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MISSION 1207
SENSOR SUBSYSTEM
POST FLIGHT ANALYSIS REPORT

NOVEMBER 1974

This report consists of 294 pages.

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PUBLICATION REVIEW

This report has been reviewed and is approved.



DAVID F. BERGANINI
Major, 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 1207, BYE 15319-74. This Volume II report also combines data from all black and white and color films utilized on 1207.

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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Eastman Kodak	- D. Schoessler	6
AFSPPF/EV		7, 8, 9, 10

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SECTION I

SUMMARY

1.1 BACKGROUND

Mission 1207 was launched from Vandenberg AFB on 10 November 1973. Mission statistics, camera data, and RV recoveries are summarized in Tables 1-1 thru 1-3.

TABLE 1-1

MISSION STATISTICS

Mission Number - 1207
Launch Date - 10 November 1973
Launch Time (Z) - 2010
Satellite Vehicle - SV-7 (6630)
Sensor Subsystem - SN-010
Orbit Inclination (degrees) - 96.9
Initial Perigee (NM) - 88.7
Initial Apogee (NM) - 154.4
Argument of Perigee (degrees) - 142.8
Initial Period (minutes) - 88.9
Range of Photo Altitudes (NM)
1207-1, 87-105
1207-2, 86-100
1207-3, 88-104
1207-4, 88-118

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TABLE 1-2

CAMERA STATISTICS

Camera Designation	Forward Camera	Aft Camera
	A	B
Film	1414	1414/SO-255/FE-3916
Focal Length (inches)	59.9917	59.9680
Equivalent Filter Type	W-12/W-2E3	W-12/W-2E3
Initial Focus Setting (microns)*	137	33/63
Supply Footage (feet)	107,426	100,406/4,984/501
Supply Spool No.	2331	2470
Supply Film Weight (lbs)	850.1	853.7
Optical Set Numbers	031	038
Initial Pneumatics (lbs)	34.0	
Estimated Remaining Pneumatics (lbs)	4.5	

*Focus was not changed on either camera.

TABLE 1-3

RV RECOVERY STATISTICS

	<u>RV-1</u>	<u>RV-2</u>	<u>RV-3</u>	<u>RV-4</u>
Recovery Date	24 Nov 73	17 Dec 73	13 Jan 74	20 Feb 74
Recovery Time (Z)	2345	2353	2248	0008
Recovery Rev	229	602	1039	1656
Capacity Load (%)	99	88	99	80
Balance Status (%)	1.0	0.4	0.2	0.3

NOTE: All capsules were retrieved by aerial recovery.

This report details the technical evaluation of the cameras employed on this flight. Important aspects of the satellite vehicle performance, post recovery handling, and exploitation of the product are also included. The product is evaluated principally with regard to 1414 Film, but data from both the SO-255 and FE-3916 Films is also included.

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

SN-010 (SV-7) was tested extensively on the ground prior to launch during both the Acceptance test phase at SSC and during vehicle integration at SVIC. The results of these tests are detailed in the following reports:

- A. Flight Model (SN-010) Acceptance Team Report, BYE 15283-72, 9 February 1973.
- B. SV-7 (SN-010) Flight Readiness Report, BYE 15310-73, 15 October 1973.

1.2 CAMERA OPERATIONS AND PERFORMANCE

Mission 1207, the first of the Block II Systems, was a successful 1200 Series operation. All film was transported and recovered. Mission 1207 contained 207,832' of 1414 (black and white), 4,984' of SO-255 (color), and 501' of FE-3916 (infrared) Film. Except for a film tear on Op 304, there were no significant anomalies.

This was the second mission that used the FE-3916 IR Film. It is the first mission in which successful results were obtained (Mission 1206 film was fogged during Supply buildup). It also is the first mission where an interchangeable filter (ICF) was incorporated in the optical configuration. The ICF operated as designed.

A Supply caging pin, among other design changes, was incorporated in SV-7 to preclude the Supply from rotating during the ascent phase of operation. The caging pin operated properly.

1.2.1 Camera Operations

The active photographic mission was terminated on Day 103 and was the longest mission to date. Long life tests continued in the Solo phase to Day 124.

Because of recurring resonance in the fine film path at velocities associated with the initial orbital altitudes, the nominal orbit perigee was raised by two miles on Rev 289. A film tear was found on Op 304 which most probably was caused by ingestion of a connector cap into the Take-up during operations. In addition, a noisy drive capstan problem existed throughout the mission which had a small effect on metering capstan performance.

Ten out of eleven PFA engineering test objectives were fully accomplished. Two acquisitions for measuring on-orbit lens MTF were not usable and the test was cancelled after 1207-3.

1.2.2 Image Quality

Photographic image quality was Very Good and essentially equivalent from both cameras. Mean 2:1 contrast VEM resolution performance was 155 $\pm$ 15 cycles/mm, which is comparable to or better than previous winter missions. Peak VEM resolution was approximately 180 cycles/mm. Deployed CORN

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tribars read 1.8' to 2.9' ground resolved distance in seven acquisitions, format location and incident contrast being variable. Single acquisitions on color and infrared color read 2.6' and 5.5' respectively. There was a consistent trend for in-track quality measurements to be slightly better than cross-track quality measurements.

Although the PFA Team had been concerned about a possible degradation of image quality with subsequent RVs, an in-depth quality assessment revealed no significant losses with time into the mission. However, there was a predominance of low sun angle photography during the latter half of the mission. Local weather and acquisition geometry rather than camera system performance as such continue to be the principal sources of quality degradation.

As with previous missions, intermittent anomalous arching of major axis quality (scan angle quality dependency) was observed and continues to be unexplained. A detailed analysis to isolate this cause is underway. On-orbit effective field curvature was VEM measured to be essentially flat, insuring the adequacy of platen tilt settings. There was no loss in resolution detected in mission photography as compared to ground test data. However, this was an area of concern since, during Chamber A-1 testing, outgassing occurred and contaminated camera optical surfaces. However, resolution variability was more severe (14%) on-orbit than in Chamber A-2 (8%), which is characteristic of past missions.

GAWA calculations have been discontinued as this technique has served its initial purpose of verifying CRYSPER performance prediction programming with mission image suitability for the photo-interpreter. PI suitability ratings have been replaced by the National Imagery Interpretability Rating Scale (NIIRS). Mission 1207 was rated 3.7 on the whole. Average NIIRS values reflect appropriate responses to weather conditions, obliquity, scale, and solar elevation.

1.2.3 Focus

Mission 1207 was the second 1200 Series mission that required no on-orbit focus changes. Focus for the color and IR film portions was also deemed adequate.

1.2.4 Film Synchronization

The following are the results of an analysis on the 1414 Film. Except for the Aft Camera in-track OAAA setting, the ground settings for IMC were within .01 inch/second mean smear residual error. The Aft Camera in-track direction was determined to be .032 inch/second and was corrected on Op 132 by commanding a three step OAAA change.

The SO-255 Film on the Aft Camera was found to be too slow by .058 inch/second in the cross-track direction. Since this film was at the tail of the Supply on 1207-4, no corrections could be made. Recommendations for future missions have been made based upon Missions 1206 and 1207 color on-orbit tests, see Section III.

The anticipated on-orbit variability of image motion was less than that which was measured except

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for the Aft Camera in-track direction. The on-orbit measured variability was less than the original SV design budget. The Aft Camera in-track was .015 inch/second in excess of the budget.

1.2.5 Exposure

Exposure analysis performed on the 1414 Film indicated a slight overexposure (.05 log E) relative to the present criterion of 1.0 mean scene density. However, the acquisitions were subjectively rated Good. Therefore, a slight change in criterion is recommended, see Section VI.

Exposure differences between the Forward and Aft Cameras were corrected with a two count exposure bias (-.06 log E) applied to the Aft Camera during Op 138.

The color and IR films were both considered to be correctly exposed by subjective and limited microdensitometer analysis. No changes in exposure criteria are recommended.

1.2.6 Engineering Tests

Eleven engineering tests were performed during the course of Mission 1207. In ten out of the eleven tests, satisfactory results were obtained. Five of these tests called for CORN deployment of lines, tribars, gray scales, and radiometric patches. Five other tests supported the optimization of focus and image motion compensation during the mission and one was designed to verify color film synchronization. This last test resulted in a recommendation to change the color film speed on future missions.

The attempt to measure on-orbit modulation transfer functions via the PFALINES analysis was unsuccessful due to unusable acquisitions. It is recommended that line acquisitions for this purpose be obtained on Mission 1208.

1.3 PROCESSING AND REPRODUCTION

Defilming of all RVs was accomplished without any major difficulty. All core locking pins were sheared except for 1207-1. Black and white processing and reproduction was accomplished without incident. Experimentally modified Redondo Printers were used to print the 1207-4 second generation duplicate positives made at BRIDGEHEAD.

A minor delay during the processing of the FE-3916 original positive was encountered during 1207-4. Film creases and wrinkles confined to non-imagery mission film necessitated a machine cut in Op 694.

NPIC analyses have shown that the black and white duplicates from the original negative are similar in resolution transfer to previous 1200 Series missions. The experimental second generation DP made at BRIDGEHEAD is a good replacement for that previously used. The black and white DPs made from the color original positives (SO-255 on 1207-1, and FE-3916 on 1207-4) were similar to past 1200 Series missions. The second generation color DPs made on Aerial Color Print Film SO-287 provided a substantial improvement in resolution over that of SO-356 used on previous missions. The tone reproduction of SO-287 is poorer than the color original positive and comparison copies made onto SO-356. The color

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DPs made from the color IR original positive were judged good to excellent for color balance; however, these DPs possessed poor resolution. This poor resolution is the result of the low resolution capability of the color IR original positive.

1.4 EXPLOITATION SUITABILITY

The overall interpretation suitability on Mission 1207 was average, with the majority of the targets read out by NPIC rated a 4 on the NIIRS scale. The NIIRS ratings from Mission 1207 have confirmed the relationship of the interpretability of a photograph and the basic acquisition conditions of weather, photo scale, obliquity, and solar elevation.

The new SO-287 Film for color duplicate positive reproduction resulted in an improvement in the exploitation capability of color photography due to the fact that it possesses a higher resolution level than the previously used SO-356. The image quality of the color DP is still lower than the black and white DP, but many photointerpreters state that occasional color coverage of their targets is beneficial. Tone reproduction and color fidelity problems were noted in the color DP made from the SO-255 original positive. An SO-356 DP had to be substituted for the SO-287 DP for the photointerpreters engaged in the wheat yield study.

The FE-3916 IR Film, while of low resolution, resulted in good to excellent interpretation comments from the photointerpreters working on the wheat yield study.

1.5 AEROSPACE VEHICLE SUMMARY

1.5.1 Mission Preflight Planning

Mission 1207 represents the first of the Block II Satellite Vehicle and Panoramic Camera Systems. Soft seat RCS Valves were installed and because of their expected leak-free performance, RCS fuel was to be drawn from RCS Tanks 1 and 2 before using the OA Tank. RCS Tanks 3 and 4 were removed. The OA Tank was loaded with 3,200 pounds of fuel. The Panoramic Camera System deleted the anti-telescope cage of the Supply unit and was instrumented to monitor the Supply response during launch. A nominal one rev load cycle for payload revs was planned for use throughout the mission to insure best weather updates.

The Mission 1207 orbit was designed to:

- A. Maintain solar (Beta) angle within +2° to -8° for the planned 90 days.
- B. Have orbit adjusts to occur on a three-day cycle with every third OA to be a positive and negative burn for close control of argument of perigee.

1.5.2 New Secondary Flight Objectives

During the mission, a new objective was defined:

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Exercise a direct solar photography experiment to determine camera and film degradation. The experiment was run at the end of 1207-4.

1.5.3 Active Mission

The seventh 1200 Series Satellite Vehicle (SV-7) was placed into the nominal 88 x 154 NM orbit by the Titan IID Booster on 10 November 1973. Ascent events were all nominal and proper stabilization of the SV allowed initiation of deployment of the solar arrays at the first station contact. Subsatellite (+Y) was properly ejected on Rev 2. The SSU (-Y) Subsatellite was properly ejected on Rev 13. Preflight mission planning included a 45 day mapping mission, a 90 day panoramic mission, and a 30 day Solo operation. The Panoramic Camera operated throughout the mission and its RVs were aerially recovered on Days 15, 38, 65, and 103. All of the film was transported into the RVs including 4,984' of SO-255 Color Film in RV-1 and 501' of FE-3916 IR Film in RV-4. A metering capstan resonance at peak Vx/h values was determined during the PFA of RV-1 to be affecting image quality. The perigee altitude was raised two miles by OA-8 on Rev 289. All other Panoramic Camera operations were normal. All the Mapping Camera operations were normal and 98.4% of the film was transported to RV-5, which was aerially recovered on Day 58. A direct solar photography experiment was conducted on Rev 1650 using the Mono A mode.

1.5.4 Solo and Mission Termination

Limited Solo testing started after completion of the Mapping Camera mission on Rev 942. Tests were restricted to prevent the possibility of ejecting the remaining Terrain or Stellar film. Full Solo testing started after completion of the primary mission with the recovery of RV-4 on Rev 1656.

All planned Solo tests were completed except for Lifeboat Execute which could not be done on the deboost rev, and the Stellar/Terrain Terrain Shutter reset which was prevented by the Emergency Terrain Thermal Shutter failure. The active phase was extended at SPO request to include an additional performance evaluation of RCS-1. This activity continued until the successful deboost of SV-7 on Rev 1998, Day 124.

