packets have been included on each mission starting with 1206. The packet is composed of small area samples of the films in use. The flight samples are carried to provide information about changes in sensitometric properties due to radiation incurred during the course of the mission. Comparisons are made between the flight samples and control samples retained for this purpose.

Effects of solar flares and/or unusual orbit such as through radiation belts were the primary intent of the RMPs. However, accumulative radiation effects could also be monitored.

For SO-255 Color Film, previous measurements had been limited to the green density; no appreciable degradation was noted.

In Mission 1208, a decreasing trend in the maximum blue density was noticed. This observation prompted a revaluation of the 1206 and 1207 RMPs. Similar trends in the blue record appear in these missions also, see Table 3-31. It is believed that these effects cannot be compensated for in processing.

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TABLE 3-31

MAXIMUM BLUE DENSITY ON SO-255 SAMPLES

(density values)

RV	Mission 1206			Mission 1207			Mission 1208		
	Control	Flight	Difference (Control-Flight)	Control	Flight	Difference (Control-Flight)	Control	Flight	Difference (Control-Flight)
1	3.05	3.20	-.15	3.04	2.99	.05	3.20	3.20	0
2	3.44	3.37	.07	3.48	3.37	.11	3.20	3.02	.18
3	3.36	3.26	.10	3.17	3.00	.17	3.20	2.96	.24
4	3.38	3.12	.26	3.21	2.91	.30	3.20*	2.79	.41

NOTE: The asterisk (*) indicates that for 1208, proper control samples were not available. The maximum blue density from the flight sample in 1208-1 was used as the control.

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PROCESSING, REPRODUCTION, AND DUPLICATE IMAGE QUALITY

[redacted]

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SECTION IV

PROCESSING, REPRODUCTION, AND DUPLICATE IMAGE QUALITY

4.1 INTRODUCTION

This section discusses defilming, processing, titling, and reproduction of Mission 1208 Forward and Aft Camera original records as well as results of NPIC evaluations of duplicate image quality. All production operations were accomplished at BRIDGEHEAD except for the Priority 4 customer requirements from black and white original negatives. This work was done at AFSPPF.

4.2 SUMMARY

Defilming operations were normal except for 1208-3 where the Aft core locking pin was found to be bent. The bent pin was removed by drilling after normal techniques for removal had failed.

Abnormally high base plus fog levels were noted on certain sections of 1208-1. They were found to be associated with specific manufactured film rolls. These rolls were identified and compensation was provided by special processing techniques for the remaining segments of 1208. Particulate matter wound in the Forward stack of RV-1 resulted in the puncture of four convolutions in Op 38 and another dimple and puncture in Op 1 IOR. It appears that a foreign particle remained imbedded in the film (Op 1 IOR) until it transferred to a processor dryer roller and caused a base side film scratch which continued through Op 17. Processing was interrupted in Op 18 IOR and the roller was cleaned before normal processing resumed.

Black and white reproduction of geographic area duplicate positives from RV-2 -3, and -4 was achieved using the ABCC printing method which provides additional contrast in shadow areas plus an in-line production capability for contrast changes.

All 1208 target complex copies were reproduced at BRIDGEHEAD for the first time.

Processing of the 1208-4 color originals was accomplished without incident. The SO-255 color original was processed in the Grafton Processor, process number E-26-8C, which was modified to provide a .10 log E increase in photographic speed.

Reproduction of the color originals was accomplished using additive Rainbow Printers. The color duplicates were made with Aerial Color Print Film SO-287 which had been preflashed to provide substantial improvements in sensitometric reproduction.

NPIC's evaluation of the duplicates from the black and white original negative (ON) shows them to be of good quality, similar to recent 1200 Series missions in regard to resolution transfer and tone reproduction. An evaluation of the natural color original positive and its duplicates shows that the resolution losses for the color DP are still significant as compared to the green record black and white DP made from the same original. The tonal range and contrast of the color DP is not as good as either the green record DP or the second generation black and white DP from the ON. The color balance of the color DP is good, and has

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improved significantly over that of Mission 1207, principally due to the flashing that was given to the color DPs before processing. No significant resolution losses were found on the duplicate copies made from the flashed color IR original positive. However, the red record DP was preferred over the color DP for both resolution and edge sharpness quality.

The tone reproduction quality of both the color DP and the red record, black and white DP made from the false color original positive are similar, but neither is as good as the second generation DP copy. The color balance of the false color original positive is better than that in Mission 1207; there is a concern however, that a fuller color gamut of IR reflectances is not being displayed on the color DP copy with the current color original positive/DP system.

4.3 RECEIPT AND DEFILMING

4.3.1 Mission Segment 1208-1

The RV/TU arrived at the BRIDGEHEAD processing facility in good condition at 1635 EDT, 25 April 1974. All parachute apparatus was wet. The RV cover recesses had small amounts of water in them from the wet recovery. The battery discharge units had not been installed on the RV. Both core locking pins were engaged and intact. Both film rolls were dry, well stacked, and well centered in the TU. The small amount of particulate collected from inside the dome included a 1" long piece of wire which had been lodged in the Forward roll during Op 38 and punctured four convolutions of film. A severe dimple was detected near the head of the Forward roll at presplice. The cause was not found, but the dimple correlates with the puncture of Forward Op 1 IOR. Tag ends were removed and processed prior to normal defilming to allow early PFA Team quality evaluation. The Forward Camera film weighed 221 pounds and the Aft Camera Film weighed 221 pounds.

4.3.2 Mission Segment 1208-2

The RV/TU arrived at the BRIDGEHEAD processing facility at 0945 EDT, 23 May 1974.

Both core locking pins were engaged and intact. Both rolls were well stacked and well centered on the TU with no festooning into the dome. The hinge and thermal access door on the entrance side were sprung. A white residue was noted around the Forward side exit door and cutter assembly.

During despooling, it was discovered that the brake on the Forward side was not operational. It was commanded several times but no braking could be accomplished. The audible sound of the brake solenoid actuation was detected thus indicating that the problem was in the brake assembly. This necessitated hand-held tension on the stack when the motor was turned off for splicing.

Two deep scratches were noted inside the dome and a 1" tear in the acrylic tape covering the fiberglass on the relay housing was noted on the Forward side adjacent to a canister alignment pin.

The dome was clean with only a small amount of particulate retrieved.

The Forward Camera film weighed 230 pounds and the Aft Camera film weighed 221 pounds.

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4.3.3 Mission Segment 1208-3

The RV/TU arrived at the BRIDGEHEAD processing facility at 0850 EDT, 19 June 1974.

Upon removal of the RV canister, it was evident that the deorbit core locking pin on the Forward side had sheared resulting in a 50' film spill. Prior to handling the film, the builder roller arms were raised electrically using special test equipment. This was to preclude possible damage to the builder roller verify microswitch on the Forward side which evidenced intermittent failure during the mission. The 50' of spilled film was then respooled onto the TU stack.

The film stacks were good with the exception of a rough edge on the inside of the Forward stack approximately 3/4" from the outside diameter.

The most significant problem occurred when attempting to withdraw the Aft core locking pin that had been bent during recovery. Normal techniques for removing a bent pin failed, requiring that the pin assembly be drilled out. This effort consumed 18 hours before pin removal. However, production time was not lost because the Forward Camera film was being processed during this effort.

The RV suffered the following damage during removal of the bent core locking pin:

A. Complete destruction of the piston and actuating pin (621-5440-001).

B. Cut wire bundle and damage to the solenoid assembly (622-3415-004).

C. Removal and damage to actuator assembly plate (622-3544-001).

D. A fracture in the support assembly cross frame member of approximately 7mm.

E. Damage to primary battery (P/N66P797-001-9, S/N 021).

F. Minor physical damage (rubs, abrasions, etc.) to the Aft side wire bundles in the area of the A-2 canister recess.

A small amount of particulate was retrieved from the dome.

The Forward Camera film weighed 199 pounds and the Aft Camera film weighed 191 pounds.

4.3.4 Mission Segment 1208-4

The RV/TU arrived at the BRIDGEHEAD processing facility at 0930 EDT, 25 July 1974. No major problems occurred. The film stacks were good and the deorbit pins did not shear. A small amount of shredded film was found in the RV canister. The film was damaged when the tag ends were pulled through the camera at mission completion. The TU electronics (A-2 and A-15) on the Aft side were removed and sent directly to the vendor for analysis of the integrator reset problem experienced during Mission Segment 1208-4.

The Forward Camera film weighed 212 pounds and the Aft Camera film weighed 226 pounds.

4.4 PROCESSING AND TITLING

4.4.1 Mission Segment 1208-1

Table 4-1 presents the processing data for the 1414 original negatives.

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TABLE 4-1

1414 PROCESSING DATA, RV-1

	Forward Camera	Aft Camera
Processor	Yardleigh 5	Yardleigh 6
Developer	19DN	19DN
Flight Frames:		
30° Scan	763	763
60° Scan	1,231	1,230
90° Scan	1,148	1,148
120° Scan	270	270
Totals	3,412	3,411
Footage:		
Preflight	1,829	1,970
Flight	26,213	26,141
Manufacturing Splices	16	22

After processing 4,572', the Forward Camera film was cut in the IOR of Op 18 because a scratch was detected on the base side of the film. Investigation revealed that this scratch originated at a small puncture in the interop space prior to Op 1 and continued through Op 17. The puncture correlates with the dimple detected during defilming (reference paragraph 4.3.1). It is suspected that a foreign particle was ingested into the film stack during orbital operations causing the puncture and the subsequent dimple. The particle remained imbedded in the film during defilming and was carried through the processor and lodged on a dryer turn-around roller causing the base scratch. The roller was cleaned and processing resumed.

The Base plus Fog density of different film segments of both Forward and Aft Cameras was noted to change significantly at some of the manufacturing splices. The densities ranged from .18 to .38. This is discussed more fully in paragraph 4.4.5.

4.4.1.1 Optical Titling

Approximately 99.3% of the Forward Camera frames and 99.1% of the Aft Camera frames were completely and accurately titled by the Optical Titling System.

4.4.2 Mission Segment 1208-2

Table 4-2 presents the processing data for the 1414 original negatives.

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TABLE 4-2

1414 PROCESSING DATA, RV-2

	Forward Camera	Aft Camera
Processor	Yardleigh 6	Yardleigh 6
Developer	19DN/26DN	19DN/26DN
Flight Frames:		
30° Scan	2,117	2,063
60° Scan	1,350	1,352
90° Scan	931	853
120° Scan	118	118
Totals	4,516	4,386
Footage:		
Processed in 19DN	13,057	13,280
Processed in 26DN	15,797	14,478
Totals	28,854	27,758
Manufacturing Splices	18	19

4.4.2.1 Optical Titling

Approximately 99.6% of the Forward Camera frames and 98.1% of the Aft frames were completely and accurately titled by the Optical Titling System.

A modification of the titling format to include the camera designation and classification every 15° of scan was instituted on this segment upon request of the user community.

4.4.3 Mission Segment 1208-3

Table 4-3 presents the processing data for the 1414 original negatives.

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TABLE 4-3

1414 PROCESSING DATA, RV-3

	Forward Camera	Aft Camera
Processor	Yardleigh 6	Yardleigh 6
Developer	19DN/26DN	19DN/26DN
Flight Frames:		
30° Scan	1,991	1,972
60° Scan	1,316	1,266
90° Scan	781	727
120° Scan	40	40
Totals	4,128	4,005
Footage:		
Processed in 19DN	16,170	9,565
Processed in 26DN	9,088	14,660
Totals	25,258	24,225
Manufacturing Splices	17	17

4.4.3.1 Optical Titling

Over 99% of the frames were completely and accurately titled by the Optical Titling System.

4.4.4 Mission Segment 1208-4

Table 4-4 presents the processing data for the 1414 original negatives.

TABLE 4-4

1414 PROCESSING DATA, RV-4

	Forward Camera	Aft Camera
Processor	Yardleigh 6	Yardleigh 6
Developer	19DN/26DN	19DN/26DN
Flight Frames:		
30° Scan	1,072	637
60° Scan	1,911	1,565
90° Scan	853	708
120° Scan	0	0
Totals	3,836	2,910

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TABLE 4-4 (CONT'D)

	Forward Camera	Aft Camera
Footage:		
Processed in [redacted]DN	24,982	4,411
Processed in [redacted]N	1,845	16,583
Totals	26,827	20,994
Manufacturing Splices	20	13*

NOTE: The asterisk (*) means that this value includes the 1414 to SO-255 splice.

Table 4-5 presents the processing data for the SO-255 and FE-3916 original positives. The E-26-8C Grafton process was modified to yield a photographic speed increase of .10 Log E relative to previous missions.

TABLE 4-5

SO-255/FE-3916 PROCESSING DATA, RV-4

(Aft Camera)

	SO-255	FE-3916
Processor	Grafton	MP^2
Process Chemistry	E-26-8C	E-31-3A
Flight Frames:		
30° Scan	244	222
60° Scan	196	128
90° Scan	30	115
120° Scan	0	0
Totals	470	465
Footage	2,588	3,036
Manufacturing Splices	2*	1

NOTE: The asterisk (*) means that this value includes the SO-255 to FE-3916 splice.

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4.4.4.1 Optical Titling

Over 99 % of the frames in the black and white portion were completely and accurately titled by the Optical Titling System.

4.4.4.2 Manual Titling of the Color Film

The title side of the film web was flashed before processing to produce a light cyan color. This permitted manual titling using the UNIMAK Film Titler.

An exposing source for edge flashing is incorporated in the Grafton Processor. Hence, the SO-255 Film is flashed on the processor. The FE-3916 is edge-flashed off-line before processing on the MP^2.

4.4.5 Base Plus Fog Problem on 1414 Film

Abnormally high Base plus Fog levels were noted on certain sections of 1208-1, with significant changes occurring across some manufacturing splices. The pieces of film that made up the flight rolls were grouped in two populations based on the fog characteristics. One population was near-normal, with values of Base plus Fog ranging from .18 to .24 and the other was abnormally high, with values of .30 to .38, see Table 4-6 on page 4-10. The high Base plus Fog densities are associated with specific manufactured film rolls and the probable cause is a film backing contaminant which, when in contact with the emulsion, causes a fog buildup with time. Although the specific cause of the problem has not been identified, accelerated keeping tests; which identify rolls with a potential fog problem, have been included in the film manufacturing cycle.

In an effort to compensate for the sensitometric change induced by the high fog found on 1208-1, a new process, designated 26DN, was selected for use on those remaining portions of Mission 1208 which were expected to exhibit high fog in the standard 19DN process. The 26DN process reduced the fog somewhat and regained a more desirable sensitometric curve shape. A comparison of normal and high fog samples from the 19DN process is given in Figure 4-1.

In order to use the appropriate process for each segment of the original negative, the dual nose hopper capability that exists on the Yardleigh 6 was used to bring both 19DN and 26DN developers to the developer coating station. During the defilming operation, flashed stock was inserted at those manufacturing splices where a change from 19DN to 26DN or vice versa was required based on the splice/piece profiles for each roll on RV-2, RV-3, and RV-4. The developer switch was then accomplished as these flashed stock inserts were being processed and imagery was not sensitometrically affected by the transitions. The tape splices which attached the flashed stock inserts resulted in the loss of 1.25 linear inches of imagery at each separation. In addition, minus density areas (up to .75" diameter) occurred immediately adjacent to the trailing edge of some of these splices.

Table 4-6 provides a tabulation of the Base plus Fog level and process used for each piece of 1414 Film in both cameras for Mission 1208.

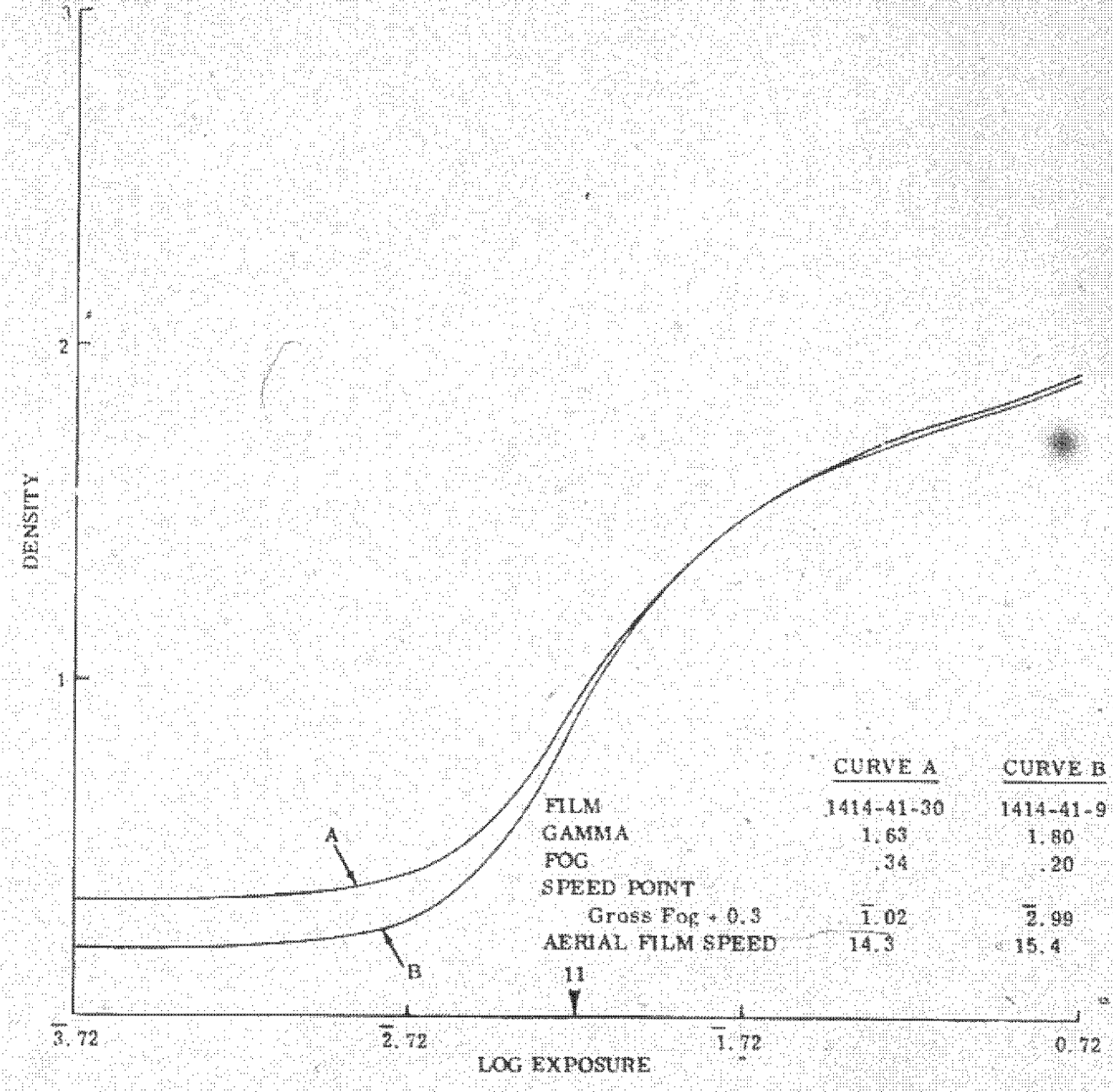
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COMPARISON OF NORMAL AND HIGH FOG SAMPLES
IN 19DN PROCESS



	CURVE A	CURVE B
FILM	1414-41-30	1414-41-9
GAMMA	1.63	1.80
FOG	.34	.20
SPEED POINT		
Gross Fog + 0.3	1.02	2.99
AERIAL FILM SPEED	14.3	15.4

FIGURE 4-1

BYE 15256-75

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TABLE 4-6

MISSION 1208 BASE PLUS FOG DATA

— Forward Camera —

Mission Segment	From Op	From Frame	To Op	To Frame	Base Plus Fog	Developer (DN)
1208-1	-	-	P17	001	.23	19
	P17	001	10	009	.36	19
	10	009	20	009	.31	19
	20	009	29	005	.34	19
	29	005	34	048	.38	19
	34	048	43	046	.36	19
	43	046	47	027	.18	19
	47	027	53	033	.19	19
	53	033	61	009	.19	19
	61	009	68	013	.33	19
	68	013	78	012	.23	19
	78	012	90, 91	IOR	.24	19
	90, 91	IOR	101	032	.22	19
	101	032	111	008/009	.22	19
	111	008/009	116 117	IOR	.34	19
	116 117	IOR	126	034	.20	19
	126	034	-	-	.18	19
1208-2	-	-	138 139	IOR	.18	19
	138 139	IOR	145 146	IOR	.26	26
	145 146	IOR	156/157	IOR	.19	19
	156/157	IOR	164	066	.31	26
	164	066	167	028	.25	26
	167	028	179	003	.29	26
	179	003	200	029	.19	19
	200	029	215	010	.31	26
	215	010	232 233	IOR	.13	19
	232 233	IOR	246	011	.31	26
	246	011	268	026	.16	19

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TABLE 4-6 (CONT'D)

Mission Segment	From Op	From Frame	To Op	To Frame	Base Plus Fog	Developer (DN)
1208-2	268	026	285	010	.17	19
	285	010	304	004	.30	26
	304	004	323	001	.31	26
	323	001	335	025	.24	19
	335	025	341	005/006	.28	26
	341	005/006	351	005	.25	26
	351	005	362/363	IOR	.27	26
	362/363	IOR	-	-	.20	19
1208-3	-	-	374	020	.22	19
	374	020	384	006	.35	26
	384	006	394	029	.21	19
	394	029	412	038	.26	26
	412	038	429	011	.19	19
	429	011	441	039	.21	19
	441	039	455/457	IOR	.22	19
	455/457	IOR	477	007	.32	26
	477	007	493/494	IOR	.18	19
	493/494	IOR	498/499	IOR	.30	26
	498/499	IOR	513	024	.20	19
	513	024	515/516	IOR	.20	19
	515/516	IOR	527	006	.20	19
	527	006	534/535	IOR	.31	26
	534/535	IOR	551	003	.33	26
	551	003	562	052	.17	19
	562	052	569	030	.29	26
	569	030	-	-	.19	19
1208-4	-	-	586/587	IOR	.19	19
	586/587	IOR	594	003	.19	19
	594	003	613/614	IOR	.18	19
	613/614	IOR	629	019	.21	19
	629	019	634	001	.30	26

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TABLE 4-6 (CONT'D)

Mission Segment	From Op	From Frame	To Op	To Frame	Base Plus Fog	Developer (DN)
1208-4	634	001	639	008	.20	19
	639	008	652	009	.21	19
	652	009	665	010	.21	19
	665	010	672	013	.22	19
	672	013	678	062	.20	19
	678	062	687	005	.18	19
	687	005	696	032	.19	19
	696	032	702	020	.24	26
	702	020	708	009	.20	19
	708	009	724 725	IOR	.19	19
	724 725	IOR	730	019	.19	19
	730	019	735	002	.18	19
	735	002	750	017	.20	19
	750	017	752	026	.20	19
	752	026	759	005	.19	19
	759	005	-	-	.18	19
			— Aft Camera —			
1208-1	-	-	P6/P7	IOR	.20	19
	P6/P7	IOR	1/2	IOR	.36	19
	1/2	IOR	12	004	.37	19
	12	004	19 20	IOR	.19	19
	19 20	IOR	28/29	IOR	.32	19
	28 29	IOR	32	002	.21	19
	32	002	38/39	IOR	.31	19
	38/39	IOR	43	085	.20	19
	43	085	49	005	.37	19
	49	005	51	032	.21	19
	51	032	56	021	.19	19
	56	021	57/58	IOR	.30	19
	57 58	IOR	63	003	.22	19

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TABLE 4-6 (CONT'D)

Mission Segment	From Op	From Frame	To Op	To Frame	Base Plus Fog	Developer (DN)
1208-1	63	003	67	022	.37	19
	67	022	75	013	.18	19
	75	013	89	015	.21	19
	89	015	94/95	IOR	.34	19
	94/95	IOR	106	002	.31	19
	106	002	112/113	IOR	.20	19
	112/113	IOR	115	026	.20	19
	115	026	121	025	.22	19
	121	025	126	011	.35	19
	126	011	-	-	.38	19
1208-2	-	-	134	034	.37	26
	134	034	141	054	.26	26
	141	054	146	018	.17	19
	146	018	157	006	.19	19
	157	006	165	015	.27	26
	165	015	170/171	IOR	.35	26
	170/171	IOR	185	023	.33	26
	185	023	207/208	IOR	.18	19
	207/208	IOR	218/219	IOR	.18	19
	218/219	IOR	230	021	.22	19
	230	021	248	003	.32	26
	248	003	267	002	.21	19
	267	002	282	013	.32	26
	282	013	300	001	.32	26
	300	001	315	024	.17	19
	315	024	327/328	IOR	.18	19
	327/328	IOR	334	007	.20	19
	334	007	341/342	IOR	.21	19
	341/342	IOR	353/354	IOR	.29	26
	353/354	IOR	-	-	.33	26

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TABLE 4-6 (CONT'D)

Mission Segment	From Op	From Frame	To Op	To Frame	Base Plus Fog	Developer (DN)
1208-3	-	-	364	010	.35	26
	364	010	369	018	.33	26
	369	018	385	020	.20	19
	385	020	392	026	.20	19
	392	026	401	003	.20	19
	401	003	412	006	.19	19
	412	006	431	004	.28	26
	431	004	443	018	.34	26
	443	018	455	017	.30	26
	455	017	473/474	IOR	.18	19
	473/474	IOR	491	002	.26	26
	491	002	513	015	.28	26
	513	015	516	019/020	.21	19
	516	019/020	530	009	.20	19
	530	009	544	007	.33	26
	544	007	555	006	.32	26
	555	006	562	052	.34	26
	562	052	-	-	.28	26
1208-4	-	-	577	074/075	.30	26
	577	074/075	588	026	.35	26
	588	026	604	047	.22	19
	604	047	617	002	.23	19
	617	002	630/631	IOR	.34	26
	630/631	IOR	647/648	IOR	.36	26
	647/648	IOR	660	006	.35	26
	660	006	670/671	IOR	.22	19
	670/671	IOR	678/679	IOR	.35	26
	678/679	IOR	688/689	IOR	.29	26
	688/689	IOR	699	013	.35	26
	699	013	706	008	.31	26
	706	008	-	-	.35	26

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4.4.6 Sensitometry

Sensitometric exposures are used to establish and maintain process control. In the case of the original camera films, flight roll film samples or other film samples of the same emulsion batch are evaluated prior to mission arrival so that process conditions can be adjusted, if necessary, to obtain the optimum sensitometry for the particular batch of flight film involved. The mission rolls are then processed under these adjusted conditions with additional sensitometric strips attached.

Since the flight roll film samples for 1208 were from the normal fog population (1414-41-9 and 1414-41-47), additional samples from the high fog population (1414-41-30) were utilized with the 26DN process.

Sensitometric curves for each RV are shown in Figures 4-2 thru 4-7 and are most representative of the sensitometry of the flight film.

4.5 REPRODUCTION AT BRIDGEHEAD

4.5.1 Breakdown of Originals

After processing, the original materials were "broken-down" according to the Geographic Area covered. For Mission 1208, there were 24 Geographic Areas designated in the world and the coverage (ops/frames) for each area was spliced together to form composite rolls of up to 450 feet. Duplicate copies for each customer were then prepared according to their requirements for each Geographic Area.

4.5.2 Duplication of Black and White Original Negatives

4.5.2.1 Geographic Area Duplicate Positives

All of the regular duplicate positive copies of complete composite rolls for customers in Priorities 1 thru 3 were prepared using Kodak High Definition Duplicating Film (Estar Base) SO-192, processed in the viscous mode to provide a system sensitometry suitable for reproduction of entire composite rolls. Figure 4-8 shows the system sensitometry for RV-1, while Figure 4-9 shows the sensitometry for RV-2, RV-3, and RV-4.

The system sensitometry shown in Figure 4-9 is achieved using the Actinic Butterfly Contrast Control (ABCC) printing method. This method of printing provides an improved system sensitometry and an in-line production capability for contrast changes on an op/area basis.

For RV-1, Redondo Printer settings were selected to return the original negative densities of each op/area part between .40 and 1.80, with small tolerances for system variability. With ABCC printing (RV-2, RV-3, and RV-4) the upper limit was raised to 2.00 because the system provides additional contrast in shadow areas. When the input density range was too great to be returned between the desired limits on a single "medium" print, two or three levels were utilized generating "multiple prints" which included "light" and/or "dark" copies as well. Multiple prints were required as indicated in Table 4-7.

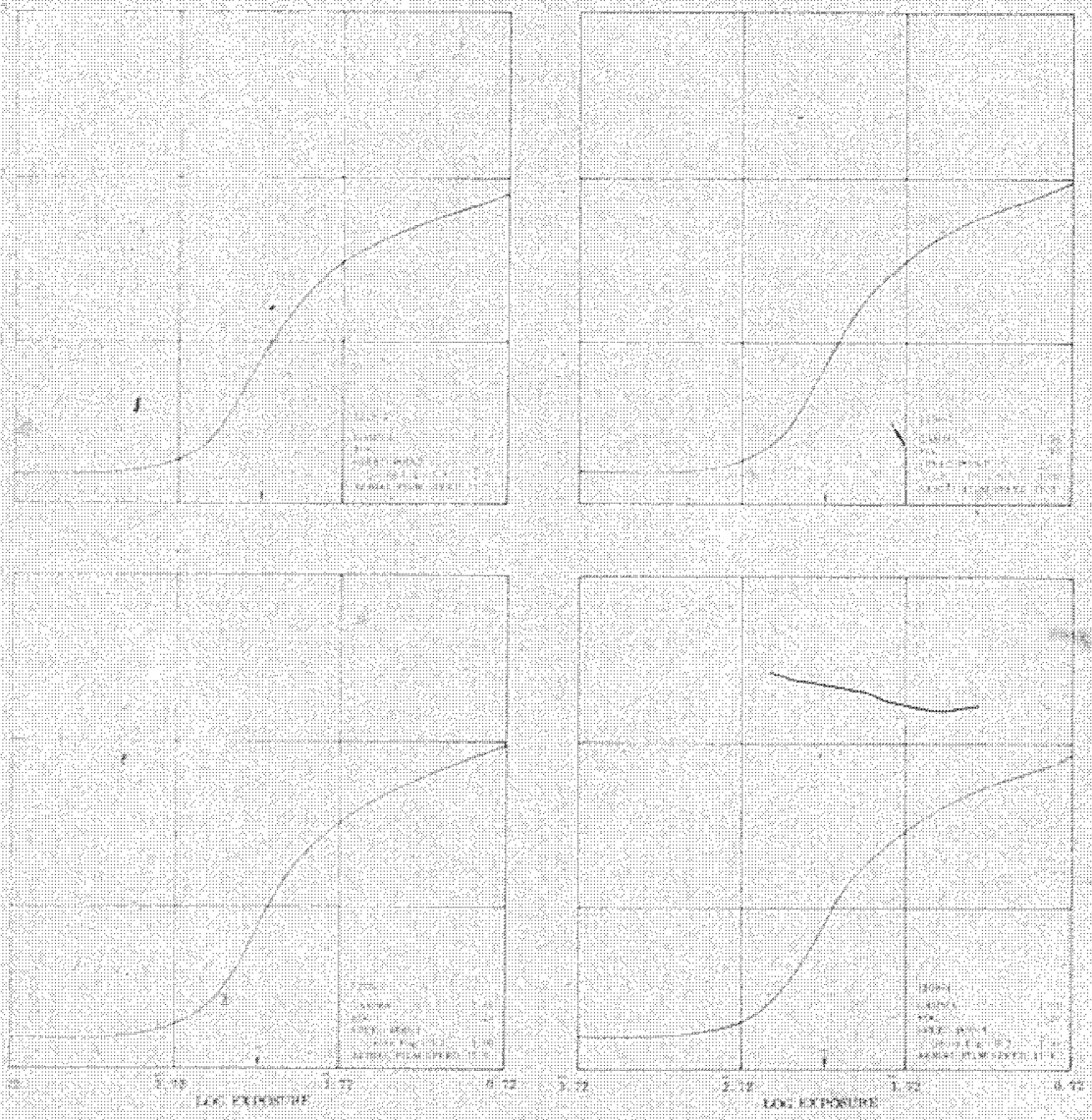
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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-41

FORWARD CAMERA



NOTE: Exposure Data:

Sensitometer	IB
Filter	Daylight
Slide	1.25 second
Scale Factor	1.28

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FIGURE 4-2

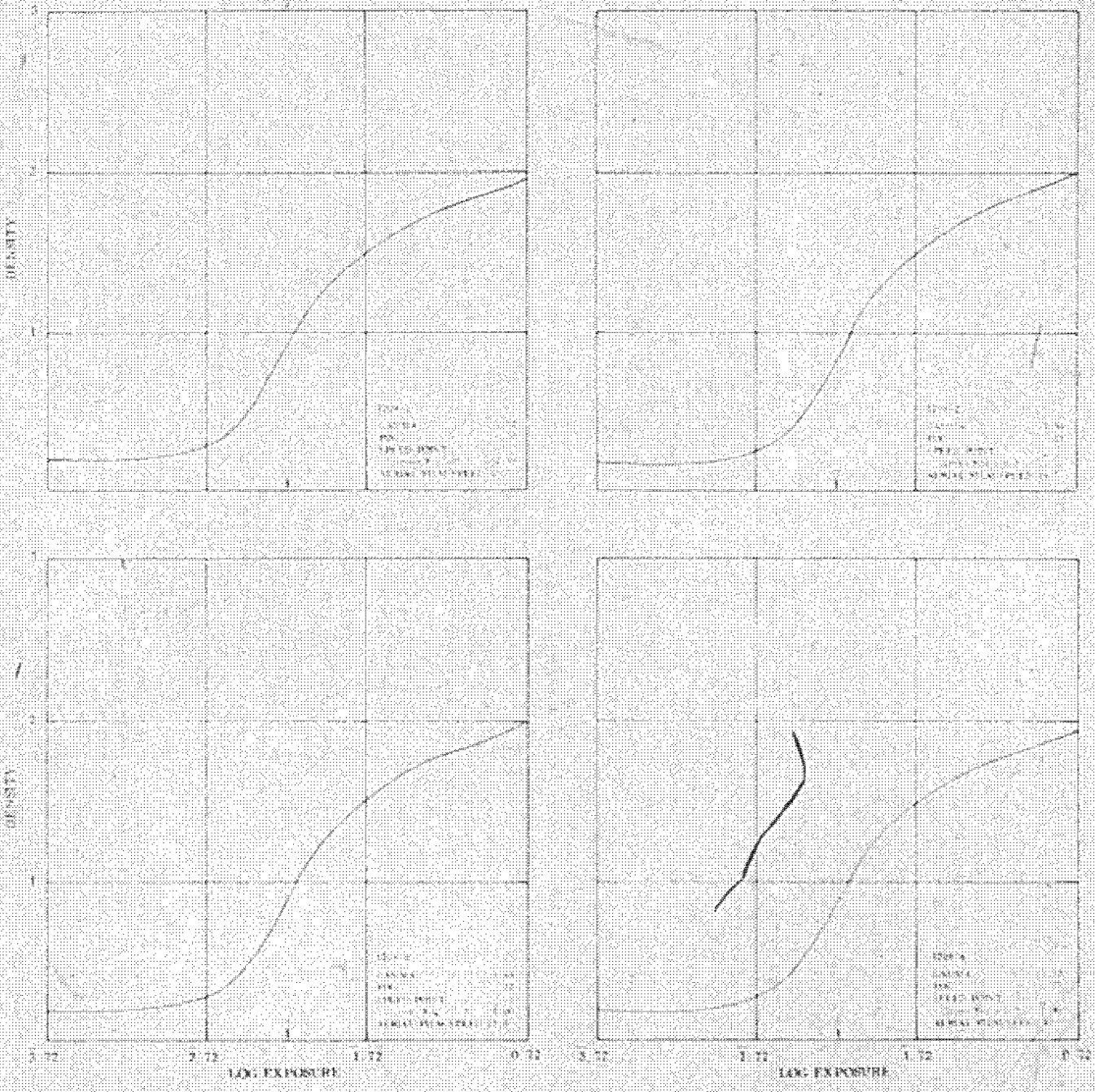
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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-41