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SECTION II

CAMERA OPERATIONS

2.1 INTRODUCTION

The Mission 1207 Satellite Vehicle was launched from VAFB, SLC-4E, at 1210 PST on 10 November 1973 using a Titan IIB Booster Vehicle. All primary payload recovery vehicles were successfully air retrieved and were within the predicted impact dispersion. Recoveries were on Days 15, 38, 65, and 103 respectively.

2.2 SUMMARY

The countdown and launch phases were accomplished without incident. After insertion, the Sensor System (SS) 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 6, Op 4, and continued with no camera system malfunctions through the end of the mission. The Forward Camera film Supply was depleted during the down-ramp of Op 699 (Mono A). The Aft Camera Supply was depleted at the conclusion of Op 700 (Mono B). Rewind velocity was constrained to 5 inches/second and photography at scan centers of $\pm 45^\circ$ was prohibited throughout the flight.

The nominal orbit perigee was raised by 2 NM on Rev 289 because of recurring resonance in the fine film drive at path velocities associated with the initial orbit photographic altitudes.

The Aft Camera Supply contained the following films; (1) 1414, (2) a 4,984' segment of SO-255 Color, and (3) a 501' segment of FE-3916 IR Color. 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	1	80	50		135	82	4,984
FE-3916	4	1644	694		1853	700	501

The active photographic mission was terminated with the RV-4 recovery on Day 103. A Solo phase of the mission extended the vehicle life to Day 124, at which time the vehicle was deboosted and re-entered. The extended Solo phase was designed to simulate a 180 day lifetime duty cycle.

2.3 ON-ORBIT OPERATIONS

2.3.1 Launch and Orbital Parameters

Appendix B gives a table of basic parameters including period, perigee, apogee, inclination, and

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argument of the perigee. Also Figures B-1 and B-2 are provided for beta angle history, period, and perigee. Figure B-2 shows the effects of the 34 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 1207 are given in the following paragraphs:

2.3.2.1 Ascent

The countdown and launch were accomplished without incident, with uncage (Seqs 204 and 205) and OB stow (Seqs 213 and 214) occurring 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 3 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 3

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, with the exception of the execution of the OOAA nominal settings. A loss of telemetry during a portion of the health check masked the execution of the OOAA nominal setting commands. Focal plane position indicated 137 microns for the Forward Camera and 33 microns for the Aft.

D. Rev 5

The OOAA nominal settings were again commanded and were verified for the operational photography that began on this rev.

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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 Events

Eleven engineering tests were defined in the SV-7 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

<u>Test</u>	<u>Objective</u>	<u>Status</u>
1. Thru Focus (1414)	Optimize focus.	Accomplished; confirmed focus (1414) was optimum in RV-1.
2. Smear Slits (1414)	Validate IMC settings.	Accomplished; optimum biases determined in RV-1; implemented (Aft in-track) and confirmed in RV-2.
3. Smear Slits (SO-255)	Evaluate smear slit imagery for validating IMC settings with SO-255.	Completed in RV-1; no OOAA changes recommended.
4. CORN Acquisitions (SO-255)	Evaluate and radio-metrically calibrate SO-255.	Completed in RV-1 with a single acquisition reading of 2.6' GRD.
5. CORN Acquisitions (FE-3916)	Evaluate image quality of FE-3916.	Completed in RV-3 with a single acquisition reading of 5.6' GRD.
6. Lens MTF (1414)	Measure on-orbit lens MTF.	Two acquisitions were accomplished but were not usable; test cancelled after RV-2 in favor of Test 11.
7. Tucson Acquisition	Standard scene for quality assessment.	Satisfied only for RV-1, RV-2, and RV-4.
8. Color Thru Focus (SO-255)	Optimize focus.	Accomplished in RV-1; confirmed that focus (SO-255) was optimum.
9. Tribars for Resolution	Photo quality assessment.	Satisfied only for RV-1, RV-2, and RV-4; acquisitions were in common with Test 7. Results indicate an average of 2.2' GRD (floating contrast) and 2.8' (2:1 normalized contrast).
10. Smear Versus Scan Angle	Assess smear as a function of scan angle location.	Accomplished mission goal.
11. Dense Culture Acquisition (1414)	Photo/EM correlation.	Accomplished; system performance verified.

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2.3.2.4 Special Events

Table 2-3 (listed on pages 2-15 thru 2-18) presents the chronology of the health checks, engineering tests, and miscellaneous events accomplished during this mission.

2.3.2.5 Solo Phase

The Solo phase of Mission 1207 was used to perform the following tests:

A. Redundant SCC Health Check

After transfer from SCC-2, the operational health of SCC-1 was verified by commanding different values of Vy/h from each decoder during the Solo phase. The execution of the proper Vy/h value confirmed the selection and operability of SCC-1.

B. Optical Bar Temperature Test

During Rev 1696, the vehicle was intentionally rolled 90° and left in inertial attitude for approximately 15 minutes. The optical bars were continuously rotated for four minutes at the center of the time interval, two minutes either side of the solar sub-point. Temperature changes were observed on the optical bars but were within the range (2° F) observed with the vehicle in normal flight attitude.

2.3.3 Mission Expendables

The profiles of film consumption presented in Figure 2-1 are segmented in Table 2-4.

The distribution of film footage as functions of the various operating modes is presented in Figures 2-2 thru 2-10.

TABLE 2-4

FILM USAGE SUMMARY

<u>Segment</u>	<u>Rev Span</u>	<u>Camera</u>	<u>Recovered Footage</u>
RV-1	Launch - 225	Forward	28,964
		Aft	27,402
RV-2	226 - 599	Forward	26,015
		Aft	26,077
RV-3	599 - 1036	Forward	28,982
		Aft	29,036
RV-4	1037 - 1654	Forward	23,465
		Aft	23,376

Of this footage, the engineering and other non-intelligence operations consumed approximately 4,800' and 4,500' for the Forward and Aft Cameras, respectively.

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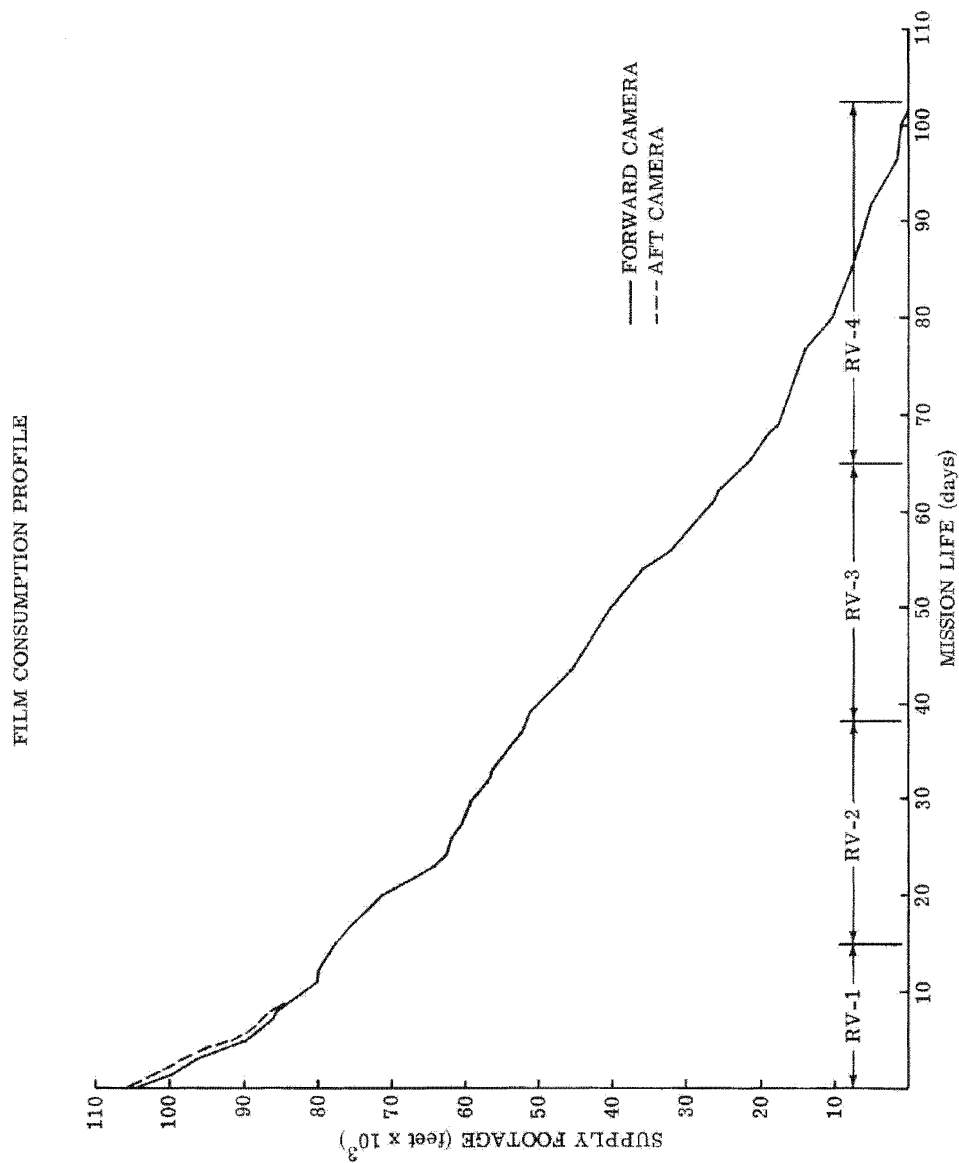
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FIGURE 2-1

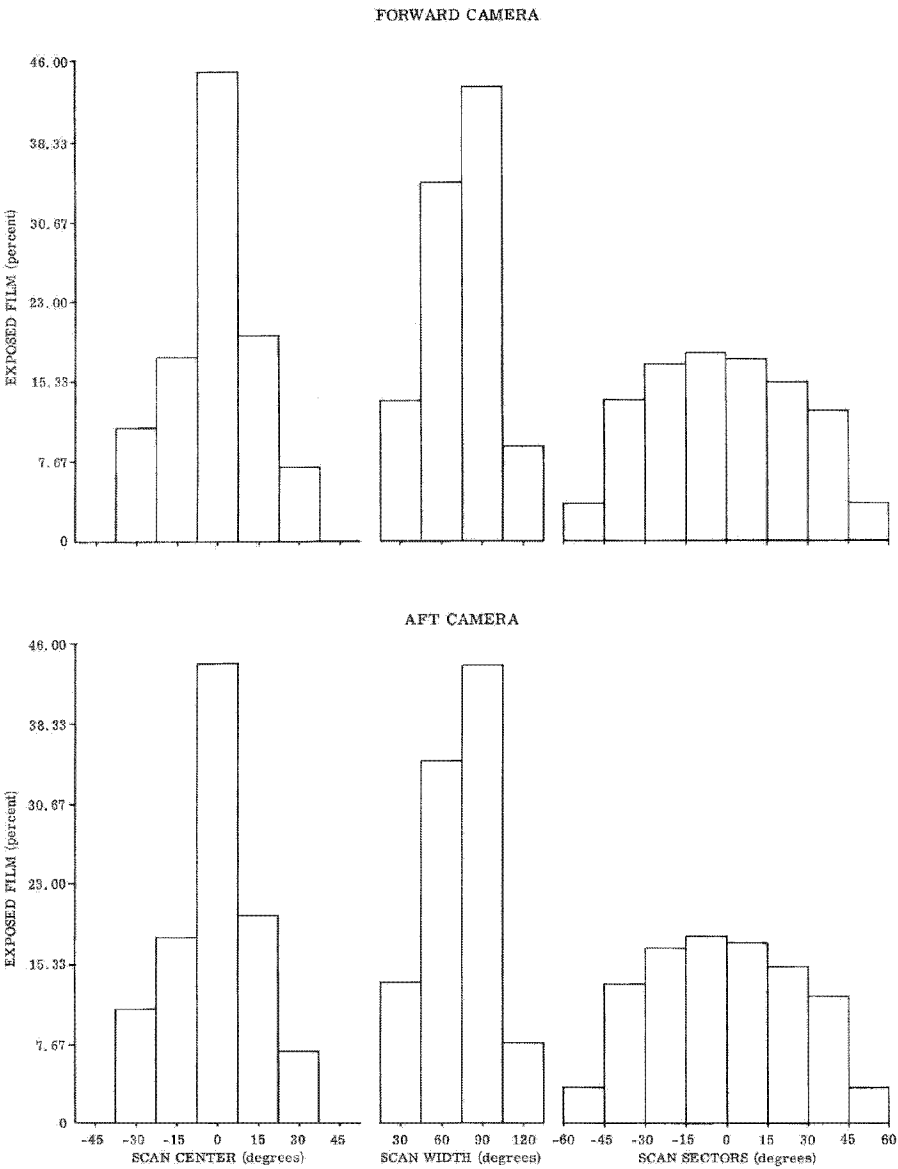
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PHOTO FOOTAGE DISTRIBUTION VERSUS
SCAN WIDTH/SCAN CENTER/SCAN SECTOR



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2-6

FIGURE 2-2

POST FLIGHT ANALYSIS REPORT
1207

PHOTOGRAPHIC FRAMES DISTRIBUTION VERSUS
SCAN WIDTH/SCAN CENTER/SCAN SECTOR

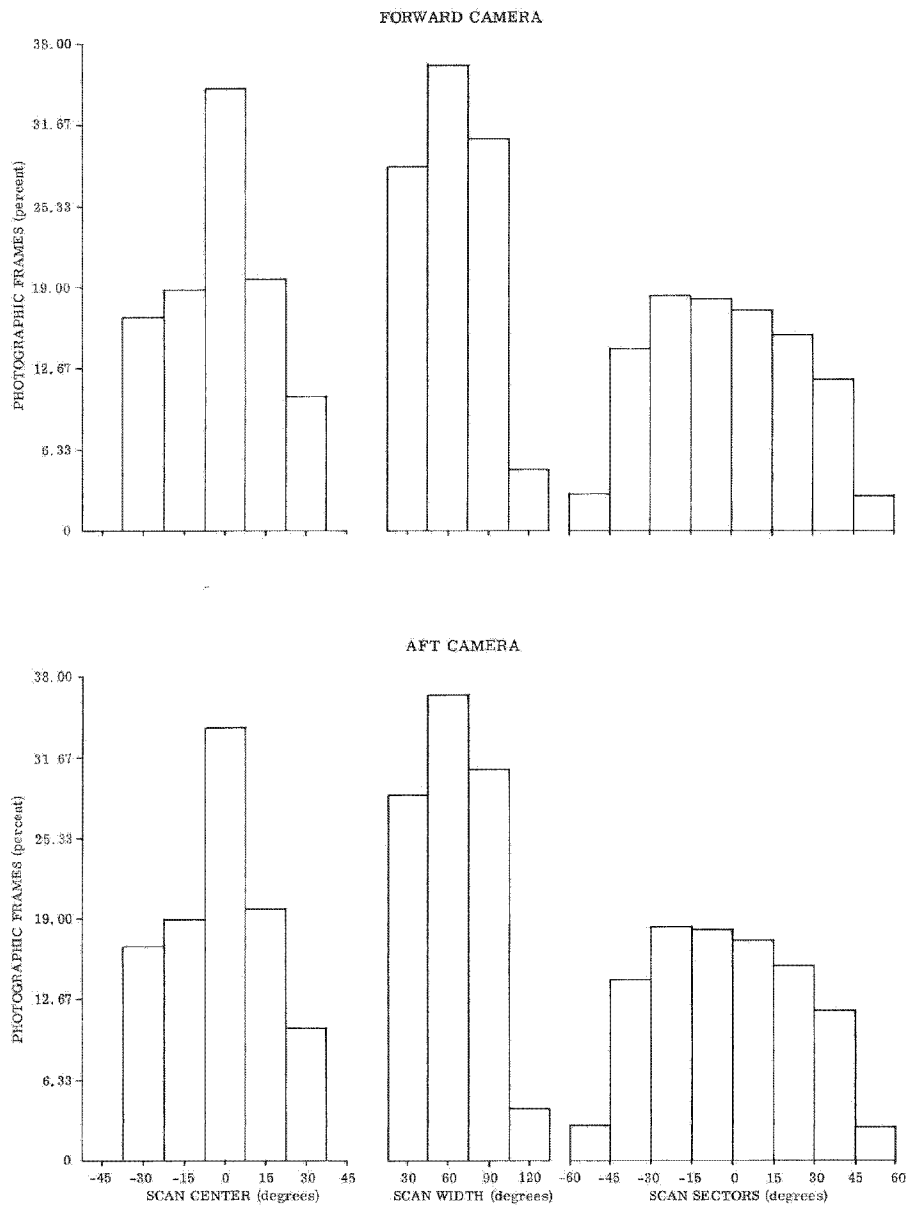


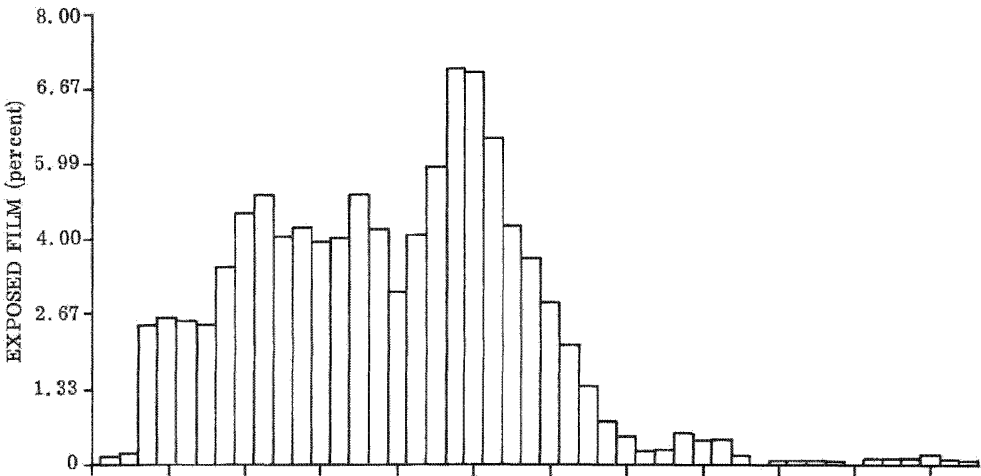
FIGURE 2-3

~~TOP SECRET-HEXAGON~~

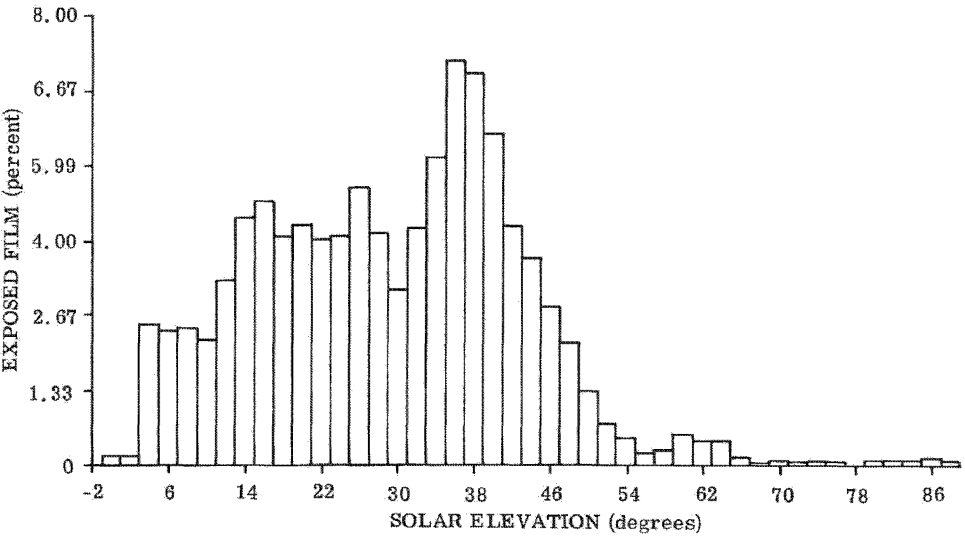
POST FLIGHT ANALYSIS REPORT
1207

PERCENTAGE OF EXPOSED FILM VERSUS SOLAR ELEVATION

FORWARD CAMERA



AFT CAMERA



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FIGURE 2-4

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~~TOP SECRET - HEXAGON~~

POST FLIGHT ANALYSIS REPORT
1207

PERCENTAGE OF EXPOSED FILM VERSUS VEHICLE ALTITUDE

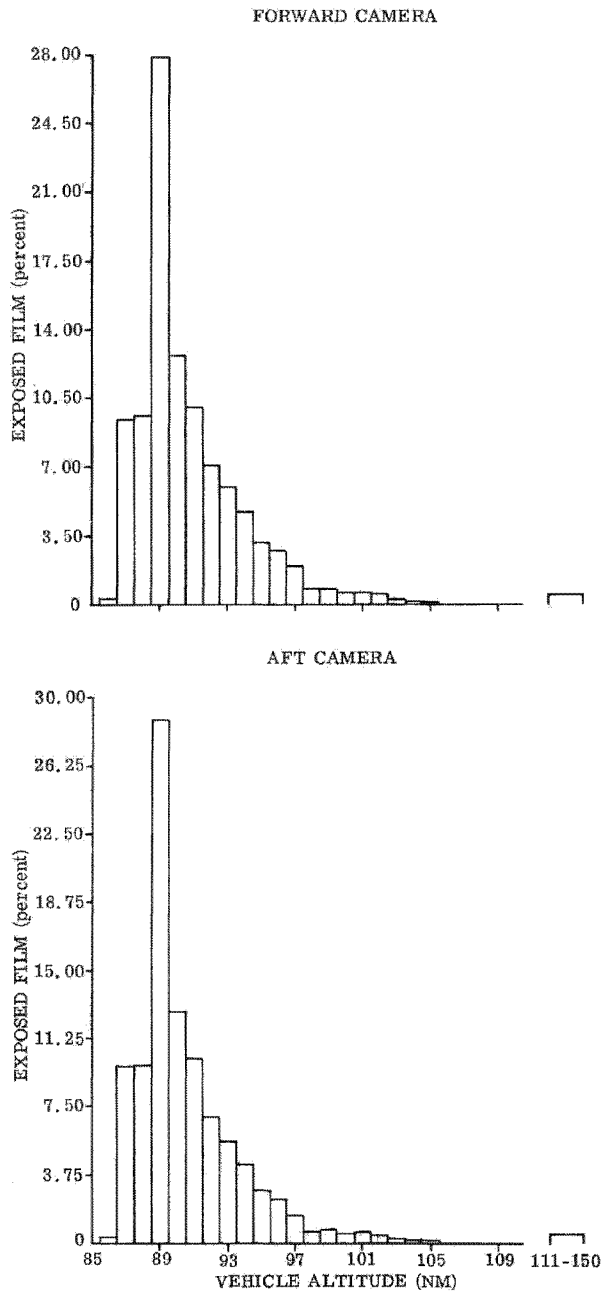


FIGURE 2-5

~~TOP SECRET - HEXAGON~~

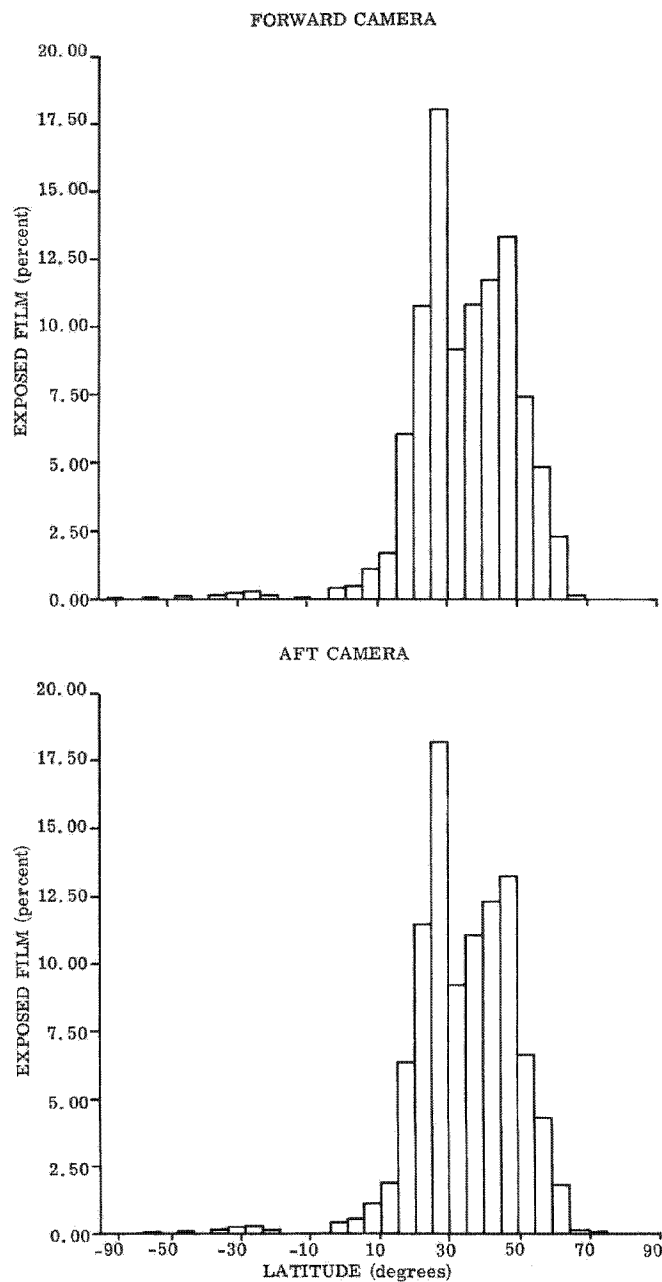
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POST FLIGHT ANALYSIS REPORT

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PERCENTAGE OF EXPOSED FILM VERSUS LATITUDE



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2-10

FIGURE 2-6

~~TOP SECRET-HEXAGON~~POST FLIGHT ANALYSIS REPORT
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PERCENTAGE OF EXPOSED FILM VERSUS SLIT STEPS