AFT CAMERA



NOTE: Exposure Data

Sensitometer	IIB
Filter	Daylight
Time	1.25 second
Log E_{11}	1.22

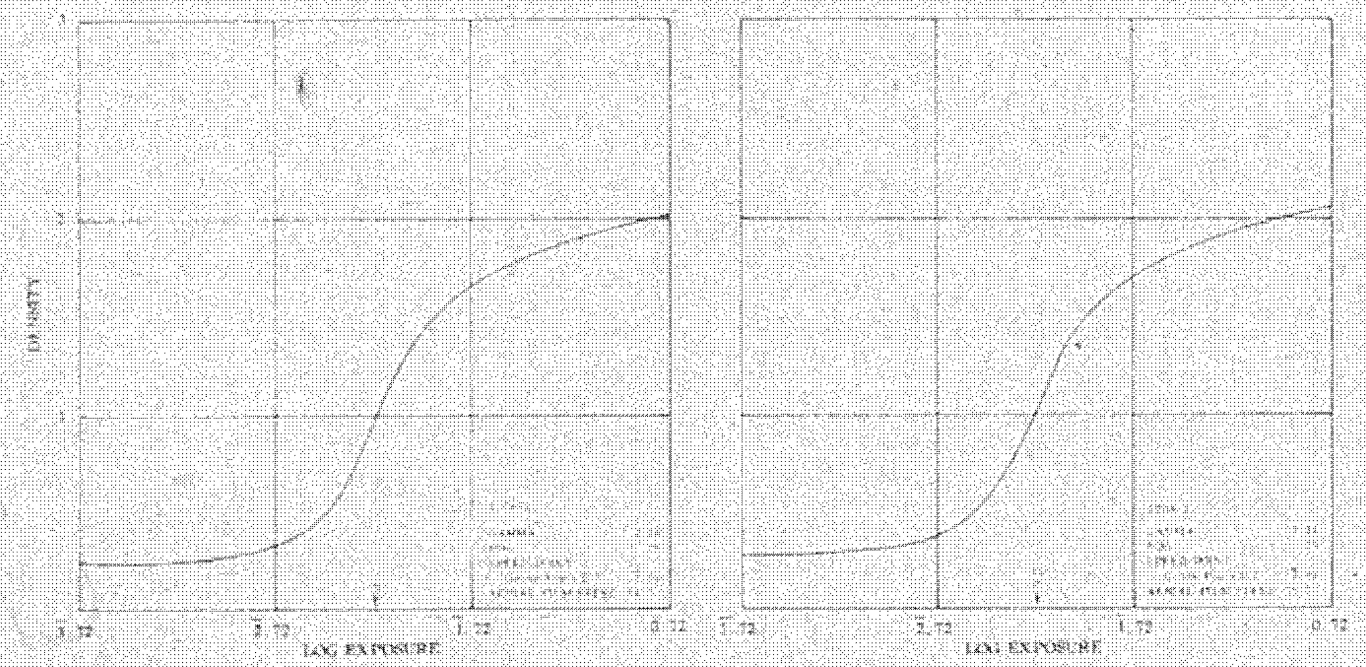
FIGURE 4-3

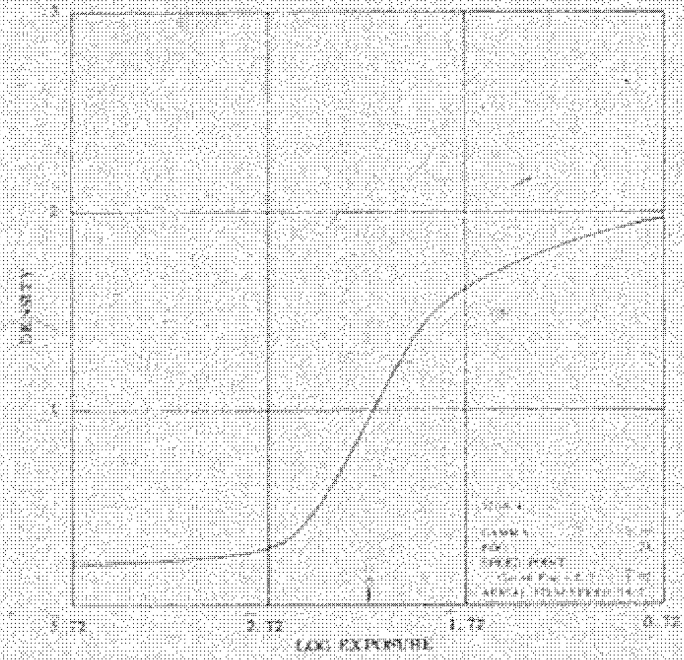
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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-41-30

FORWARD CAMERA





NOTE: Exposure Data:

Speed Setting	16
Filter	Daylight
Exposure Time	1/25 Sec
Low F_{11}	1.22

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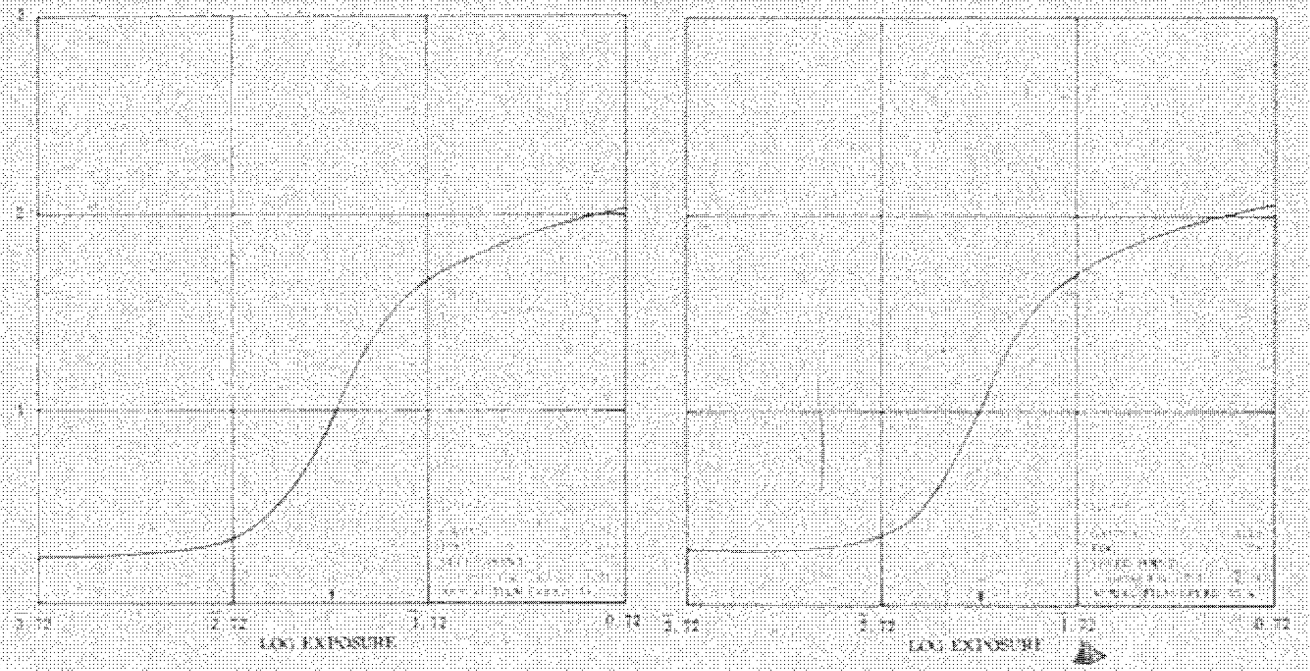
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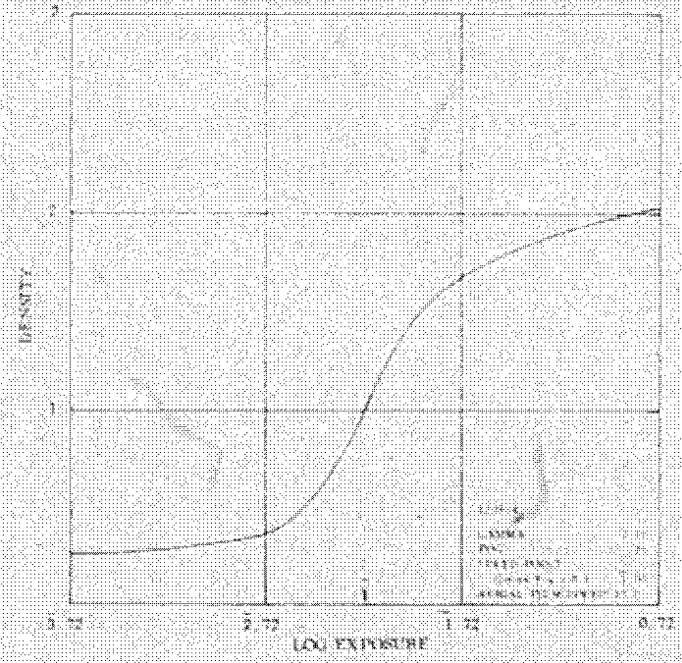
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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-41-30

AFT CAMERA





NOTE: Exposure Data:

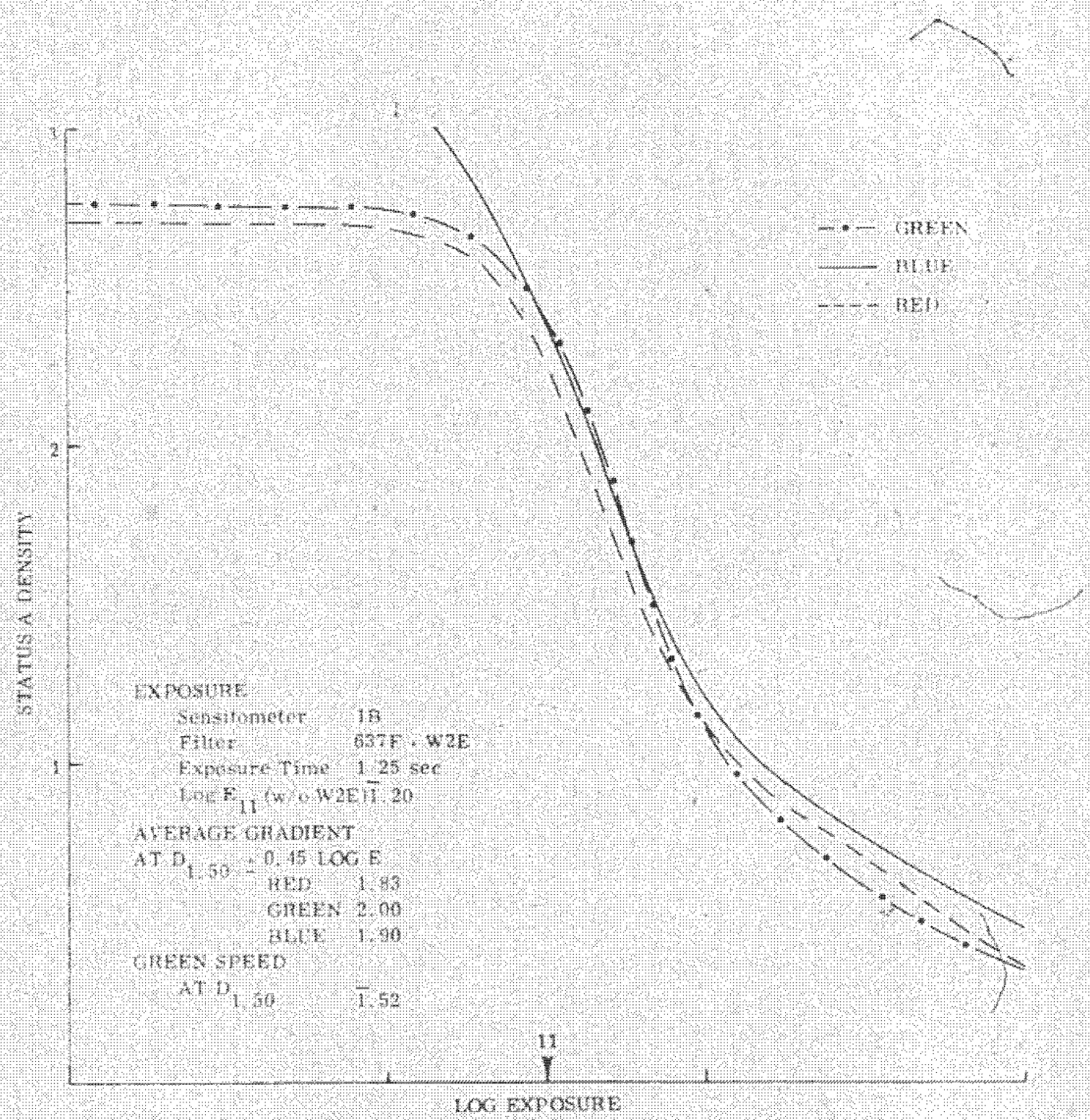
Sensitometer	IB
Filter	Daylight
Exposure Time	1/25 Sec
Log E_{11}	1.22

FIGURE 4-5

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SENSITOMETRIC CURVES FROM 1208-4 AFT CAMERA, FILM TYPE SO-255-117



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FIGURE 4-6

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SENSITOMETRIC CURVES FROM 1208-4 AFT CAMERA, FILM TYPE FE-3916

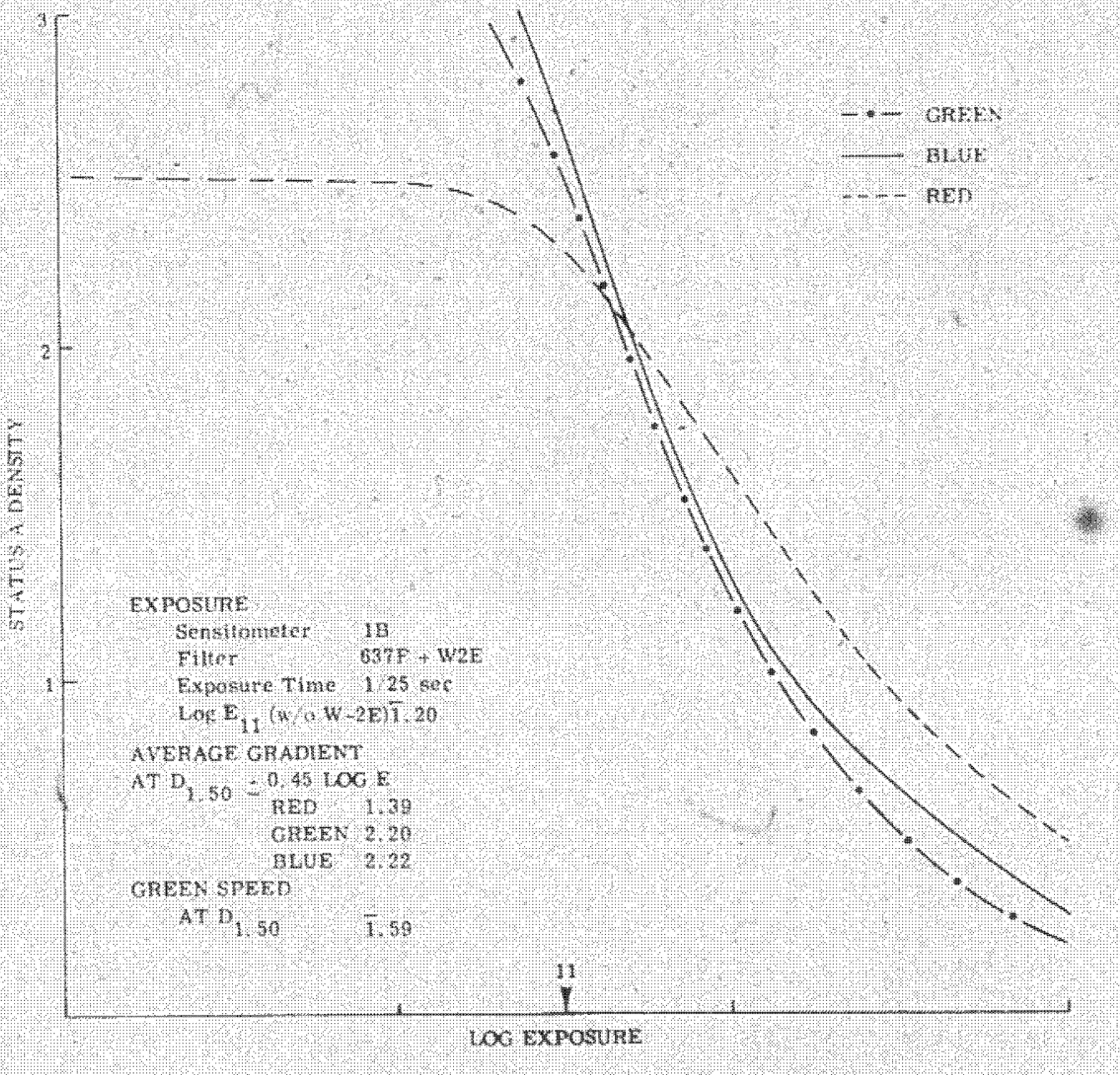


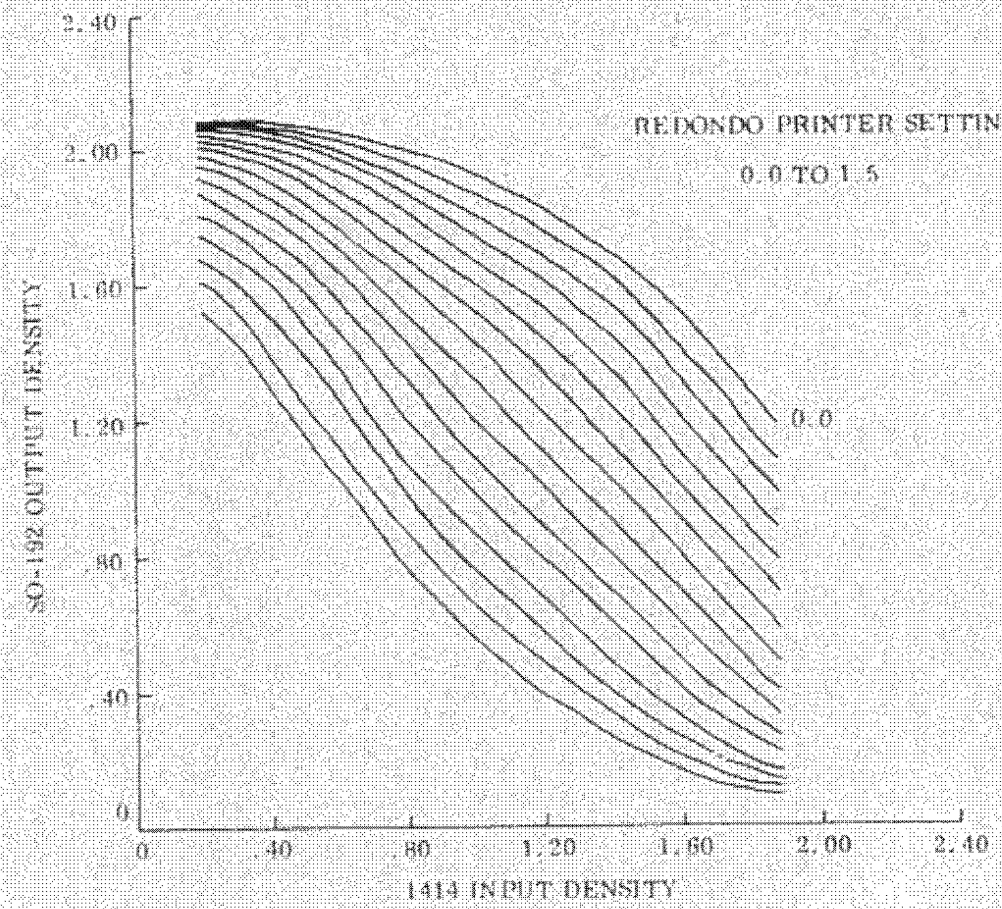
FIGURE 4-7

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SYSTEM REPRODUCTION CURVES FOR RV-1



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FIGURE 4-8

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SYSTEM REPRODUCTION CURVES FOR RV-2, RV-3, AND RV-4

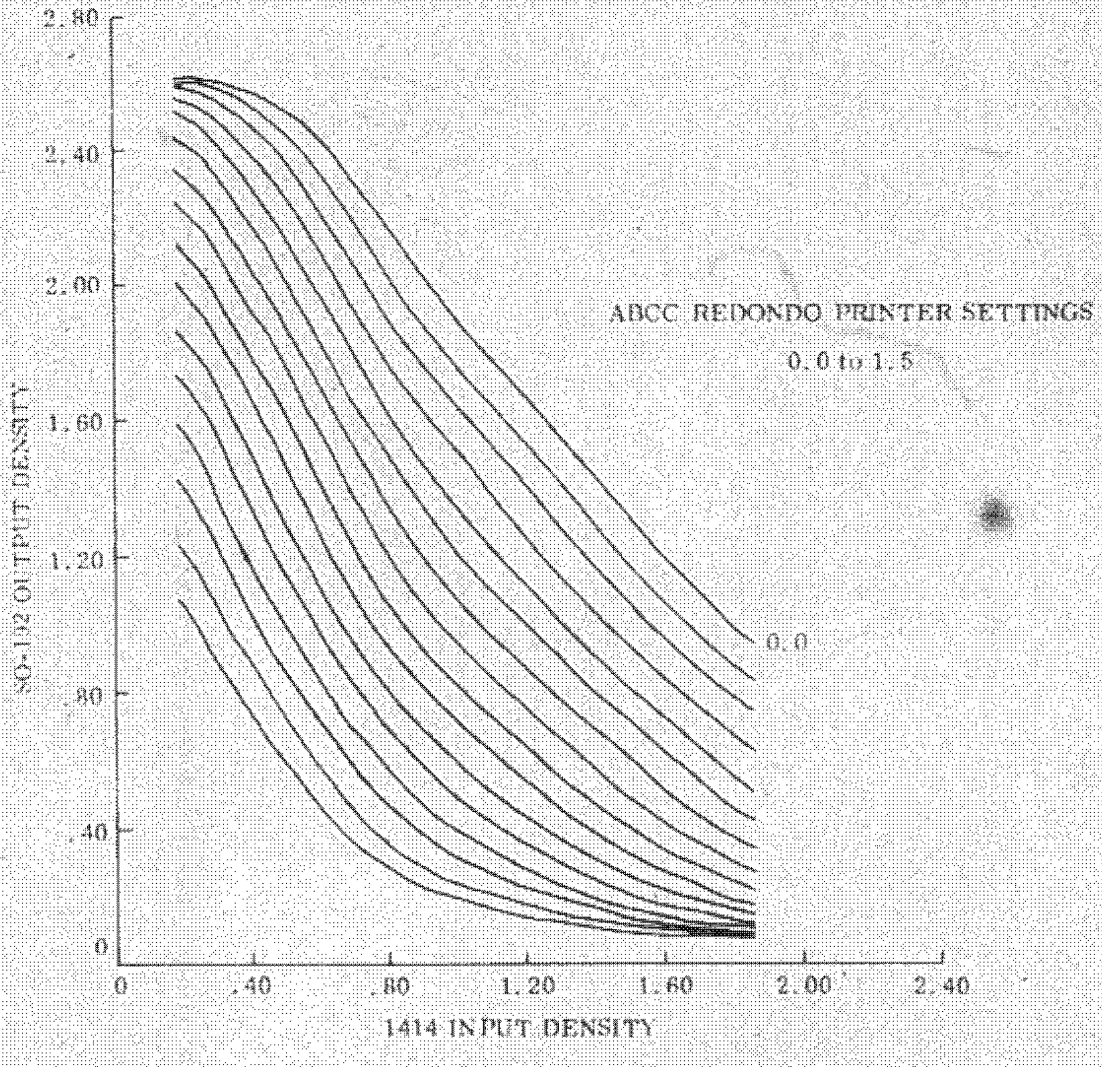


FIGURE 4-9

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TABLE 4-7

BRIDGEHEAD DUPLICATE POSITIVE MULTIPLE PRINTING SUMMARY

(percent)

Mission Segment	Operational Parts Multiple Printed
1208-1	1.6
1208-2	1.3
1208-3	5.5
1208-4	1.9

In addition, the following number of complete op/area parts were reproduced at higher than normal contrasts, see Figure 4-10, for better reproduction of low contrast areas on the original negative. These copies were shipped instead of normal contrast copies. Table 4-8 gives a summary of high contrast parts.

TABLE 4-8

BRIDGEHEAD HIGH CONTRAST PRINTING

(number of parts)

Mission Segment	High Contrast Op/Area Parts
1208-1	14
1208-2	19
1208-3	32
1208-4	7

A large number of op/area parts also contained low contrast imagery that could have benefited from higher than normal contrast reproduction. However, a large proportion of these parts are not candidates for high contrast "instead of" normal contrast reproduction because the entire op/area is not low contrast imagery. If frames of a predominately low contrast part contain input density ranges too great to be properly reproduced at the high contrast level, then the part is printed at normal contrast. In some cases, high contrast copies of this type of imagery were provided using specialized duplication techniques, see paragraph 4.5.2.4.

4.5.2.2 Geographic Area Duplicate Negatives

All duplicate negative copies were prepared using Kodak Direct Duplicating Aerial Film (Estar Base) 2422, processed in the viscous mode to provide the system sensitometry shown in Figure 4-11. The Cavuga Scanning Printers were used for printing most of the duplicate negatives. Intensity of the

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SYSTEM REPRODUCTION CURVES USED FOR HIGH CONTRAST PRINTING

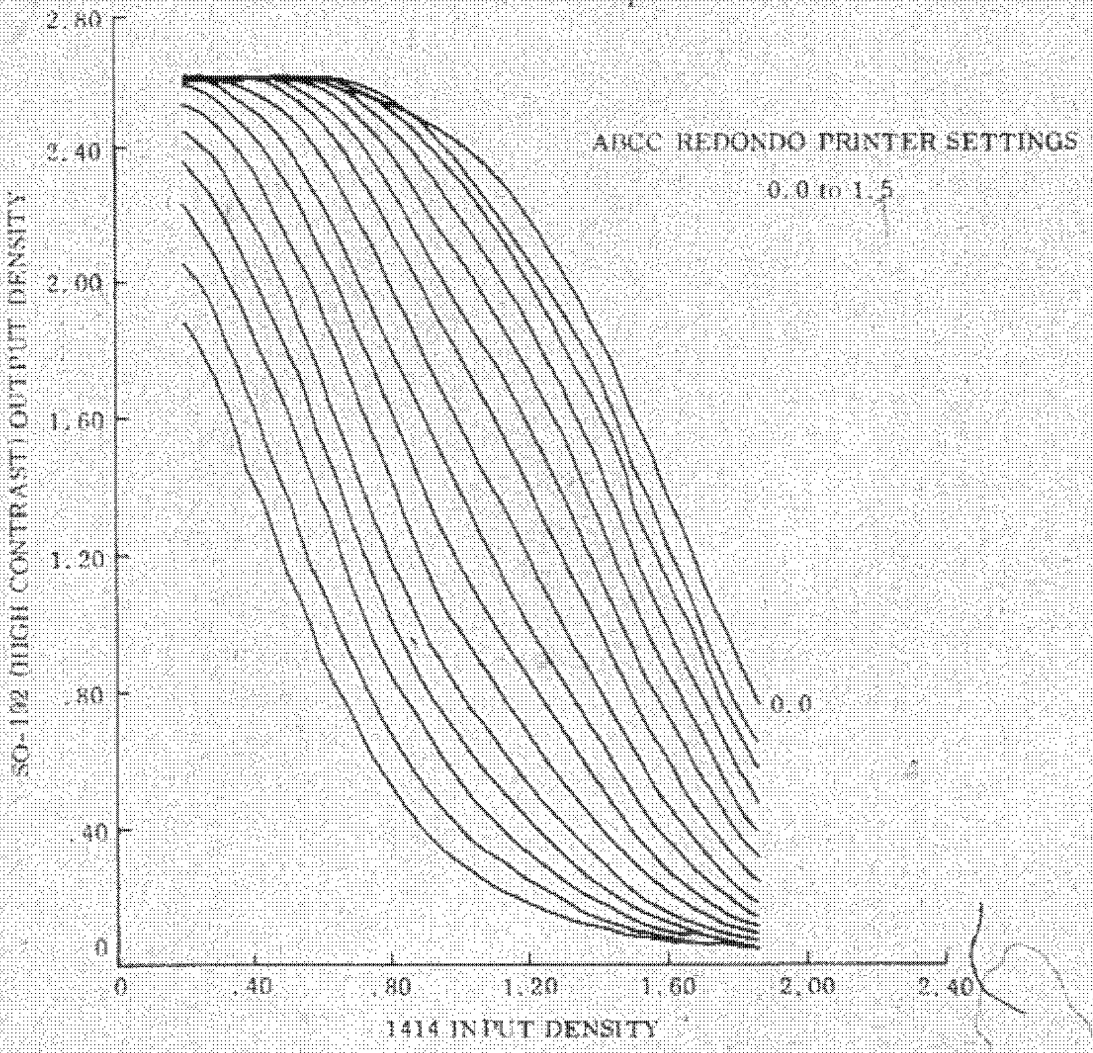


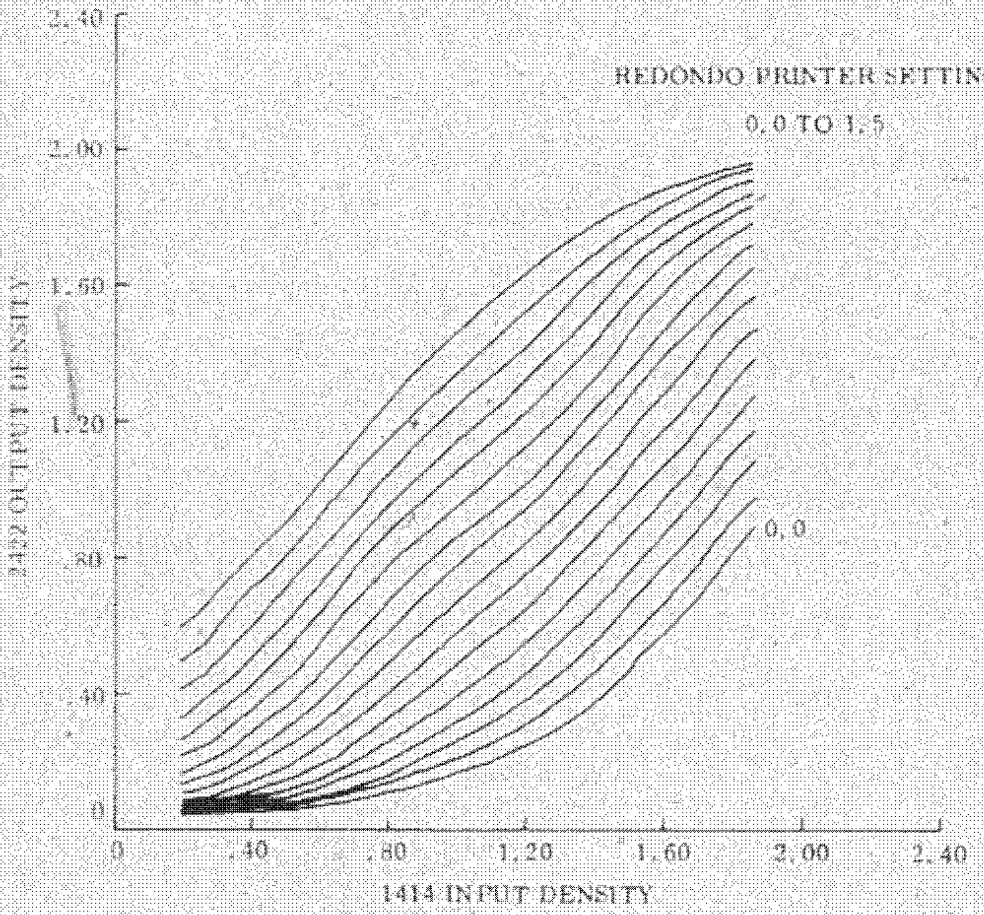
FIGURE 4-10

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SYSTEM REPRODUCTION CURVES USED FOR DUPLICATE NEGATIVE PRODUCTION



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FIGURE 4-11

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Scanning printerlamp is modulated within frames to return the Dmin to .40. In a few instances of "subject failure," the Dmax then exceeds the upper limit of 1.70 and an additional "light print" is printed on the Redondo to reduce the density in these high density areas. A summary of the "light print" requirements is presented in Table 4-9.

TABLE 4-9

BRIDGEHEAD DUPLICATE NEGATIVE MULTIPLE PRINTING SUMMARY

(percent)

Mission Segment	Operational Parts Multiple Printed
1208-1	0.0
1208-2	0.2
1208-3	3.4
1208-4	0.0

4.5.2.3 Machine-Cut Duplicates

To provide duplicate positive copies for PFA and NPIC Team evaluations as quickly as possible, machine-cut copies were prepared. These copies are printed before each machine-cut of approximately 1,300', from the original negative processor, is broken down in Geographic Area parts. Each entire machine-cut was printed onto SO-192 using the Cayuga Scanning Printer.

4.5.2.4 Specialized Duplication

Specialized duplication techniques were employed for low contrast target areas of particular interest selected by the NPIC Team. Two film emulsion types, providing different contrast levels for expanding the original negative density range, were used. Kodak Aerial Duplicating Film SO-182/Kodak Minicard Film 6451 (same emulsion) and Kodak High Definition Aerial Duplicating Film SO-192 (processed to high contrast). The system sensitometry for this application is shown in Figures 4-10 and 4-12.

Most of the specialized duplicate copies are shipped to customers in 6.6" x 12" clear sleeves, although some entire op/area parts were requested. Table 4-10 summarizes the amount of specialized duplication done on Mission 1208.