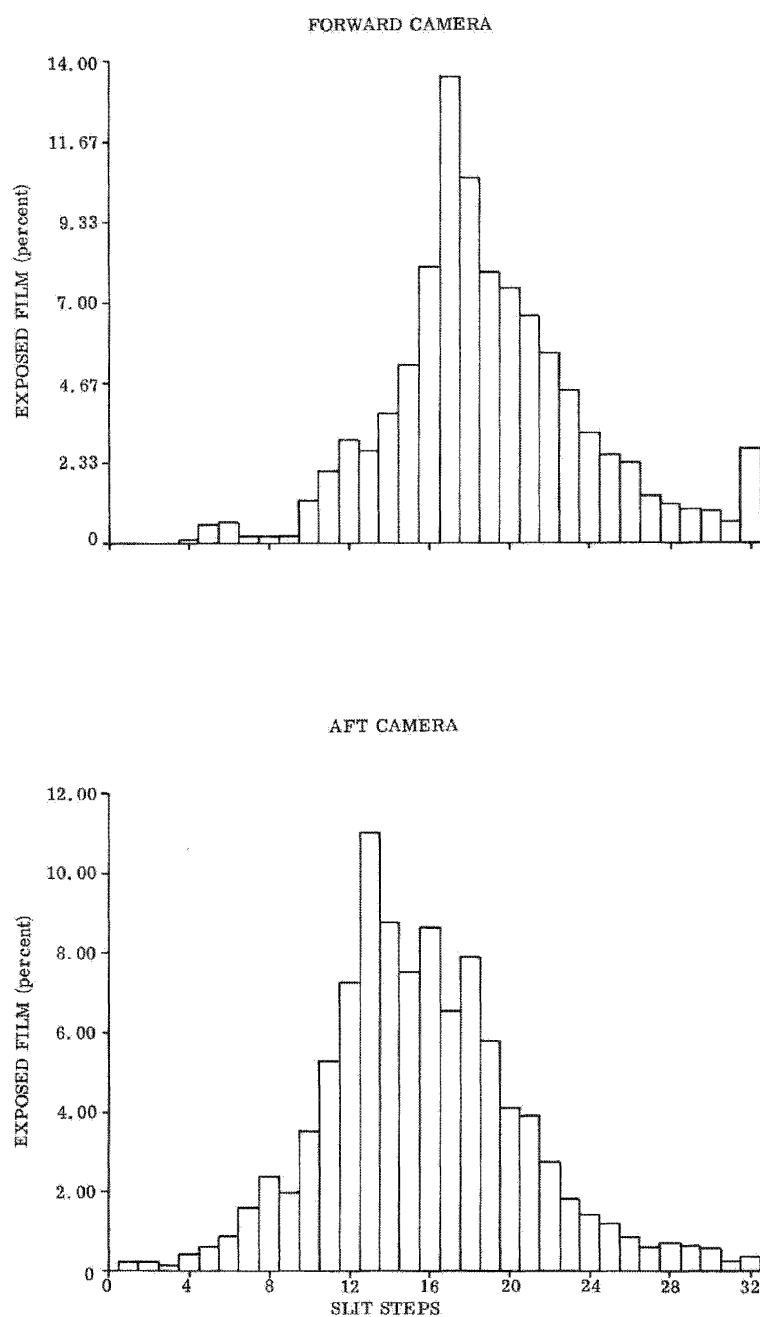


FIGURE 2-7

~~TOP SECRET-HEXAGON~~

2-11

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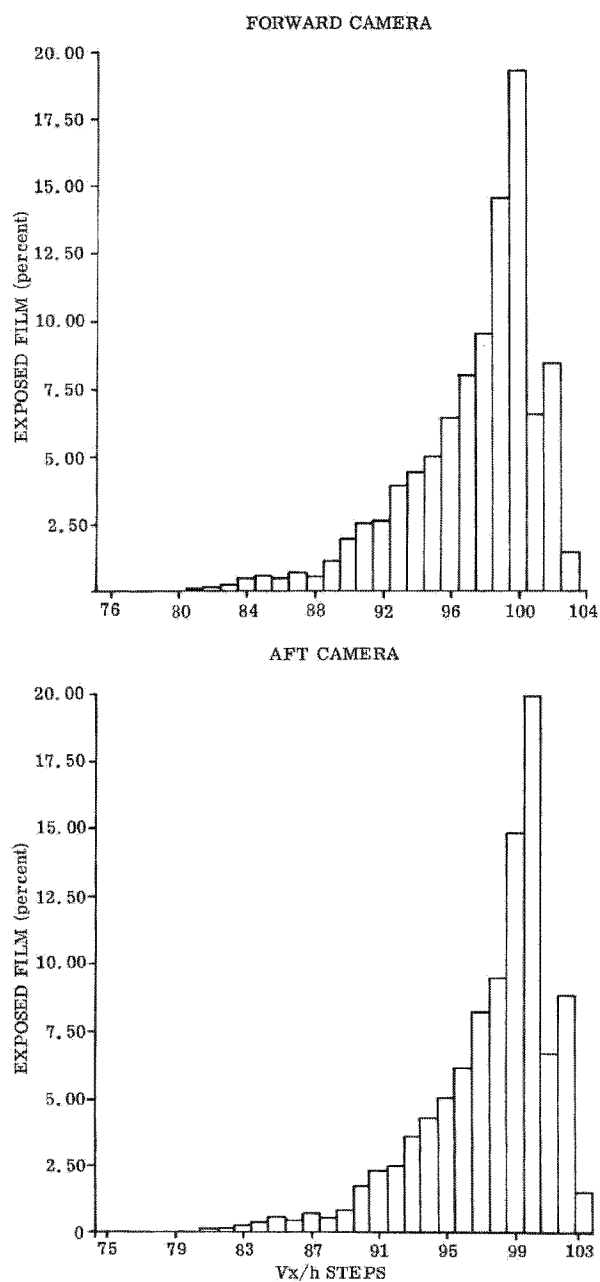
Handle via Byeman

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POST FLIGHT ANALYSIS REPORT

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PERCENTAGE OF EXPOSED FILM VERSUS V_x/h STEPS

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FIGURE 2-8

~~TOP SECRET-HEXAGON~~POST FLIGHT ANALYSIS REPORT
1207

DISTRIBUTION OF LAND MASS COVERAGE AS A FUNCTION OF SCAN SECTORS

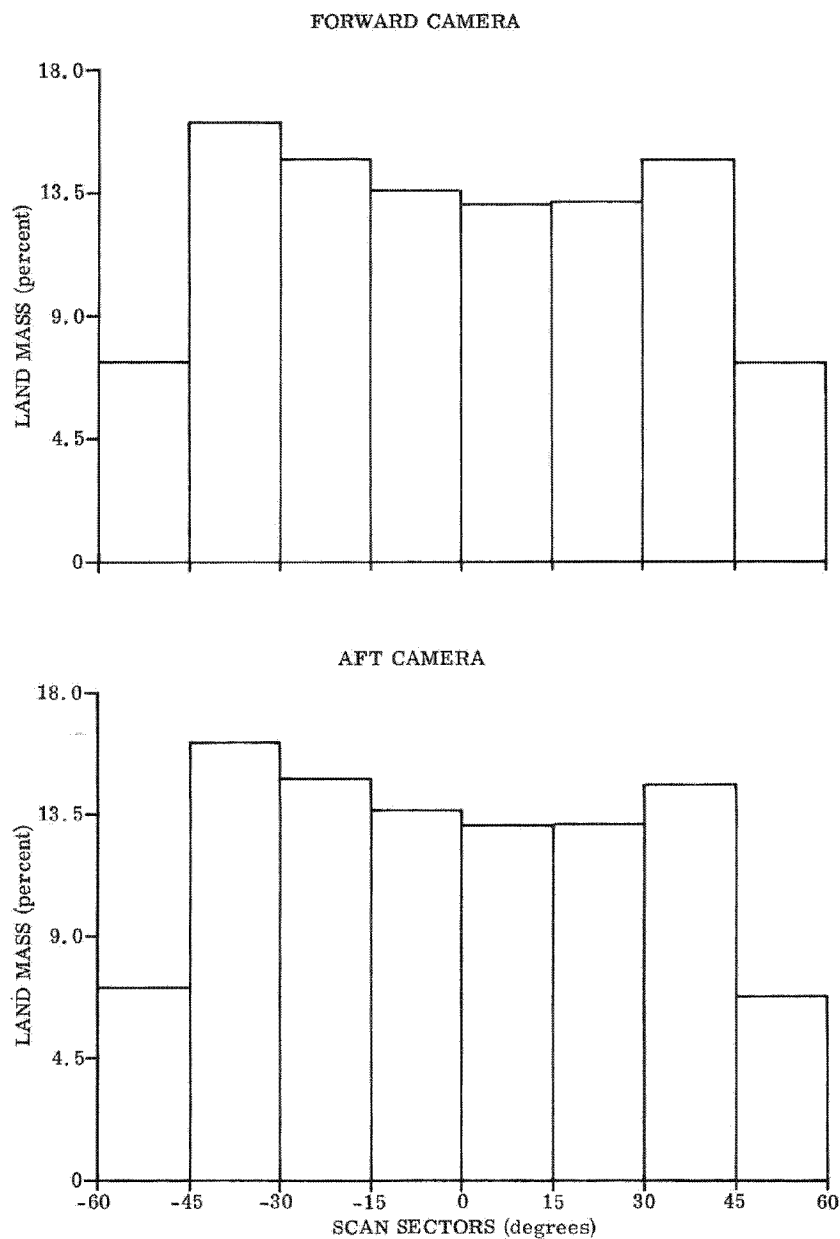


FIGURE 2-9

~~TOP SECRET-HEXAGON~~

BYE 15339-74

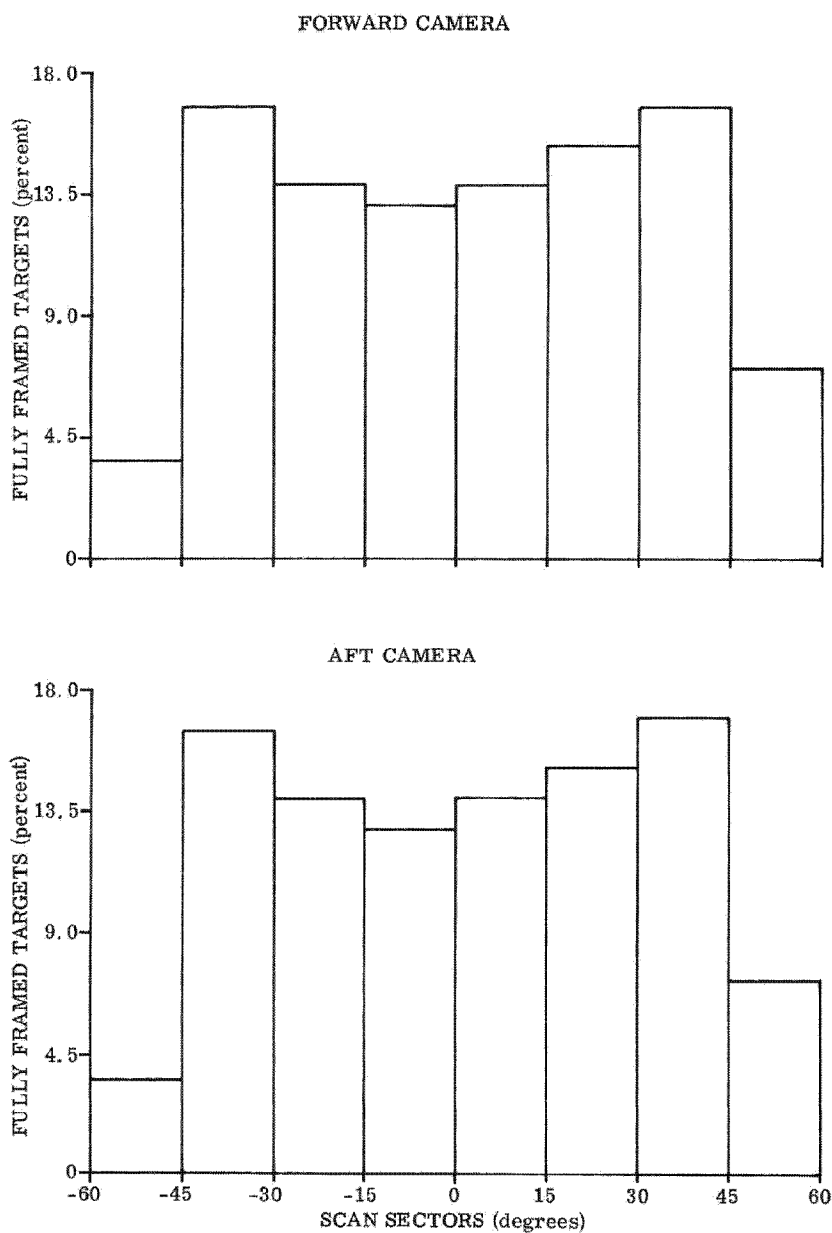
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POST FLIGHT ANALYSIS REPORT

1207

DISTRIBUTION OF FULLY FRAMED TARGETS VERSUS SCAN SECTORS



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2-14

FIGURE 2-10

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1207

TABLE 2-3

SUMMARY OF SPECIAL EVENTS

— Mission Segment 1207-1 —

<u>Rev</u>	<u>Op Number</u>	<u>Test Number</u>	<u>Predicted Wx (%)</u>	<u>Event (location)</u>	<u>Verified Wx (%)</u>	<u>Footage</u>
0				Uncage/Redundant Uncage		
0				Stow A/Stow B		
1				Uncage Verify		
2				Conditional Constant Velocity		102
3	1-3			SCC-2 Health		186
3				OOAA Nominal Setting		
5	4			OOAA Nominal Verify Due To Data Dropout Rev 3		
8	7			SS Engineering Test		66
15	15	1	85	Thru Focus (+16, +8, +16, 0 - Houston)	80	31
32	22	7/9		Tucson Acquisition	99	
47	27	1		1414 Thru Focus (-8, 0-Atlanta)	99	30
65	39	1	25	1414 Thru Focus (-16, -8, 0, +8 - San Francisco)	00	37
80				Aft Camera Set For SO-255; W-2E3 Filter, OOAA Nominal		
80	50	8	65	SO-255 Thru Focus (-14, 0, +14 - Dallas/Ft Worth)	99	60
81	51	1	65	1414 Thru Focus (-16, -8, 0) Fwd; SO-255 Smear Slit (Los Angeles) Aft	60	31
112	68	1 8	90	1414 Thru Focus (+8, 0) Fwd; SO-255 Thru Focus (-14, 0 - Birmingham) Aft	99	30
113	69	4	75	SO-255 Target (Gallup)	99	30
129	77	4	65	SO-255 Target (Tucumcari)	10	33
130	79	1	40	1414 Thru Focus (-8, -16, 0) Fwd; SO-255 (-14, 0 Everett/Seattle) Aft	00	40
136				Aft Camera Set for 1414, W-2E3 Filter, OOAA Nominal		
146	87	10	95	1414 Smear vs Scan (San Francisco)	85	65