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SYSTEM REPRODUCTION CURVES FOR SPECIALIZED
HIGH CONTRAST PRINTING

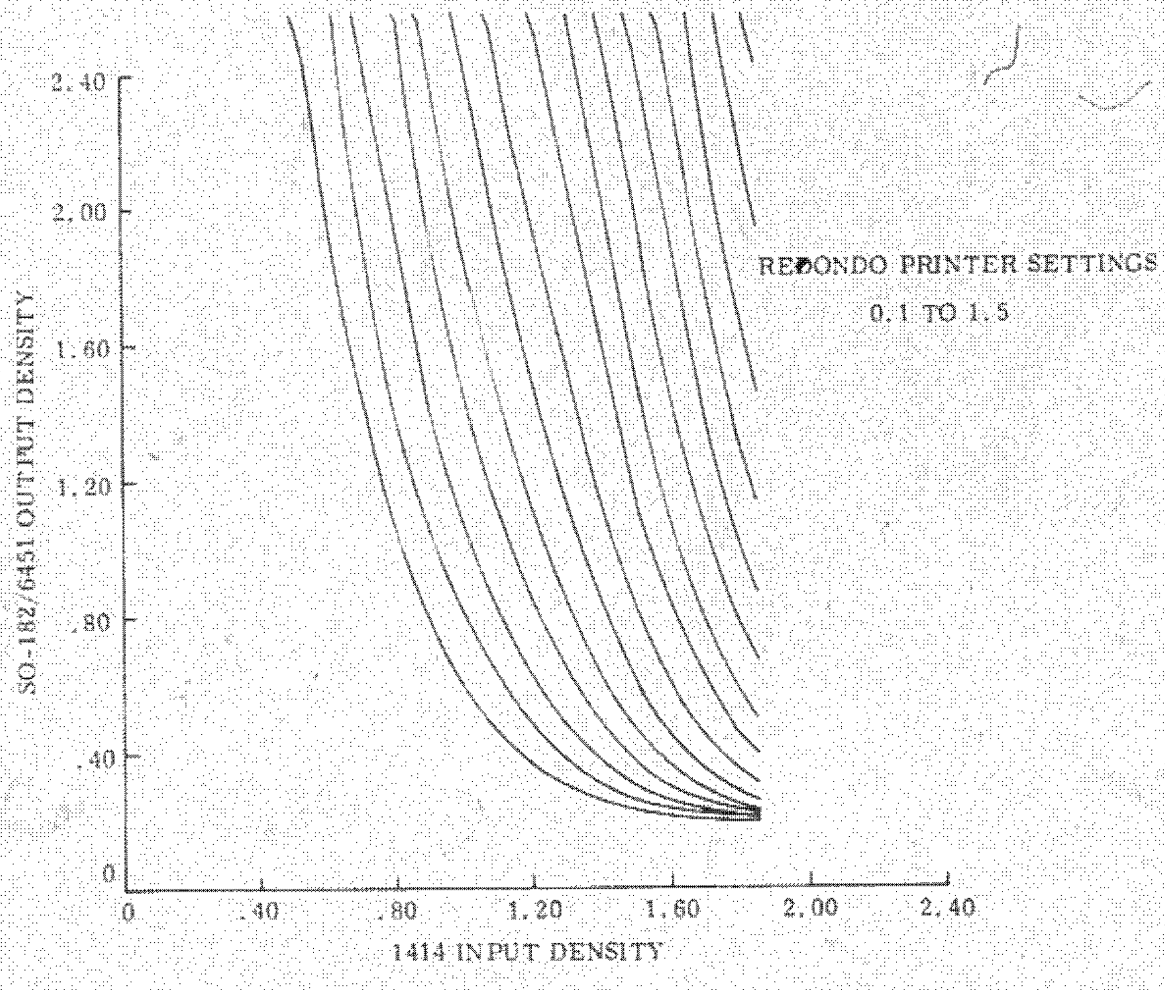


FIGURE 4-12

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TABLE 4-10

SPECIALIZED DUPLICATION

(units)

	1208-1	1208-2	1208-3	1208-4
Single Prints				
6451/SO-182	4	5	2	2
SO-192 (High Contrast)	27	26	6	10
Both 6451/SO-182 and SO-192	-	-	-	-
Complete Op/Area Parts				
6451/SO-182	-	-	-	-
SO-192 (High Contrast)	14	19	32	21

4.5.2.5 Target Complex Duplication

Target Complexes are smaller areas of interest within the Geographic Area. Select frames from operations over these Target Complexes were identified by the Exploitation Subcommittee (EXSUBCOM) of the COMIREX and reproduced by Target Complex number as third generation duplicate positives.

4.5.2.5.1 Master Duplicate Negative

The master negatives for Target Complex reproduction were printed on Kodak Direct Duplicating Aerial Film (Estar Base) 2422 using Cayuga Scanning Printers. The printing criterion is to return the average density to 1.10, which is not the same as the criterion for Geographic Area printing. The master negatives for each numbered complex were then spliced together to form composite rolls of up to 150 feet.

4.5.2.5.2 Target Complex Duplicate Positives

The duplicate positives delivered to customers were printed from the master negatives as third generation copies on Kodak High Definition Aerial Duplicating Film (Estar Base) SO-192. Both normal and high contrast reproduction were required. Figure 4-13 shows the normal contrast system sensitometry for RV-1 and Figure 4-14 shows it for RV-2, -3, and -4 where ABCC printers were used. The high contrast system sensitometry for all RVs using ABCC printers is shown in Figure 4-15.

4.5.3 Duplication of Color Original Films

4.5.3.1 Black and White From Color

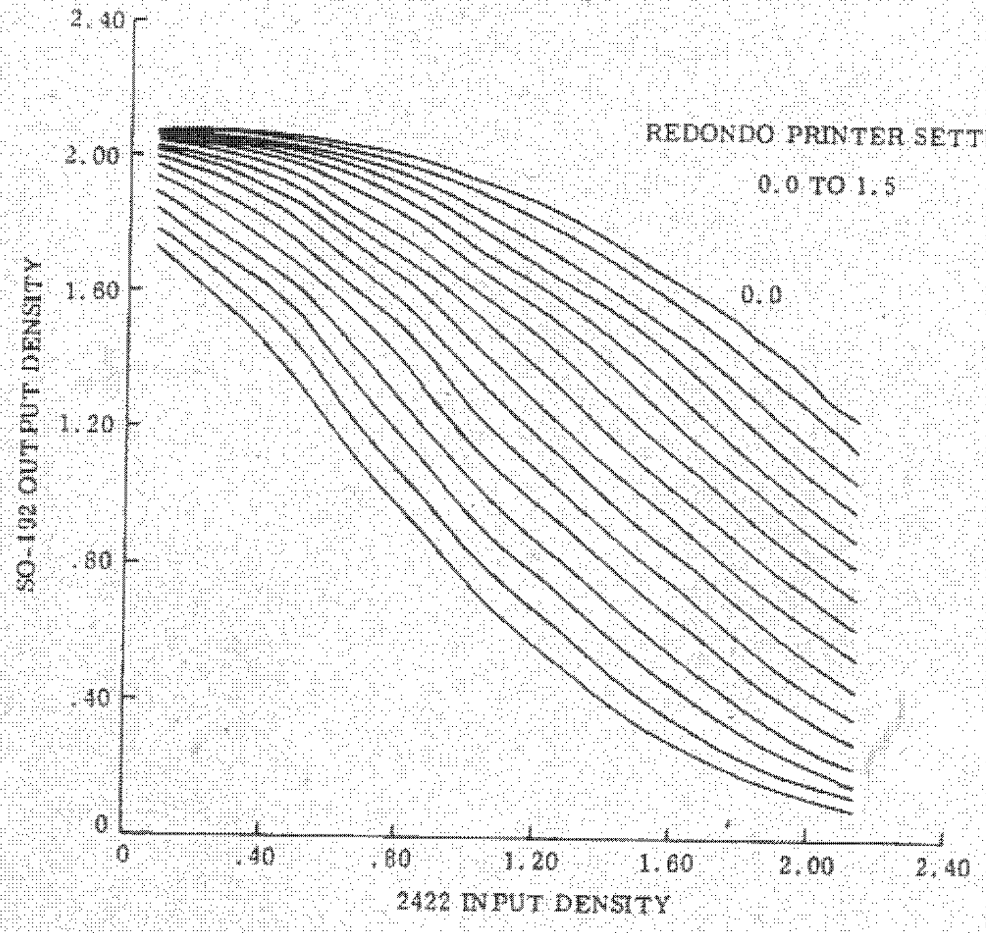
The production of second generation black and white master internegatives from both the SO-255 and FE-3916 color original positives was accomplished on the Framingham Printer using a Wratten 16 Filter in the printing aperture. Kodak Aerial Duplicating Film SO-182, viscous processed to a

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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION
DUPLICATE POSITIVES FROM RV-1



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FIGURE 4-13

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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION
DUPLICATE POSITIVES FROM RV-2, RV-3, RV-4

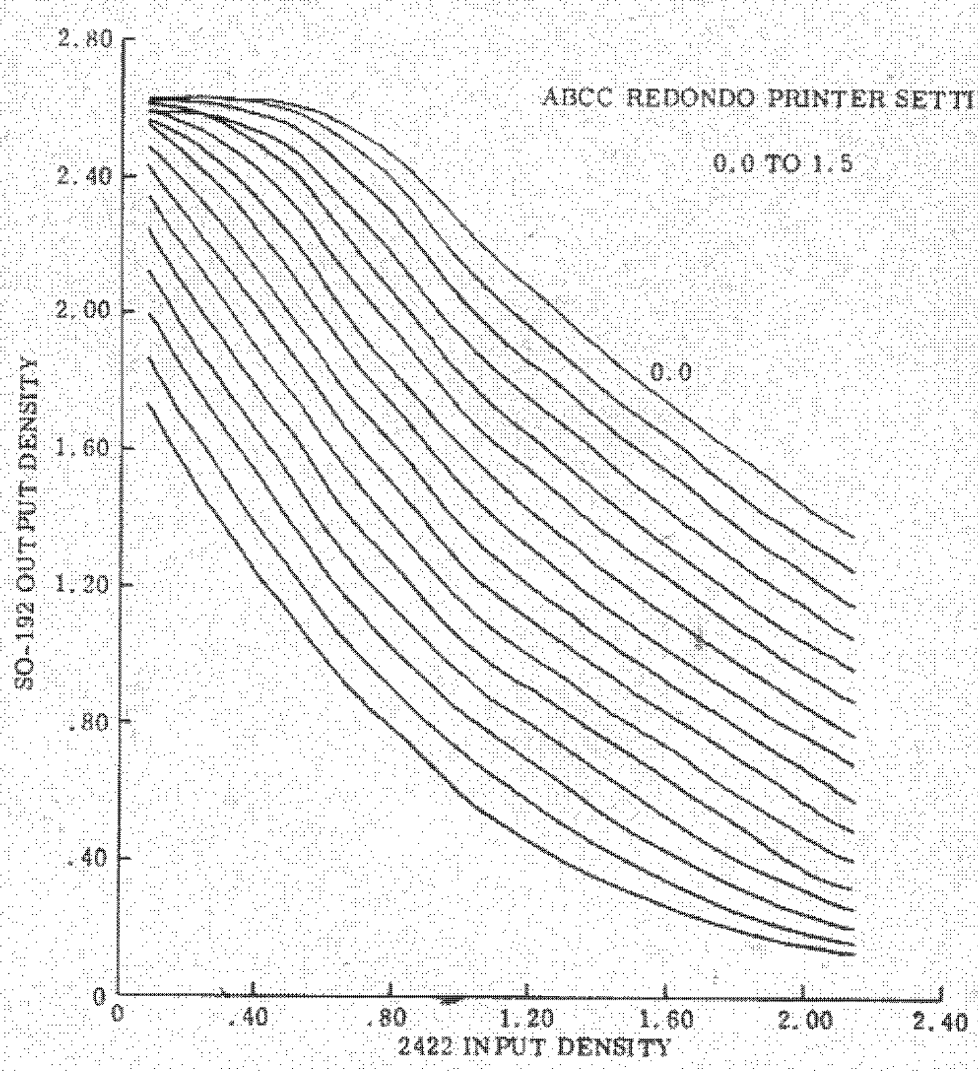


FIGURE 4-14

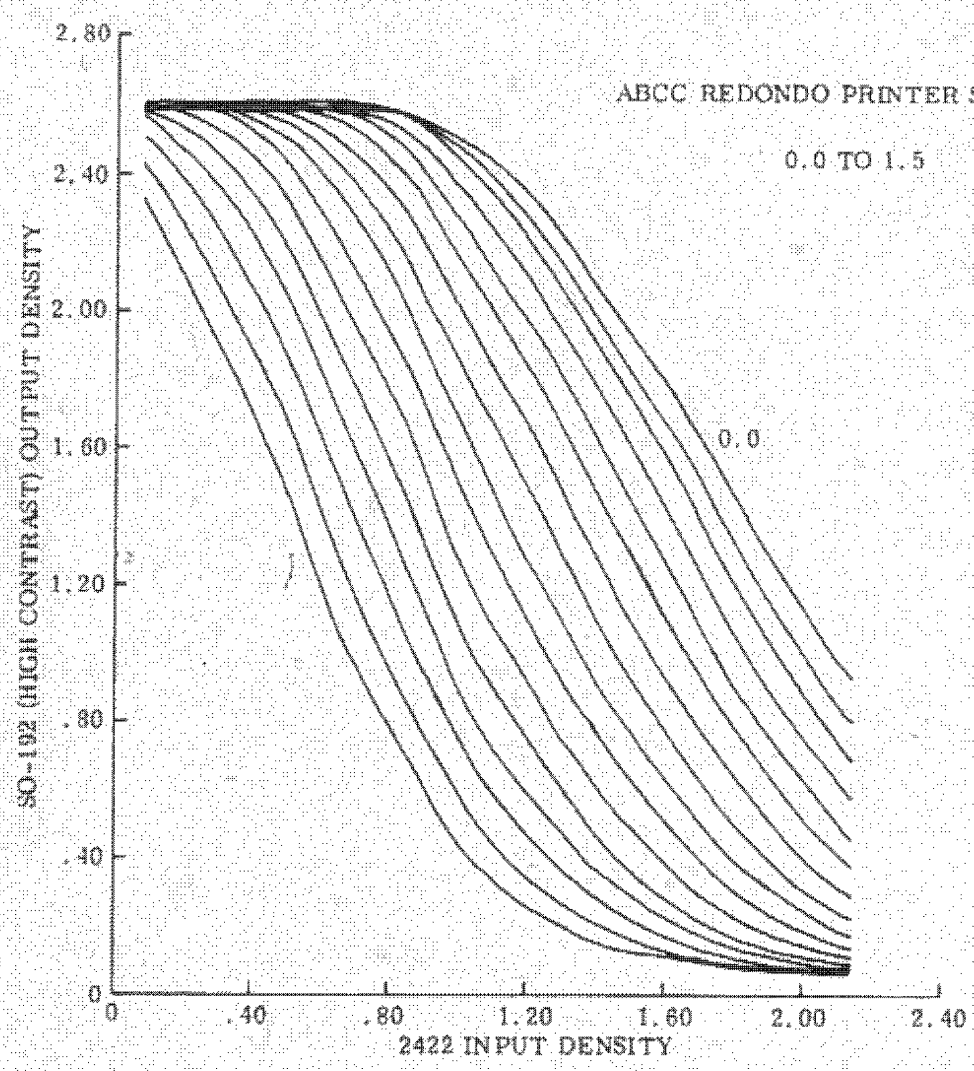
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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION DUPLICATE POSITIVES (HIGH CONTRAST) FROM ALL RVs



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FIGURE 4-15

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low contrast, was used for preparing the internegatives. The system sensitometry for the SO-255 black and white green record and FE-3916 black and white red record master internegatives is shown in Figure 4-16.

Third generation duplicate positive copies from the black and white internegatives were made on SO-192 using ABCC Redondo Printers, to provide contrast adjustment in the third generation duplicates. Copies were made at low, medium, or high contrast to accommodate the tonal range of densities from the green record and red record internegatives onto the full range of SO-192, see Figure 4-17. The percentage of parts made at each contrast level is listed in Table 4-11.

TABLE 4-11

BLACK AND WHITE PRODUCTION FROM COLOR CONTRAST LEVELS

Contrast	No. Parts	Percent
Low	20	33.3
Medium	37	61.7
High	3	5.0

Third generation duplicate negatives were also prepared from the black and white internegatives using 2422 Film, see Figure 4-18.

Requirements for black and white from color included Target Complexes. For this purpose, a second black and white internegative was prepared as required and composited by Target Complex into 150' rolls. Third generation SO-192 duplicate positives were then generated in the same manner as for Geographic Areas.

4.5.3.2 Color Duplicate Positives

The production of all color duplicate positive copies was accomplished using the additive Rainbow Printer. System sensitometry representative of the reproduction of the SO-255 color original and FE-3916 color IR original onto Aerial Color Print Film SO-287 is shown in Figures 4-19 and 4-20, respectively. In order to adjust for the color contrast mismatches in each color original positive, selective layer preflashing of the color print film was performed. This preflashing technique effectively lowers the upper scale maximum densities and reduces individual layer contrasts.

4.5.3.3 Color Internegatives

The 7271 color internegatives printed from the SO-255 and FE-3916 color originals were processed in the Ragdoll Processor. This material is supplied for the purpose of making enlargements onto paper or transparency materials.

4.5.4 Total Footages

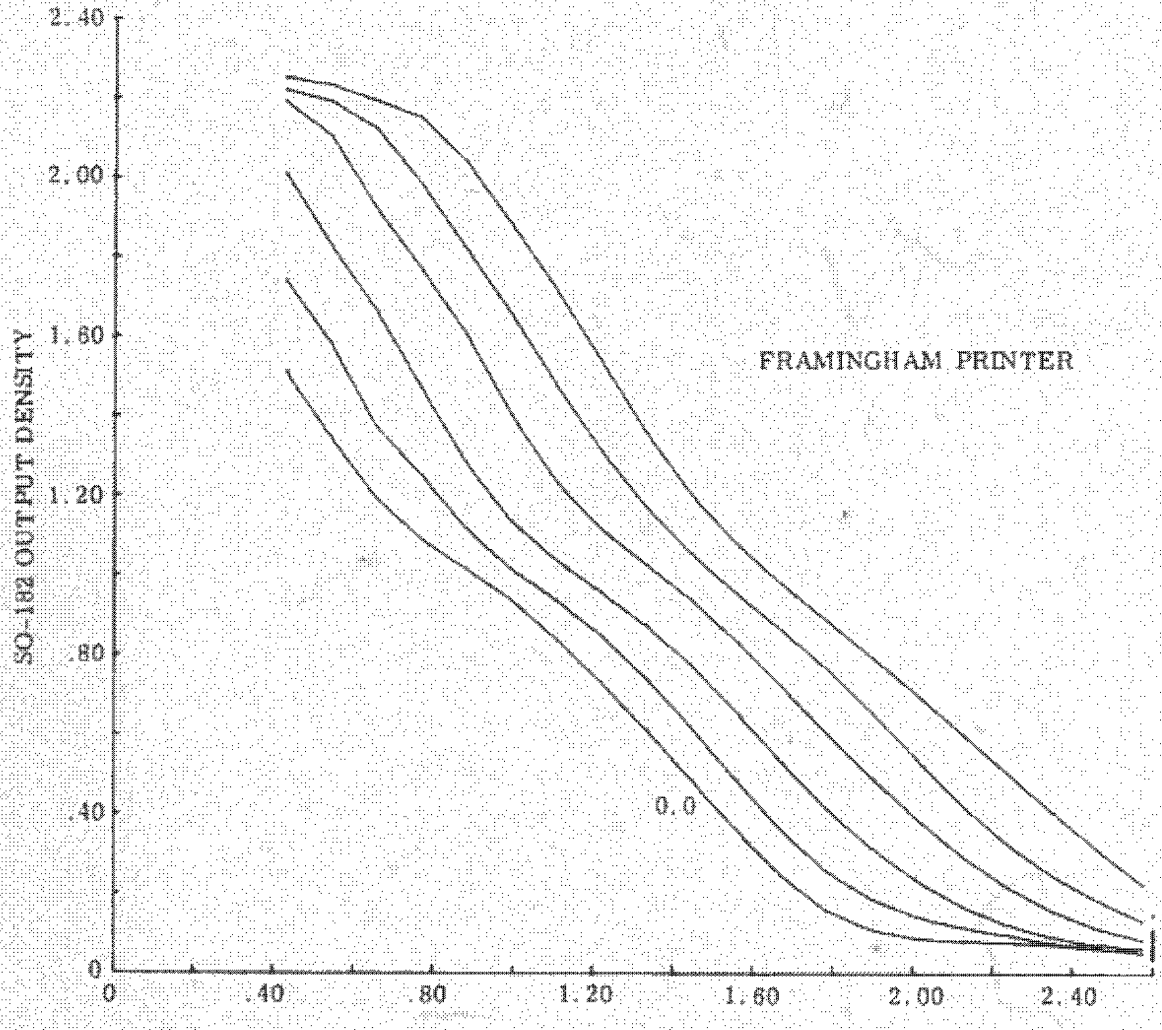
The total duplicate footage shipped from BRIDGEHEAD for Mission 1208 is summarized in Table 4-12.

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SYSTEM REPRODUCTION CURVES, BLACK AND WHITE FROM COLOR,
FOR SECOND GENERATION INTERNEGATIVES



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FIGURE 4-16

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SYSTEM REPRODUCTION CURVES, BLACK AND WHITE FROM COLOR,
FOR THIRD GENERATION DUPLICATE POSITIVES

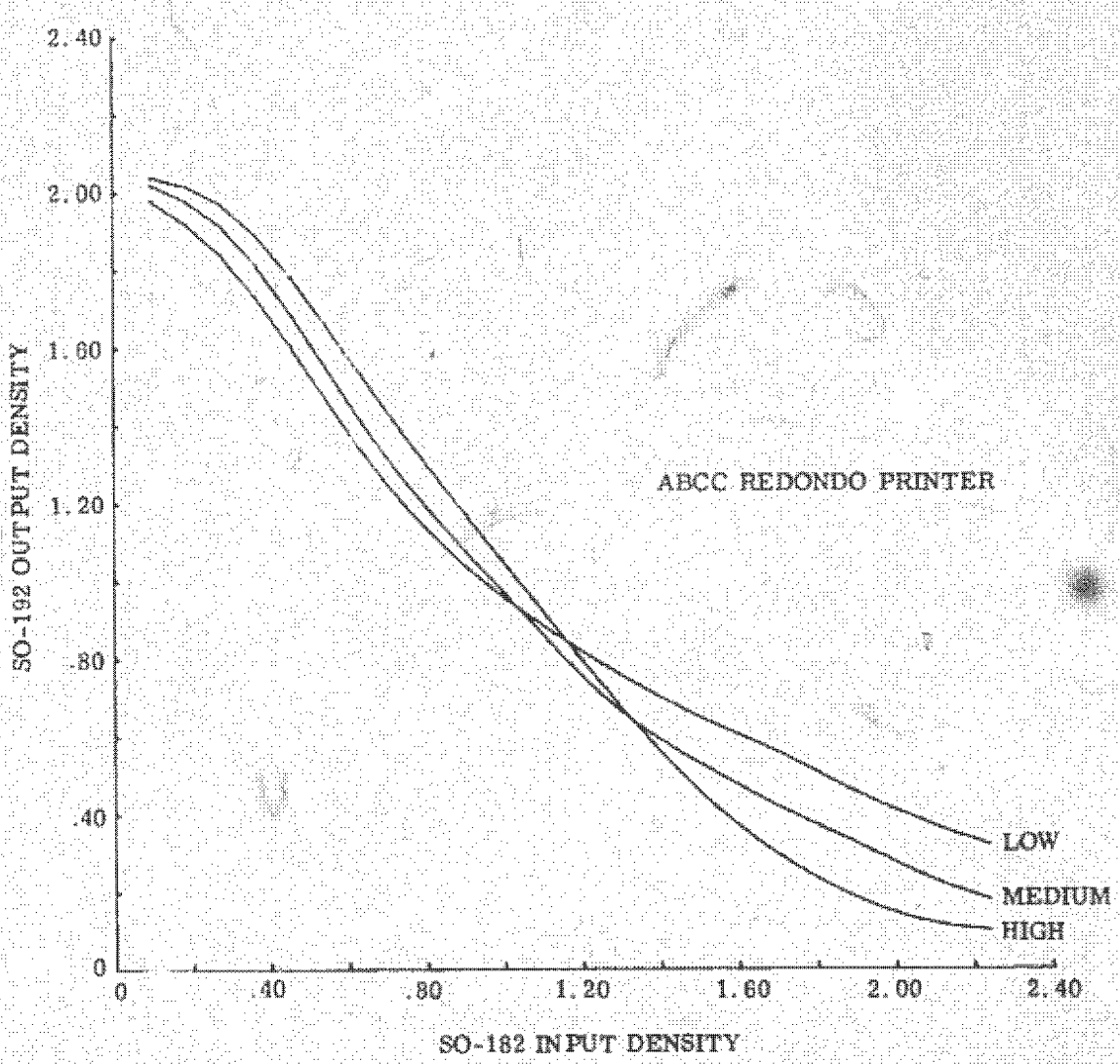


FIGURE 4-17

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SYSTEM REPRODUCTION CURVE, BLACK AND WHITE FROM COLOR
FOR THIRD GENERATION DUPLICATE NEGATIVES

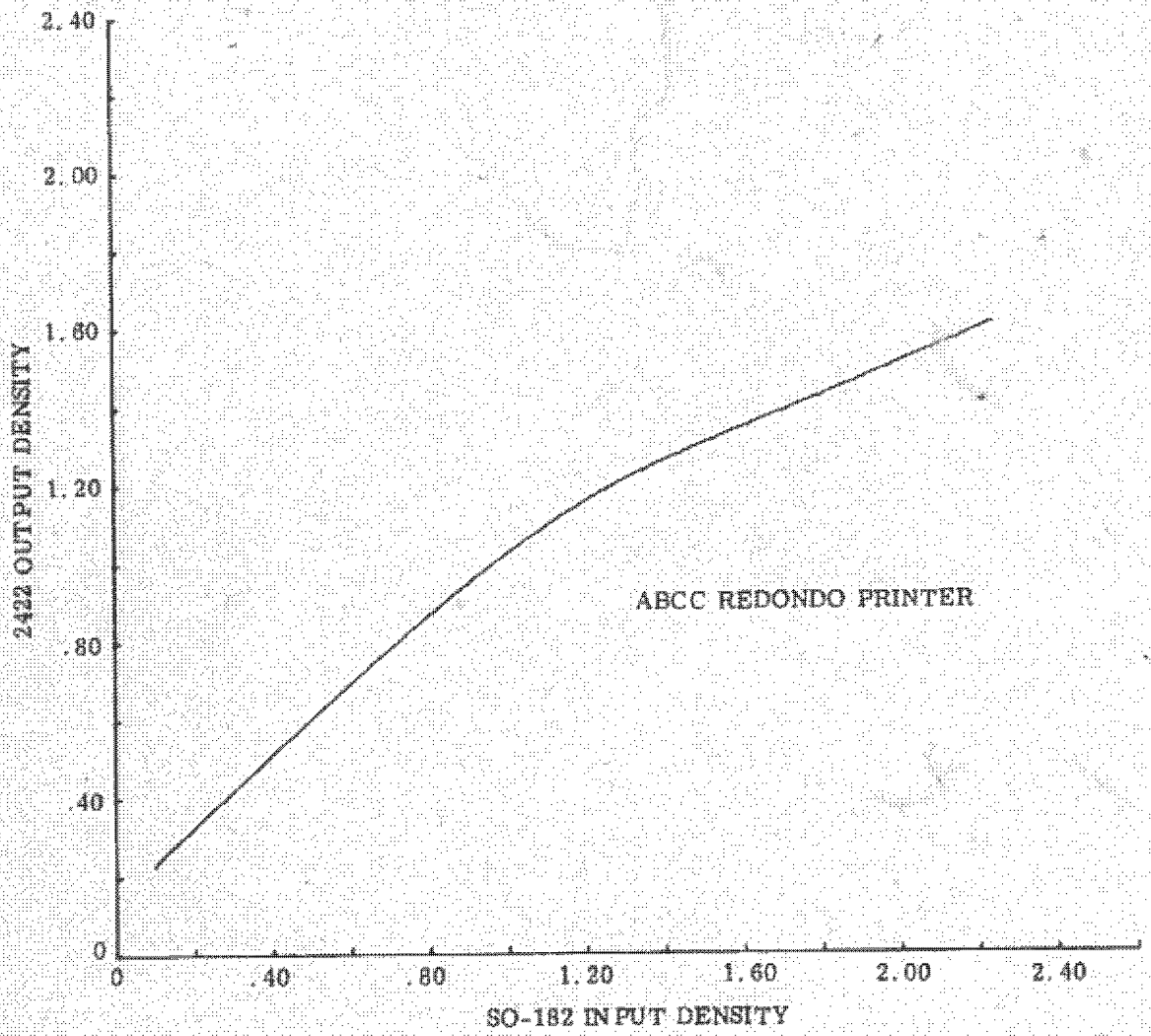


FIGURE 4-18

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1208

SYSTEM REPRODUCTION CURVES FOR COLOR DUPLICATE POSITIVES

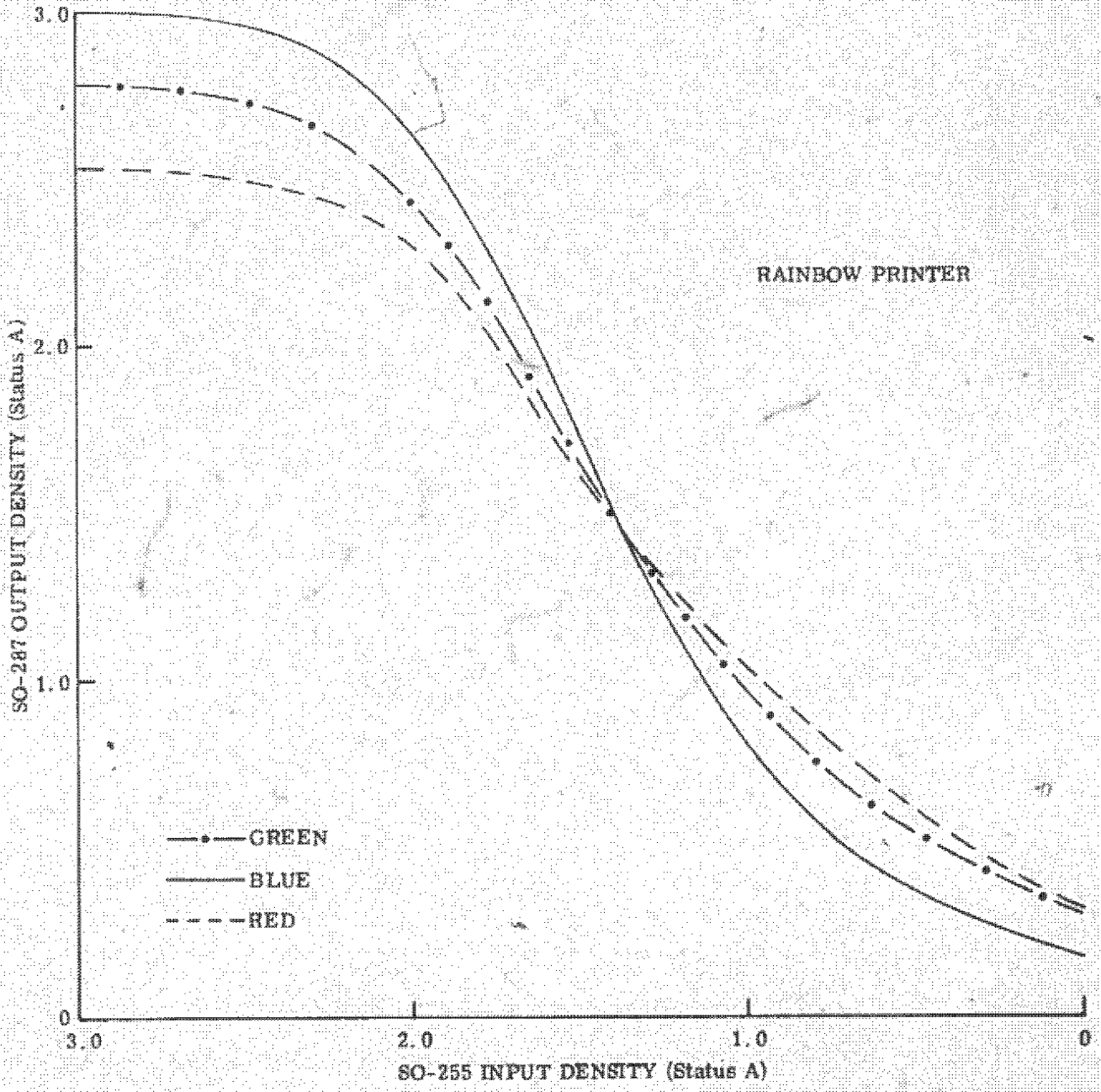


FIGURE 4-19

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SYSTEM REPRODUCTION CURVES FOR IR COLOR DUPLICATE POSITIVES

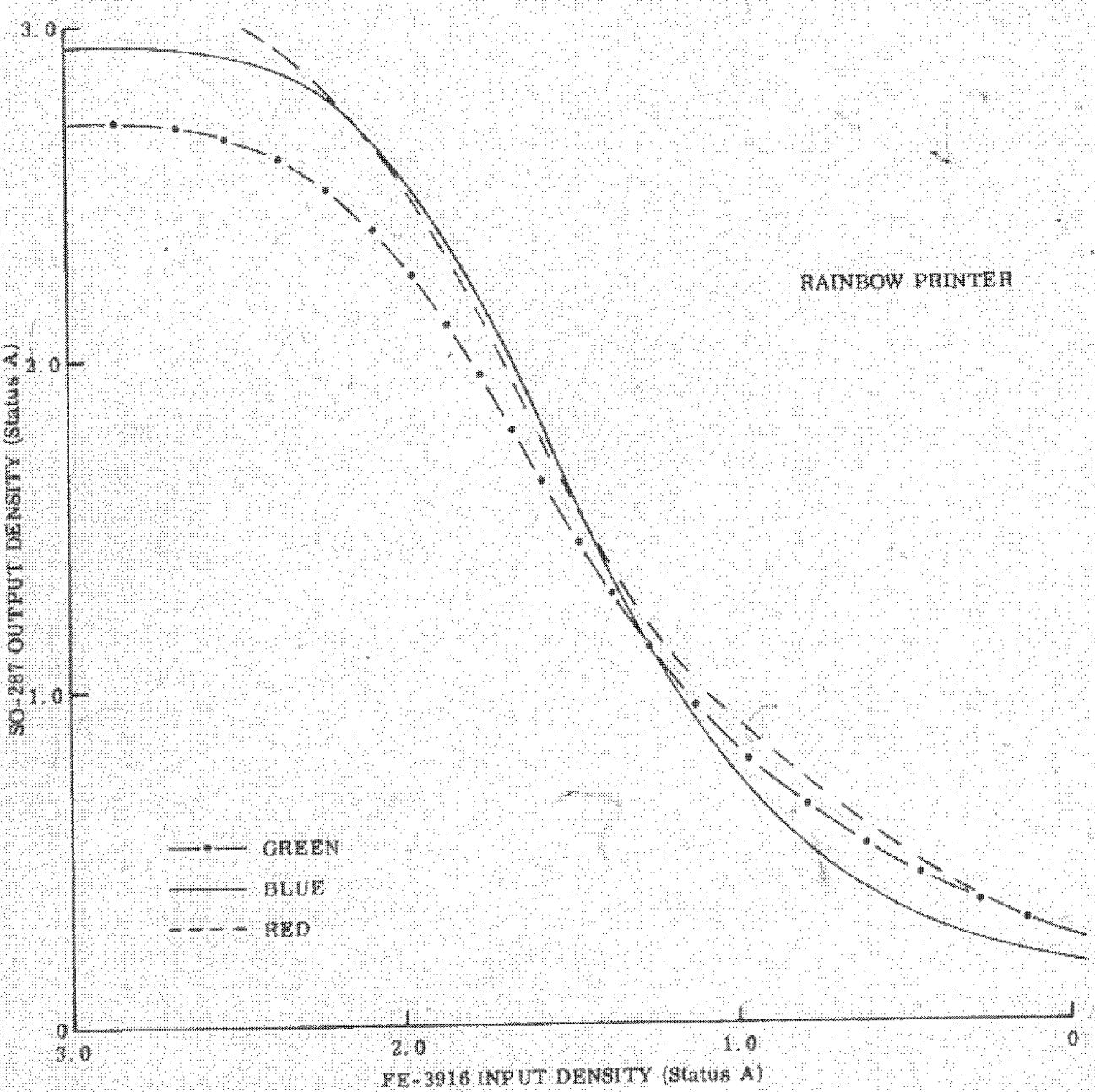


FIGURE 4-20

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TABLE 4-12

DUPLICATE FOOTAGE SUMMARY

(feet)

Mission Segment	Black and White: Geographic Area & Machine Cuts	Black and White: Specialized Duplication	Black and White from Color	Color Duplicate Positives	Color Internegs
1208-1	1,355,897	12,707	-	-	-
1208-2	1,470,823	14,106	-	-	-
1208-3	1,322,853	8,565	-	-	-
1208-4	1,262,514	8,253	146,847	32,526	5,386
Totals	5,412,087	43,631	146,847	32,526	5,386

4.6 REPRODUCTION AT AFSPPF

4.6.1 General

Reproduction at AFSPPF consisted of duplicating Geographic Areas only. Target Complexes have been deleted from AFSPPF requirements. After Priority 1, 2, and 3 production requirements were completed at BRIDGEHEAD, the ON was sent to AFSPPF for completion of the Priority 4 Geographic Area requirements.