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POST FLIGHT ANALYSIS REPORT

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TABLE 2-3 (CONT'D)

<u>Rev</u>	<u>Op Number</u>	<u>Test Number</u>	<u>Predicted Wx (%)</u>	<u>Event (location)</u>	<u>Verified Wx (%)</u>	<u>Footage</u>
154	92			PN Equalization		
160	95	3A		1414 Smear Slit		124
			75	(Boston)	40	
			65	(Providence)	75	
162	96	1	25	1414 Thru Focus (+16, 0, -8, -16; Riverside/San Diego)	95	129
173	105	1	95	1414 Thru Focus (+16, +8, 0, -8, -16; Paris/Lesquri)	99	68
225	115	1	00	1414 Thru Focus (+16, 8, 0, -8; New York)	00	34
225	116			Protective Wrap (Florida)		179
				1207-1 Footage:		1,275
				Accumulative Footage:		1,275
— Mission Segment 1207-2 —						
226				Transfer to TU-2, Prep I		
227				Complete Transfer, Prep II		61
313	146			PN Equalization		
339	156	3A	70	1414 Smear Slit (Cincinnati)	95	33
355	166	3A	75	1414 Smear Slit (Tampa/ St. Petersburg)	65	31
371	176	3A	90	1414 Smear Slit (New York/Philadelphia)	99	117
405	186	7/9	85	Tucson Acquisition	80	
454	198	3A	90	1414 Smear Slit (Los Angeles)	99	86
		6	75	1414 Lens MTF (Inyokern)	99	
461	200			PN Equalization		
517	223	10	75	1414 Smear vs Scan (New York)	10	84
				1207-2 Footage:		412
				Accumulative Footage:		1,687

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TABLE 2-3 (CONT'D)

— Mission Segment 1207-3 —

<u>Rev</u>	<u>Op Number</u>	<u>Test Number</u>	<u>Predicted Wx (%)</u>	<u>Event (location)</u>	<u>Verified Wx (%)</u>	<u>Footage</u>
599				Transfer to TU-3, Prep I		
600				Complete Transfer, Prep II		61
616	253	6	99	1414 Lens MTF (Quartzsite)	99	50
681	279	10	70	1414 Smear vs Scan (Los Angeles)	70	86
719	296			PN Equalization		
931	379			PN Equalization		
	380			PN Equalization		
1032	423			Protective Wrap		
				1207-3 Footage:		197
				Accumulative Footage:		1,884

— Mission Segment 1207-4 —

1037				Transfer to TU-4, Prep I		
1038				Complete Transfer, Prep II		61
1092	468			PN Equalization		
1184	511	10	90	1414 Smear vs Scan (Positive) (Sacramento)	95	128
			75	(SF Bay Area)	85	
1232	529	7/9	99	Tucson Acquisition	99	30
1252	540			PN Equalization		
1263	552	11	65	1414 TM Correlation (Baltimore)	25	133
			65	(Washington)	70	
1280	562	10	75	1414 Smear vs Scan (Negative) (Dallas/Ft Worth)	99	74
1281	563	11	90	1414 TM Correlation (Los Angeles)	99	121
1344	594	11	80	1414 TM Correlation (New York)	50	128
1362	601	10	95	1414 Smear vs Scan (Negative) (Los Angeles)	99	79
1400	617			PN Equalization		

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POST FLIGHT ANALYSIS REPORT
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TABLE 2-3 (CONT'D)

<u>Rev</u>	<u>Op Number</u>	<u>Test Number</u>	<u>Predicted Wx (%)</u>	<u>Event (location)</u>	<u>Verified Wx (%)</u>	<u>Footage</u>
1409	620	10	90	1414 Smear vs Scan Positive (New York - Philadelphia)	99 99	112
1563	683			PN Equalization		
1644	694			Aft Camera Set For FE-3916 IR, W-12 Filter, OOA Nominal		
1650	699			Solar (Mono A)		180
1653	700	5	55	FE-3916 IR (Mono B) (Houston)	95	29
1653				Prep II Constant Velocity	Depleted	
1654				Constant Velocity	Depleted	
				1207-4 Footage:	1,119(Fwd)/968(Aft)	
				Accumulative Footage:	3,003(Fwd)/2,852(Aft)	

The non-intelligence usage is summarized in Table 2-5.

TABLE 2-5

NON-INTELLIGENCE FILM USAGE
(feet)

<u>Event</u>	<u>Forward Camera</u>	<u>Aft Camera</u>
Pre-Launch	1,928	1,657
PFA Engineering		
RV-1	742	742
RV-2	351	351
RV-3	136	136
RV-4	807	836
Other Engineering (Health Checks, RV Preps, Solar, Wrap)	967	787
Total Utilization	4,839	4,509
Film Recovered	107,426	105,891
Percentage of Non-Intelligence	4.50	4.26

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1207

2.4 SENSOR SYSTEM ANOMALIES

2.4.1 Film Tear Anomaly

During the despooling of Aft Camera TU-3, a film tear was discovered at the start of the first of three occurrences of mis-stacking (blocking). The most probable cause of the tear was the ingestion of a connector dust cap into the film stack. Both the dust cap and some small particles of debris were found. A thorough data analysis was performed because of the potentially serious effects a tear can have on the camera system. Simulations were run to duplicate the tear mechanism, and computer models were used for telemetry data analysis. Specific corrective action has been taken to control the use of connector caps to preclude the possibility of one coming free in future systems.

2.4.1.1 DescriptionA. Film Data

The tear was located 8,000' from the core of 1207-3, in Frame 026, Op 304, of a 42 frame 90° scan angle-scan length operation. The tear is "U"-shaped, extending from the film's untitled edge to a point about 2.9" into the web. The "U" is approximately 1" long along the major axis with the base of the "U" toward the head of the film.

The torn section of film had a triple accordian type fold with the first fold base-to-base, the second emulsion-to-emulsion, and the third base-to-base, see Figure 2-11. However, the imagery in each folded section was properly oriented. Because a puncture signature was not apparent, the point at which the tear occurred was not obvious. It was impossible to determine if any edge damage existed prior to the tear since the plus-density normally resulting from mechanical damage was not detectable. It should be noted that the emulsion at the film's edge was covered with tape when the film was processed.

Small high frequency minus-density marks occur on the head side of the film at the tear's apex (the base of the "U"). These fine lines, running along the film's major axis, show a coarser pattern along its minor axis. Initially these were thought to be caused by lack of contact between the viscous developer and the emulsion. However, testing at SSC indicates these were very likely produced by scuffing.

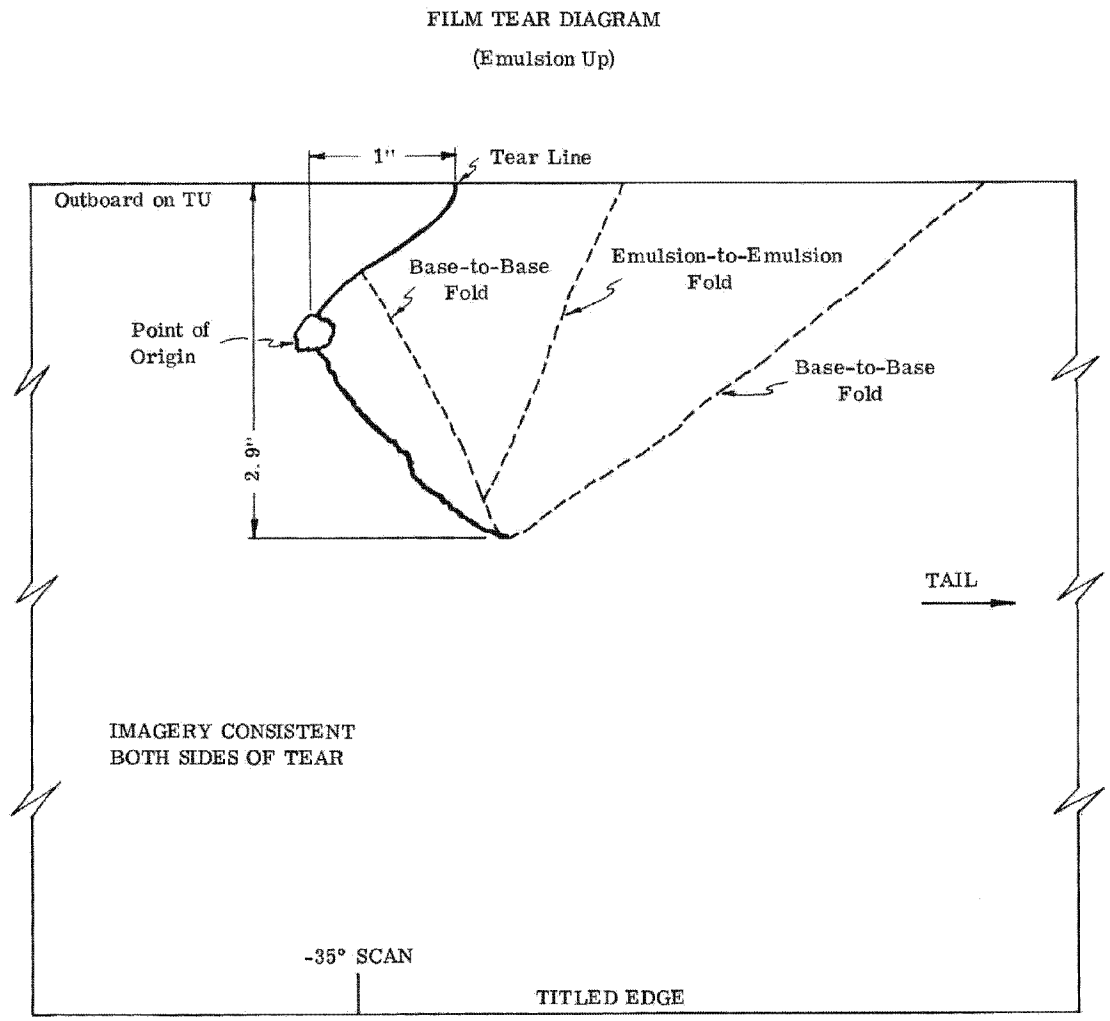
Prior to processing, the film was repaired by placing tape on the film's base side. At the point of the tear, the tape extended around the film edge onto the emulsion side. Passing the repaired section through the processor-dryer caused a crease and fold-over in Frames 026, 027, and 028. These creases and fold-overs have imagery but no plus-density pressure marks. Prior to duplicating, the torn area was taped on both the base and emulsion sides of the film. Thus, faint tape marks are visible on the duplicate prints.

Streaks of dendritic static occurred near the end of this operation. These streaks were located along the Aft Camera's major axis near the center of format.

B. Telemetry Data~~TOP SECRET-HEXAGON~~

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FIGURE 2-11

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(1) Non-characteristic Variations in Telemetry Signals

A detailed examination of pertinent telemetry data for the period that the tear position was between the Supply and Take-up revealed significant non-characteristic variations in two signals. These were the Output Coarse Tension and the Take-up Summed Error signals. The variations are shown in Figure 2-12 together with Frame 031. Frame 031 is included for a time reference.

The Output Coarse Tension signal shows an increase of approximately .1 pound with a sudden drop after .2 to .3 second. The Take-up Summed Error shows a torque increase of approximately 1.5 lb/ft with a sudden drop at about the same time as the coarse tension. This signal appears delayed in the telemetry downlink due to a processing filter. This delay cannot be determined prior to the event as it is a function of the signal's frequency. However, it can exceed two hundred milliseconds.

(2) Derived Data

The placement of the tear position at the time the optical bar was at nadir during Frame 031 was calculated using the film path length from the slit to the Take-up. It should be noted that HOPER and SURVEY Programs erroneously indicated that the tear location was at Frame 029 due to data drop out. Figure 2-13 shows the placement of the tear's apex with respect to the center of the slit and Take-up rollers. When the OB was at nadir during Frame 031, the tear's apex was 5' past the crest of Roller No. 83. Roller No. 83 is a designation identifying the last roller before TU-3 on the Aft Camera.

This information would indicate that the non-characteristic telemetry variations were a result of a phenomenon that occurred between Roller No. 83 and the Take-up stack. In addition, it is highly probable that these telemetry variations are indications of the same phenomenon that tore the film. This is based on the fact that the tear position transversed the distance from the Take-up Steerer to the Take-up in approximately four seconds and these variations appear in that time period. Attributing the telemetry variations to the same phenomenon as the tear is consistent with a single failure philosophy; otherwise, two phenomena would have occurred. One would have caused a tear without any telemetry indication and the other would have resulted in telemetry variations without any apparent associated effects. The two phenomena hypothesis was rejected on the basis of its low probability.

2.4.1.2 SimulationsA. Experiments

Tests to simulate the tear's occurrence were conducted at SSC on the Engineering Model and auxiliary test set-ups. Small debris including 5/8" diameter steel washers, metal shavings, wire clippings, etc. were inserted between: (1) the film and entrance roller, and (2) the entrance web and the stack, see Figure 2-14. The tests were repeated several times with virtually no damage to the film. A 5/8" diameter washer, when placed between the film and the entrance roller, left a small circular

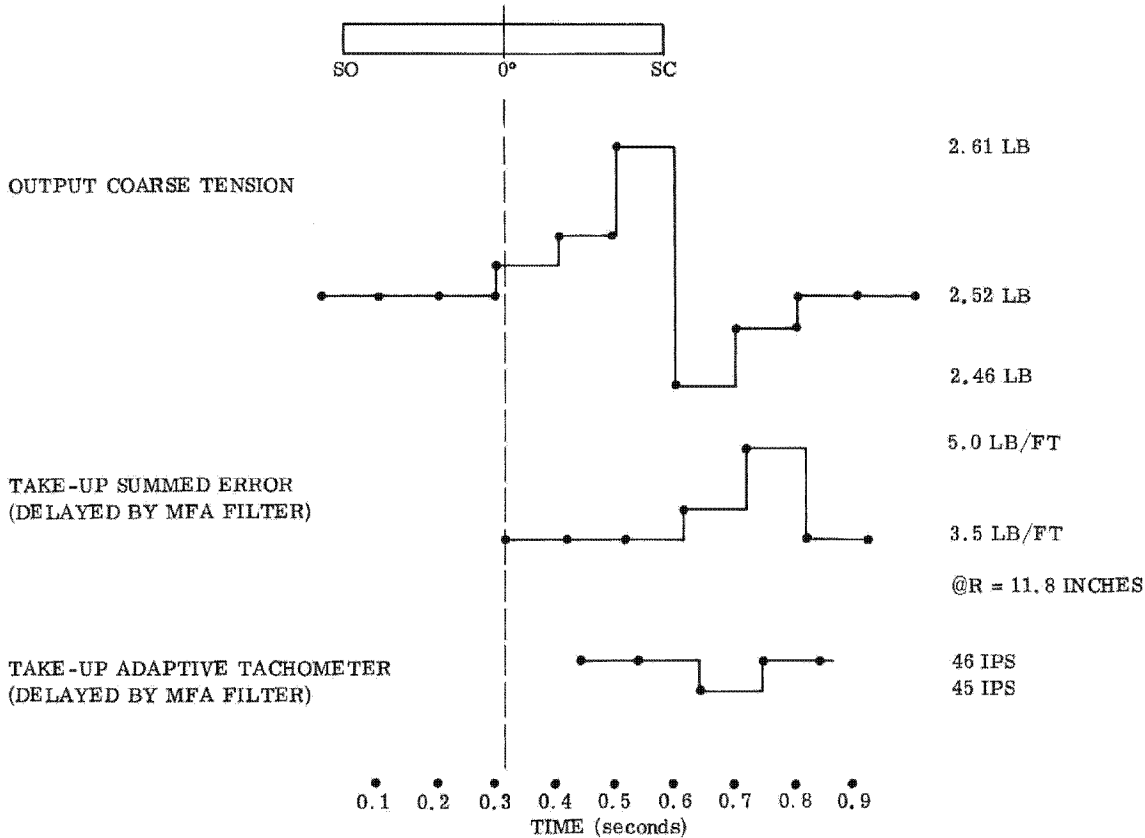
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FILM PATH TELEMETRY DATA ASSOCIATED WITH FILM TEAR
(Op 304, Frame 031)



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FIGURE 2-12

2-22

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FILM PATH DIMENSIONS ASSOCIATED WITH FILM TEAR

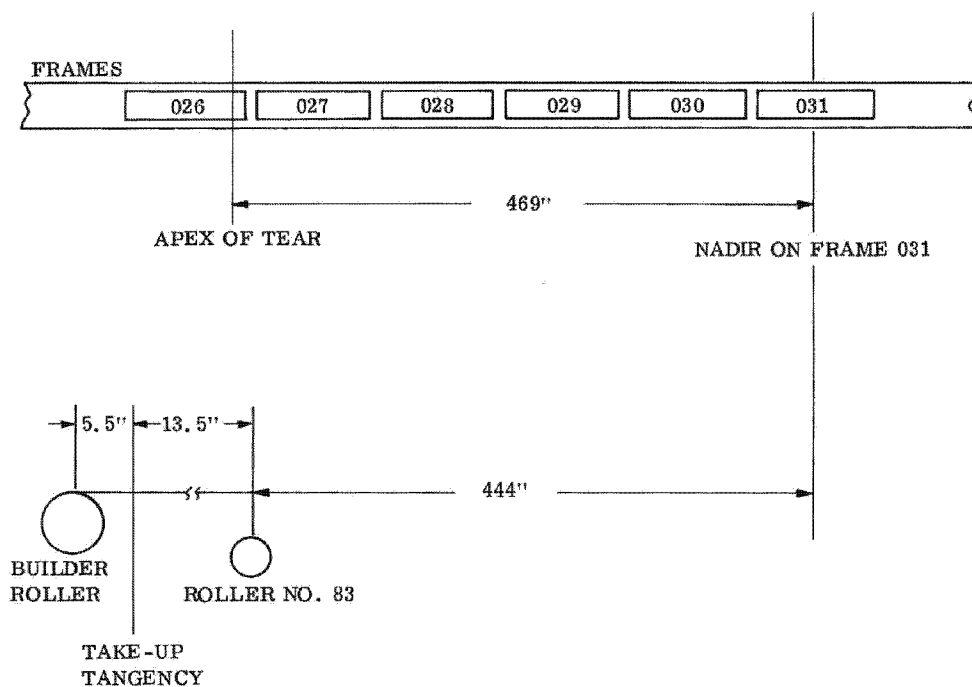


FIGURE 2-13

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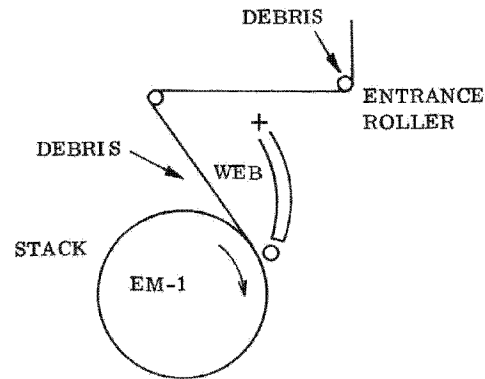
~~TOP SECRET~~ HEXAGON

POST FLIGHT ANALYSIS REPORT

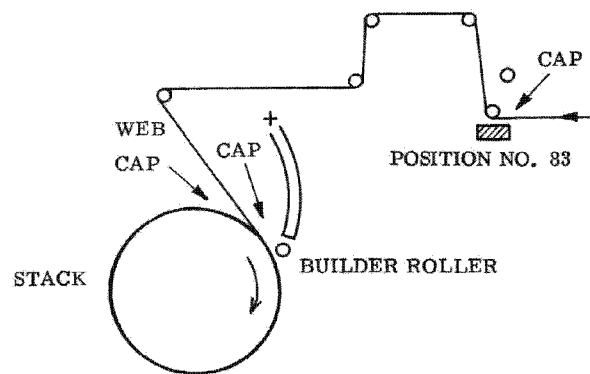
1207

FILM TEAR SIMULATION

— USING MISCELLANEOUS SMALL DEBRIS —
(Washers, Metal Shavings, Solder, etc.)



— USING PLASTIC CONNECTOR CAP —



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~~TOP SECRET~~ HEXAGON

2-24

FIGURE 2-14

~~TOP SECRET - HEXAGON~~POST FLIGHT ANALYSIS REPORT
1207

impression on the film, but did not tear the film. Based on these tests, small sized miscellaneous debris was dismissed as a possible cause of this tear.

SSC conducted a test to determine if a connector cap had passed between the film web and the RV cutters and forced the film into the cutter teeth initiating a tear. Since no AVE cutters were available, an AGE cutter assembly of similar design was set-up and film run between the cutter jaws. When the connector cap was introduced, the film hit the cutter teeth causing film tears and folds of similar appearance. However, teeth marks were clearly discernible in all cases. Since the flight film did not show any indication of teeth marks, the cutter/cap combination was dismissed as the most probable cause.

Using this same AGE assembly, but not threading through the cutters, tests were run ingesting a cap between the film and a roller. The film repeatedly broke during the majority of these tests. This entire set-up was brought into a dark room and unexposed film was used for the tests. The film was then processed and signatures identical to those on the flight film were obtained. Emulsion was repeatedly scraped from the film without leaving plus-density marks. The spatial pattern of the scrapings was identical to that on the flight film at the apex of the tear. Based on these tests, it was concluded that the connector cap caused the tear.

Take-up EM-1, mounted in the RV-2 position on the Engineering Model, was used to evaluate the cap/film dynamics. Data from the Engineering Model Coarse Tension Sensor, Take-up Summed Error and Take-up Tachometer were recorded for comparison with on-orbit diagnostics. An AVE Roller No. 83 Assembly was mounted as shown in the lower graph of Figure 2-14. Connector caps were repeatedly inserted: (1) at the Roller 83 position, (2) between the builder roller and the stack, and (3) at the tangency of the stack entrance web and the stack. The diagnostics matched the on-orbit diagnostics best when the cap was inserted between the entrance web and the stack. Repeated testing (approximately 12 tests) at this point resulted in no tear to the film. The cap was always ingested into the stack. Repeated tests (approximately 40 tests) at Roller 83 resulted in one film tear.

B. Computer Model

Since the telemetry variations occurred after the last roller in the Take-up, a kinematic model of cap ingestion into the stack was developed and used in a digital simulation. The purpose was to see if ingesting a cap would result in tension and Take-up Summed Errors similar to those noted in the telemetry data. Figure 2-15 is a diagram of the geometrical relationships and definitions necessary to the kinematic model.

One of the major difficulties in simulating the ingestion is that it was not possible to ascertain just what shape the flexible plastic cap would assume in the stack. The shape is quite dependent on the completely unknown attitude of the cap at the moment it gets clamped. Because of this uncertainty a relatively simple geometry was assumed: the cap was assumed to deform the stack as a radial fin

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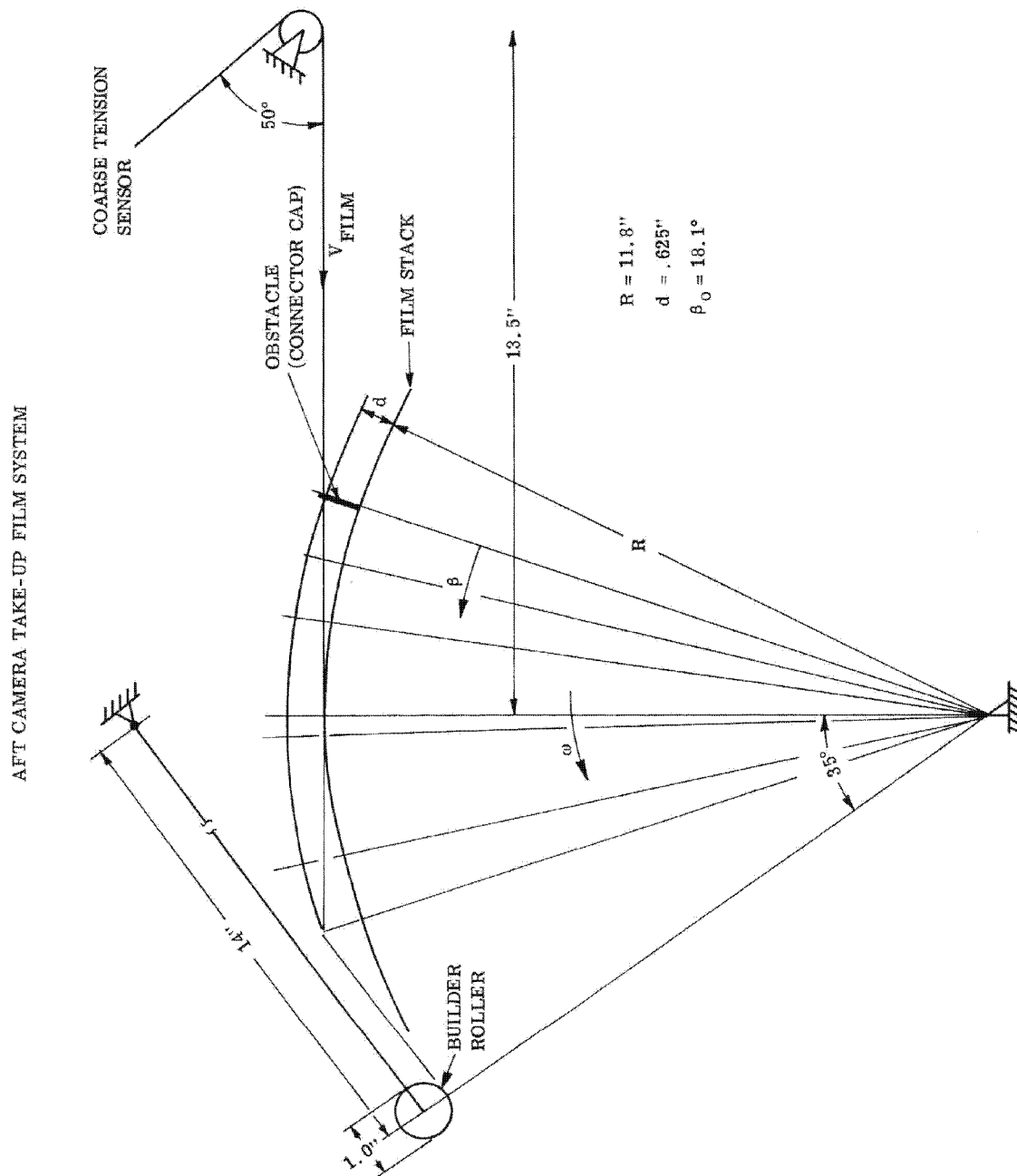
2-25

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POST FLIGHT ANALYSIS REPORT

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~~TOP SECRET - HEXAGON~~

FIGURE 2-15

~~TOP SECRET - HEXAGON~~POST FLIGHT ANALYSIS REPORT
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without thickness and a radial dimension of .625 inch. This assumption would be correct if the cap buckles completely under the pressure of the film web. The effect of the fin is to increase the effective radius from R to $(R + d)\cos A$

where: $d = .625''$ is the fin height

$$A = \cos^{-1} \left[R / (R+d) \right] - B; \left\{ B \leq 2\cos^{-1} \left[R / (R+d) \right] \right\}$$

and,

B = the angular displacement from the point where the fin first touches the web

$$A = -\cos^{-1} \left[R / (R+d) \right]; \left\{ B \geq 2\cos^{-1} \left[R / (R+d) \right] \right\}$$

2.4.1.3 Analysis of Data and Simulations

A. Film Data and Experiments

The following conclusions can be drawn from the results of analyzing the film and experimental data:

(1) The film could not have been folded at the time the image was recorded at the slit because imagery exists on all sections of the torn film with proper orientation and registration. Also, because torn film will fold as it passes over rollers, the film was not torn prior to the slit.