4.6.2 Regular Duplication

4.6.2.1 Duplicate Positives

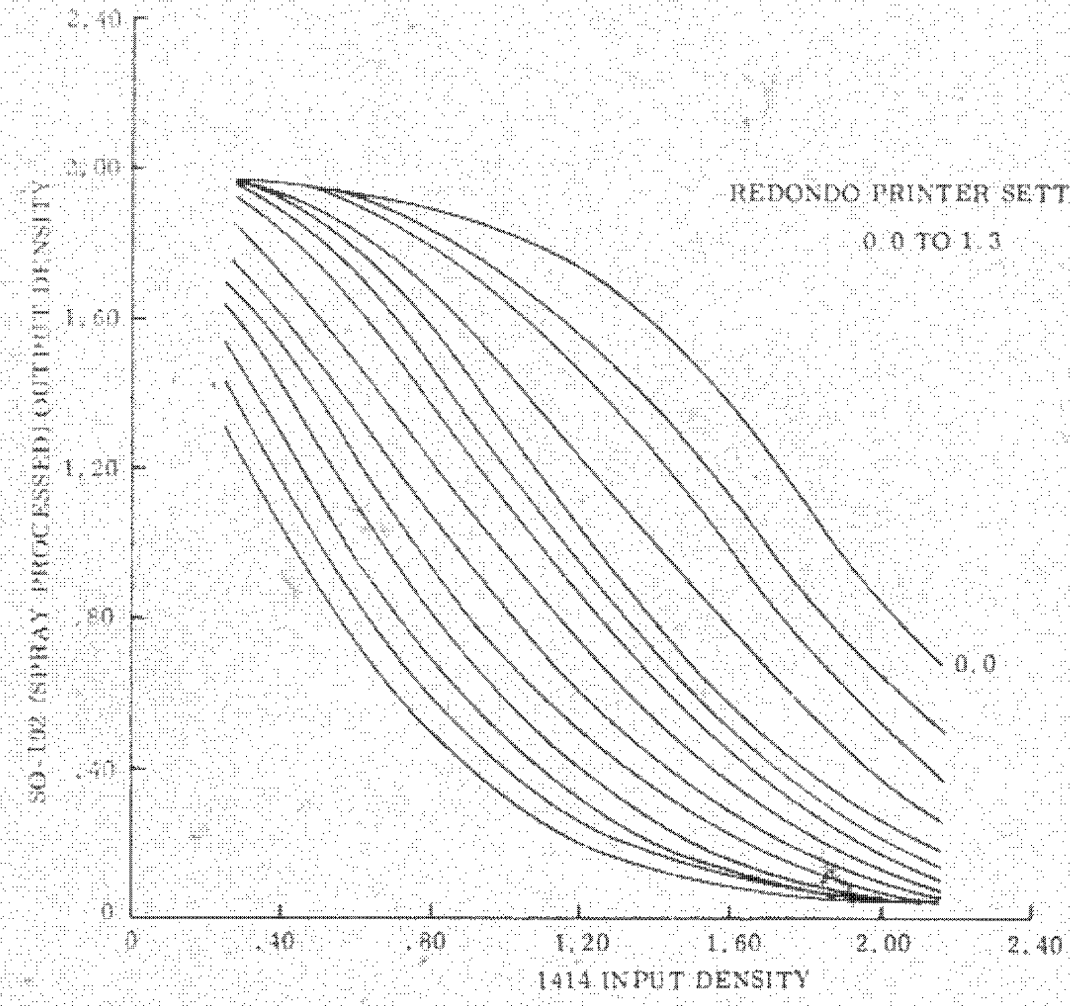
Geographic Area duplicate positives for Priority 4 customers were prepared using SO-192 processed in the spray mode to provide system sensitometry, see Figure 4-21. Redondo Printer settings were selected to return the average ON densities of each op/area part to 1.10 with appropriate tolerances for system variability. Multiple prints are required whenever input densities are too great to be returned between the desired limits on a single "medium" print. Two or three levels were utilized in multiple printing. These multiple prints also include "light" and/or "dark" copies. A summary of the percentage of multiple printing by AFSPPF is presented in Table 4-13.

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SYSTEM REPRODUCTION CURVES



BYE 15256-75

FIGURE 4-21

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TABLE 4-13

AFSPPF DUPLICATE POSITIVE MULTIPLE PRINTING SUMMARY

(Number of Parts)

Mission Segment	Operational Parts Multiple Printed
1208-1	30
1208-2	2
1208-3	9
1208-4	0

4.6.2.2 Duplicate Negatives

All DN copies for Priority 4 customers were prepared using Kodak Direct Duplicating Aerial Film (Estar Base) 2422 processed in the spray mode to provide system sensitometry, see Figure 4-22. Redondo Printer settings were selected to return the original negative minimum densities to duplicate densities of .55 for each op/area on the duplicate negative.

4.6.3 Specialized Duplication

Specialized duplication is employed for selected areas of operational interest identified by the NPIC interpreters. Two films which expand the contrast levels of the ON were used. These films are Kodak Minicard Film 6451 and Kodak High Resolution Aerial Duplicating Film SO-192 (immersion processed to a high gamma). No additional specialized duplicates were requested on Mission 1208.

4.6.4 Total Footages

Table 4-14 lists the total duplicate footage shipped from AFSPPF.

TABLE 4-14

AFSPPF DUPLICATE FOOTAGE SUMMARY

(feet)

Mission Segment	Geographic Area
1208-1	173,208
1208-2	173,083
1208-3	150,740
1208-4	137,732
Total	634,763

4.6.5 Customers

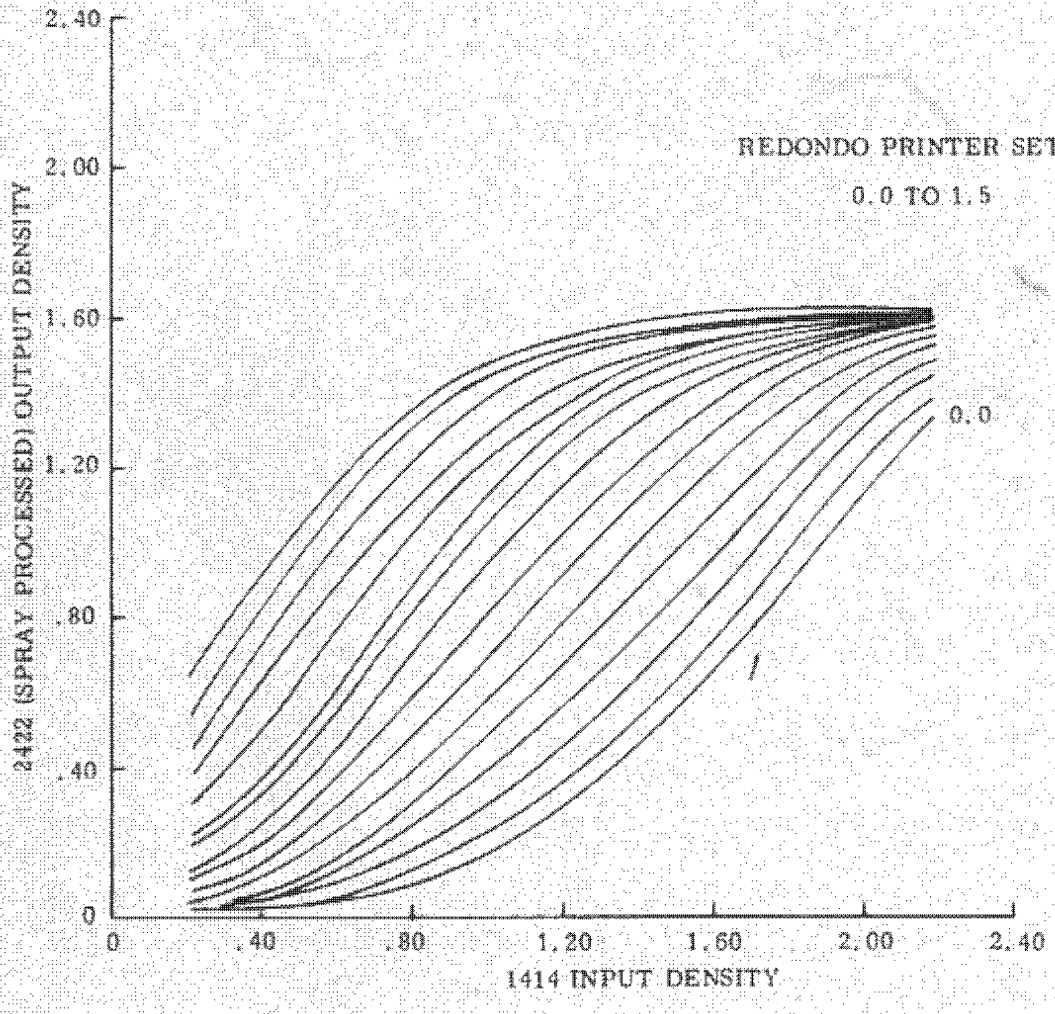
The following is a listing of customers for 1208 material who required Geographic Area coverage.

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SYSTEM REPRODUCTION CURVES



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FIGURE 4-22

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Geographic Area Coverage (Priority 4)

DMAAC

UK

CANADA

AUSTRALIA

4.7 BLACK AND WHITE DUPLICATE IMAGE QUALITY STUDY

4.7.1 Introduction

Commencing with Mission 1208, the Target Complex third generation duplicate positives for NPIC were produced at BRIDGEHEAD rather than at the Air Force Special Projects Production Facility (AFSPPF). The following two sections present NPIC's evaluation of resolution transfer and tone reproduction quality with emphasis on this system.

4.7.2 Resolution Transfer

The CORN tribar resolution targets acquired on the engineering photography were read on the original negative (ON), 2nd and 3rd generation duplicate positives (2DP and 3DP), and the 2nd generation duplicate negative (2DN) copies. The data from 11 frames of photography was used for this analysis. The same mathematical model was used to analyze the resolution transfer data as in the 1207 PFA Report, i.e., duplicate resolution values minus ON resolution values were regressed as a first order linear function of ON resolution. First, the mission data, generation by generation, was compared to that from previous missions. This was done using a stepwise regression procedure and "blocking" with respect to missions. At the 95% confidence level, it is concluded that the 2DP and 3DP copies are similar to those from Missions 1206 and 1207, while the 2DN is similar to those from Missions 1204 thru 1207. Therefore, the duplicate copies from Mission 1208 are of a quality similar to that of recent 1200 Series missions.

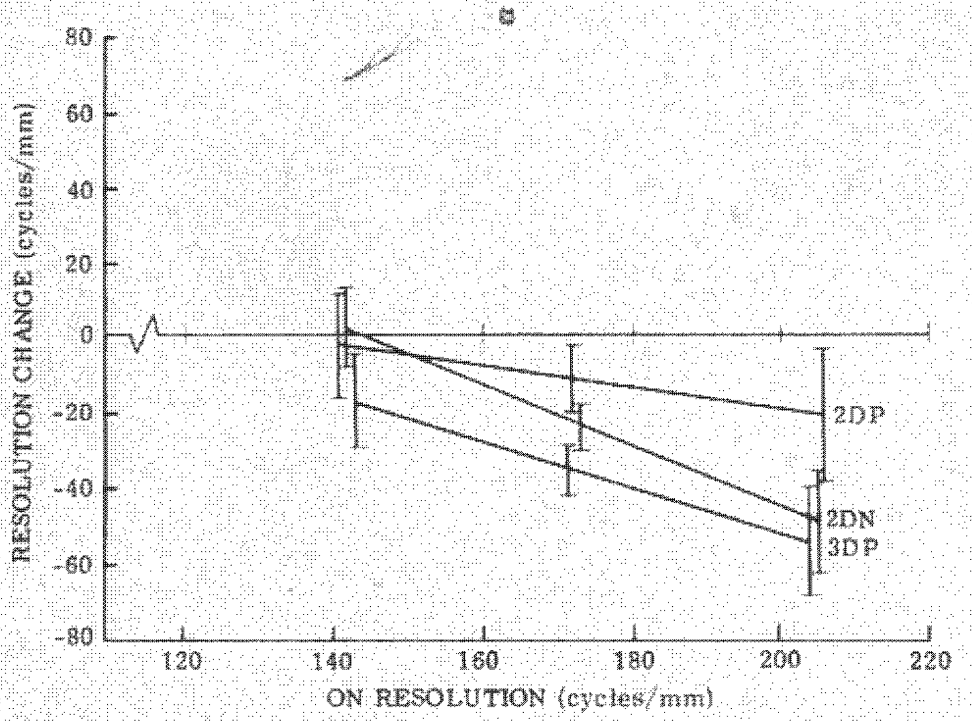
Secondly, the three duplicate generations for Mission 1208 were compared to each other, this time "blocking" with respect to duplicate generations. With 95% confidence, it was concluded that the 2DP, 2DN, and 3DP copies are significantly different from each other, as has been found with most previous missions. Figure 4-23 shows the resolution transfer data for Mission 1208, with +2 sigma confidence intervals. Table 4-15 summarizes the resolution transfer results at four different ON resolution levels for Mission 1208.

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RESOLUTION TRANSFER REGRESSION ANALYSIS FOR MISSION 1208 DATA

(90% Confidence Intervals For Sample Size of 11)



BYE 15256-75

FIGURE 4-23

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TABLE 4-15

SUMMARY OF RESOLUTION TRANSFER

(percent change)

Generation	ON Resolution (cycles/mm) 150	175	200	225
2DP	-4	-7	-10	-12
2DN	-4	-15	-23	-30
3DP	-14	-21	-26	-30

4.7.3 Tone Reproduction

Microdensity traces were made on both the ON and duplicate copies of the five-step CORN target gray panels acquired on the engineering photography. One frame from each of the four RVs was traced using a 2 micron aperture. Figures 4-24 and 4-25 show the data, plotting equivalent macrodensity of the frames as a function of the logarithm of the target reflectance.

A comparison of the ON and 2DN curves shows them to be similarly printed, RV-to-RV. A comparison of the 2DP and 3DP copies show the 3DP copies to be slightly lower in density level and of less contrast in three of the four frames. In order to see if the lower density for the 3DP copies of the engineering photography was consistent with operational DPs, macrodensity readings were taken from a number of operations selected throughout the mission.

These readings revealed no consistent trends of density variation with respect to the 2DP. Therefore the trends found in the density level of four frames of engineering photography were not representative of the overall mission imagery.

4.8 COLOR IMAGE QUALITY STUDY

4.8.1 Conventional Color

4.8.1.1 Resolution Transfer

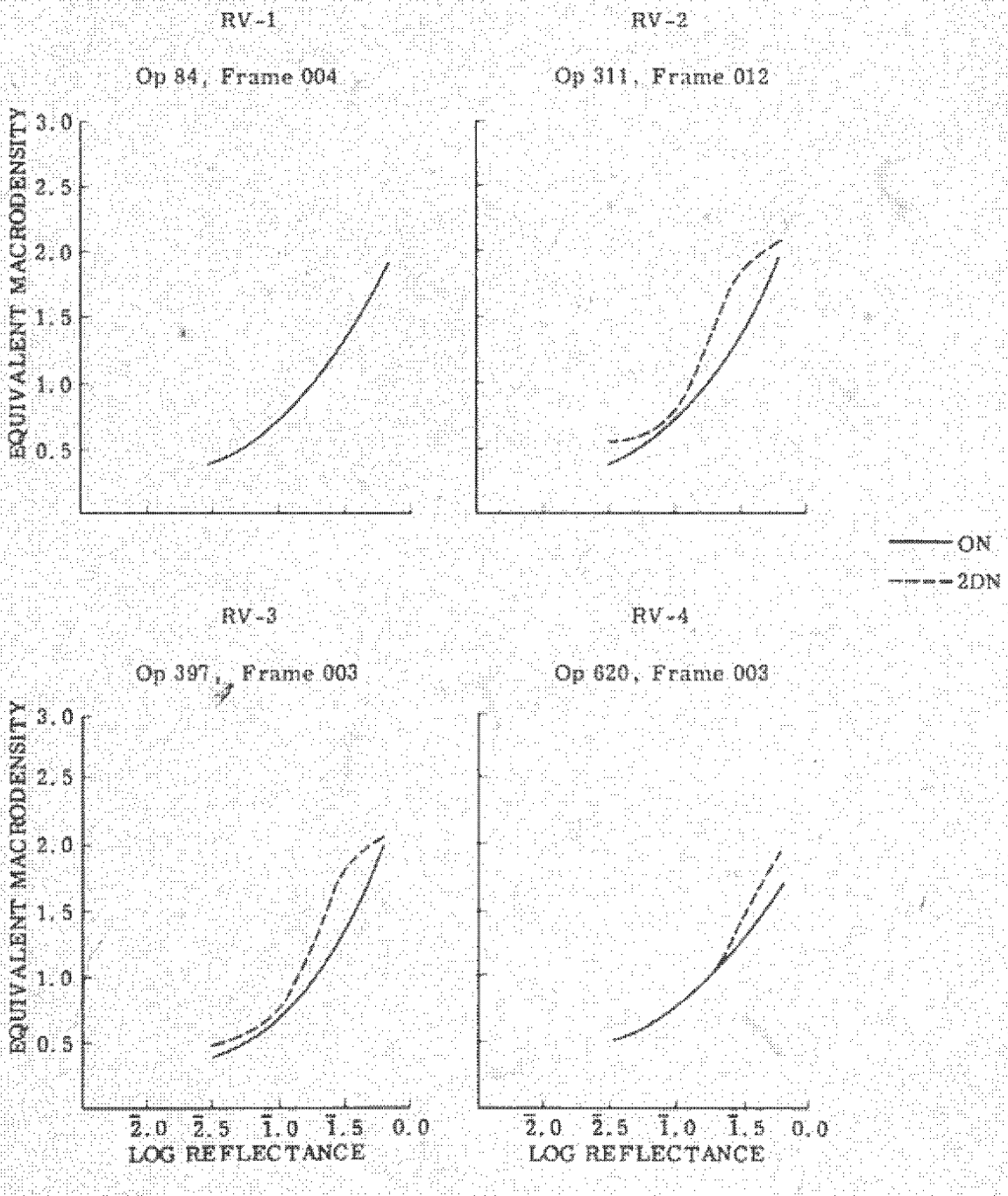
Four readers read the two 51/51 Tribar Targets acquired on 1208-4 color photography. SO-255 Color OP, SO-287 Color DP, and the black and white green record duplicate positive (GRDP) copies were read. Results are presented in Table 4-16 on page 4-52. The resolution of each frame represents the geometric mean of the in-track and cross-track readings. This data indicates a significant resolution loss for the color DP and no significant loss for the green record DP. Figures 4-26 thru 4-28 illustrate quality differences between the color OP, color DP, and green record DP.

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TONE REPRODUCTION COMPARISON

(Forward Camera)



NOTE: 2DN not available for RV-1.

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FIGURE 4-24

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POST FLIGHT ANALYSIS REPORT
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TONE REPRODUCTION COMPARISON FOR MISSION 1208

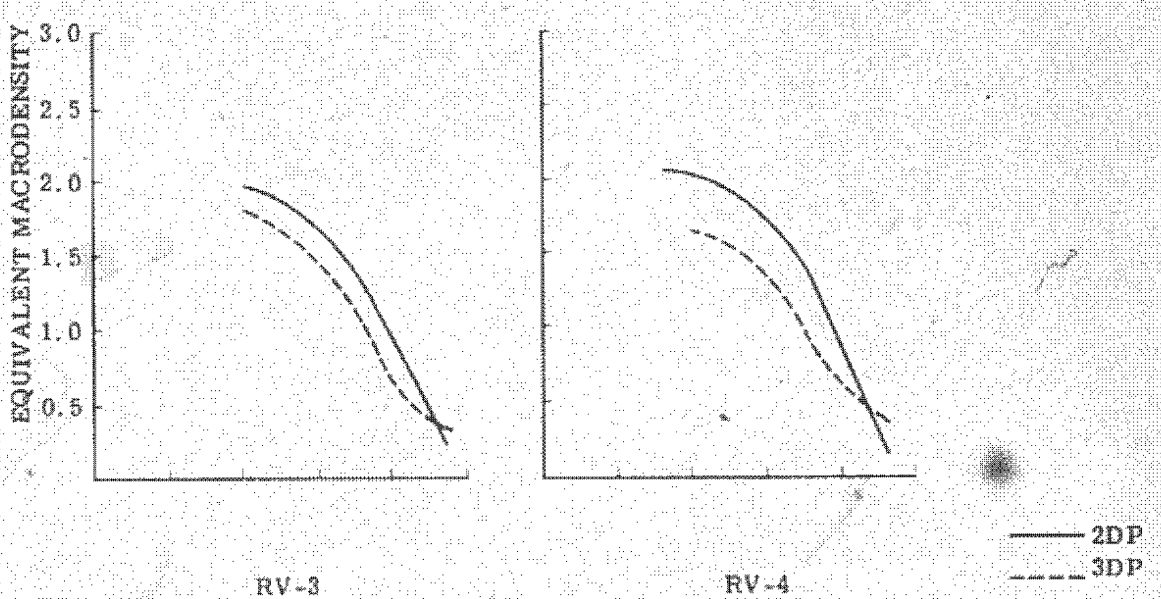
(Forward Camera)

RV-1

Op 84, Frame 004

RV-2

Op 311, Frame 012



RV-3

Op 397, Frame 003

RV-4

Op 620, Frame 003

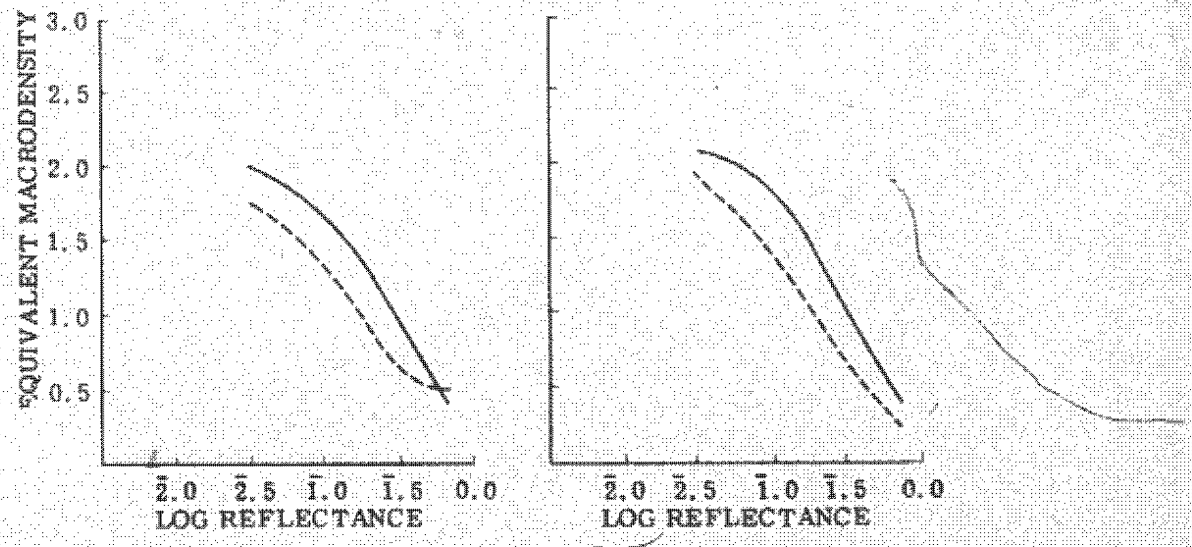


FIGURE 4-25

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TABLE 4-16

RESOLUTION TRANSFER FOR COLOR PHOTOGRAPHY

Op	Frame	SO-255 (CDP) (cycles/mm)	SO-287 (CDP) (%)	SO-192 (GRDP) (%)
741	003	127	-21.4	-8.5
745	003	97	-21.7	2.8
	Average	112	-21.6	-5.7

NOTE: The resolution gain on Op 745 for SO-192 possibly results from the slight contrast increase in duplication coupled with the relatively low color OP resolution input, or from resolution reader variability, or from a combination of these two factors.

The resolution loss for the color DP is approximately 8% worse than that found with Mission 1207. A flashing technique for Mission 1208 was used to lower the excessive shadow densities seen in Mission 1207; there was concern that this would lower the resolution transfer to the color DP. To test this possibility, an optimally printed CORN target frame from Mission 1206-4 was evaluated. BRIDGEHEAD printed this frame with and without flashing. The resolution of the frame was 128 cycles/mm, which is representative of the 1208-4 color OP quality. Resolution readings of the two copies were found not to be significantly different from each other. Therefore, flashing of the color DP does not seem to account for the larger resolution loss in Mission 1208.

To determine if the limited resolution transfer data from the NOFORN CORN targets is indicative of the resolution difference between the duplicate copies, ten target areas from different original positives were subjectively compared on the green record DP and the color DP. A split-field viewing table was used for side-by-side comparisons of the target areas. From this study, it was found that the green record DP was slightly better than the color DP in resolution and edge sharpness. The CORN resolution transfer data is therefore indicative of the mission resolution difference between the color DP and the green record DP.

4.8.1.2 Tone Reproduction

In the image interpretability portion of this report, paragraph 5.3.4, it is noted that 23% of the photointerpreters surveyed said that in some cases the contrast of both the color DP and the green record DP was unsatisfactory. To see if there might be a difference in highlight or shadow density detail between the color DP and the green record DP, two separate evaluations were performed.

In the first evaluation, microdensity scans were made on CORN five-step gray patches and selected operational targets. The operational targets were selected from the OP in view of possible reproduction difficulty due to small tonal differences between the object and background. Two targets containing subtle highlight detail and one target containing subtle shadow density detail were traced with a 6 micron diameter circular aperture on the color OP, color DP, and green record DP. A visual filter

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was used for all the traces in order to approximate the visual tone differences that the photointerpreter sees when viewing through all three layers of the color film. Figure 4-29 shows the comparison of color OP and color DP based on visual density data acquired from the five-step gray patches. Density data derived from traces of the operational targets is presented in Table 4-17.

TABLE 4-17

TONE REPRODUCTION OF SELECTED OBJECTS

(Conventional Color Acquisition Film)

Target	Film	Subject Density	Background Density	Density Difference
Light	Color OP	.78	.89	.11
Roof	Color DP	.56	.69	.13
	Green Record DP	.53	.70	.23
Light	Color OP	.68	.85	.17
Aircraft	Color OP	.49	.65	.16
	Green Record DP	.35	.50	.15
Dark	Color OP	1.88	2.29	.41
Roof	Color DP	1.68	2.13	.45
	Green Record DP	.83	1.53	.70

Three differences were noted in comparing the density data of the color DP to the green record DP:

A. The green record DP highlights were lighter.

B. The highlight contrast of the green record DP was higher than the color DP.

C. The shadow contrast of the green record DP was higher than the color DP.

The second evaluation entailed a subjective comparison of ten target areas from different operations. These were compared on the color DP, green record DP, and the second generation black and white DP from the Forward Camera (2DP). A split-field viewing table was used. From the comparisons, it was found that:

A. The green record DP was preferred over the 2DP for highlight density detail, and both were preferred over the color DP.

B. The 2DP was preferred over the green record DP for shadow density detail, and both were preferred over the color DP.

C. The green record DP preference over the color DP for highlight density detail was slightly greater than the green record DP preference over the color DP for shadows.

Taking both the objective and subjective data into account, it is concluded that the green record

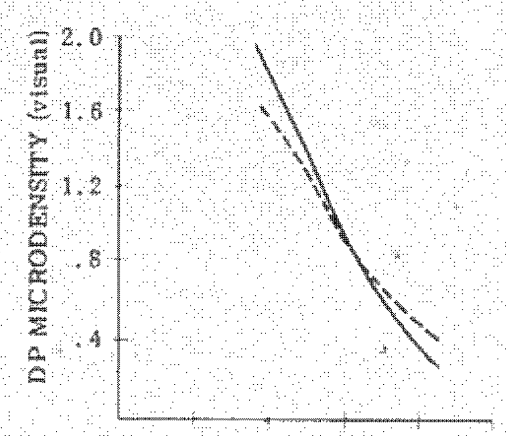
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TONE REPRODUCTION EVALUATION

(Aft Camera, Op 745, Frame 003)



——— GREEN RECORD DP
- - - - SO-287 COLOR DP

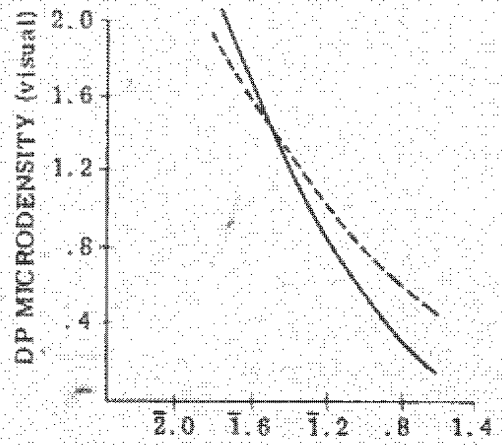


FIGURE 4-29

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DP contrast and print density level are good, and that both the green record DP and the 2DP are of better tone reproduction quality than the color DP.

4.8.1.3 Color Balance

The major objection with Mission 1207's color DP's color balance was the dark purplish shadow areas. Figure 4-30 shows the system reproduction curves for Mission 1207 color DP. Figure 4-31 shows the same curves for this mission's color DP. The excessive shadow densities have been corrected on this mission, and the color balance of the color DPs is good.

4.8.2 False Color (FE-3916 Acquisitions)

4.8.2.1 Color Rendition

The color rendition of the original positive FE-3916 False Color Film differs in many ways from that of the conventional color SO-255 Film. Figure 4-32 shows a comparison of colors as formed on false color (IR sensitive) and natural (conventional) color films. The three image layers of the false color (FE-3916) film are sensitized to IR, red, and green spectral radiation instead of blue, green, and red as is the case with SO-255 Color Film. Figure 4-33 shows the spectral sensitivity of FE-3916 Film. The W-12 Filter cut off response is also shown. The high blue absorption of the W-12 Filter coupled with the low blue sensitivity of FE-3916 Film essentially eliminates all recording of blue light reflectances.

4.8.2.2 Resolution Transfer

Four readers read the two 51/51 Tribar CORN Targets acquired on the false color film. The FE-3916 color OP, SO-287 color DP, and the black and white red record DP copies were read. Table 4-18 lists the results. The resolution of each frame represents the geometric mean of the in-track and cross-track resolution readings. Neither the resolution loss for the color DP nor the gain for the red record DP is considered significant.

TABLE 4-18

RESOLUTION TRANSFER

Op	Frame	FE-3916 (COP) (cycles/mm)	SO-287 (CDP) (%)	SO-192 (RRDP) (%)
758	3	68	-5.1	8.3
764	4	65	-12.4	0.0
	Average	66	-8.8	4.1

NOTE: The resolution gain on Op 758 for SO-192 possibly results from the slight contrast increase in duplication coupled with the relatively low color OP resolution input, or from resolution reader variability, or from a combination of these two factors.