(2) One edge of the torn film has a small trailing flap of film that has no folds. If the tear had passed backwards over a roller, this flap would have folded. Because film recycles in the fine film path, the tear must have occurred after the fine film path.

(3) Torn film passing through the forward Steerer would have generated telemetry signals; because none occurred, the film did not tear until after passing the forward Steerer.

(4) The possibility that the dust cap wedged in the film cutter area and produced the tear by forcing the film against the cutter teeth has been eliminated, because no teeth marks were evident on the film. Simulation testing of this situation at SSC has shown that tearing and folding very similar to the actual case does result; however, cutter teeth marks were always clearly evident on the film.

(5) Experience has shown that a tear such as this one results in continuous folding as the film passes over subsequent rollers; therefore, it is unlikely that the tear occurred prior to Roller 83.

(6) If the tear was produced by an object like a dust cap, it would have occurred prior to the builder roller because a dust cap could not pass under the builder roller without producing a signal on the builder roller radius pot. No such signal occurred.

~~TOP SECRET - HEXAGON~~

2-27

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~~TOP SECRET - HEXAGON~~

POST FLIGHT ANALYSIS REPORT

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(7) The absence of folds on the trailing film flap and the direction of the existing tear and folds indicate that the tear occurred when the film was moving in the forward direction. During despooling the film travels in the reverse direction; therefore, the tear occurred prior to despooling.

B. Telemetry Data and Computer Model

The effect of ingesting the plastic cap in the stack was simulated with a specially modified version of the HANCOT17 Program (HANCOT17F). The simulation showed the telemetry data to be consistent with the film transport effects that could be predicted.

Apart from an increase in tension torque, the fin causes .265" more film to go onto the stack than would go on the unperturbed stack. This amount is taken out of the two coarse tension sensors, causing these to displace .265/4" or a total displacement of .0665 inch. This is equivalent to a tension increase of .047 pound. When the cap breaks away after encountering the builder roller, the excess film rushes back into the two coarse tension sensors. Since the tension sensor excursion is of the same order as the normal travel caused by the film motion in the fine film transport (the recycle profile), the excursion due to the cap intrusion is somewhat obscured.

Figures 2-16 and 2-17 show the simulated Take-up Coarse Tension Sensor motion and Summed Error Amplifier output during the disturbance caused by the cap intrusion and subsequent film tear. The telemetry data is shown on the same plot. The vertical lines through the circles representing the telemetry data indicate the $\pm 1/2$ bit uncertainty due to the digital nature of the telemetry signal.

Figure 2-16 indicates that the actual tension sensor excursion was somewhat larger than that obtained in the simulation. Therefore, this may be an indication that the buckling assumption was incorrect and that the cap may have remained intact, or it may have been embedded with its 1.375" disk positioned radially rather than at a tangent, as assumed. Since the assumed geometry is the one that yields the least possible excess film wrap, it is not surprising that the results of this experiment underestimates the actual excursion.

Figure 2-17 shows that the summed error voltage is perturbed only during the escape of the cap, which results in rapid tension sensor motion. The slower tension buildup phase causes little perturbation because the velocity loop can easily keep up with the variation in position feedback voltage.

This consistency between the simulation output and the telemetry data, together with the single phenomena hypothesis, indicate that the film tore as a result of the stack ingesting the cap.

C. Dendritic Marks

The cap is also a probable cause of the dendritic marks that occurred in the frames near the end of the operation. These marks occurred shortly after the tear, which is the most likely time for the cap to still have been near the film. This was the only occurrence of this type of marking on this or any other mission, and was at the time a cap was loose in the film path. In addition the marks closely

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TENSION SENSOR MOTION

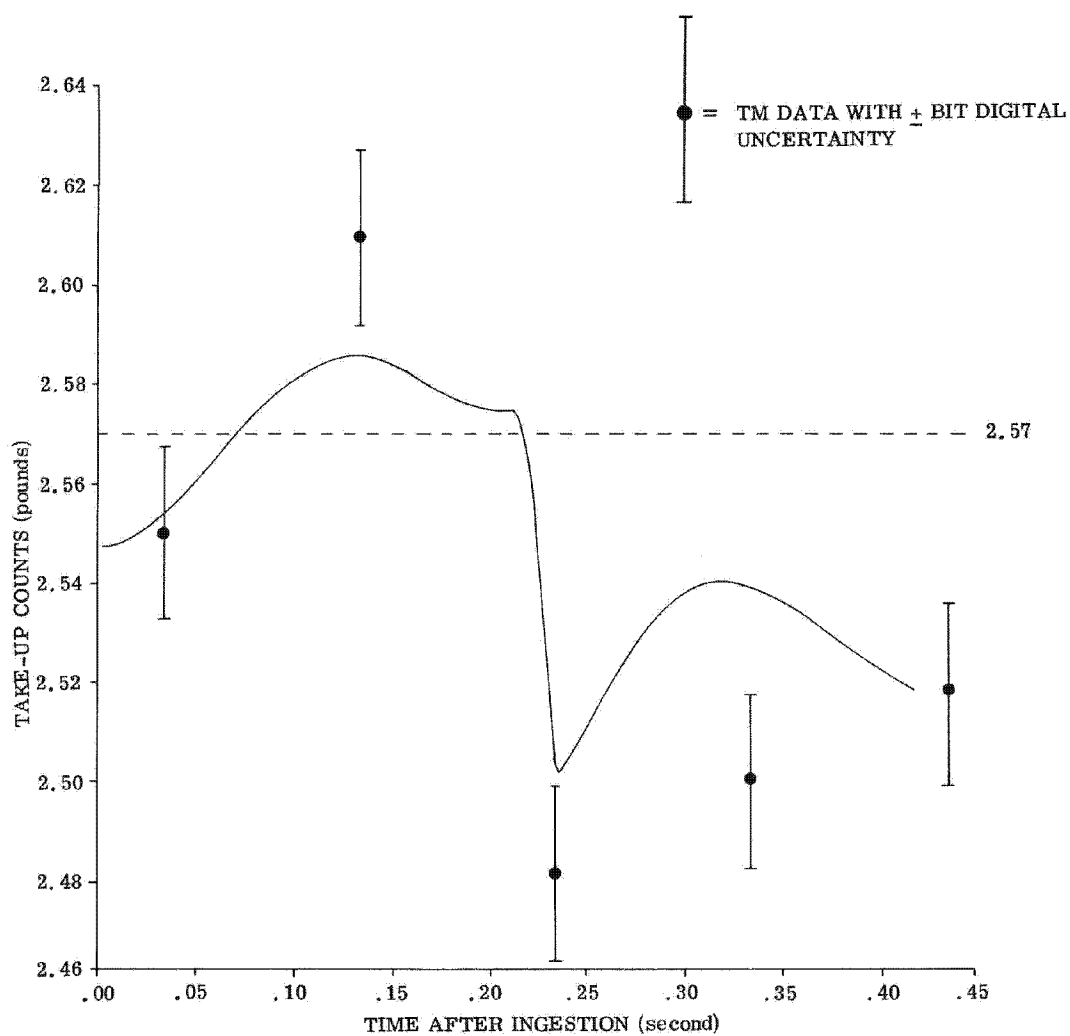


FIGURE 2-16

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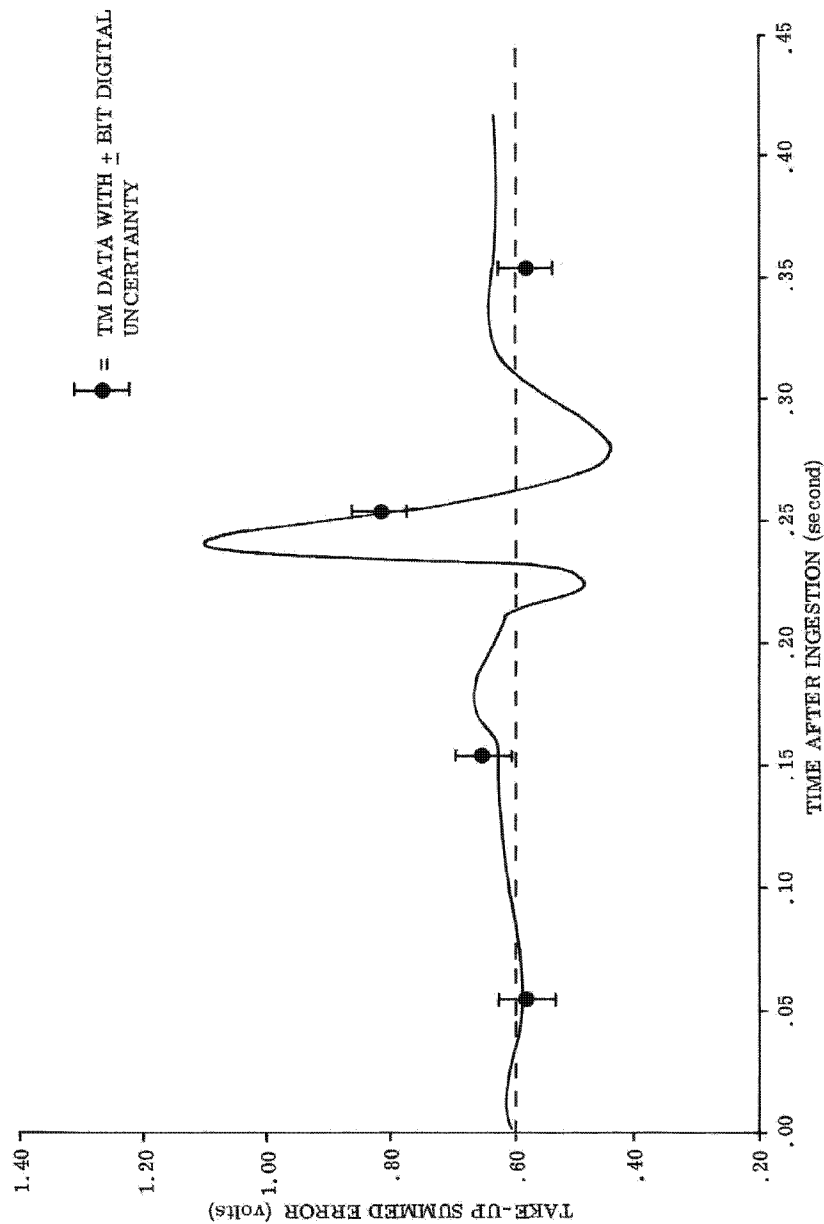
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TAKE-UP SUMMED ERROR VOLTAGE



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FIGURE 2-17

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correlate with the deformation marks on the cap; this is strong evidence that the marks are associated with the cap.

2.4.1.4 Conclusions

A. It has been concluded that the most probable cause of the film tear and the dendritic marks that occurred in Op 304 was the connector dust cap found in RV-3.

B. The exact point in the film path and mechanism of the tear has not been positively defined. However, it is known to have occurred in RV-3, and it is highly probable that ingestion of the cap into the film stack caused the tear.

2.4.1.5 Recommendation

An improvement in contamination control is recommended with specific corrective action directed toward the control of items such as connector caps to prevent this type of anomaly in future systems.

2.4.2 Metering Capstan Electronic Resonance

During Mission 1207-1, the Forward Camera's metering capstan summed error signal exhibited an electronic resonance at V_x/h commands of .0470, .0474, and .0478 radians/second. Analysis of the smear slit imagery verified the increased cross-track smear in frames acquired at these V_x/h values.

As a result of this analysis and a smear/scale trade-off study, perigee was raised approximately 2 NM during the orbit adjust maneuver. On Rev 289, this action resulted in a marked reduction in the percent of exposed film taken at these three V_x/h commands during the remainder of the mission.

2.4.2.1 Preflight Data

The last thru- V_x/h sequence carried out on SV-7 prior to launch was run during the Chamber 2A-2 test. Table 2-6 shows the variability of the Forward Camera's MCSE in the range of the V_x/h commands at which resonance occurs. The data is the composite two sigma of the Forward MCSE signal during the 3 to 5 frames taken at each V_x/h command. Some resonance can be seen at a V_x/h of .0482 radian/second. The other two values of V_x/h , included for reference, are typical of the two sigma values obtained during this sequence.