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MISSION SEGMENT 1207-1 SYSTEM REPRODUCTION CURVES FOR SO-255 ONTO SO-287

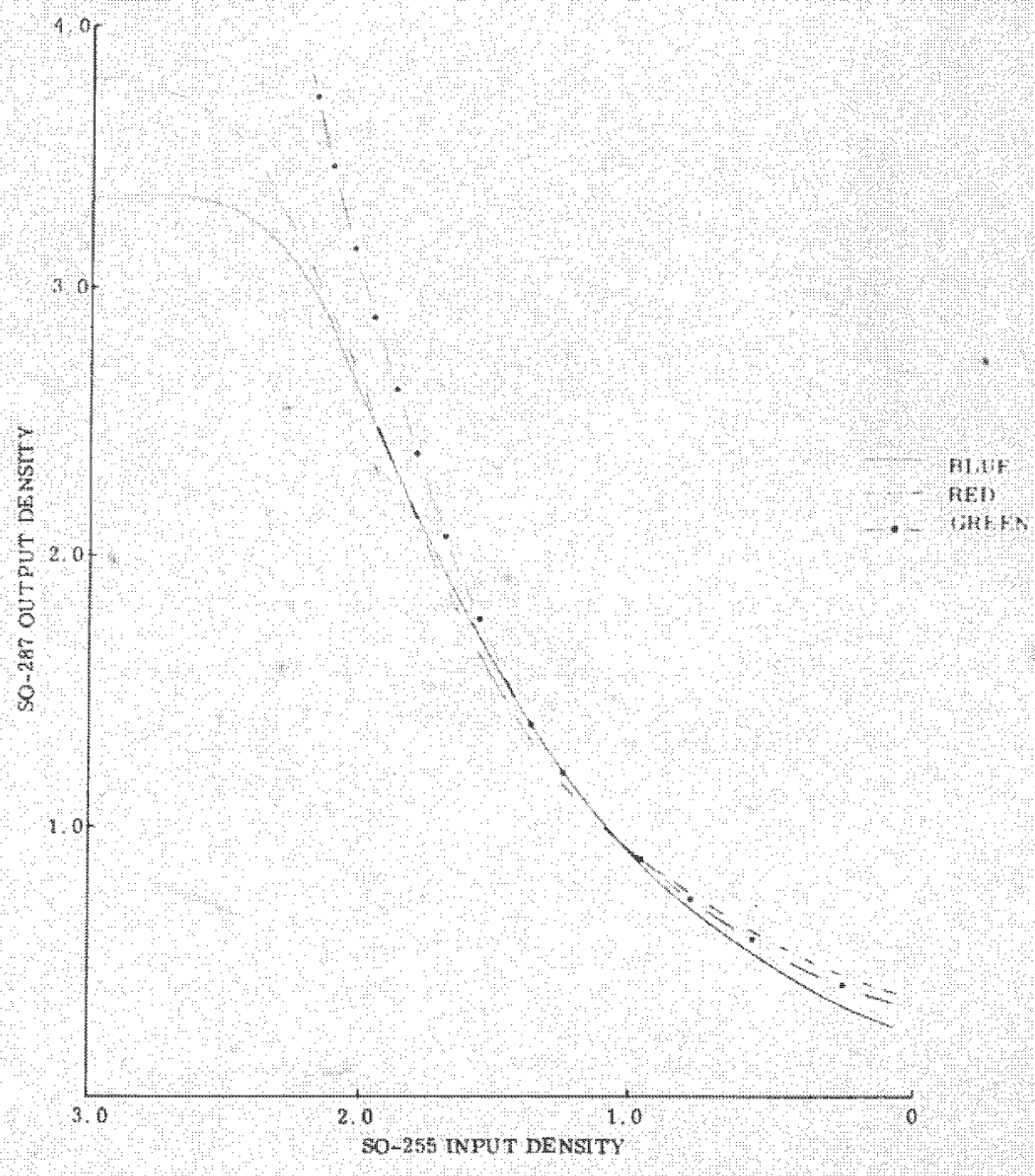


FIGURE 4-30

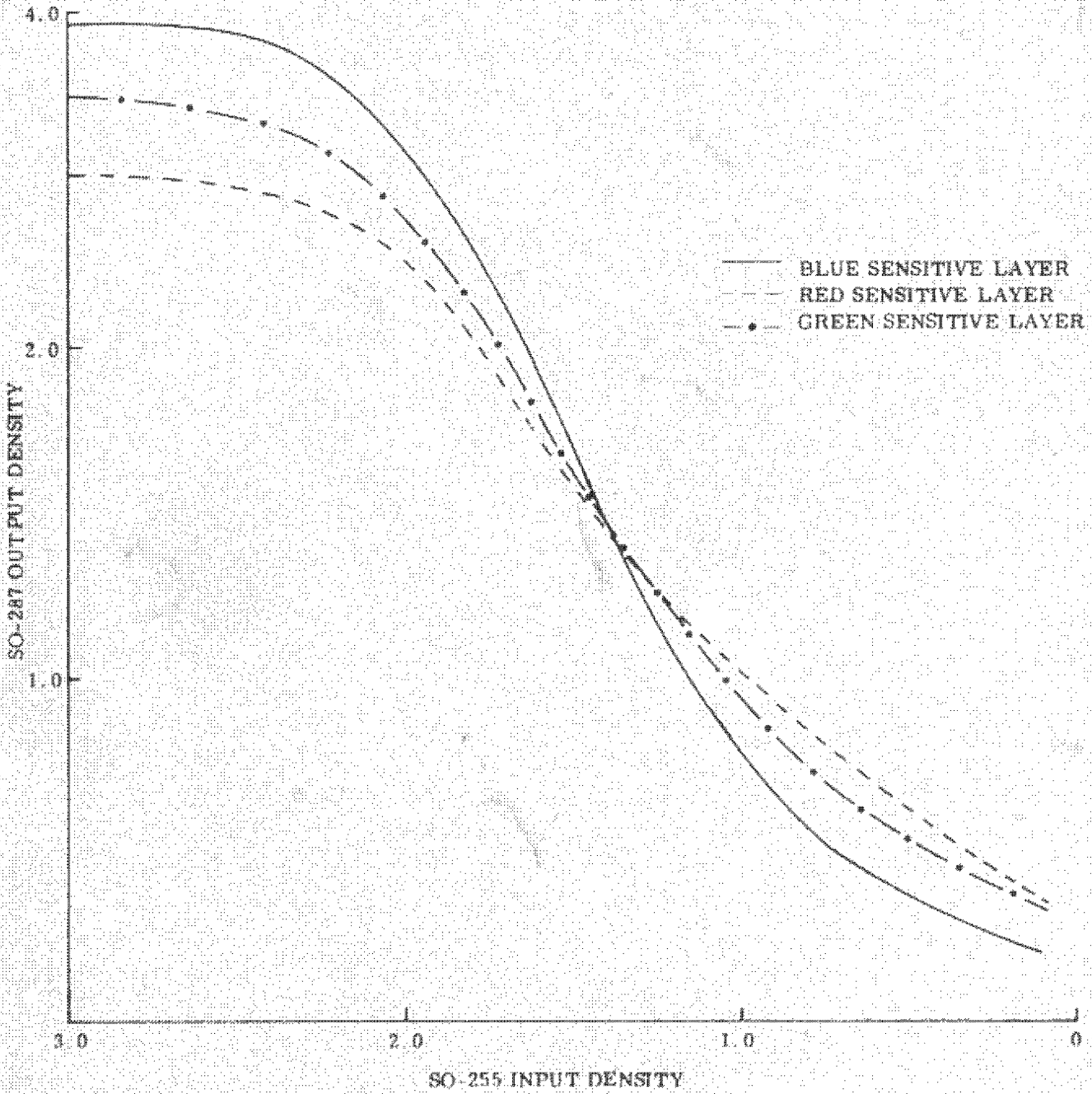
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MISSION SEGMENT 1208-4 SYSTEM REPRODUCTION CURVES FOR
SO-255 ONTO SO-287



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FIGURE 4-31

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SPECTRAL SENSITIVITY OF FE-3916 FILM AND W-12 FILTER RESPONSE

(Preliminary Data)

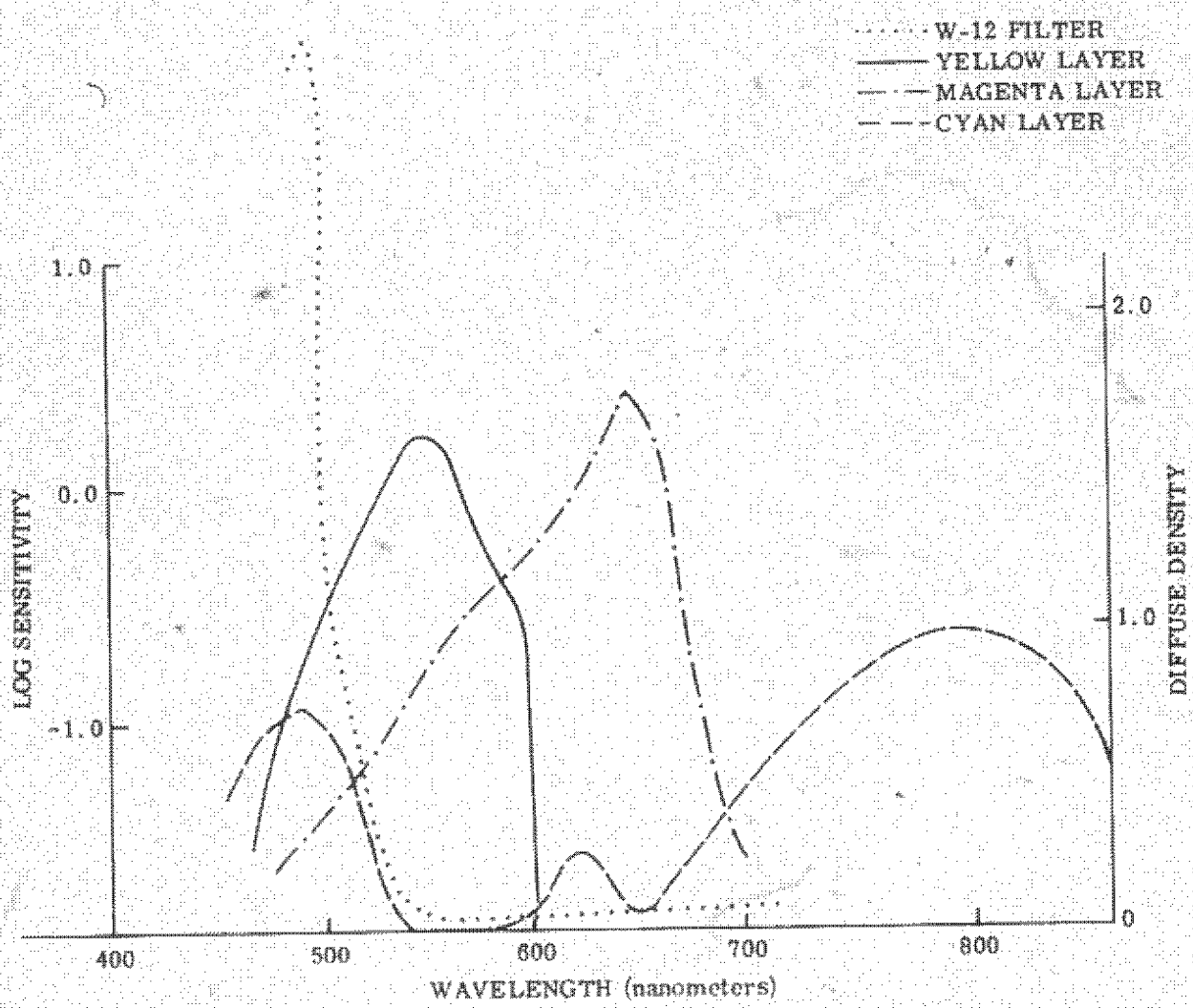


FIGURE 4-33

BYE 15256-75

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To see if the limited resolution transfer data from NOFORN CORN targets was indicative of the misleading resolution differences between the color DP and red record DP, ten target areas from different color OPs were compared on these two copies. From this analysis, it was found that there was a slight difference in resolution and edge sharpness, with the red record DP being preferred. Comparison of the red record DP to the 2DP copy of the Forward Camera's acquisition of the same targets still shows the vast resolution superiority of the ON material.

4.8.2.3 Tone Reproduction

An overall preference for the tone reproduction of the 2DP copy over both the color DP and the red record DP copies was evident from PI comments. An analysis similar to that for the conventional color photography tone reproduction was conducted to determine the reasons for this preference. Microdensity scans were made of the engineering photography CORN five-step gray patches and selected operational targets. The operational targets were selected on the basis of possible reproduction difficulty due to poor tonal differences in the original positive. These targets from the color OP, color DP, and red record DP were traced with a 6 micron diameter circular aperture. A visual filter was used for all traces so as to approximate the visual tone differences that the PI saw when viewing through all three layers of the color films. Figure 4-34 compares the color OP input and color DP output using visual microdensity data extracted from the five-step gray patches. Table 4-19 lists the density data derived from the traces of three operational targets.

TABLE 4-19

TONE REPRODUCTION OF SELECTED OBJECTS

(False Color Acquisition Film)

Target	Film	Subject Density	Background Density	Density Difference
Light Aircraft	Color OP	.71	1.28	.57
	Color DP	.27	.48	.21
	Red Record DP	.22	.28	.06
Light Aircraft	Color OP	.72	1.02	.30
	Color DP	.43	.63	.20
	Red Record DP	.25	.37	.12
Dark Pipeline	Color OP	2.50	2.71	.21
	Color DP	2.40	2.58	.16
	Red Record DP	1.23	2.06	.83

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FE-3916 TONE REPRODUCTION

(Mission 1208-4, Op 764, Frame 004)

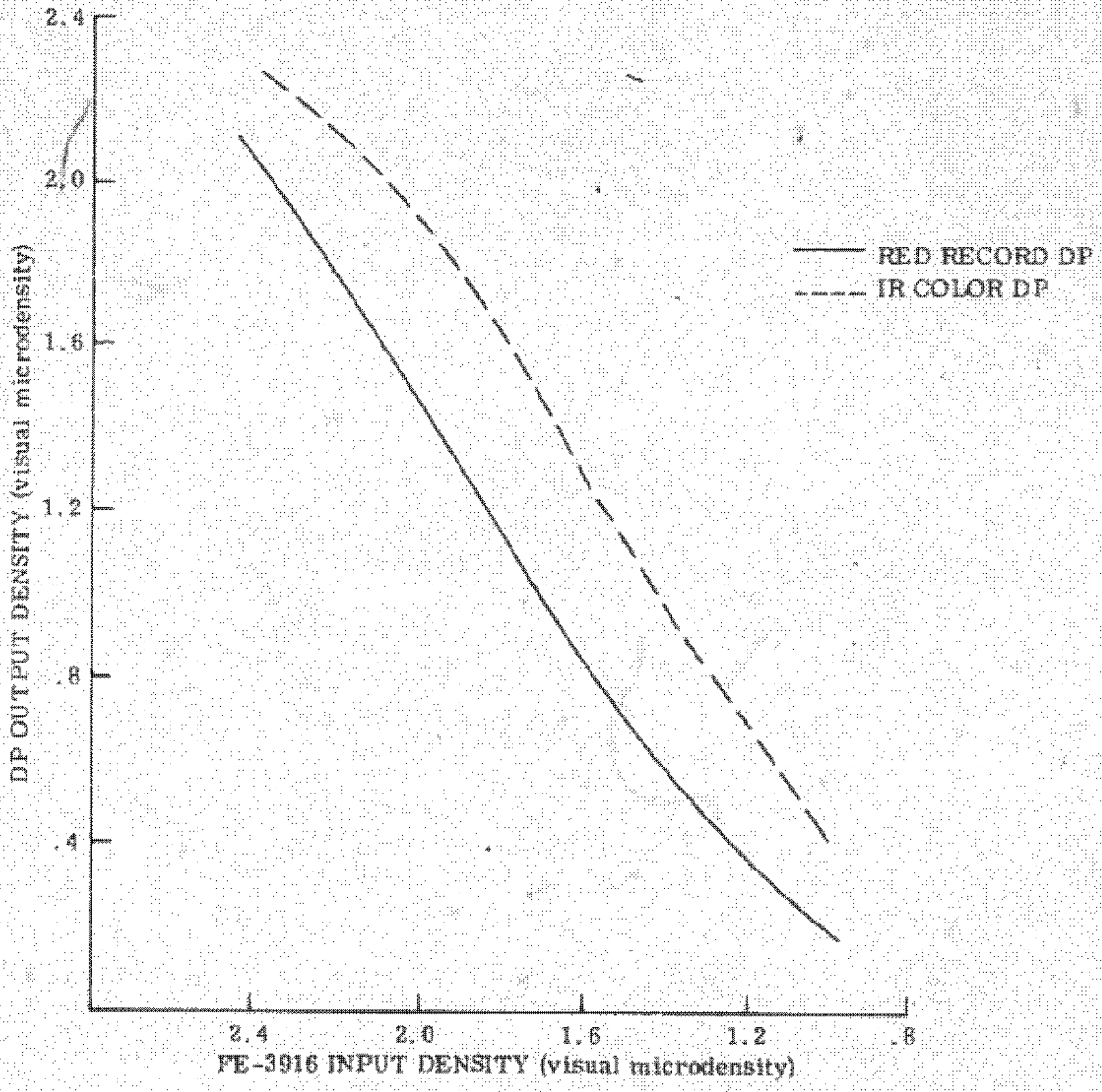


FIGURE 4-34

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Two differences were noted in comparing the color DP to the red record DP density data:

A. The color DP is darker, of lower contrast, and contains less shadow density detail than the red record DP.

B. The color DP is of higher contrast and contains more highlight density detail than the red record DP.

A subjective paired comparison of the color DP, red record DP, and 2DP copies was conducted. Ten target areas from different operations were compared on a split-field viewing table. From this evaluation it was found that:

A. The red record DP was generally preferred over the color DP for highlight density detail.

B. The red record was generally preferred for shadow density detail.

C. The 2DP was preferred in every case for highlight density detail.

D. The red record DP shadows were felt to be equal to the 2DP shadows in some cases, but never better.

Analysis of both objective and subjective data indicates that:

A. There is variability in the reproduction of highlights and shadows for both the color DP and red record DP. This variability was large enough to explain why no overall PI tonal preference for either film was discovered.

B. The 2DP reproduced highlights much better than the red record DP.

C. Red record DP shadows were close to the 2DP shadows for density detail, but never better.

Therefore, it appears that for maximum tonal information, the PIs preferred the 2DP because of the better highlight tone reproduction. The color DP and red record DP are essentially equivalent in tone reproduction, but both are poorer than the 2DP copies.

4.8.2.4 Color Balance

The characteristic curve for FE-3916 is given on page 4-21, Figure 4-7. All densities below 2.0 contain an excess of cyan dye. Since most photographed objects are recorded below this density level, the color DP exhibits a cyan cast. The magnitude of this cast, however, is not as severe as that seen on Mission 1207 which was a winter mission, as compared to this summer mission.

Subjective analysis of the color balance of the SO-287 color DP indicates an overall red rendition of IR reflecting objects rather than the expected magenta to red colors. The magenta to red colors result because vegetation reflects both green and IR radiation. The green radiation records as cyan and magenta dye on the color DP, while IR radiation records as magenta and yellow dye, refer to Figure 4-32. The specific resultant color depends on the ratio of the green to IR object reflectance.

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It appears that the color gamut of the color OP/DP system is compressed such that reliable discrymination of IR reflectances might be difficult. This problem has not adversely affected photo-interpreter readout, but is an area of concern for future missions.

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EXPLOITATION SUITABILITY

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SECTION V

EXPLOITATION SUITABILITY

5.1 INTRODUCTION

This section analyzes the exploitation suitability of Mission 1208. The National Imagery Interpretability Rating Scale (NIIRS) ratings are analyzed with respect to mission trends and mission unique problems. A questionnaire sent to all photointerpretation sections at NPIC was used to evaluate the exploitation suitability of the duplicate positives made from the color originals. Special analyses on the effects of acquisition lighting conditions and microscopic plus-density marks are also presented.

5.2 SUMMARY

The interpretability of the black and white acquisitions from Mission 1208 was typical of the most recent 1200 Series missions. The average NIIRS rating for the mission is 3.0. This is slightly better than the ratings for Mission 1207; however, the better photo altitude of this mission could account for this difference. The fogged film on RV-1 resulted in 10% fewer targets rated NIIRS 5 and 6 than the unfogged film. The processing modifications on subsequent RVs appear to have compensated for the degradation. The focus and OOAA adjustment made on RV-2 significantly improved the NIIRS ratings.

The interpretation suitability of the color duplicate positives from RV-4 was the best to date. The color DP from the natural color OP (SO-255) is still inferior to the black and white DP. However, 46% of the PIs surveyed stated that they would accept occasional color coverage of their military targets for possible supplementary intelligence information.

The interpretation suitability of the color and red record DPs made from the FE-3916 DP was poor for military intelligence, but good for economic intelligence, e.g., wheat yield estimates.

Front-lighting on Mission 1208 was more of a degrading factor than either specular reflections or high solar elevations. Overall, 9% of the photography was acquired with camera/target/sun (CATS) angles of 10° or less. For good interpretability, the CATS angle should be no less than 7°, the specular reflection angle no less than 5°, and the solar elevation no higher than 80 degrees.

The microscopic plus-density marks, first reported in the 1207 PFA Report, were present in the 1208 ON film. They are objectionable and can slow down the interpretation process, especially in searching target areas for signs of new activity. The cause of this anomaly is still under investigation.

5.3 INTERPRETABILITY

5.3.1 Mission Trends

The quality of Mission 1208 imagery for photointerpretation was assessed using the expanded version of the National Imagery Interpretability Rating Scale. This expanded scale was first used with Mission 1207. The NIIRS ranges in values from 0-9. The lowest rating of "0" relates to an unusable

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acquisition; the highest rating of "9" relates to detail fine enough to detect human facial features. A description of the scale and its use can be found in paragraph 5.3.1.1 of the 1207 PFA Report or in the NIIRS Handbook. The overall totals of target ratings per NIIRS category for each RV of Mission 1208 are tabulated in Appendix D. This table, as well as all subsequent analyses in this section, includes all NIIRS ratings of black and white acquisitions reported up to 30 September 1974.

Figure 5-1 presents, in histogram form, the distribution of the clear, complete, and stereo acquired OAK and OAK Supplement targets for Mission 1208. Figure 5-2 presents the same data in cumulative distribution form. Note the trend for higher rated photography (greater than NIIRS 3) in RV-2 as compared to RV-1, the smaller rating increase from RV-2 to RV-3, and the stabilization from RV-3 to RV-4. A non-parametric statistical test, the Smirnov Test[1], was used to verify the statistical significance of these changes. The changes in RVs 1 thru 3 were found to be significant with greater than 99% confidence, while no change was evident from RV-3 to RV-4.

5.3.1.1 Focus and OOAA Adjustments

The ratings of the photography from 1208-2 were divided into two groups: before focus and OOAA adjusts were made (Op 132-156), and after they were made (Op 160-364). The distribution of ratings with respect to this breakdown is given in Figure 5-3. There is a significant increase in the NIIRS rating levels after the focus and OOAA adjustments. Note that 2.3% of the photography was rated NIIRS 6 after the adjustments, while only .4% received this rating before the adjustments. This is consistent with the assumption that fine adjustments to the camera system will be reflected for the most part by how good the best photography is.

5.3.1.2 High Base Plus Fog Density

Approximately 35% of all Forward Camera frames and 59% of all Aft Camera frames were acquired on fogged black and white film. The fog raised the minimum densities on the ON and shortened the density range. No specific complaints were noted from the photointerpreters regarding lack of shadow detail; therefore the magnitude of the problem is not large. The NIIRS ratings were analyzed in order to determine if the fog affected the overall interpretability. On RV-1, where no special processing was given to the fogged film, the NIIRS ratings were divided into two groups. The first group of targets (302) were evaluated on DPs made from fogged ON film, while the second group (420 targets) were from unfogged film. A significant improvement in the ratings made from unfogged film was noted, see Figure 5-4. The number of targets rated either NIIRS 5 or 6 increased from 20.2 to 30.1 percent. Therefore, the fogged ON film did appear to have an overall degrading effect.

A modification of the ON processing chemistry was implemented on RVs 2, 3, and 4 for the fogged film. Their NIIRS ratings were analyzed to see if the modified processing compensated for the

[1] Practical Non-parametric Statistics, W. J. Conover, J. Wiley and Sons, Inc. 1971.

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DISTRIBUTION OF NIIRS RATINGS FOR BLACK AND WHITE PHOTOGRAPHY

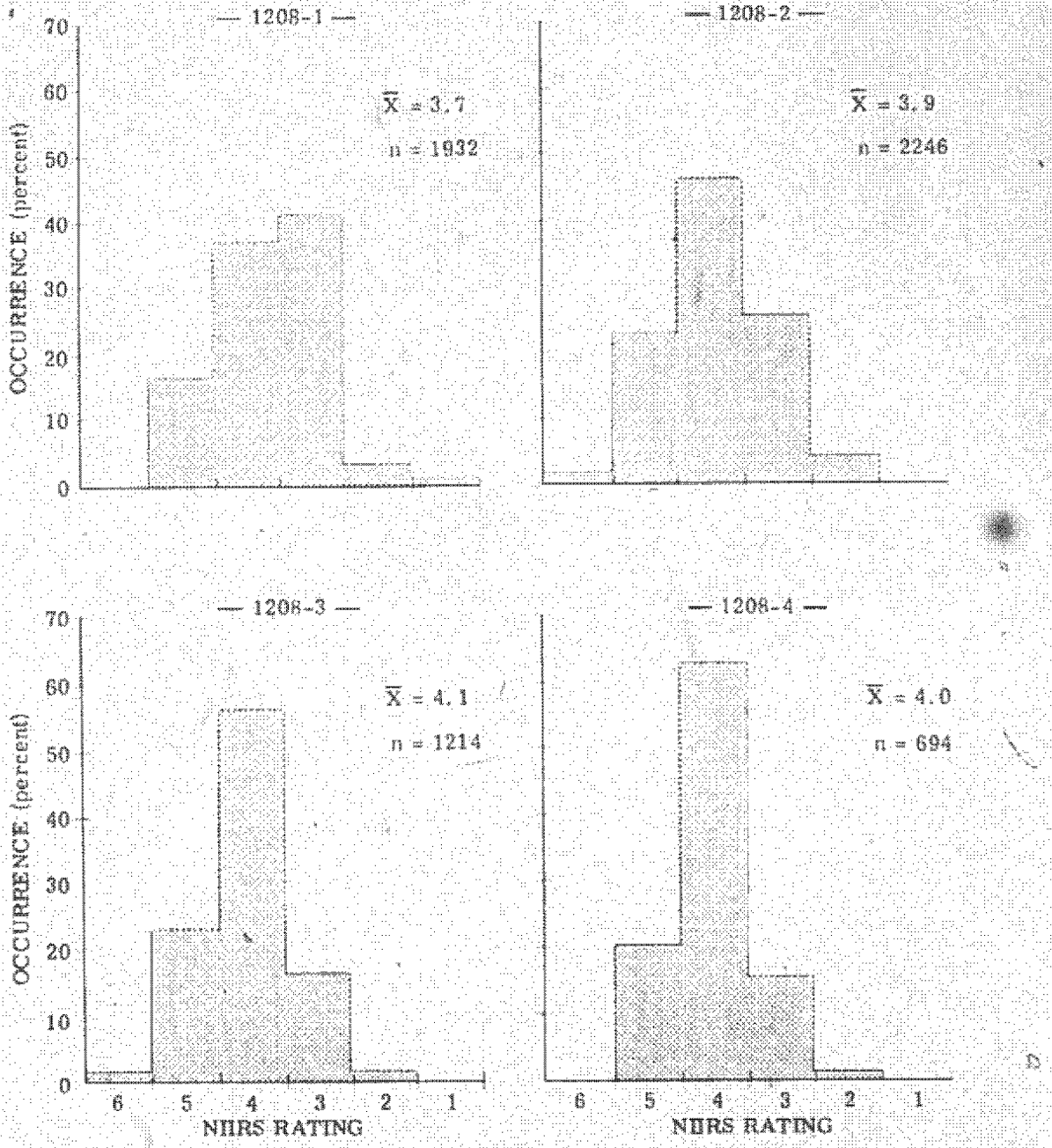
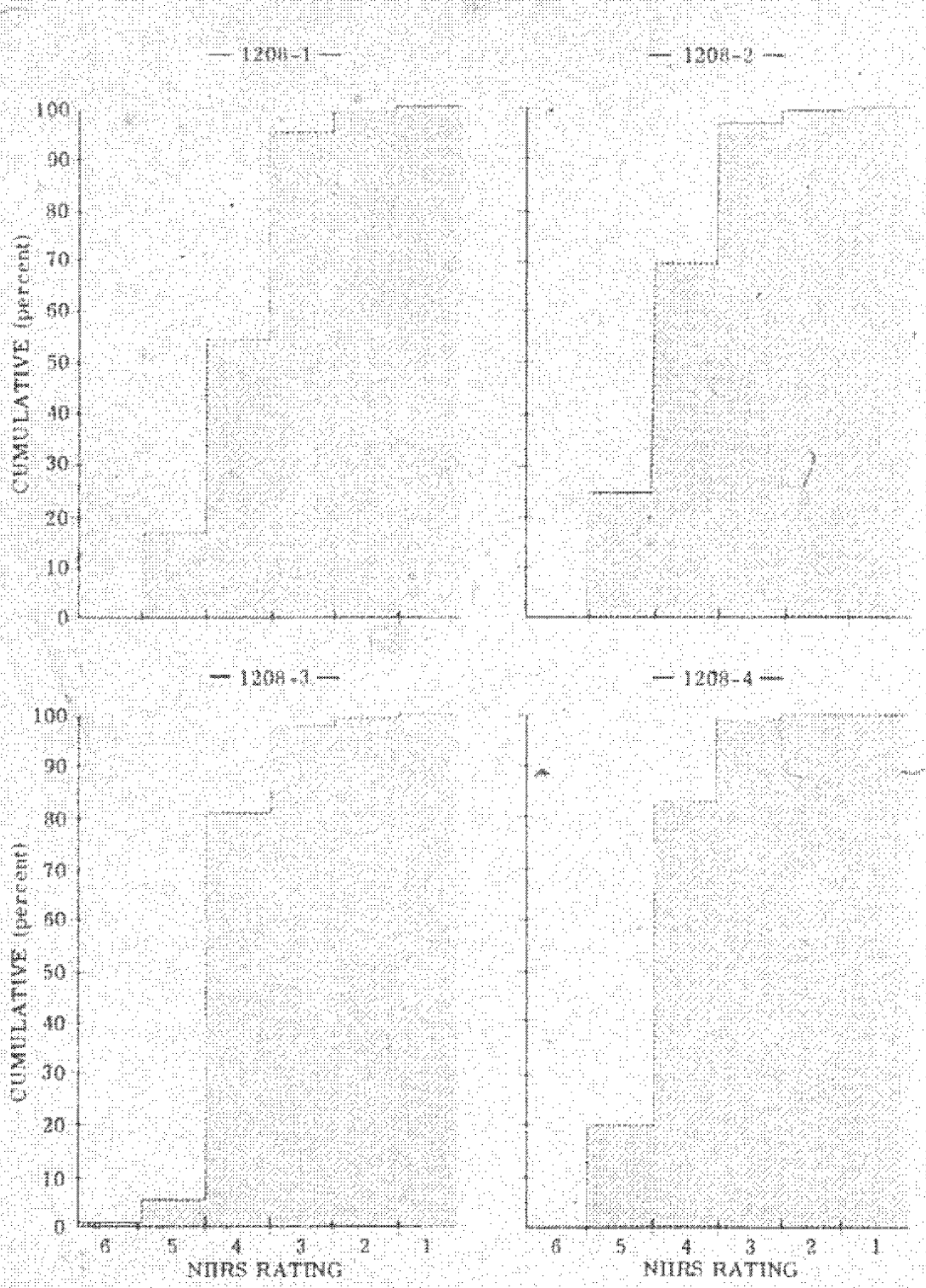


FIGURE 5-1

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CUMULATIVE DISTRIBUTION OF NIIRS RATINGS FOR BLACK AND WHITE PHOTOGRAPHY



BYE 15256-75

FIGURE 5-2

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DISTRIBUTION OF NIIRS RATINGS FOR BLACK AND WHITE PHOTOGRAPHY

— 1208-2 —

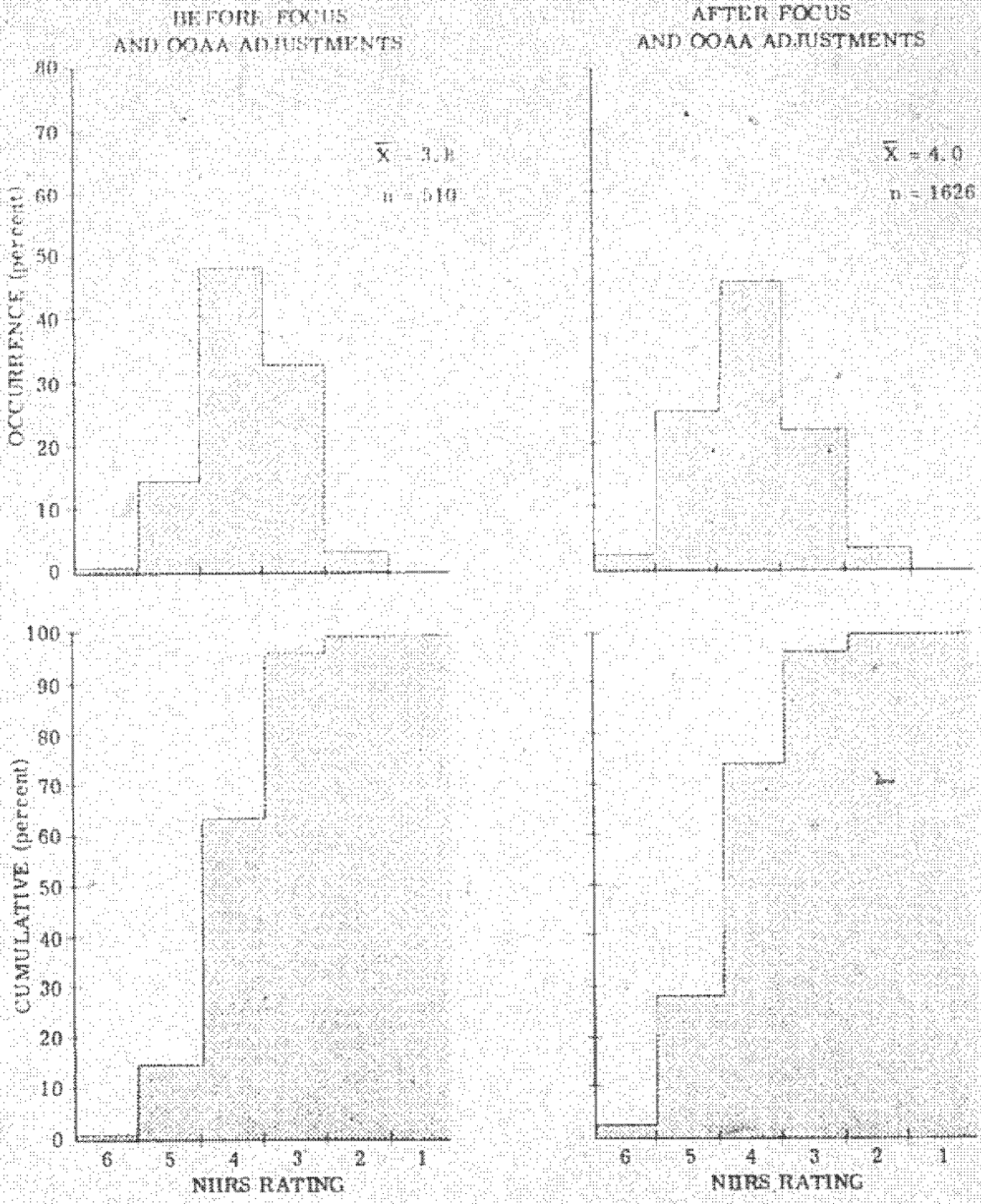


FIGURE 5-3

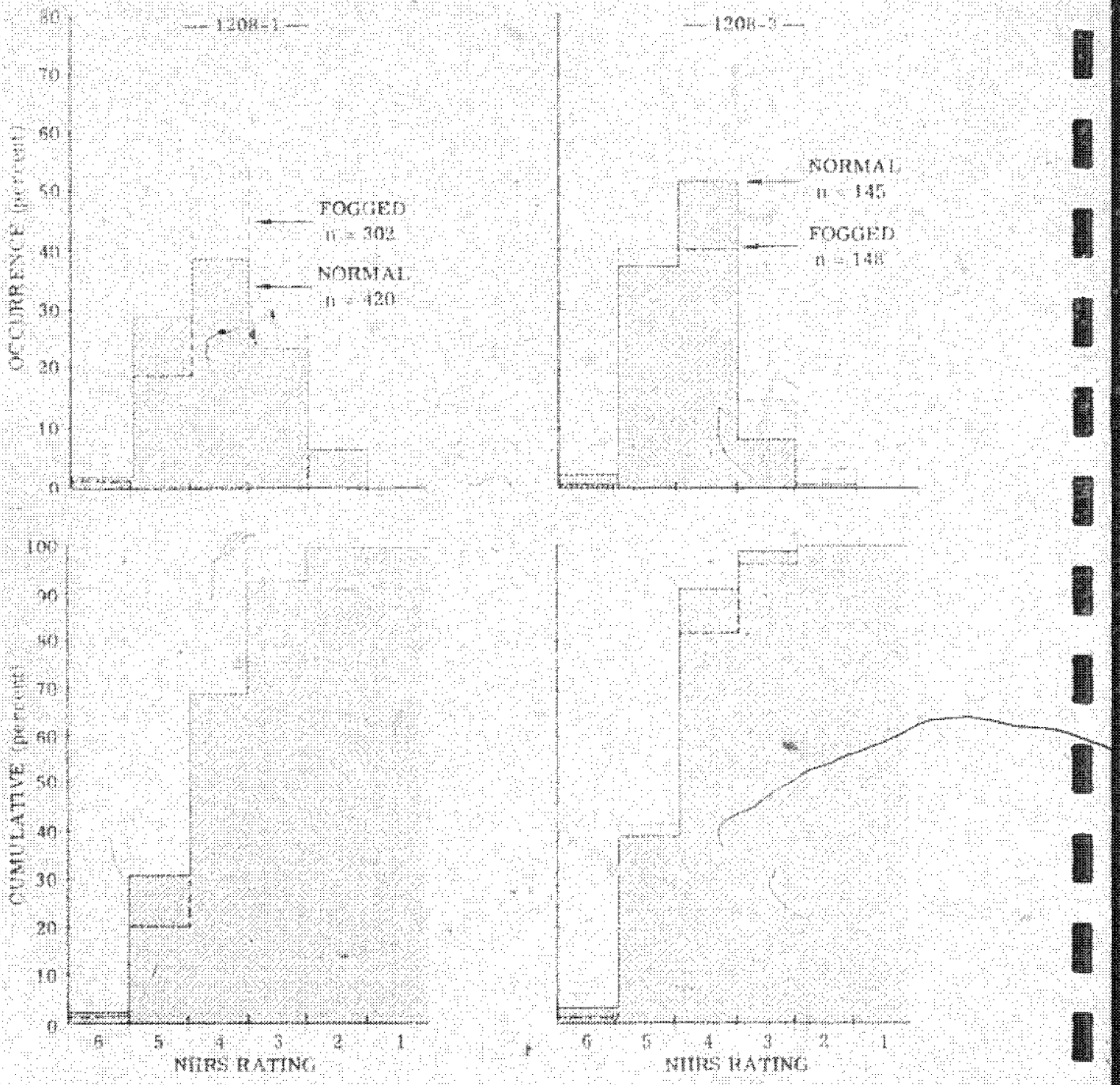
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DISTRIBUTION OF NIIRS RATINGS

FOGGED VERSUS NORMAL BLACK AND WHITE PHOTOGRAPHY



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FIGURE 5-4

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fogging. A valid comparison between the fogged and no fogged film could be made only with RV-3 data. Other factors were found which could have caused a change in the NIIRS ratings for RVs 2 and 4. The geographic areas were much different for the fogged versus no fog comparison for RV-2, while the photo scale was different for RV-4. No significant increase was detected in the ratings of 145 targets from the unfogged ON film as compared to those from 148 targets on the fogged ON film in RV-3, see Figure 5-4. Therefore, the processing modification did appear to have compensated for the degradation introduced by the fogged ON film.

5.3.2 Comparison with Past Missions

Figure 5-5 compares the distributions of NIIRS ratings of clear, completely covered, stereo acquired targets for Missions 1207 and 1208. As mentioned previously, Mission 1207 is the only other 1200 Series mission rated using this scale. Of the two, Mission 1208 appears to be the higher rated mission; an analysis using the Smirnov Test confirmed this hypothesis with greater than 99% confidence. The arithmetic mean NIIRS rating for 1208 is 3.9; for 1207 it is 3.7. One of the main factors accounting for the higher ratings for Mission 1208 could be its lower acquisition altitudes. Figure 5-6 compares the two missions in this respect. The effect of photo scale on interpretability has been well documented in previous PFA reports; the 8.5 NM median altitude difference between these missions could account for their NIIRS rating difference.

5.3.3 Geographic Area Breakdown

The acquisition conditions typically associated with various geographic areas photographically covered by 1200 Series missions do have an effect on NIIRS ratings. The geographic areas which accounted for most of the priority targets readout from Mission 1208 are USSR, China, Middle East, Southeast Asia, East Europe, and India. Table 5-1 lists the NIIRS rating distribution per geographic area.

A comparison of Mission 1208 percentage of coverage of the different geographic areas with that of Mission 1207 showed that the coverage in the USSR has increased by 15%, while the coverage in the Middle East and Southeast Asia decreased by 10% and 4%, respectively. India and Eastern Europe now account for significant portions of coverage, whereas in past 1200 Series missions this was not the case. However, these coverage changes do not appear to have affected the overall distribution of NIIRS ratings for 1208.

5.3.4 Natural Color Acquisitions

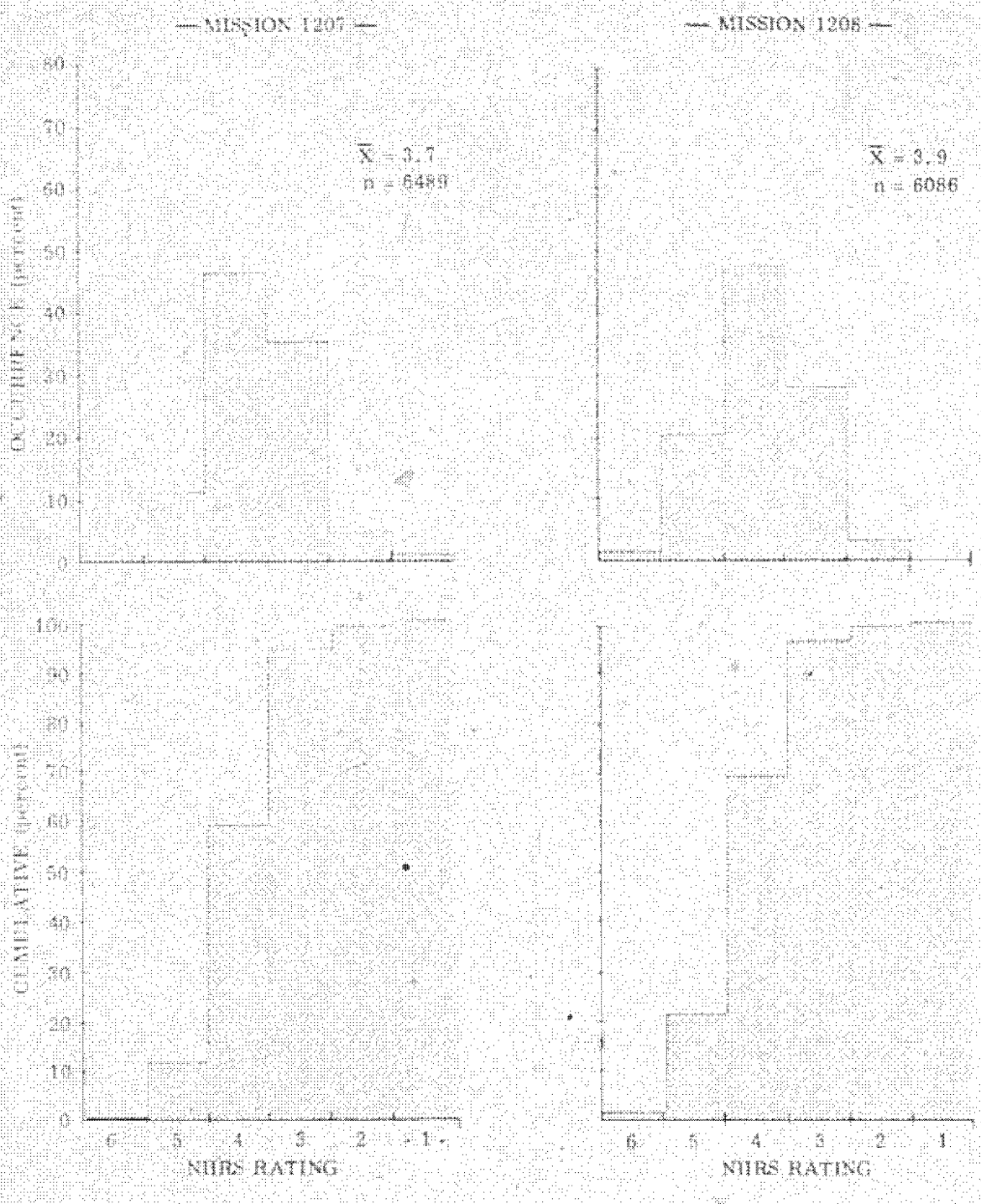
A previous evaluation of SO-287 (introduced in 1207-1 for making the color DPs) showed that this film improved exploitation of color photography because of its ability to retain more of the resolution contained in the original. However, a number of technical shortcomings were noted that adversely affected interpretation; i.e., high contrast, high shadow density level, and poor color balance. Adjustments were made for these problems on Mission 1208; refer to paragraph 4.8.1. Surveys were sent to a number of PIs at NPIC to determine what effect on interpretability the adjustments on the SO-287 color DP had.

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COMPARATIVE DISTRIBUTION OF NIIRS RATINGS
(Oak and Oak Supplement Target(s))



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COMPARISON OF ACQUISITION ALTITUDES

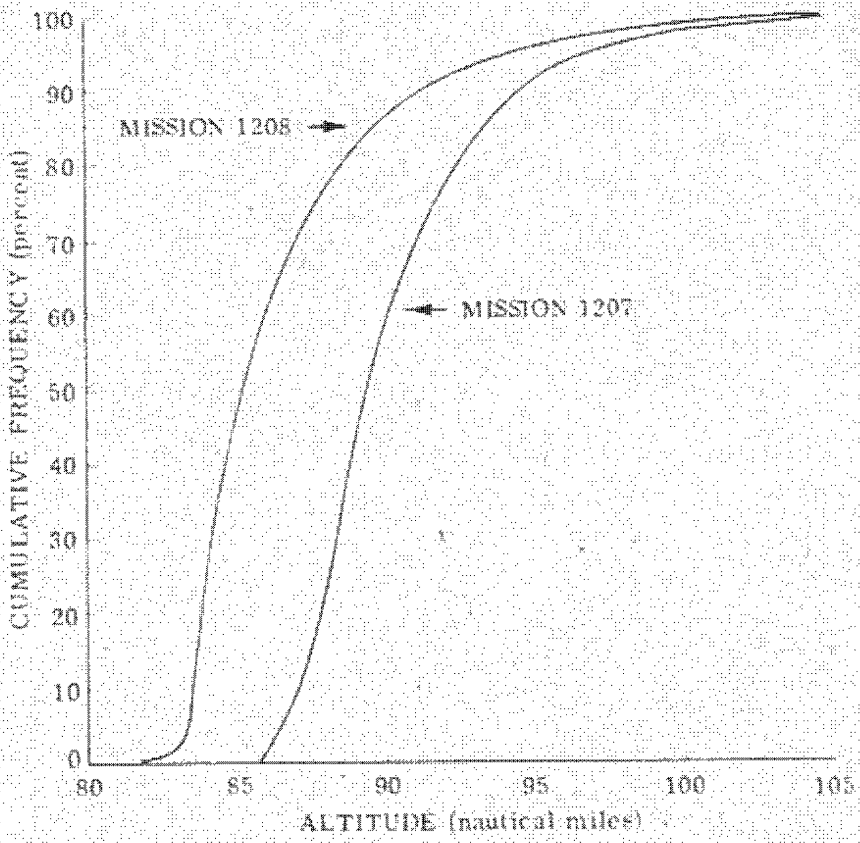


FIGURE 5-6

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TABLE 5-1

NIIRS RATINGS DISTRIBUTION FOR COMIREX GEOGRAPHIC AREAS

Geographic Area	Area Code	NIIRS Rating (Percent/Area Code) 1	2	3	4	5	6	Geographic Percentage of Mission		Average NIIRS Rating		Sample Size
USSR	A	0	1	20	44	33	2	12.9		4.2		739
	B	0	0	8	56	32	4	8.4		4.3		484
	C	0	0	5	38	55	2	10.5		4.5		605
	D	0	0	15	41	43	1	4.9		4.3		279
	N-O	0	7	38	45	10	0	0.5	Overall	3.6		29
								Total: 37.2	Average	4.3	Total:	2,136
China	E	1	14	45	31	8	1	4.8		3.4		276
	L	0	1	22	57	19	1	20.4		3.9		1,170
	M	0	6	21	49	13	1	11.5	Overall	3.7		657
								Total: 36.7	Average	3.8	Total:	2,103
Middle East	G	0	3	63	32	2	0	17.0		3.3		974
	H	0	10	55	35	0	0	0.5		3.3		31
	U	0	0	18	82	0	0	0.2	Overall	3.8		11
								Total: 17.7	Average	3.3	Total:	1,016
Southeast Asia	F	2	28	50	18	2	0	1.6		2.9		90
East Europe	K	0	0	18	67	13	2	4.7		4.0		270
India	P	1	3	50	41	5	0	1.5		3.4		86

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Forty-nine surveys were returned; results are summarized in the following paragraphs.

The color balance of the CDP for 1208 was found to be significantly improved over that of 1207. Ninety-five percent of the PIs agreed that the color balance and shadow density level were satisfactory to the point where interpretability was not hindered. However, 23% of the PIs felt that the contrast of the color DPs and green record DPs was still, in some cases, unsatisfactory.

Most PIs in this survey, as well as others who have viewed the color DP for this mission, agree that the interpretability of the 1208 color DP is the best to date. However, all of the PIs surveyed still rate the black and white acquisition as being superior to the color DP or its green record DP. All felt the black and white record exhibits higher resolution, better contrast, and better edge definition. The black and white record is still the best choice for interpreting a great majority of targets and for satisfying most of the readout requirements. Although some PIs would be completely satisfied with color imagery, 97% of those surveyed could not answer all of their requirements with just color coverage.

Forty-six percent of these PIs felt that even though the black and white DP was superior to color for resolution, contrast, and edge definition, they would accept occasional color coverage for the following reasons:

A. Periodic checks on color coding of equipment.

B. Observation of stains, paints, and wing markings at airfields.

C. Observation of seasonal changes in terrain and vegetation.

D. Periodic checks on camouflage practices, disruptive painting of equipment, and net canvas covers.

E. Checks at SAM sites for firing blasts and mishaps.

F. Checks on missile equipment signatures.

G. Observation of industrial areas.

H. Monitoring nuclear material mining signatures.

Thirty percent of the PIs felt that color benefits search operations and quoted the following reasons:

A. Easier to spot man-created disturbances and activities on land; e.g., ground scarring.

B. Easier to spot naval vessels (the decks are usually painted reddish-orange).

C. Better perception of armor equipment against sand backgrounds.

The degree to which the color DP is used, relates directly to its resolution; i.e., the higher the resolution, the more targets that can be read out. Therefore, it appears that a major effort should be applied to improving the resolution of the color OP and DP. As the resolution of the color DP improves, so will the exploitation capability of color photography.

5.3.5 False Color Acquisitions

Mission 1208-4 acquired 3,036' of FE-3916 Infrared False Color Film. Unlike 1207-4, which

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acquired false color film imagery with a large percentage of snow cover, the coverage of 1208-4 was totally free of snow cover. This large amount of snow-free false color resulted in more PI experience with false color. Consequently, many problems and questions arose in the two main areas of military intelligence and economic intelligence.

5.3.5.1 Military Intelligence Targets

The problems arising with the increased false color coverage were not totally unexpected. Military intelligence targets, which require the highest possible resolution for readout, suffered because of the significant resolution difference between false color and black and white coverage. The resolution of the false color DP and its black and white red record DP for 1208-4 are approximately 70% of the natural color DP resolution (refer to paragraph 4.8.2).

The poorer resolution of the color DP affected the PI's ability to answer requirements for military intelligence in two areas: object detail and stereo viewing. A degradation of the quality in either area affects the ability to do most military intelligence readouts. The problems with lowered resolution and its effects on object detail are obvious; the connection between resolution and stereo quality is not as obvious. One might assume that the better resolution of one image could make up for the deficiency in the other. However, the PIs who require maximum resolution for readout, have not found this to be true. The poor object detail of the red record DP in stereo with the black and white DP results in significant eyestrain. Consequently, not only is the first phase readout of the material affected, but also subsequent work by the PI can be hindered.

5.3.5.2 Wheat Yield Estimates

The vast majority of the benefits derived from the false color film acquisitions came in the economic intelligence area, specifically with respect to wheat yield estimates. Unlike military intelligence targets, the majority of targets relating to wheat yield estimates do not require high resolution or stereo coverage.

The IR reflectance from plant life, recorded on the false color film was useful in determining the vigor and condition of growing wheat in the Soviet Union. Differences between a healthy crop and one experiencing stress from drought are readily apparent on the color DP. The crop areas which are bright red in color indicate a healthier crop with a higher yield potential. The crop areas which are less saturated and grayish-red in color indicate that the crop is under stress and the yield will be low.

To aid in wheat yield analysis, information regarding agriculture techniques is gathered. This includes subjects such as planting equipment, harvesting equipment, fertilization techniques, and stored by-products. The requirements for analysis of agriculture equipment is similar to that of military intelligence. Therefore, the black and white DP is needed because the resolution capability of the IR color DP or the red record DP fails to provide sufficient detail to interpret equipment. Overseeding is best seen

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in the IR, lodging (a flattening of the crop) best in the natural color, and crop damage best in the false color.

Inclusion of false color acquisition film has been shown to be of benefit to economic intelligence and a problem to military intelligence. Careful consideration of all factors should be employed in determining how much false color film is used until a film capable of matching the resolution of the natural color film is introduced.

5.3.6 Front-lighting, Specular Reflections, and High Solar Elevation Acquisitions

After considering the established problems relating to weather and obliquity, probably the next significant factor affecting photointerpretation is the lighting conditions of the target. Full front-lighting (shadowless acquisition), specular reflections, and high solar elevations, in many instances, result in photography of poor interpretability.

Front-lighting and specular reflections are not new; these conditions are present during missions that are in orbit any time from mid-spring to late summer. Mission 1208 is the latest mission to be affected by these conditions, but it is not the worst case. Mission 1206 imagery is considered to be the worst affected. The main reason for Mission 1208 not being as bad as Mission 1206, even though the launch times are very similar, is that Mission 1208's orbit was not sun-synchronous. This orbit puts the effects of front-lighting and specular reflections out in the outermost scan locations at opposite sides from nadir. On Missions 1203, 1205, and 1208, front-lighting generally occurred on the Aft Camera imagery at negative scan angles, and specular reflections occurred on the Forward Camera at plus scan angles. For Mission 1206, front-lighting and specular reflections occurred at nadir. When front-lighting and specular reflection occurred at opposite scan locations, imagery was unaffected on one camera. Since Mission 1206 had both effects at nadir, good complementary imagery from the other camera was lacking.

Besides the difficulty of reading out individual targets, these degrading factors also affect the ability to search the imagery. The PIs spend 60% to 80% of their time performing search tasks. Also, since a majority of the PIs use the Aft Camera imagery for their searching tasks (because of its more natural look angle), front-lighting is the most frequent and worst of these degrading lighting conditions.

5.3.6.1 Front-lighting

Front-lighting occurs when the camera is looking at a target at the same angle as the sun. The camera/target/sun relationship is such that no shadows are visible because they are "hidden" behind the objects. Imagery with no shadows appears dimensionless, and in many cases, objects and details are completely lost. All targets acquired without shadows are readout degraded to some extent. In the desert areas of the Middle East and North Africa where targets such as trucks, tanks, and missile deployments tend to blend in with the background, there can be a total loss of detail. The most severely affected target type is radar and associated equipment since their detection and classification relies heavily on the shadows they cast. An average 1200 Series mission scene requires a camera/target/sun (CATS) angle

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greater than 7° to avoid front-lighting and to be of use to the PI. The amount of imagery acquired on Mission 1208 with a CATS angle of 10° or less is listed in Table 5-2.

TABLE 5-2

1208 PHOTOGRAPHY ACQUIRED WITH CATS ANGLES 10° OR LESS

Mission Segment	Frames Acquired (%)	*Imagery Acquired* (%)
1208-1	10	2
1208-2	20	6
1208-3	47	13
1208-4	63	16
1208 Overall	36	9

NOTE: The asterisk (*) denotes that the imagery acquired was based on 15° imagery sectors.

As can be seen from this table, front-lighting became more severe as the mission progressed. Even though there is a large increase in the number of frames affected between 1208-3 and 1208-4, the percentage of imagery affected shows only a small increase.

Different geographic latitude bands are affected by front-lighting as a function of the time of year. Mission 1208-1 imagery was mainly affected by front-lighting for acquisitions between 10° and 20° North Latitude. By the end of the 1208-3, front-lighting was affecting imagery for acquisitions between 40° and 45° North Latitude.

5.3.6.2 Specular Reflections

Specular reflections occur when solar illumination reflects from a ground object directly into the camera. Specular reflections can produce severe blooming, and can significantly affect the usefulness of the imagery for interpretation. The effects of specular reflections are more dependent on target and location than on front-lighting. Scenes with highly reflective surfaces are the most adversely affected by the problem. The amount of imagery acquired with specular reflections of 10° or less is presented in Table 5-3.

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TABLE 5-3

1208 PHOTOGRAPHY ACQUIRED WITH SPECULAR ANGLES 10° OR LESS

Mission Segment	Frames Acquired (%)	Imagery Acquired* (%)
1208-1	11	2
1208-2	18	5
1208-3	46	13
1208-4	63	16
1208 Overall	35	9

NOTE: The asterisk (*) denotes that the imagery acquired was based on 15° imagery sectors.

Since specular reflections do not occur everywhere they are predicted, the actual amount of frames and imagery affected is smaller than shown in Table 5-3. Specular angles of less than 5° can severely degrade the imagery.

5.3.6.3 High Solar Elevation Photography

Acquisitions of targets at high solar elevations tend to produce results which are similar to those of front-lighting. When the solar elevation is large, the shadows are very short; this makes the detection of small low contrast objects more difficult. Table 5-4 lists the percentage of frames acquired with a solar elevation of 70° and greater.

TABLE 5-4

MISSION 1208 PHOTOGRAPHY ACQUIRED WITH SOLAR ELEVATIONS OF 70° OR HIGHER

Mission Segment	Frames Affected (%)
1208-1	12
1208-2	29
1208-3	35
1208-4	8
1208 Overall	21

That portion of 1208 which had the highest average solar elevation (66°) and the greatest number of frames above 70° solar elevation is 1208-3. Mission 1208 also has the highest mean solar elevation of any recent 1200 Series mission, see Table 5-5.

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TABLE 5-5

MEAN MISSION SOLAR ELEVATIONS

Mission	Average Solar Elevation (degrees)
1204	31
1205	52
1206	38
1207	29
1208	60

A larger portion of 1208 was affected by high solar elevation than any other lighting condition, since high solar elevations affect the entire frame. Photography above 30° solar elevation adversely affects photographic interpretation.

5.3.7 Microscopic Plus-Density Marks (Specks)

Microscopic plus-density marks on the processed ON, first reported in the 1207 PFA Report, continue to be evident on Mission 1208 films. These marks are exposed silver within the emulsion layer of the ON and cause clear specks on the DPs used for photointerpretation.

These specks are generally circular or semi-circular shaped, appear individually but in large quantity, and in random order in affected areas. Prior evaluation of Mission 1207 films by BRIDGEHEAD indicates that the specks range in diameter from 1 micron to 12 microns with the majority being in the 4 micron to 12 micron range. Often these were in clusters of 5-30 individual specks in an area of approximately .2 mm diameter.

The specks, in many cases, give the appearance of specular or other high reflective ground targets. Complaints have been received from photointerpreters concerning these marks. The majority of specks are minute enough to cause little interference with general target interpretation, although bothersome in viewing films at high magnification. The larger specks do cause false indications of targets and therefore hinder the PIs in their interpretation. The photo scale of a 1200 Series mission is sufficiently small so that a 12 micron speck can be misinterpreted as a 4' ground object. They are objectionable and can slow down the interpretation process, especially in searching target areas for signs of new activity.

A high percentage of Mission 1208 black and white film was affected by plus-density marks. Minute specks occurred over entire frames, between frames, and over entire operations. However, there were some operations that were not affected. The anomaly occurred in both Forward and Aft Camera films, but is not evident on the natural color and false color films exposed in the Aft Camera.

The cause of this anomaly has not been determined. BRIDGEHEAD reports that it does not appear

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in raw stock which is flash exposed and spliced into the mission record for process control, nor does it appear in material supplied from the flight load prior to launch. Their testing has failed to reproduce this anomaly. The only known occurrences have appeared on material recovered from orbit. Testing is continuing to identify the cause.

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CONCLUSIONS

AND

RECOMMENDATIONS

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SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 CAMERA OPERATIONS AND PERFORMANCE

A. Mission 1208 was the longest active photographic mission to date and was terminated on Day 106 following depletion of both film supplies. In addition to its normal 1414 Film, the Aft Camera film Supply contained 2,588' of SO-255 Color Film and 3,036' of FE-3916 IR False Color Film.

B. The preflight focus setting on the Aft Camera for 1414 Film remained unchanged throughout the mission. Evaluation of the RV-1 photography indicated a need to change the Forward Camera focal plane distance by +8 microns. Focus was adjusted 30 microns for both SO-255 and FE-3916 Film; no readjustments from the preflight planned values were required.

C. Preflight synchronization settings on the OOAA for 1414 Film were verified by smear slit image displacement analysis. No changes were required on the Forward Camera in-track and Aft Camera cross-track directions. After RV-1 analysis, the Aft Camera in-track setting was changed by -3 steps, slowing down the film by approximately .024 inches/second. Because the Aft Camera in-track setting has required similar changes in the last three missions, it is recommended that a complete review of preflight procedures for setting the Aft Camera in-track direction be conducted. The Forward Camera cross-track setting was changed by +1 step, speeding up the film by approximately .013 inches/second. This change was made after RV-2 analysis as the subtlety of the change required the larger data base which was available after RV-2 recovery. Image motion variability was within the design tolerance.

D. Color film smear slit image displacement analysis was not performed on Mission 1208. However, subjective quality assessments of smear slit imagery indicated that the OOAA settings were adequate.

E. Analysis of the Aft Camera failure to transport film on Rev 1268 indicates that a relay failure caused the problem. It is recommended that all similar AVE relays be reviewed for possible related failures.

F. Small plus-density marks were found on processed film from both the Forward and Aft Cameras. These appear to be the same as those marks that were first observed on the film from Mission 1207. Investigation of this phenomenon is continuing in order to gain a better understanding of the nature and effect of the marks.

G. Edge damage which occurred in Op 562, Forward Camera, was found to be associated with an abnormal splice. It is recommended that splice-making and inspection procedures be reviewed to insure good splices in the future.

H. Mission 1208 major axis profiles were generated using a different sampling technique from that used on previous missions. This new sampling method involves selecting cultural areas at given SA/SC combinations, and then chipping these areas from a DP. The areas are then analyzed by VEM for the

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purpose of performance analysis score (PAS) of that mission. Major axis profiles so derived for 1208 show no loss in quality as a function of format position; i.e., the so called "Arch" phenomenon. However, a slight loss in performance as a function of scan angle is observed. These results raise the question as to the validity of past VEM determined major axis profiles.

I. Evaluation of the lens MTF via line CORN target deployments indicates no measurable loss between ground testing and orbital operations. It is recommended that testing of this type be discontinued due to the uncertainties in data analysis procedures and in data spreads.

J. There remains a significant difference between field curvature measured in Chamber A-2 and that measured on-orbit. The orbital data indicated a slight change in focus as a function of field angle while the ground test data indicated a significant change of up to 16 microns. Investigations to determine the source of this discrepancy are continuing.

K. The slit commands for Mission 1208 generally produced a mean scene density of 1.1 which coincided with the peak of subjective quality.

L. The Aft Camera exposure for 1414 Film was biased with respect to the Forward Camera with a two count exposure bias (-.06 log E). This bias was effective in meeting the mean scene density criterion.

M. Exposure analysis of both SO-255 and FE-3916 indicated that they were overexposed by approximately .1 log E. The Aft Camera exposure bias for 1414 was not included when using these films. It is recommended that camera related exposure biases be included in the exposure algorithms for these films on future missions.

N. Exposure analysis of snow biased operations indicated substantial underexposure due to dirty and localized snow. It is recommended that no exposure biases be used during late spring and summer operations.

6.2 PROCESSING, REPRODUCTION, AND DUPLICATE IMAGE QUALITY

A. The quality of the black and white DPs has remained consistent with those of recent 1200 Series missions. The third generation Priority 2 DPs made at BRIDGEHEAD for this mission are of acceptable quality.

B. The resolution transfer of the color DP is still inferior to that of the green record DP for SO-255 color acquisitions. The tonal range and contrast of the color DP, although acceptable, were not as good as either the green record DP or second generation DP of the black and white ON. The color balance of the color DP is good, principally due to the flashing given the SO-287 Film.

C. The low resolution of the FE-3916 False Color Film continues to be the limiting factor in the image quality of its duplicate copies. There is a concern that a more complete color gamut of IR reflectances is not being displayed on the color DP copies. It is recommended that this be investigated, and if a better duplication procedure is found, that it be implemented.

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6.3 EXPLOITATION SUITABILITY

A. The interpretability of the black and white photography was typical of the most recent 1200 Series missions. The majority of targets read out by NPIC fell in the 4 and 5 NIIRS categories, with a range of 1 to 6.

B. The fogged 1414 Film on RV-1 resulted in 10% fewer targets with a NIIRS rating of 5 or 6 compared to the unfogged film. It is recommended that more stringent control procedures be instituted to keep fogged film from being used in flight rolls of future missions.

C. The interpretation suitability of the color duplicate positives was the best to date. Forty-six percent of the photointerpreters surveyed at NPIC stated that they would accept occasional SO-255 color coverage of military targets for possible supplementary intelligence information. The FE-3916 False Color Film yields DPs which are poor for military intelligence uses, but good for economic intelligence.

D. The conditions of front-lighting, specular reflection, and high solar elevations existing at the instant of acquisition lowered the interpretation suitability of some of the photography from Mission 1208. For good interpretability, the CATS angle should be no less than 7°, the specular reflectance angle no less than 5°, and the solar elevation no higher than 80 degrees. It is recommended that the possible degrading effects of these acquisition conditions be taken into account for future 1200 Series mission photography.

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STATUS OF PFA RECOMMENDATIONS TO DATE

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SECTION VII

STATUS OF PFA RECOMMENDATIONS TO DATE

7.1 INTRODUCTION

This section summarizes the actions taken on PFA recommendations from Mission 1207, as well as those from previous missions for which action had not been completed at the time of publication of the 1207 PFA Report.

7.2 CAMERA-RELATED RECOMMENDATIONS

7.2.1 Mission 1205

A. RECOMMENDATION: The image quality of the photography acquired during this mission was affected in a major way by atmospheric haze and poor weather. The PFA Team believes that, to some extent, this situation was aggravated by the relatively late launch time and hence post-noon acquisition times over the targets. It is recommended that the haze formation versus time of day study currently underway by Global Weather Central (GWC) be completed as soon as possible, and that this be factored into the launch time decisions. In addition, the factors discussed in PFA Technical Report No. 4, (The Effects of Launch Time on Photographic Quality) should be given consideration in the launch time selection.

ACTION: Missions 1206, 1207, and 1208 were affected by haze. Summer missions are more susceptible to the heavy haze conditions that exist during June, July, and August. The impact of the launch times on image acquisitions should be a primary factor in planning any mission but during summer operations this impact is much more significant. Study of this problem is continuing.

B. RECOMMENDATION: Based on AUGIE reports, steerer carriage position offsets were indicated when the rewind constraint was relaxed, thus indicating different tracking. It is recommended that prelaunch steerer carriage position offsets and post-launch offsets be compared operation-by-operation with mis-stacking evidenced in some way by the film (dots, rubs, or TU mistracking), to determine the utility of carriage position telemetry.

ACTION: Carriage position offsets have been found to correlate with the direction of dot placement on the film. In addition, some carriage position fluctuations have been correlated with mis-stacking on the Take-up. The difficulty in employing the carriage position telemetry to analyze stacking arises from the fact that carriage position offsets and fluctuations can occur as a result of misalignments and film edge variations which do not affect stacking. The carriage position telemetry has limited utility in determining mis-stacking and mistracking in the quantitative level necessary to make rewind decisions. This analysis completes the action on the PFA recommendation.

C. RECOMMENDATION: On-axis measurements of the orbital lens MTF are in reasonable agreement with Chamber A-2 results. However, the off-axis MTFs appear lower for the orbital case.

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This result should be evaluated on future systems in greater depth since it could be an indication of a change in performance between the laboratory and orbit cases.

ACTION: The line-lens MTF study was repeated on 1208 and is reported in paragraph 3.5.5.

7.2.2 Mission 1207

A. RECOMMENDATION: Preflight synchronization settings on the OOAA for 1414 Film required a change on the Aft Camera in the in-track direction. Similar corrections were required on Missions 1206 and 1208. It is recommended that the ground tests used to set the Aft Camera in-track film speed be reviewed for possible sources of error.

ACTION: Analysis and testing are continuing to determine if a systematic error exists in setting the Aft Camera in-track film speed prior to launch.

B. RECOMMENDATION: Analysis of the film tear on Mission 1207 indicated that a connector cap most probably was ingested into the Take-up and caused the tear. It is recommended that specific corrective action be taken to control the use of connector caps and all such loose AGE equipment to preclude their inclusion with the AVE.

ACTION: A coordinated effort among all associate contractors and the SPO has resulted in specific procedures for handling loose AGE equipment. This action completed the PFA recommendation.

C. RECOMMENDATION: Microscopic plus-density marks appear periodically on the mission photography, more so on the Forward than on the Aft Camera. It is recommended that an investigation of 1208 film and test film be conducted.

ACTION: Investigation is continuing.

D. RECOMMENDATION: It is recommended that possible sources of field curvature discrepancies between ground test and on-orbit data be identified and investigated.

ACTION: Investigation is continuing.

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GLOSSARY

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APPENDIX A

GLOSSARY OF TERMS

ABCC	Actinic Butterfly Contrast Control
ACC Mode	Software Option that Finds Areas of Intelligence Value for a Rev Span.
ACS	Attitude Control System.
AFSPPF	Air Force Special Projects Production Facility.
Aft	Aft-looking Camera, Camera B.
AIM	Aerial Image Modulation.
AOB	Air Order of Battle.
AOES/System II	General Purpose Satellite Flight Support Software at STC.
AUGIE	Acronym for Data Compression Technique Used for RTS to STC Data Transmission.
AVE	Aerospace Vehicle Equipment.
BBRT	Bird Buffer Retrieval Tape. Records at STC from Transmissions from RTS.
BRIDGEHEAD	Primary Film Processing and Immediate Post Flight Evaluation Facility.
BUFT	Backup Film Transport.
C-	Camera Power-off Command.
C+	Camera Power-on Command.
CATS	Camera, Target, and Sun Angular Relationship
CEI	Contract End Item.
CEWG	Color Evaluation Working Group.
Chamber A	Photographic Vacuum Test Chamber Located at East Coast SSC Facility.
Chamber A-2	Photographic Vacuum Test Chamber Located at SVIC Facility.
CIE	Commission Internationale de l'E' clairage (lighting).
c/mm	Cycles Per Millimeter.
COMIREX	USIB Committee on Imagery Requirements and Exploitation.
CORN	Controlled Range Network.
CORREL	On-orbit Adjust Assembly Calibration Test Program.
CRYSPER	On-orbit Performance Prediction Program Combining Target Acquisition, Atmospheric, Illumination, and Camera Performance Models.
CRYSTAL BALL	Photometric Atmospheric Model Computer Program. Used to Calculate Exposure for Orbital Acquisitions.
CV	Constant Velocity.
CW	Continuous Wave.
DEA	Decision Element Array.
DGMAP	Computer Program for Magnetic Force Field Predictions.

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APPENDIX A (CONT'D)

DIM	Dynamic Image Motion.
D log E Curve	Sensitometric Response of Film to Light. Plot of Density to Log of Exposure.
DMAAC	Defense Mapping Agency Aerospace Center.
DMATC	Defense Mapping Agency Topographic Center.
DN	Duplicate Negative.
DP	Duplicate Positive.
DRAP	Pulse Code Modulation TM Data Retrieval and Analysis Program.
DREWL	Double Row East-West Line CORN Target.
ECO	Engineering Change Order.
ECS	Extended Command System.
EM	Electromechanical.
EMI	Electromagnetic Interference.
END	Equivalent Neutral Density.
EOD	Electro-Optical Division of SSC.
ESD	Emergency Shutdown.
EXSUBCOM	Exploitation Subcommittee of COMIREX.
EXTREFLS	Focal Plane Position Transducer and LSFS Reading Extractor Program.
FAFXTR	Program that Locates CORN Deployed Targets and Edge Catalog Targets.
FAK	Forward Assembly Kit.
FBS	Film-to-Bar Synchronization
FFL	Flauge Focal Length.
FIDAP	Flash Image Displacement Analysis Program.
FOCMO	Thru Focus Motion Plot and Line Indicated Focus Program.
Fwd	Forward-looking Camera, Camera A.
FPP	Focal Plane Position.
fps	Feet Per Second.
FT	Film Transport.
FT +	Film Transport-on Command.
FT -	Film Transport-off Command.
FTFD	Field Test Force Director.
GAWA	Grand Area Weighted Average.
GMT	Greenwich Mean Time.
GOB	Ground Order of Battle.

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

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REV	Orbital Revolution.
RMS	Root Mean Square.
ROM	Rough Order of Magnitude.
RTS	Remote Tracking Station.
RV	Recovery Vehicle.
SAL	Scan Angle Length.
SBA	Satellite Basic Assembly.
SBAC	Satellite Basic Assembly Contractor.
SCF	Satellite Control Facility.
SE OT	Sensor Event Generator.
SLC-4E	Space Launch Complex-4 East.
SOC	Satellite Operation Center.
SOF	Start of Frame.
Solo	System Engineering Test after Fourth RV Separation.
SS	Sensor Subsystem.
SSC	Sensor Subsystem Contractor.
SSTC	Sensor Subsystem Test Console.
STC	Satellite Test Center.
SU	Supply Unit.
SURVEY	Quick-look Time and Data Characteristics Program.
SV	Satellite Vehicle.
SVFRT	Satellite Vehicle Frame Reference Time.
SVIC	Satellite Vehicle Integrating Contractor.
SVT	Satellite Vehicle Time.
SWA	Forward Camera Slit Width.
SWB	Aft Camera Slit Width.
SYNCER	FIDAP Subroutine for Determining Film Synchronization Error.
TBALL	'TUNITY Executive Program for the Sensor Event Generator.
TCA	Two-Camera Assembly.
THISUM	Command Message Update in History Generator for 'TUNITY.
TM	Telemetry.
TMOTION	Estimate of Image Smear Program for Laboratory Tests.
TOBACC	Time for OB Velocity Command.

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

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BASIC

ORBITAL PARAMETERS

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APPENDIX B

BASIC ORBITAL PARAMETERS

Day	Rev	Period (min/sec)	Perigee (NM)	Apogee (NM)	Inclination (degrees)	Argument of Perigee (degrees)	Beta Angle
0	Nom	88:59	85.5	162.9	94.5	143.4	
0	1	89:00	85.5	164.5	94.5	141.0	-2.6
1	8	88:58	85.6	163.5	94.5	138.9	-2.6
2	24	88:54	85.6	161.0	94.5	134.8	-2.3
3	40	88:50	85.6	158.4	94.5	130.6	-2.1
OA-1	46						
4	57	88:57	85.8	165.1	94.5	130.9	-1.9
5	73	88:53	85.7	162.7	94.5	126.7	-1.7
6	89	88:48	85.7	160.1	94.5	122.7	-1.5
OA-2	94						
OA-3	96						
7	105	88:58	85.4	161.1	94.5	147.5	-1.3
8	121	88:54	85.4	158.5	94.5	143.2	-1.1
9	138	88:48	85.3	155.0	94.5	138.4	-0.9
OA-4	143						
10	156	88:58	85.5	162.4	94.5	140.4	-0.7
11	170	88:53	85.4	159.5	94.5	136.1	-0.5
12	186	88:47	85.3	156.5	94.5	132.0	-0.3
OA-5	192						
13	202	88:58	85.4	165.4	94.5	133.9	-0.1
14	218	88:54	85.4	162.5	94.5	129.8	0.1
15	235	88:48	85.4	159.1	94.5	125.3	0.3
OA-6	240						
OA-7	242						
16	251	88:58	85.5	160.7	94.5	147.2	0.5
17	267	88:54	85.5	158.0	94.5	143.0	0.8
18	283	88:49	85.4	155.2	94.5	138.8	1.0
OA-8	289						
19	299	88:58	85.6	162.7	94.5	140.1	1.2

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Day	Rev	Period (min sec)	Perigee (NM)	Apogee (NM)	Inclination (degrees)	Argument of Perigee (degrees)	Beta Angle
20	313	88:53	85.5	160.2	94.5	135.5	1.4
21	332	88:47	85.5	156.3	94.5	131.2	1.6
OA-9	337						
22	348	88:59	85.7	166.2	94.5	133.4	1.9
23	364	88:54	85.6	163.1	94.5	129.6	2.1
24	380	88:48	85.4	159.5	94.5	125.5	2.3
OA-10	386						
OA-11	388						
25	397	88:58	85.6	160.3	94.5	147.2	2.5
26	413	88:52	85.4	157.2	94.5	142.8	2.7
27	429	88:47	85.2	154.2	94.5	138.4	3.0
OA-12	434						
28	445	88:58	85.6	162.0	94.5	141.8	3.2
29	461	88:53	85.5	159.1	94.5	137.6	3.5
30	477	88:47	85.4	155.8	94.5	133.3	3.7
OA-13	483						
31	494	88:59	85.4	165.3	94.5	135.4	3.9
32	510	88:54	85.5	162.5	94.5	131.1	4.2
33	526	88:49	85.4	159.5	94.5	127.0	4.4
OA-14	532						
OA-15	534						
34	542	88:59	85.6	161.0	94.5	147.9	4.7
35	558	88:54	85.5	158.3	94.5	143.5	4.9
36	575	88:48	85.4	154.6	94.5	138.8	5.2
OA-16	580						
37	591	88:57	85.6	161.8	94.5	140.7	5.5
38	607	88:51	85.4	158.6	94.5	136.5	5.7
39	623	88:46	85.3	155.4	94.5	132.3	6.0
OA-17							
40	639	89:00	85.5	166.3	94.5	135.6	6.2

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Day	Rev	Period (min/sec)	Perigee (NM)	Apogee (NM)	Inclination (degrees)	Argument of Perigee (degrees)	Beta Angle
41	655	88:55	85.5	163.4	94.5	131.4	6.5
42	672	88:50	85.5	160.4	94.5	126.9	6.8
OA-18	683						
43	688	88:58	85.8	166.6	94.5	128.3	7.0
44	704	88:53	85.7	163.3	94.5	124.3	7.3
45	720	88:46	85.5	159.5	94.5	120.4	7.6
OA-19	726						
OA-20	728						
46	736	88:59	85.3	161.9	94.5	148.5	7.8
47	753	88:54	85.4	158.7	94.5	143.6	8.1
48	769	88:49	85.4	155.7	94.5	139.2	8.4
OA-21	774						
49	785	88:59	85.6	163.0	94.5	141.1	8.6
50	805	88:49	85.6	160.1	94.5	136.9	8.9
51	817	88:48	85.5	156.6	94.5	132.7	9.2
OA-22	823						
52	834	88:58	85.5	164.9	94.5	133.8	9.5
53	850	88:52	85.3	161.3	94.5	129.6	9.8
54	866	88:51	85.1	157.7	94.5	125.5	10.1
OA-23	871						
55	882	88:59	85.6	167.6	94.5	129.6	10.3
56	896	88:54	85.5	164.3	94.5	125.5	10.6
57	914	88:49	85.4	160.8	94.5	121.4	10.9
OA-24	920						
OA-25	922						
58	931	88:58	85.6	160.6	94.5	147.6	11.2
59	947	88:53	85.5	157.8	94.5	143.1	11.5
60	963	88:48	85.4	154.9	94.5	138.7	11.8
OA-26	975						
61	979	88:59	85.6	162.9	94.5	142.5	12.1

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Day	Rev	Period (min sec)	Perigee (NM)	Apogee (NM)	Inclination (degrees)	Argument of Perigee (degrees)	Beta Angle
62	996	88:53	85.6	159.5	94.5	138.2	12.4
63	1012	88:47	85.5	155.4	94.5	133.5	12.8
OA-27	1017						
64	1029	88:59	85.6	165.5	94.5	136.4	13.1
65	1044	88:54	85.5	162.2	94.4	132.2	13.4
66	1060	88:49	85.4	158.7	94.4	128.1	13.7
OA-28	1065						
67	1076	88:57	85.7	165.2	94.4	130.2	14.0
68	1092	88:52	85.7	161.7	94.4	126.1	14.3
69	1109	88:44	85.6	156.8	94.4	121.5	14.6
OA-29	1120						
70	1125	89:06	85.7	174.1	94.5	127.0	14.9
71	1141	88:59	85.6	169.8	94.5	122.8	15.2
72	1157	88:53	85.5	165.9	94.4	118.9	15.5
OA-30	1162						
OA-31	1164						
73	1173	88:58	85.5	160.2	94.4	147.7	15.9
74	1190	88:52	85.5	157.0	94.4	143.0	16.2
75	1206	88:46	85.3	153.5	94.4	138.5	16.5
OA-32	1211						
76	1222	88:57	85.6	161.8	94.4	141.1	16.8
77	1238	88:52	85.5	158.7	94.4	137.0	17.1
78	1254	88:45	85.3	154.1	94.4	132.8	17.4
OA-33	1260						
79	1270	88:59	85.5	164.9	94.4	137.5	17.8
OA-34	1282						
80	1286	88:55	85.6	162.3	94.4	134.1	18.1
81	1303	88:49	85.4	158.5	94.4	129.9	18.4
OA-35	1313						
82	1321	88:59	85.9	166.2	94.4	133.0	18.8

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APPENDIX B (CONT'D)

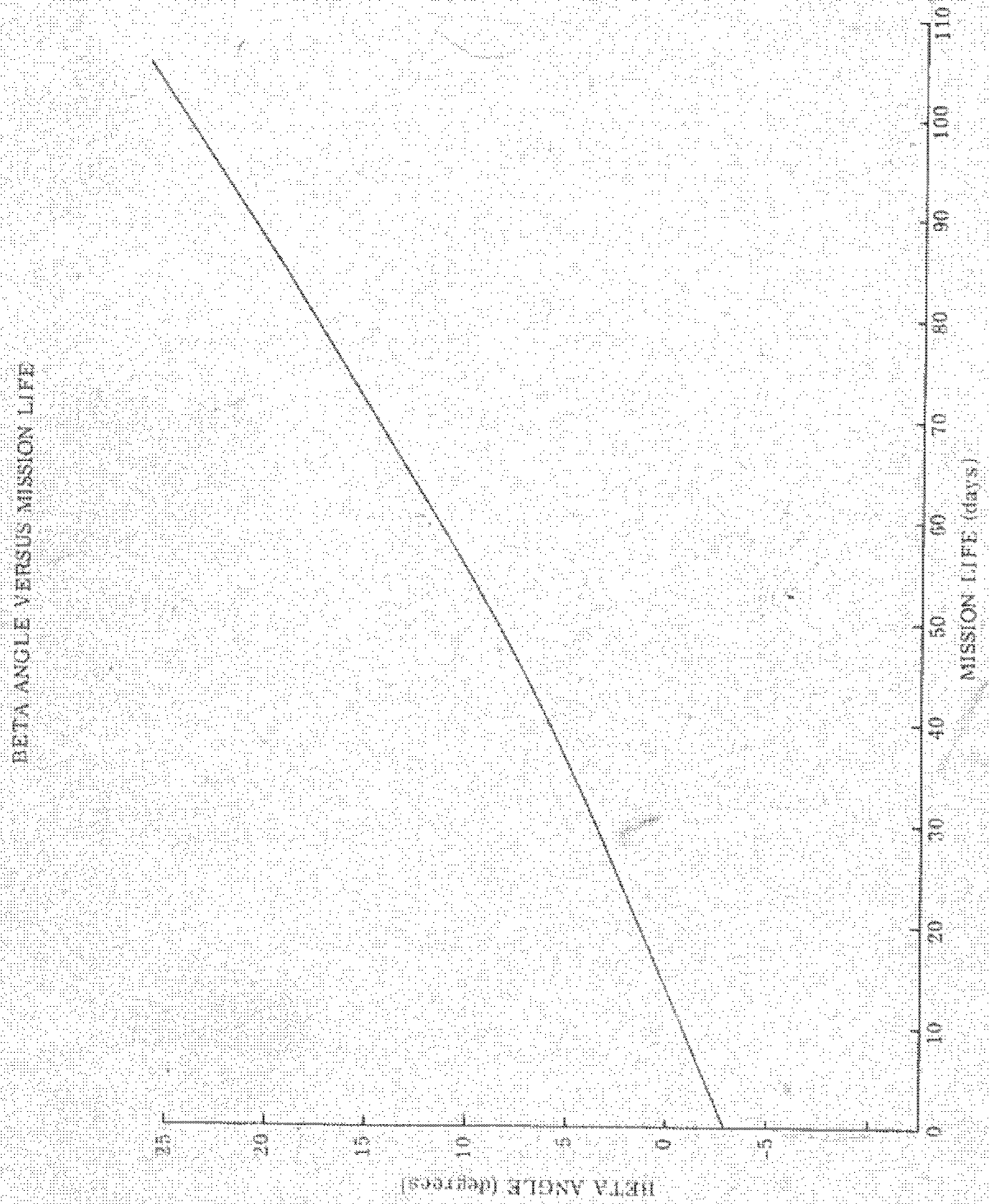
Day	Rev	Period (min sec)	Perigee (NM)	Apogee (NM)	Inclination (degrees)	Argument of Perigee (degrees)	Beta Angle
83	1335	88:55	85.9	163.3	94.4	129.3	19.1
84	1351	88:49	85.7	159.5	94.4	125.2	19.4
OA-36	1357						
85	1368	88:57	85.7	167.3	94.4	125.9	19.8
86	1384	88:50	85.5	162.8	94.4	121.8	20.1
87	1400	88:42	84.9	156.8	94.4	117.6	20.4
OA-37	1406						
OA-38	1408						
88	1416	89:02	85.8	164.3	94.4	148.0	20.8
89	1432	88:57	85.6	160.7	94.4	143.6	21.1
90	1449	88:50	85.5	156.3	94.4	138.0	21.4
91	1465	88:44	85.2	152.3	94.4	134.4	21.8
92	1481	88:37	84.9	147.8	94.4	129.9	22.1
93	1497	88:29	84.5	142.9	94.4	125.5	22.4
OA-39	1502						
94	1513	88:49	85.8	155.1	94.4	136.0	22.8
95	1530	88:42	85.7	151.2	94.4	133.2	23.1
96	1546	88:36	85.5	147.2	94.4	128.8	23.4
OA-40	1551						
97	1562	88:48	85.9	155.1	94.4	134.3	23.8
98	1578	88:42	85.7	151.3	94.4	130.0	24.1
99	1594	88:35	85.5	147.2	94.4	125.7	24.4
OA-41	1600						
100	1611	88:47	85.8	156.1	94.4	130.3	24.8
OA-42	1616						
101	1627	88:46	85.9	155.6	94.4	128.6	25.1
102	1643	88:39	85.6	151.8	94.4	124.6	25.4
OA-43	1649						
103	1659	88:41	85.5	153.1	94.4	123.9	25.8
104	1676	88:33	85.2	148.3	94.4	119.3	26.1
105	1692	88:24	84.3	141.4	94.4	115.0	26.5

BYE 15256-75

Handle via byeman
Controls Only

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BYE 15256-75

FIGURE B-1

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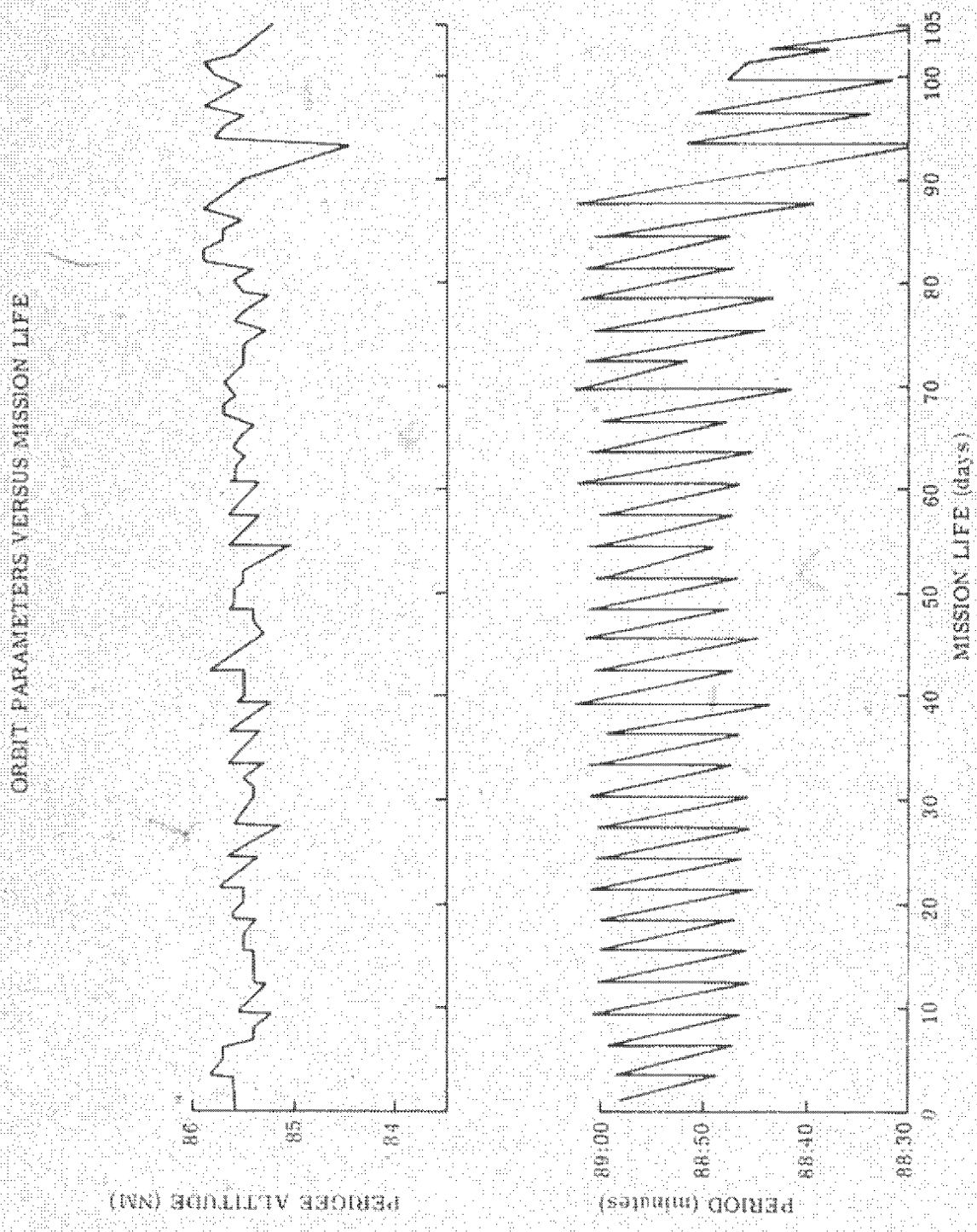


FIGURE B-2

BYE 15256-75

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CAMERA OPERATIONS

SUMMARY

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APPENDIX C

CAMERA OPERATIONS SUMMARY

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
PRE	LO	60	0	6	6	72	78	33	33	105	111
PRE	LO	60	0	6	6	35	34	33	33	170	178
PRE	LO	30	30	6	6	76	94	17	17	266	264
PRE	LO	60	15	7	4	11	20	40	23	317	307
PRE	LO	30	30	6	6	3	11	17	17	337	335
PRE	LO	60	15	7	4	11	20	40	23	388	378
PRE	LO	120	0	8	8	38	70	87	87	513	535
PRE	LO	120	0	8	8	111	111	87	87	711	733
PRE	LO	60	0	6	6	81	65	33	33	825	831
PRE	LO	60	0	6	6	31	31	33	33	889	895
PRE	LO	60	0	6	6	31	31	33	33	953	959
PRE	LO	30	30	6	6	68	53	17	17	1018	1029
PRE	LO	60	15	7	4	11	20	40	23	1089	1072
PRE	LO	60	0	6	6	8	163	33	33	1130	1268
PRE	LO	30	30	6	6	26	18	17	17	1173	1303
PRE	LO	60	15	7	4	11	20	40	23	1224	1346
PRE	LO	120	0	8	8	38	70	87	87	1349	1503
PRE	LO	120	0	8	8	111	111	87	87	1547	1701
PRE	LO	60	0	6	6	81	65	33	33	1661	1799
PRE	LO	60	0	6	6	31	31	33	33	1725	1863
PRE	LO	60	0	6	6	31	31	33	33	1789	1927
PRE	LO	60	0	6	6	31	31	33	33	1853	1991
1208 4	1	60	0	6	6	126	126	33	33	2012	2150
4	2	60	-15	6	6	24	25	33	33	2069	2208
4	3	60	30	6	6	36	35	33	33	2138	2276
5	4	30	-30	50	50	30	24	145	145	2313	2445
6	5	60	0	31	31	22	30	171	171	2506	2646
7	6	90	0	38	38	48	55	309	309	2862	3009
7	7	60	0	7	7	44	33	20	20	2931	3062
8	8	60	0	6	6	19	29	33	33	2993	3123
8	9	60	30	16	16	36	34	88	88	3107	3245
9	10	60	-15	16	16	35	37	88	88	3230	3370
10	11	90	0	68	68	46	53	551	551	3827	3974
10	12	90	0	23	23	67	67	186	186	4080	4227
14	13	30	0	14	14	49	33	43	40	4156	4303
14	14	30	0	5	5	14	14	14	14	4197	4329
19	15	30	30	7	7	14	13	20	20	4231	4362
21	16	30	-45	53	53	14	14	146	149	4393	4524
21	17	60	15	23	23	21	29	127	127	4541	4680
23	18	90	0	25	25	50	57	203	203	4796	4940
24	19	60	-30	23	23	55	68	127	127	4976	5115
25	20	30	-30	10	10	28	20	28	28	5032	5163
25	21	60	-15	8	8	20	23	44	44	5096	5235
25	22	90	0	68	68	46	53	551	551	5693	5839
25	23	90	15	15	15	67	66	122	122	5882	6027
26	24	90	0	28	28	67	67	227	227	6174	6321
26	25	90	0	50	50	55	48	275	275	6506	6644
26	26	30	30	29	29	29	22	81	81	6616	6747
27	27	30	45	25	25	14	14	73	73	6703	6834
28	28	30	45	16	16	13	13	46	46	6762	6893
28	29	120	0	62	62	36	70	564	564	7462	7527

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
38	30	60	-30	36	36	79	84	198	198	7739	7894
38	31	60	15	13	13	37	36	72	72	7846	7997
39	32	90	15	22	22	44	51	178	178	8070	8225
41	33	60	-30	35	35	52	46	193	193	8315	8455
41	34	90	0	109	109	50	57	875	875	9240	9397
41	35	60	15	18	18	57	49	99	99	9396	9545
41	36	30	30	28	28	30	22	81	81	9507	9648
42	37	60	15	19	19	21	29	105	105	9633	9782
43	38	60	-30	26	26	34	36	143	143	9810	9951
48	39	60	-15	33	33	36	35	182	182	10028	10175
53	40	30	-15	29	29	30	21	84	84	10147	10283
54	41	30	45	7	7	14	14	20	20	10176	10317
56	42	30	45	13	13	14	14	38	38	10228	10369
57	43	90	0	89	89	32	48	720	720	10980	11137
57	44	30	0	5	5	49	33	15	15	11044	11195
58	45	90	-15	122	122	30	47	988	988	12062	12220
58	46	30	-30	7	7	49	33	20	20	12131	12273
59	47	60	15	31	31	21	28	171	171	12323	12472
68	48	30	0	4	4	29	21	12	12	12364	12505
70	49	60	15	22	22	22	23	121	121	12507	12655
71	50	120	0	35	35	64	81	375	375	12946	13111
73	51	90	15	65	65	91	83	527	527	13564	13721
76	52	90	0	16	16	68	58	130	130	13762	13919
80	53	90	0	37	37	67	67	300	300	14129	14286
81	54	30	0	14	14	50	35	41	41	14220	14362
86	55	60	-30	20	20	22	31	110	110	14352	14503
87	56	60	-30	26	26	38	39	143	143	14533	14684
87	57	120	0	69	69	67	81	728	728	15328	15493
88	58	90	0	25	25	90	82	203	203	15621	15778
89	59	60	15	10	10	57	48	55	55	5733	15891
89	60	30	30	26	26	29	22	75	75	15837	15978
89	61	90	0	26	26	33	50	211	211	16081	16239
90	62	60	-15	12	12	58	50	66	66	16205	16355
96	63	60	-30	8	8	37	37	44	44	16286	16436
97	64	60	30	16	16	37	35	89	98	16411	16559
103	65	90	0	86	86	45	54	697	697	17153	17310
104	66	60	-15	38	38	52	45	209	209	17414	17586
104	67	90	15	28	28	43	44	227	227	17684	17840
105	68	60	0	41	41	52	45	226	226	17962	18111
105	69	120	0	35	35	62	78	375	375	18399	18564
106	70	30	-30	65	65	71	48	189	189	18659	18801
106	71	60	30	34	34	21	29	187	187	18857	19016
113	72	30	30	8	8	29	21	23	23	18919	19060
117	73	60	-15	45	45	20	28	248	248	19197	19336
118	74	30	0	7	7	28	20	20	20	19235	19376
119	75	30	-30	20	20	13	14	58	58	19306	19444
119	76	30	15	25	25	14	13	73	73	19393	19534
120	77	60	-15	31	31	20	29	171	171	19584	19734
121	78	60	15	38	38	34	33	209	209	19827	19976
121	79	30	45	22	22	28	20	64	64	19919	20060
122	80	90	0	37	37	33	50	300	300	20252	20410
123	81	30	-30	6	6	48	32	17	17	20317	20459
123	82	90	0	35	35	31	46	284	284	20632	20789
123	83	30	-15	31	31	47	32	90	90	20769	20911
129	84	30	0	6	6	15	14	17	17	20801	20942
134	85	30	-45	4	4	14	15	12	12	20827	20969
135	86	30	45	31	31	14	13	90	90	20931	21072

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
137	87	30	-15	10	10	13	14	29	29	20973	21116
137	88	60	+30	13	13	21	30	72	72	21066	21217
137	89	60	0	17	17	37	36	94	94	21197	21347
137	90	90	0	39	39	50	56	316	316	21563	21721
138	91	60	15	12	12	46	47	66	66	21695	21834
139	92	30	0	13	13	28	20	38	38	21751	21892
139	93	60	-15	7	7	21	30	30	30	21811	21951
144	94	30	-15	14	14	30	22	41	41	21882	22024
152	95	60	30	19	19	21	28	105	105	22098	22157
153	96	30	+4.5	4	6	28	21	17	17	22053	22195
153	97	90	0	49	49	32	47	397	397	22432	22639
153	98	60	-30	30	30	54	58	165	165	22701	22852
154	99	60	15	37	37	38	36	204	204	22943	23092
155	100	30	30	11	11	28	21	32	32	23003	23145
155	101	60	-15	56	56	20	28	309	309	23331	23481
155	102	90	15	19	19	49	58	156	156	23534	23691
160	103	60	30	10	10	57	45	55	55	23647	23795
165	104	30	0	4	4	25	22	12	12	23697	23837
167	105	30	15	15	15	14	13	44	44	23745	23986
168	106	60	30	19	19	21	28	105	105	23871	24019
169	107	90	0	44	44	47	56	356	356	24274	24431
170	108	30	30	34	34	49	33	97	97	24420	24561
171	109	30	-30	9	9	14	15	26	26	24460	24602
171	110	60	-15	21	21	21	29	116	116	24597	24747
171	111	60	15	16	16	37	36	88	88	24722	24871
171	112	60	30	16	16	38	38	88	88	24848	24997
172	113	60	15	19	19	36	36	105	105	24989	25138
176	114	60	0	15	15	37	37	83	83	25109	25258
184	115	90	0	35	35	49	57	284	284	25442	25599
185	116	60	30	19	19	57	49	105	105	25604	25753
186	117	60	-15	12	12	36	38	66	66	25706	25857
188	118	60	30	52	52	36	34	286	286	26028	26177
199	119	60	0	7	7	36	37	39	39	26103	26253
200	120	30	45	8	8	29	20	23	23	26155	26295
200	121	120	0	34	34	50	74	364	364	26569	26734
201	122	30	0	10	10	74	51	29	29	26672	26814
202	123	60	0	46	46	21	29	253	253	26946	27095
203	124	30	30	31	31	29	21	90	90	27065	27206
216	125	30	30	14	14	14	14	41	41	27120	27261
216	126	120	0	36	36	51	75	385	385	27556	27721
216	127	60	15	19	19	82	65	105	105	27743	27891
218	128	30	15	4	4	29	22	12	12	27784	27925
218	129	60	0	22	22	22	30	121	121	27927	28076
225	130	30	30	7	7	29	21	20	20	27976	28117
225	131	60	0	4	2	21	30	22	15	28019	28162
1208-2 225	131	60	0	7	9	0	0	43	51	43	51
230	132	30	-30	4	4	89	81	12	12	144	144
232	133	60	15	31	31	22	29	171	171	337	344
232	134	90	0	59	59	49	57	478	478	864	879
235	135	30	-15	6	6	49	33	17	17	930	929

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
236	136	60	0	8	8	20	29	44	44	994	1002
236	137	30	30	8	8	29	20	23	23	1046	1045
247	138	120	0	26	26	38	62	278	278	1362	1385
248	139	60	15	14	16	69	53	88	88	1519	1526
248	140	30	-30	26	26	28	21	75	75	1622	1622
248	141	90	-15	54	54	35	51	437	437	2094	2110
249	142	90	0	19	19	69	69	154	154	2317	2332
250	143	60	15	31	31	54	46	171	171	2542	2549
250	144	90	0	10	10	47	55	81	81	2670	2685
251	145	60	15	16	16	54	46	88	88	2812	2819
251	146	60	15	44	46	37	37	242	242	3091	3098
252	147	60	-15	8	8	34	35	46	44	3169	3177
252	148	30	-15	16	16	27	19	46	46	2342	3242
253	149	30	15	10	10	14	13	29	29	3295	3284
253	150	60	-15	23	23	20	29	127	127	3432	3440
258	151	30	-15	6	6	30	22	17	17	3479	3479
268	152	30	-30	23	23	14	13	67	67	3560	3559
268	153	30	-30	14	14	14	15	41	41	3615	3615
269	154	60	15	16	16	20	27	88	88	3723	3730
273	155	60	15	16	16	35	35	88	88	3846	3853
281	156	90	15	98	98	48	56	794	794	4688	4703
282	157	90	0	19	19	62	63	154	154	1904	4920
284	158	60	0	19	19	50	42	105	105	5059	5067
285	159	60	0	16	16	35	34	88	88	5182	5189
291	160	30	0	13	13	28	21	38	38	5248	5248
279	161	120	0	35	35	51	74	375	375	5674	5697
300	162	60	15	25	25	80	64	138	138	5992	5899
300	163	60	-15	16	16	37	38	88	88	6017	6025
301	164	90	0	68	68	46	54	551	551	6614	6630
313	165	30	45	26	26	48	31	81	81	6743	6742
313	166	90	-15	42	42	32	50	340	340	7115	7132
314	167	120	0	29	29	85	91	310	310	7510	7533
329	168	60	0	31	31	81	65	171	171	7762	7759
329	169	30	30	11	11	29	21	32	32	7823	7822
329	170	30	-30	24	24	14	14	70	70	7907	7906
330	171	60	15	43	43	22	30	237	237	8166	8173
331	172	60	-30	8	8	37	37	44	44	8247	8254
332	173	30	30	22	22	29	21	64	64	8340	8339
338	174	30	30	16	16	14	14	46	46	8400	8399
338	175	30	0	8	8	14	15	23	23	8437	8437
338	176	30	15	8	8	14	13	23	23	8474	8473
343	177	30	-15	4	4	14	15	12	12	8500	8500
345	178	60	0	61	61	22	29	336	336	8858	8865
346	179	30	-15	16	16	29	22	46	46	8933	8933
346	180	30	30	13	13	14	13	38	38	8985	8986
347	181	30	-45	14	14	14	15	41	41	9040	9040
347	182	30	-45	17	17	14	14	49	49	9103	9103
348	183	30	0	25	25	14	14	73	73	9190	9190
348	184	30	-30	9	9	14	14	26	26	9230	9230
349	185	60	0	32	32	22	29	176	176	9428	9435
355	186	30	-30	14	14	29	22	41	41	9498	9498
356	187	30	30	11	11	15	13	32	32	9845	9543
359	188	30	45	4	4	14	14	12	12	9571	9569
361	189	60	-15	34	34	22	30	187	187	9780	9786
363	190	120	0	28	28	64	80	300	300	10144	10166
364	191	60	-30	11	11	80	65	61	61	10285	10292
365	192	30	-45	13	0	30	0	38	0	10353	10292

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
365	193	30	0	6	6	14	21	17	17	10384	10330
370	194	30	45	10	10	13	13	29	29	10426	10372
376	195	30	45	25	0	13	0	73	0	10512	10372
378	196	30	0	19	19	14	14	55	55	10581	10441
379	197	30	-15	9	9	14	14	26	26	10621	10481
379	198	30	45	13	13	14	13	38	38	10673	10532
381	199	30	-30	4	4	14	15	12	12	10699	10559
381	200	30	30	43	43	14	13	125	125	10838	10697
382	201	30	45	7	7	14	14	21	21	10873	10732
383	202	30	45	7	7	15	15	21	21	10909	10768
384	203	30	-30	4	4	14	15	12	12	10935	10795
394	204	90	0	28	0	27	0	227	0	11189	10795
394	205	30	-15	4	4	44	14	12	12	11245	10821
396	206	60	0	15	15	22	29	93	93	11350	10933
396	207	60	15	35	35	35	35	109	109	11578	11161
396	208	90	-15	30	30	46	55	243	243	11867	11459
396	209	30	30	11	11	46	31	32	32	11947	11522
396	210	30	-30	63	63	14	15	183	183	12144	11720
399	211	30	15	19	19	14	12	55	55	12213	11787
399	212	30	45	10	10	12	13	29	29	12254	11829
410	213	30	-30	17	17	14	15	49	49	12317	11893
411	214	90	15	31	0	28	0	251	0	12596	11893
412	215	60	15	29	29	50	27	160	160	12806	12080
412	216	60	-30	30	30	35	37	165	165	13006	12242
412	217	30	-15	23	23	30	21	67	67	13103	12370
413	218	30	45	16	16	14	13	46	46	13163	12429
413	219	30	-15	6	6	14	15	17	17	13194	12461
413	220	30	-45	9	9	14	14	26	26	13234	12501
414	221	30	0	10	10	14	13	29	29	13277	12543
414	222	30	15	4	4	13	14	12	12	13302	12569
415	223	30	-30	11	11	14	14	32	32	13348	12615
428	224	90	0	35	35	32	47	284	284	13664	12946
429	225	90	0	23	23	54	47	127	127	13845	13120
430	226	30	45	19	19	29	30	55	55	13929	13195
430	227	30	0	30	30	14	15	87	87	14030	13297
435	228	60	30	14	14	21	29	77	77	14129	13402
435	229	30	-15	5	5	30	23	15	15	14173	13440
443	230	60	0	35	35	20	27	193	193	14386	13660
443	231	30	-30	25	25	28	21	73	73	14487	13754
445	232	30	-15	25	25	14	14	73	73	14574	13841
446	233	60	-15	22	22	22	30	121	121	14717	13982
451	234	30	0	12	12	30	22	35	35	14782	14040
459	235	30	30	10	10	14	13	29	29	14825	14091
459	236	60	-15	19	19	22	31	105	105	14952	14227
460	237	30	0	4	4	30	22	12	12	14994	14261
461	238	60	0	19	19	20	27	105	105	15119	14393
461	239	90	0	27	27	45	53	219	219	15383	14665
462	240	30	30	28	28	48	32	81	81	15512	14778
462	241	30	15	10	10	14	15	29	29	15555	14822
462	242	30	45	10	10	14	13	29	29	15598	14864
462	243	30	-15	8	8	14	15	23	23	15635	14902
462	244	30	-15	4	4	14	13	12	12	15661	14927
467	245	30	-15	4	4	14	14	12	12	15687	14953
473	246	90	0	17	0	28	0	139	0	15853	14953
477	247	30	-30	29	29	45	14	84	84	15982	15051
478	248	30	-15	41	41	14	14	119	119	16115	15184
478	249	30	-15	22	22	14	14	64	64	16193	15262

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Rev	Op	Scan	SCA	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
476	250	30	15	7	7	14	14	20	20	16227	15246
480	251	90	15	7	7	34	42	57	57	16318	15402
491	252	30	-45	16	0	49	0	46	0	16413	15402
491	253	30	-30	34	36	14	34	99	99	16526	15535
493	254	30	-45	4	4	14	14	12	12	16552	15561
493	255	90	0	21	21	32	48	170	170	16754	15779
493	256	30	30	5	5	48	32	15	15	16817	15826
494	257	60	0	13	13	20	29	72	72	16909	15926
494	258	30	45	10	10	28	19	29	29	16966	15974
494	259	30	-45	11	11	14	15	32	32	17012	16021
494	260	30	-15	7	7	14	14	20	20	17046	16055
495	261	30	30	13	13	14	13	38	38	17098	16105
496	262	30	-30	14	14	14	15	41	41	17153	16162
496	263	30	30	10	10	14	13	29	29	17196	16204
508	264	60	0	19	19	21	30	105	105	17322	16339
509	265	30	0	7	7	30	22	20	20	17372	16381
510	266	60	15	15	15	21	28	83	83	17476	16492
510	267	60	0	15	15	36	36	83	83	17535	16611
510	268	30	0	36	36	29	22	104	104	17728	16737
510	269	30	-15	13	13	14	14	38	38	17780	16789
511	270	90	0	25	25	31	46	203	203	18014	17038
511	271	60	-15	22	22	55	48	121	121	18190	17207
511	272	90	0	39	39	50	57	316	316	18556	17580
512	273	30	30	28	28	49	33	81	81	18686	17694
517	274	90	0	27	27	35	51	219	219	18940	17954
524	275	30	-45	14	14	49	34	41	41	19030	18039
524	276	30	30	13	13	14	13	38	38	19082	18090
524	277	30	30	14	14	14	14	41	41	19137	18145
525	278	30	30	22	22	14	14	64	64	19215	18223
525	279	30	-30	18	18	14	15	52	52	19281	18290
525	280	30	30	8	8	15	14	23	23	19319	18327
526	281	30	30	4	4	14	14	12	12	19345	18353
526	282	60	0	19	19	22	30	105	105	19472	18488
527	283	30	45	4	4	29	21	12	12	19513	18521
527	284	30	-30	10	10	14	15	30	30	19557	18566
527	285	30	-15	14	14	14	14	41	41	19612	18621
528	286	30	45	7	7	14	13	20	20	19646	18654
528	287	90	0	35	35	34	50	284	284	19964	18988
528	288	30	-30	21	21	49	33	61	61	20074	19082
528	289	30	-30	4	4	14	14	12	12	20100	19108
532	290	30	-30	7	7	14	13	20	20	20134	19141
540	291	30	-15	16	16	14	14	46	46	20194	19201
541	292	60	-15	35	25	20	28	193	193	20407	19422
542	293	30	-15	25	25	29	20	73	73	20509	19515
542	294	30	-15	13	13	14	15	38	38	20561	19568
542	295	30	-15	14	14	14	14	41	41	20616	19623
543	296	30	-15	7	7	13	13	20	20	20649	19656
543	297	90	0	35	35	29	44	284	284	20962	19984
544	298	30	-45	32	32	44	29	93	93	21099	20106
544	299	30	0	8	8	14	13	23	23	21136	20142
544	300	30	-30	36	36	13	14	104	104	21253	20260
544	301	30	-30	15	15	14	14	44	44	21311	20318
548	302	60	-30	13	13	21	29	72	72	21404	20419
556	303	30	-15	10	10	29	21	29	29	21462	20469
559	304	60	15	25	25	19	26	138	138	21619	20633
559	305	30	-15	4	4	27	19	12	12	21658	20664
559	306	30	-30	4	4	14	15	12	12	21684	20691

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Ta (ft) Fwd	Cum-Ta (ft) Aft
559	307	30	15	4	4	13	13	12	12	21709	20711
560	308	30	0	13	13	14	13	38	38	21051	20757
561	309	30	-45	24	24	13	14	75	75	21965	20815
561	310	30	15	16	16	14	13	46	46	21905	20915
566	311	60	15	14	14	22	30	77	77	22008	21072
572	312	30	-30	35	35	22	22	102	102	22139	21146
574	313	60	-15	26	26	23	29	143	143	22303	21341
574	314	90	0	30	31	46	56	251	251	22603	21625
575	315	60	15	34	34	56	47	187	187	22844	21853
576	316	30	-30	10	10	28	22	29	29	22903	21911
576	317	30	-30	4	4	14	14	12	12	22929	21935
576	318	30	-15	12	12	14	14	35	35	22978	21986
576	319	30	30	10	10	14	13	29	29	23021	22027
576	320	60	15	13	13	22	30	72	72	23119	22129
590	321	60	0	14	14	36	36	77	77	23226	22242
590	322	60	15	20	20	36	36	110	110	23374	22388
591	323	30	30	7	7	26	20	20	20	23422	22436
592	324	30	30	22	22	14	14	64	64	23500	22500
592	325	90	0	22	22	32	28	178	178	23730	22732
593	326	60	45	25	25	56	47	138	138	23903	22917
603	327	60	-30	16	16	35	36	88	88	24026	23041
604	328	30	30	34	34	29	20	99	99	24156	23160
606	329	60	-15	25	25	22	30	138	138	24314	23328
607	330	60	0	10	10	37	37	55	55	24406	23420
608	331	30	45	10	10	29	21	29	29	24464	23470
608	332	60	30	63	63	22	30	237	237	24725	23737
622	333	60	-15	25	25	37	38	138	138	24898	23913
623	334	90	0	13	13	56	57	105	105	25053	24075
625	335	90	0	47	47	67	67	381	381	25501	24523
626	336	30	45	55	55	48	32	160	160	25709	24715
626	337	30	-30	33	33	14	15	96	96	25835	24828
629	338	30	-15	11	11	14	14	32	32	25869	24872
631	339	60	-30	9	9	22	30	50	50	25953	24952
637	340	30	30	8	8	30	21	23	23	25991	24996
639	341	30	15	28	28	14	15	81	81	26085	25092
639	342	30	15	12	12	14	14	35	35	26134	25141
639	343	30	-30	17	17	15	15	49	49	26198	25205
641	344	90	0	16	16	20	27	38	38	26306	25320
641	345	60	-30	80	80	27	20	232	232	26553	25572
647	346	30	0	13	13	14	13	38	38	26617	25623
653	347	60	-30	11	11	22	31	61	61	26700	25715
654	348	60	-15	16	16	37	37	88	88	26829	25840
655	349	30	45	7	7	30	21	20	20	26875	25861
656	350	60	15	13	13	21	29	72	72	26968	25952
656	351	30	45	5	5	29	21	15	15	27017	26018
656	352	30	15	5	5	15	15	15	15	27042	26068
657	353	30	-30	23	23	13	14	67	67	27122	26129
657	354	90	0	48	48	32	47	389	389	27543	26545
660	355	30	30	16	16	41	32	46	46	27637	26643
660	356	60	0	16	16	22	30	88	88	27747	26761
671	357	30	-45	7	7	29	22	20	20	27796	26803
671	358	60	-15	32	32	22	30	176	176	27994	27009
671	359	30	-15	6	6	30	22	17	17	28041	27046
672	360	60	15	25	25	22	29	138	138	28201	27215
672	361	30	-30	10	10	29	22	29	29	28259	27266
673	362	90	0	34	34	33	44	275	275	28567	27589
673	363	60	15	17	17	56	44	96	96	28717	27731

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Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
1208-3	674	364	90	0	2	3	0	0	11	26	11	26
	685	365	90	0	37	37	130	130	300	300	441	456
	686	366	30	-30	13	13	49	33	38	38	528	527
	686	367	30	30	11	11	14	13	32	32	574	572
	687	368	30	+45	32	32	14	15	93	93	681	680
	687	369	90	0	53	53	34	50	429	429	1144	1159
	689	370	30	45	7	7	49	31	20	20	1213	1210
	689	371	60	0	17	17	21	30	94	94	1328	1334
	698	372	30	0	18	18	29	21	52	52	1409	1407
	701	373	30	-30	4	4	14	15	12	12	1435	1434
	701	374	90	0	14	14	34	49	332	332	1801	1815
	702	375	30	30	25	25	49	33	73	73	1923	1921
	704	376	30	30	7	7	14	14	20	20	1957	1955
	704	377	30	30	16	16	14	14	46	46	2017	2015
	705	378	60	-15	32	32	22	31	176	176	2215	2222
	708	379	30	15	4	4	30	21	12	12	2257	2255
	708	380	30	30	20	20	14	14	58	58	2329	2327
	714	381	60	15	10	10	21	29	55	55	2405	2411
	715	382	30	45	4	4	28	20	12	12	2445	2443
	717	383	30	-30	7	7	14	15	20	20	2479	2478
	717	384	60	30	19	19	18	24	105	105	2602	2607
	719	385	60	0	30	30	33	34	185	185	2800	2806
	720	386	90	-30	25	25	29	22	73	73	2902	2901
	721	387	60	15	34	34	22	29	187	187	3111	3117
	728	388	30	0	22	22	29	22	64	64	3204	3203
	730	389	30	-30	13	13	14	13	38	38	3256	3254
	734	390	60	-15	50	50	19	29	275	275	3550	3557
	735	391	30	30	32	32	29	20	93	93	3672	3670
	736	392	60	15	29	29	21	29	160	160	3853	3853
	736	393	90	0	21	21	45	53	170	170	4068	4082
	737	394	90	0	35	35	67	67	284	284	4419	4432
	737	395	30	-15	4	4	49	34	12	12	4480	4479
	739	396	30	+30	11	11	14	14	32	32	4526	4525
	744	397	30	0	5	5	14	14	15	15	4555	4554
	749	398	30	30	19	19	14	13	55	55	4624	4622
	752	399	90	0	14	14	32	48	113	113	4769	4783
	767	400	30	15	22	22	48	32	64	64	4881	4879
	768	401	60	-15	13	13	21	29	72	72	4974	4980
	770	402	30	-30	7	7	29	21	20	20	5023	5021
	771	403	30	30	13	13	14	13	38	38	5075	5072
	775	404	30	30	6	6	14	14	17	17	5106	5103
	784	405	90	0	25	26	31	47	227	227	5364	5377
	785	406	30	45	19	0	45	0	55	0	5464	5377
	785	407	30	-30	8	8	13	31	23	23	5500	5431
	785	408	60	30	19	19	21	28	105	105	5626	5554
	786	409	30	15	14	14	29	22	41	41	5695	5627
	795	410	60	15	14	14	19	26	77	77	5791	5730
	797	411	60	0	30	30	32	32	165	165	5988	5927
	799	412	60	0	65	65	34	34	358	358	6390	6319

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Rev	Op	Scan	SCA	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
800	413	60	15	22	0	34	0	121	0	6535	6319
800	414	60	15	24	24	34	36	132	132	6701	6487
800	415	30	-30	8	8	28	21	23	23	6752	6531
801	416	30	15	7	7	14	13	20	20	6786	6564
801	417	30	-30	13	13	13	14	38	38	6837	6616
801	418	30	15	11	11	14	14	32	32	6883	6662
801	419	30	0	8	8	15	14	23	23	6921	5699
801	420	60	15	35	35	23	32	193	193	7137	6924
802	421	30	30	7	7	30	21	20	20	7187	6965
807	422	30	-30	7	7	14	15	20	20	7221	7000
813	423	60	-30	29	29	19	27	168	168	7408	7195
815	424	30	15	19	19	27	18	55	55	7490	7265
816	425	30	0	6	6	14	15	18	18	7522	7301
817	426	30	30	28	28	14	13	81	81	7617	7395
818	427	30	-30	25	25	14	15	73	73	7704	7483
819	428	30	15	4	4	14	13	12	12	7730	7508
819	429	60	15	25	25	23	31	138	138	7891	7677
829	430	30	30	4	4	29	21	12	12	7932	7710
831	431	90	0	68	68	33	50	551	551	8516	8311
831	432	90	0	16	16	71	70	130	130	8717	8513
833	433	30	-30	22	22	45	34	64	64	8830	8609
833	434	30	-30	5	5	14	14	15	15	8859	8638
833	435	30	30	4	4	14	13	12	12	8885	8663
834	436	60	15	19	19	22	30	105	105	9012	8799
835	437	30	30	10	10	29	21	29	29	9070	8848
835	438	30	-30	10	10	14	15	29	29	9113	8892
835	439	60	-15	11	11	23	31	61	61	9197	8984
839	440	30	30	10	10	29	20	29	29	9255	9033
841	441	30	30	43	43	13	14	125	125	9393	9172
846	442	30	45	28	28	13	12	81	81	9487	9265
847	443	90	0	43	43	34	50	348	348	9869	9653
851	444	30	30	10	10	49	33	29	29	9947	9729
851	445	60	-15	20	20	24	33	110	110	10091	9868
863	446	30	-30	12	12	30	22	35	35	10146	9925
867	447	30	15	4	4	14	14	12	12	10172	9951
867	448	30	-30	16	16	14	14	46	46	10232	10011
867	449	30	30	8	8	16	14	23	23	10271	10048
868	450	30	-45	16	16	13	15	46	46	10330	10109
880	451	30	30	16	16	14	13	46	46	10390	10166
881	452	30	30	7	7	14	14	20	20	10424	10202
882	453	30	0	10	10	14	14	29	29	10467	10245
883	454	90	0	35	35	33	50	284	284	10784	10579
894	455	90	-15	50	50	69	69	405	405	11258	11053
898	456	60	-30	0	8	0	51	0	44	11258	11148
897	457	30	15	7	7	50	21	20	20	11328	11189
897	458	60	15	13	13	22	30	72	72	11422	11291
898	459	30	-30	14	14	29	22	41	41	11492	11354
899	460	30	30	31	31	14	13	90	90	11596	11457
900	461	60	-30	43	43	23	32	237	237	11856	11726
914	462	30	-15	25	25	30	22	73	73	11959	11821
914	463	30	-15	25	25	14	14	73	73	12046	11908
915	464	30	45	4	4	14	12	12	12	12072	11932
916	465	30	30	10	10	13	14	29	29	12114	11975
917	466	30	-15	4	4	14	15	12	12	12140	12002
919	467	30	30	7	7	13	12	20	20	12173	12034
928	468	30	0	7	7	13	14	20	20	12206	12068
928	469	30	0	4	4	14	14	12	12	12232	12094

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
930	470	30	-30	10	10	14	14	29	29	12275	12137
930	471	30	15	5	5	14	14	15	15	12304	12166
931	472	30	-45	6	6	14	14	12	12	12330	12192
931	473	60	0	7	7	22	29	39	39	12391	12260
933	474	60	30	7	7	36	36	39	39	12466	12335
946	475	30	30	13	13	28	21	38	38	12532	12394
946	476	30	30	25	25	14	13	73	73	12619	12490
947	477	30	0	13	13	13	13	39	35	12670	12531
947	478	30	45	10	10	13	13	29	29	12712	12573
948	479	30	15	7	7	13	13	20	20	12745	12606
948	480	30	0	8	8	13	14	23	23	12791	12643
949	481	30	0	16	16	14	14	46	46	12841	12703
962	482	30	45	19	19	14	13	55	55	12910	12771
962	483	60	0	10	10	21	29	55	55	12986	12855
964	484	30	-30	10	10	28	21	29	29	13043	12905
964	485	30	0	11	11	14	14	32	32	13089	12951
964	486	30	30	7	7	14	13	20	20	13123	12984
970	487	30	30	34	34	14	14	99	99	13236	13097
978	488	30	30	16	16	14	14	46	46	13296	13157
979	489	30	-30	13	13	14	15	38	38	13346	13210
980	490	30	-15	4	4	14	13	12	12	13374	13235
995	491	60	0	6	6	25	33	33	33	13432	13301
995	492	60	-15	6	6	25	26	33	33	13490	13360
995	493	60	30	6	6	36	35	33	33	13559	13428
996	494	30	30	16	16	30	22	46	46	13635	13496
996	495	30	30	17	17	14	14	49	49	13698	13559
996	496	60	15	24	24	21	28	132	132	13851	13719
996	497	30	45	13	13	27	20	38	39	13916	13777
998	498	90	0	32	32	33	49	259	259	14208	14085
998	499	30	-45	26	26	48	33	75	75	14331	14193
1000	500	30	-30	7	7	13	13	20	20	14364	14226
1002	501	30	30	19	19	13	12	55	55	14432	14293
1003	502	30	0	12	12	14	14	35	35	14481	14342
1009	503	30	30	17	17	14	14	49	49	14544	14405
1010	504	30	-30	10	10	14	15	29	29	14587	14449
1011	505	60	-30	17	0	23	0	94	0	14704	14449
1011	506	60	0	19	0	36	0	105	0	14845	14449
1011	507	60	15	19	19	37	29	105	105	14987	14583
1012	508	30	0	41	41	28	21	119	119	15134	14723
1012	509	30	-30	21	21	14	15	61	61	15209	14799
1012	510	30	-45	14	14	14	14	41	41	15264	14854
1012	511	30	45	16	16	14	13	46	46	15324	14913
1013	512	30	30	19	19	14	14	55	55	15393	14982
1013	513	90	15	53	53	34	50	429	429	15856	15461
1013	514	120	0	40	40	78	86	428	428	16362	15975
1019	515	60	15	22	22	71	55	121	121	16554	16151
1025	516	30	0	28	28	40	21	81	81	16675	16253
1025	517	60	15	21	21	21	29	116	116	16812	16398
1027	518	90	0	56	0	48	0	454	0	17314	16398
1028	519	60	-15	35	35	51	35	193	193	17558	16626
1028	520	30	30	49	49	28	19	142	142	17728	16787
1029	521	30	30	71	71	14	14	206	206	17948	17007
1029	522	30	-30	17	17	14	15	49	49	18011	17071
1035	523	60	-30	17	17	21	29	94	94	18126	17196
1041	524	30	15	59	59	29	20	171	171	18325	17395
1044	525	30	0	10	10	14	14	29	29	18369	17429
1044	526	30	-30	10	10	14	15	29	29	18412	17472

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1044	527	60	-15	24	24	22	29	132	132	18566	17633
1045	528	60	15	34	34	36	36	187	187	18786	17856
1045	529	60	-15	28	28	36	36	154	154	18979	18046
1050	530	60	-15	31	31	35	36	171	171	19185	18253
1056	531	30	30	19	19	29	17	55	55	19268	18327
1057	532	60	15	10	10	22	30	55	55	19345	18412
1060	533	90	0	41	41	49	57	332	332	19726	18801
1061	534	60	-15	22	22	56	48	121	121	19903	18970
1061	535	60	0	13	13	37	37	72	72	20012	19079
1061	536	60	15	11	11	37	37	61	61	20110	19177
1061	537	60	15	16	16	37	37	88	88	20235	19302
1062	538	60	-30	29	29	36	36	160	160	20429	19498
1062	539	30	15	23	23	29	19	67	67	20525	19584
1074	540	30	30	31	31	13	13	90	90	20628	19687
1074	541	30	0	7	7	14	15	20	20	20662	19722
1075	542	30	30	10	10	14	13	29	29	20705	19764
1076	543	90	0	13	13	30	46	105	105	20840	19915
1076	544	90	0	44	44	64	64	356	356	21260	20385
1076	545	30	15	9	9	48	32	26	26	21334	20379
1076	546	30	-30	6	6	14	14	17	17	21365	20424
1076	547	30	45	12	12	13	13	35	35	21413	20472
1077	548	60	-30	32	32	20	29	176	176	21609	20677
1077	549	60	15	16	16	38	36	88	88	21735	20801
1077	550	30	30	12	12	29	22	32	32	21796	20855
1077	551	60	-15	10	10	22	31	55	55	21873	20941
1078	552	60	15	10	10	36	34	55	55	21964	21030
1078	553	30	30	17	17	28	23	49	49	22041	21099
1078	554	30	30	11	11	13	14	32	32	22096	21145
1090	555	60	30	37	37	20	27	204	204	22310	21375
1090	556	60	-30	15	15	35	37	83	83	22428	21496
1090	557	60	-15	45	45	37	37	248	248	22713	21781
1090	558	30	30	13	13	29	20	38	38	22790	21839
1092	559	90	0	62	62	34	50	502	502	23318	22351
1093	560	30	30	7	7	48	32	20	20	23394	22443
1093	561	30	15	7	7	13	13	20	20	23417	22476
1094	562	60	15	52	52	20	28	296	296	23723	22790
1096	563	60	15	19	19	36	36	105	105	23864	22941
1099	564	30	0	6	5	28	20	15	15	23907	22986
1106	565	30	0	22	22	13	13	64	64	23984	23043
1107	566	30	30	14	14	13	13	41	41	24038	23097
1108	567	30	-30	8	8	15	16	23	23	24076	23136
1108	568	90	0	37	37	34	47	300	300	24410	23485
1109	569	60	0	34	34	56	49	187	187	24653	23720
1109	570	30	-15	10	10	28	21	29	29	24710	23778
1109	571	30	15	8	8	14	14	23	23	24747	23807
1109	572	30	0	16	16	14	14	46	46	24807	23967
1109	573	30	-30	7	7	14	14	20	20	24841	23901
1109	574	30	-45	14	11	14	14	32	32	24887	23947
1110	575	30	30	19	19	14	13	55	55	24956	24015
1110	576	60	30	9	9	22	29	50	50	25028	24094
1111	577	30	-15	65	65	29	23	187	188	25244	24305

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APPENDIX C (CONT'D)

Rev	Orbit	Sun Angle	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
1208-A	1121	577	30 -15	13	13	0	0	36	35	35	35
	1122	578	30 -30	14	14	77	77	41	41	154	153
	1122	579	30 30	24	24	14	15	70	70	238	238
	1123	580	30 -30	14	14	14	15	41	41	293	292
	1123	581	30 30	11	11	14	13	32	32	339	337
	1125	582	30 30	10	10	14	14	29	29	382	380
	1125	583	30 30	7	7	14	14	20	20	416	414
	1125	584	60 15	28	28	21	29	154	154	591	597
	1126	585	60 -15	13	13	35	38	72	72	698	705
	1138	586	30 0	5	5	29	20	15	15	742	740
	1139	587	90 0	43	43	33	49	349	349	1123	1137
	1141	588	90 0	34	34	67	67	275	275	1465	1479
	1141	589	30 -30	21	21	48	33	61	61	1574	1573
	1142	590	30 -30	10	10	14	14	29	29	1617	1616
	1142	591	30 -15	11	11	14	14	32	32	1663	1662
	1142	592	30 -30	9	9	14	13	25	26	1703	1701
	1142	593	30 -30	12	12	13	14	35	35	1751	1750
	1142	594	30 0	7	7	14	13	20	20	1785	1783
	1148	595	60 -15	22	22	20	28	121	121	1926	1932
	1148	596	90 -15	8	8	29	21	23	23	1978	1976
	1155	597	60 30	7	7	21	28	39	39	2038	2043
	1156	598	60 0	16	16	36	36	85	88	2162	2167
	1157	599	30 -15	13	13	28	21	38	38	2228	2226
	1157	600	30 -30	12	12	14	14	35	35	2277	2275
	1158	601	60 15	26	26	21	28	143	143	2441	2446
	1158	602	60 0	13	13	36	37	72	72	2549	2555
	1158	603	30 30	4	4	28	19	12	12	2589	2586
	1159	604	90 15	50	50	21	29	275	275	2885	2890
	1164	605	60 -15	10	10	33	34	55	55	2973	2979
	1167	606	60 15	19	19	31	30	105	105	3109	3114
	1169	607	30 0	10	10	25	18	29	29	3163	3161
	1169	608	30 15	11	11	13	12	32	32	3208	3205
	1169	609	30 -30	6	6	13	14	15	15	3236	3234
	1171	610	60 -15	10	10	20	28	55	55	3311	3317
	1171	611	60 -15	34	34	35	35	187	187	3533	3539
	1171	612	60 15	7	7	37	36	39	39	3609	3614
	1171	613	60 15	6	6	36	35	33	33	3679	3683
	1174	614	60 -15	4	4	35	36	22	22	3735	3741
	1174	615	30 0	19	19	27	18	55	55	3817	3814
	1174	616	60 -15	14	14	20	30	77	77	3914	3921
	1174	617	30 0	8	8	29	20	23	23	3966	3964
	1180	618	30 -30	26	26	13	13	75	75	4054	4052
	1180	619	30 -30	11	11	14	14	32	32	4100	4098
	1181	620	30 15	5	5	14	13	15	15	4129	4125
	1183	621	30 30	22	22	13	13	64	64	4206	4203
	1187	622	60 30	19	19	19	27	105	105	4330	4335
	1187	623	60 15	25	25	35	35	138	138	4503	4508
	1187	624	60 0	10	10	36	35	55	55	4594	4599
	1189	625	60 0	14	16	35	35	83	83	4717	4722
	1190	626	60 -15	27	27	34	35	149	149	4900	4906
	1190	627	60 30	13	13	35	34	72	72	5007	5012
	1190	628	60 -15	4	4	36	37	22	22	5065	5071
	1191	629	90 0	74	74	47	54	590	590	5711	5724
	1203	630	60 15	10	10	54	46	55	55	5820	5825
	1207	631	60 0	7	7	36	37	39	39	5895	5901
	1213	632	30 0	5	5	29	21	15	15	5939	5937

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
1220	633	60	-15	19	19	20	27	105	105	6054	6059
1221	634	60	-15	11	11	32	33	61	61	6157	6163
1221	635	60	0	7	7	33	32	39	39	6279	6234
1223	636	60	30	19	19	35	34	105	105	6369	6373
1236	637	90	0	10	10	46	55	81	81	6496	6509
1236	638	60	15	25	25	54	46	139	138	6688	6693
1237	639	60	15	16	16	36	35	88	88	6812	6917
1245	640	60	15	10	10	36	36	55	55	6903	6908
1300	641	60	0	6	6	79	39	33	33	7015	6990
1300	642	60	15	19	0	35	0	105	0	7155	6990
1302	643	30	-45	29	29	29	20	84	84	7269	7094
1302	644	90	15	22	22	34	49	178	178	7480	7311
1303	645	60	30	13	13	55	46	72	72	7607	7429
1303	646	60	-15	10	10	35	36	55	55	7697	7520
1303	647	60	15	22	22	36	36	121	121	7854	7677
1304	648	90	0	37	27	48	56	300	300	8202	8033
1304	649	30	0	17	17	48	33	49	49	8299	8115
1305	650	60	-15	35	35	21	29	193	193	8513	8337
1309	651	30	0	8	8	29	21	23	23	8565	8381
1316	652	60	30	13	13	20	28	72	72	8657	8479
1316	653	60	-15	22	22	33	35	121	121	8811	8635
1317	654	60	15	9	9	37	36	50	50	8898	8721
1318	655	30	-30	10	10	28	21	29	29	8955	8771
1318	656	60	-15	17	17	22	30	94	94	9071	8895
1319	657	60	-15	26	26	36	36	143	143	9250	9074
1320	658	60	-15	74	74	38	36	407	407	9693	9517
1320	659	30	-30	9	9	29	21	26	26	9746	9564
1321	660	60	15	13	13	21	28	72	72	9841	9664
1321	661	60	-30	14	14	36	37	77	77	9954	9778
1325	662	90	0	16	16	48	55	130	130	10132	9963
1327	663	30	30	8	8	48	31	23	23	10203	10017
1332	664	90	0	22	22	32	48	178	178	10413	10243
1333	665	60	-15	21	21	55	49	116	116	10584	10407
1334	666	60	15	17	17	36	35	94	94	10714	10536
1336	667	60	-30	5	5	37	38	29	28	10779	10602
1335	668	60	15	21	21	36	35	116	116	10931	10753
1336	669	60	15	122	122	35	35	671	671	11637	11459
1336	670	30	15	5	5	29	20	15	15	11681	11494
1348	671	60	-15	14	14	20	29	77	77	11778	11600
1349	672	60	-15	13	13	37	37	72	72		
1349	673	60	0	25	25	37	37	138	138	12082	11884
1350	674	60	-15	29	29	36	37	160	160	12258	12081
1351	675	60	15	16	16	37	36	88	88	12383	12205
1354	676	30	-30	49	49	28	21	142	142	12553	12368
1355	677	90	0	31	31	34	49	251	251	12818	12668
1356	678	90	0	73	73	67	67	391	591	13496	13326
1356	679	90	0	11	11	68	68	89	89	13653	13483
1367	680	30	30	45	45	48	32	131	131	13832	13646
1368	681	60	15	25	25	22	29	138	138	13992	13813
1369	682	60	15	89	89	36	37	490	490	14518	14340
1374	683	30	30	17	17	29	21	49	49	14596	14410
1375	684	60	0	38	38	21	29	209	209	14826	14646
1382	685	90	0	22	22	48	56	178	178	15052	14882
1382	686	60	15	21	21	57	69	116	116	15225	15047
1383	687	60	-15	14	14	36	37	77	77	15318	15151
1383	688	60	-15	13	13	37	37	72	72	15447	15270
1384	689	60	15	30	30	37	36	165	165	15649	15471

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
1395	690	90	0	87	87	46	56	705	705	16402	16212
1397	691	60	-15	14	14	58	48	77	77	16535	16357
1397	692	60	0	15	15	37	37	83	83	16655	16477
1399	693	30	-30	13	13	29	22	38	38	16722	16537
1400	694	60	-15	15	15	22	33	83	83	16827	16650
1401	695	60	-15	13	13	38	37	72	72	16937	16759
1401	696	30	30	33	33	29	21	96	96	17062	16876
1401	697	30	15	9	9	15	15	26	26	17103	16917
1402	698	60	15	17	17	23	30	94	94	17220	17041
1413	699	90	0	38	38	45	54	308	308	17573	17403
1415	700	60	15	26	26	50	42	143	143	17766	17588
1416	701	60	-15	9	9	33	34	50	50	17849	17672
1417	702	60	0	34	34	44	51	275	275	18168	17998
1422	703	30	-30	9	9	45	30	26	26	18239	18054
1429	704	90	0	54	54	31	46	437	437	18707	18537
1430	705	90	0	50	50	66	66	405	405	19178	19008
1431	706	60	15	30	30	54	65	165	169	19397	19219
1431	707	30	0	5	5	27	19	15	15	19439	19253
1433	708	60	0	9	9	20	31	50	50	19509	19334
1445	709	90	0	34	34	45	52	275	275	19929	19661
1446	710	60	-15	13	13	53	45	72	72	19984	19775
1448	711	60	30	9	9	35	34	50	50	20039	19852
1462	712	60	0	13	13	36	36	72	72	20147	19979
1466	713	60	15	17	17	34	34	94	94	20275	20096
1466	714	60	0	9	9	35	35	50	50	20360	20183
1471	715	90	0	16	16	48	56	130	130	20538	20359
1481	716	60	-15	25	25	57	49	138	138	20743	20565
1482	717	60	15	13	13	36	36	72	72	20841	20664
1482	718	30	30	9	9	28	20	26	26	20895	20710
1487	719	30	15	10	10	14	14	29	29	20938	20753
1487	720	60	-15	14	14	22	31	77	77	21037	20861
1497	721	30	-30	13	13	29	21	38	38	21104	20920
1498	722	30	-30	12	12	14	14	35	35	21153	20969
1511	723	60	0	13	13	21	24	72	72	21246	21069
1515	724	30	15	9	9	29	21	26	26	21300	21115
1515	725	30	15	25	25	13	12	73	73	21386	21201
1531	726	60	15	36	36	21	23	198	198	21605	21427
1535	727	30	-30	25	25	28	21	73	73	21706	21521
1536	728	30	-30	11	11	13	14	32	32	21751	21547
1536	729	60	15	10	10	22	29	55	55	21828	21651
1546	730	60	-15	21	21	36	37	116	116	21980	21804
1547	731	30	0	15	15	28	20	44	44	22052	21948
1552	732	30	0	6	6	14	14	18	18	22084	21980
1554	733	30	0	8	8	14	14	23	23	22121	21947
1559	734	60	-15	47	47	21	23	259	259	22401	22225
1560	735	30	30	8	8	30	20	24	24	22457	22271
1561	736	30	-15	5	5	13	15	15	15	22489	22301
1562	737	60	0	19	19	23	27	105	105	22610	22433
1569	740	30	-30	7	7	20	21	20	20	23107	22923
1570	741	60	0	9	9	22	29	50	50	23179	23002
1575	742	60	0	22	22	26	35	121	121	23326	23150
1576	743	30	0	46	46	28	20	133	133	23487	23312
1577	744	30	30	19	19	13	13	55	55	23555	23380
1585	745	30	0	6	6	13	13	17	17	23585	23410
1592	746	30	30	23	23	14	14	67	67	23656	23481
1595	747	30	30	30	30	14	14	87	87	23767	23592
1596	748	30	30	23	23	13	13	67	67	23847	23672

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APPENDIX C (CONT'D)

Rev	Op	Scan	SCA	Frames Fwd	Frames Aft	Interop (ft) Fwd	Interop (ft) Aft	Photo (ft) Fwd	Photo (ft) Aft	Cum-Tu (ft) Fwd	Cum-Tu (ft) Aft
1597	749	30	15	5	5	15	15	15	15	23877	23702
1607	750	30	-30	58	58	13	14	169	168	24058	23884
1610	751	60	15	21	21	21	29	116	116	24195	24028
1612	752	60	0	78	78	47	55	632	632	24874	24715
1617	753	30	30	12	12	46	32	35	35	24957	24782
1625	754	60	0	12	12	21	29	66	66	25044	24877
1626	755	90	-15	22	22	48	57	178	178	25270	25110
1633	756	30	15	6	6	50	13	17	17	25337	25162
1634	757	30	0	6	6	13	13	17	17	25387	25192
1635	758	30	-15	5	5	13	14	15	15	25395	25221
1641	759	60	-15	16	16	17	25	88	88	25500	25334
1647	760	30	30	13	13	29	20	38	38	25567	25392
1647	761	30	15	8	8	14	19	23	23	25604	25430
1650	762	60	-15	14	14	22	30	77	77	25733	25537
1660	763	30	-15	7	7	29	21	20	20	25759	25578
1667	764	30	15	5	5	14	14	15	15	25791	25607
1673	765	60	-15	12	22	21	29	66	66	25868	25702
1677	766	60	0	15	15	37	36	83	83	25998	25821
1678	767	30	-30	5	5	28	21	15	15	26031	25867
1684	768	30	30	0	30	0	13	0	87	26051	25967
1690	769	30	-15	19	19	14	14	55	55	26130	26035
1691	770	30	-30	10	10	14	14	29	29	26143	26089
1693	771	60	0	7	7	22	29	39	39	26204	26137
1693	772	30	-30	9	9	28	21	26	26	26255	26184
1693	773	90	0	15	15	36	51	122	122	26416	26357
1694	774	60	-15	34	31	57	49	185	167	26658	26573
						32	42			26690	26615

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~~TOP SECRET~~ [redacted]

PI INTERPRETABILITY NIIRS RATINGS SUMMARY

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POST FLIGHT ANALYSIS REPORT
1208

APPENDIX D

BI INTERPRETABILITY NIIRS RATINGS SUMMARY

Stereo Coverage From 1414 Film Type

Mission	All Weather Conditions							Clear Weather Only						
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
1207-1	0	4	335	1088	992	172	5	1	0	3	290	1027	912	131	3	0
1207-2	0	6	213	851	870	216	14	0	0	6	211	816	782	163	6	0
1207-3	0	24	439	1628	1132	242	7	0	0	24	414	1554	998	186	2	0
1207-4	0	14	169	653	414	76	4	0	0	13	161	596	333	28	0	0
1207 Total	0	48	1136	4230	3408	707	30	1	0	47	1076	3993	3015	510	11	0
1208-1	0	19	347	827	982	135	10	0	0	17	322	737	940	76	6	0
1208-2	0	45	529	1159	776	153	5	0	0	41	517	1065	611	92	1	0
1208-3	0	21	311	767	264	35	1	0	0	21	293	705	323	22	1	0
1208-4	0	3	180	511	106	36	2	0	0	3	150	463	121	9	1	0
1208 Total	0	88	1367	3290	2228	357	18	0	0	82	1282	2970	1795	199	9	0

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