Table 2-7 shows that the increased variability of the Forward Camera's MCSE is attributable to the increased amplitude of the frequencies corresponding to once and twice per metering capstan revolution. These are the Fourier components at which the electronic resonance is seen. The Fourier analysis was performed on frames from the same sequence on which Table 2-6 is based.

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TABLE 2-6

COMPOSITE TWO SIGMA FOR THE FORWARD METERING CAPSTAN
SUMMED ERROR AS A FUNCTION OF COMMANDED V_x/h

Commanded V_x/h (second^{-1})	Forward MCSE Two Sigma (inch/second)
.0486	.038
.0482	.048
.0478*	.067
.0474*	.067
.0470*	.087
.0466	.038

NOTE: The asterisk (*) means values at which metering capstan electronic resonance is dominant.

TABLE 2-7

FORWARD METERING CAPSTAN SUMMED ERROR FOURIER COMPONENTS
AS A FUNCTION OF COMMANDED V_x/h , FROM 2A-2 TEST

Commanded V_x/h (second^{-1})	Forward Frame	Forward MCSE Fourier Components 1/Rev (inch/second)	2/Rev (inch/second)
.0486	055	.008	.012
.0482	058	.013	.005
.0478*	062	.012	.026
.0474*	066	.024	.018
.0470*	071	.039	.037
.0466	073	.004	.004
.0462	078	.004	.008

NOTE: The asterisk (*) means values at which metering capstan electronic resonance is dominant.

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12072.4.2.2 Orbital Data

After launch, increased variability due to metering capstan electronic resonance was observed on the Forward Camera. Approximately 40% of the AUGIE mode out-of-limit reports for the Forward MCSE (not attributed to splices) occurred at the three V_x/h commands at which electronic resonance is prevalent. The two sigma values for the Forward MCSE from 1207-1 operations showed significant increases at the same V_x/h commands. Finally, smear slit measurements of 1207-1 imagery showed that greater peak smear had occurred at these V_x/h values.

A random sample of two sigma values for the Forward MCSE as a function of commanded V_x/h is shown in Figure 2-18. Each data point is the average two sigma for the family of frames from one orbital operation taken at a particular V_x/h command. All of the data was taken from 1207-1 operations before Op 70.

This V_x/h electronic resonance phenomenon is very sensitive to the absolute angular velocity of the metering capstan. Consequently, small velocity variations such as that due to IMC cause the resonance to come and go. This has been found to be generally true for 1207 operations. In fact, increased variability was observed in one operation and not in another, although both had identical film-velocity and scan-mode commands.

2.4.2.3 Explanation of Phenomenon

The resonance is electronic. It originates in the metering capstan tachometer electronics, and is confined to a very narrow band of V_x/h commands close to .048 radian/second. The amplitude was determined from a Fourier analysis of the MCSE signal at frequencies corresponding to once and twice per metering capstan revolution.

Typical traces of the pertinent metering capstan electronics signals are shown in Figure 2-19. The sinusoidal metering capstan encoder master track signal is squared off using a Schmitt trigger. The squared encoder pulse width (W_{enc}) depends on the individual trigger characteristics, but in general, "ON" time is slightly less than "OFF" time. The leading edges of the precision pulse train are generated coincident with the leading edges of the squared MC encoder master track signal. A regenerative condition occurs that effectively changes the MC tachometer gain and results in the electronic resonance when the metering capstan's angular velocity is such that the trailing edges of the squared MC encoder master track signal coincide with the trailing edges of the precision pulse train.

2.4.2.4 Future Systems

The problem has been eliminated from SV-8 and subsequent vehicles by modifying the MC tachometer circuitry to narrow the precision pulse width to 9.5 microseconds. This increases the V_x/h at which trailing edge coincidence occurs to approximately .07 radian/second, well outside the operational envelope. A careful examination of the SV-8 MCSE signals from the Chamber A-1 thru V_x/h test has shown

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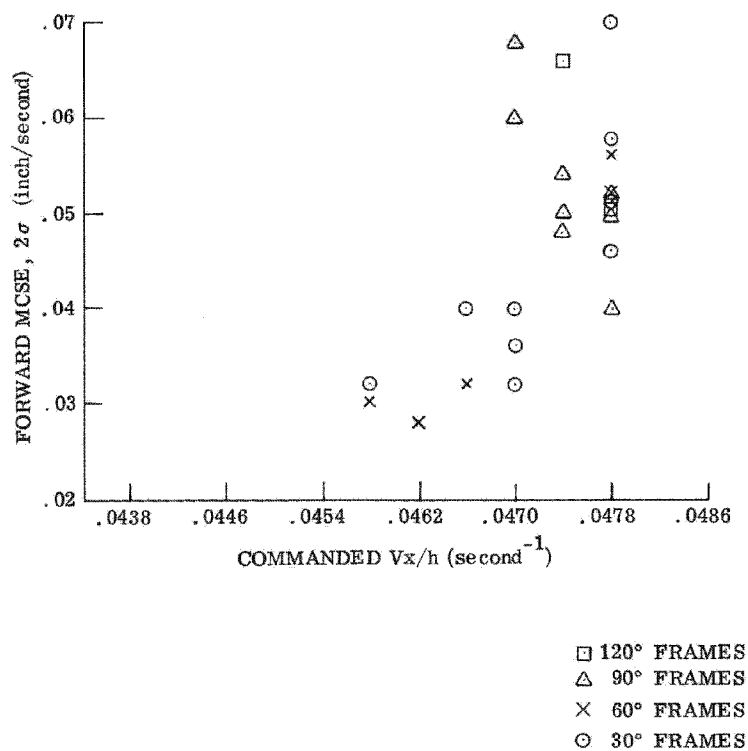
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1207-1 FORWARD MCSE TWO SIGMA AS A FUNCTION
OF COMMANDED V_x/h 

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FIGURE 2-18

METERING CAPSTAN ELECTRONIC RESONANCE SIGNALS

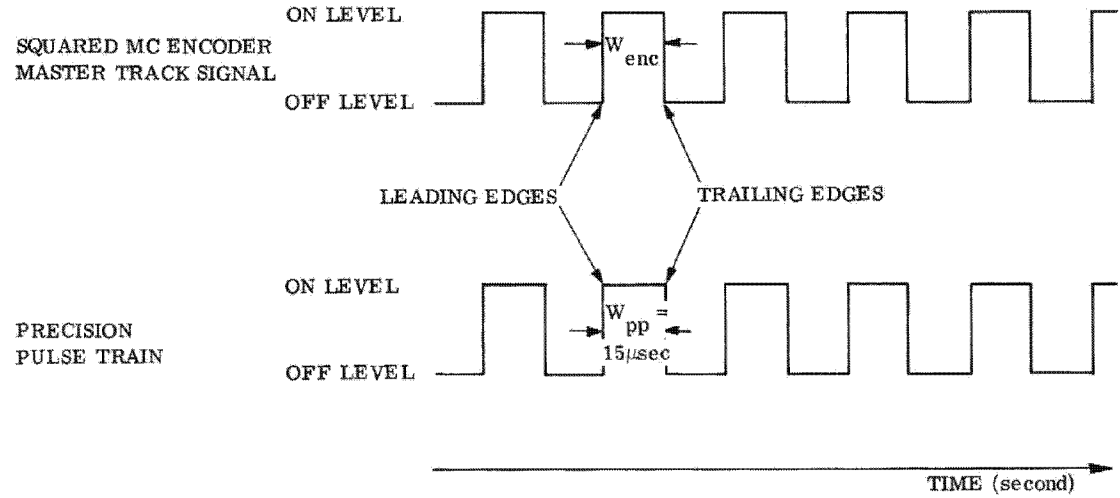


FIGURE 2-19

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that the narrowed precision pulse width has effectively eliminated the MC electronic resonance.

2.4.3 Effect of Input Drive Capstan Noise on Metering Capstan Performance

An intermittent Input Drive Capstan disturbance occurred on the SV-7 Forward Camera during ground testing. This was reported as an area of concern in the SV-7 Flight Readiness Report. The amplitude was sufficient to affect MC performance, with the dominant frequency being 78 Hz. Prior to the 1207 launch, two attempts were made to eliminate the disturbance. The first was replacing the Servo Electronics Box, and the second was by increasing the effective load on the drive capstans.

Mode "B" orbital data showed that the amplitude of the MCSE Fourier components, centered on 78 Hz, increased directly with the noise of the Input Drive Capstan Summed Error (IDSE). The 78 Hz disturbance was conceivably due to an interaction between the Drive Capstan Servo and the Twister Subassembly coupled through the fine tension sensors. Frictional loading of the drive capstan and the zero crossing of the cross-track IMC velocity modulation also were factors affecting the disturbance amplitude.

The Drive Capstan Servo mechanism design has been changed between SV-7 and SV-8. The changes, made as part of the metering capstan settling time improvement and the incorporation of a Drive Capstan Interrupt Assembly, prevent the servo-mechanism from dithering during the pause portion of the recycle profile. This new design had no 78 Hz disturbance throughout its ground test cycle.

2.4.3.1 Preflight Indications

An uncharacteristically high peak-to-peak disturbance on the Forward Camera IDSE was observed a number of times during the ground test cycle. These disturbances were accompanied by a similar Output Drive Capstan Summed Error (ODSE) disturbance of smaller amplitude which degraded metering capstan performance. However, the cross-track two sigma synchronization error data derived from photographic tests indicated that the camera remained well within specification.

Because the drive capstan disturbance resulted in some synchronization error, several attempts were made to reduce the amplitude of the disturbance. The Servo Electronics Box was replaced. An in-air test run was made after the replacements which indicated an improvement.

The problem appeared again in a frame taken during the 2A-2 vacuum tests. A second attempt to reduce the disturbance was made by increasing the effective load on the drive capstans by altering the coarse tension offset. A subsequent in-air run showed that the desired effect had not been obtained. The noise was seen once more during the Horizontal Preship Baseline Test.

2.4.3.2 Orbital Indications from Mode "B" Data

The average amplitude of the Forward MCSE signal around 78 Hz increases with the IDSE amplitude, see Figure 2-20.

The study was restricted to Mode "B" operations because the drive capstan signal is sampled only in this telemetry format. In addition, only frames having a commanded Vx/h of less than or equal to

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FORWARD METERING CAPSTAN SUMMED ERROR (MCSE) AVERAGE
FOURIER AMPLITUDE AROUND 78 Hz VERSUS FORWARD INPUT DRIVE
CAPSTAN SUMMED (IDSE) ERROR TWO SIGMA VALUE

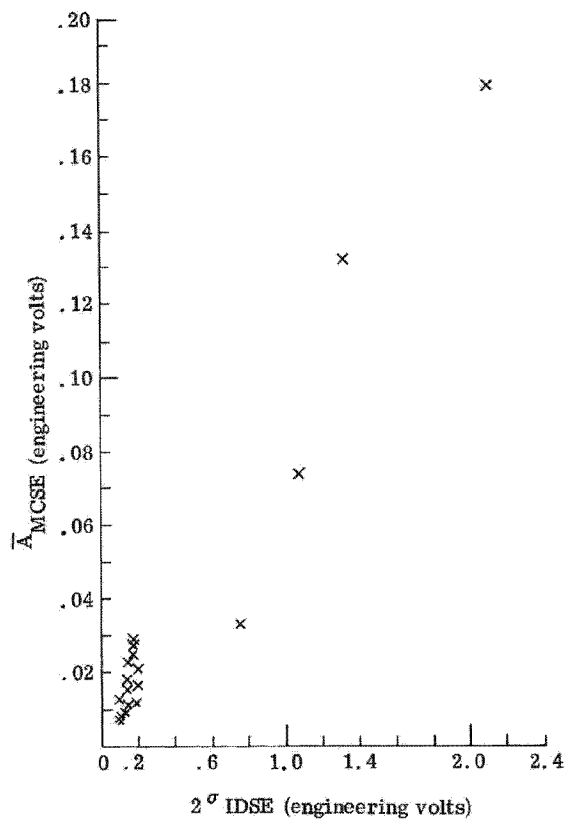


FIGURE 2-20

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.0466 second⁻¹ were used to avoid possible confusion with disturbances due to metering capstan resonance, which is a separate phenomenon. Twenty frames from ten operations covering a Vx/h range from .0458 to .0466 second⁻¹ were used.

The ordinate values in Figure 2-20 are the average Forward MCSE Fourier amplitudes over the 6 Hz band centered on 78 Hz. The bulk of the frames had typical IDSE variability. These data points are bunched near the origin. The relationship between the Forward MCSE 78 Hz amplitude and the Input Drive Capstan (IDC) variability only becomes apparent for the typical frames that exhibit a marked increase in the Input Drive Capstan variability.

2.4.3.4 Nature of the Phenomenon On-Orbit

To explore the effect of the Forward Input Drive Capstan disturbances on metering capstan performance, the AUGIE out-of-limit reports for the Forward MCSE were used; this approach provided a larger data base than could be derived from Mode "B" data.

The number of Forward MCSE out-of-limits per thousand photographic feet of film is plotted as a function of Vx/h range in Figure 2-21. Range A includes all values of Vx/h less than .0384 second⁻¹ because of the small amount of film run at the higher altitudes. All other ranges are combined from four commanded Vx/h values. Figure 2-21 shows that as the film speed is lowered, the disturbance that caused the metering capstan out-of-limits occurred more frequently. The increase in frequency of occurrence for Range G is greater than Range F because G includes the three values of Vx/h for which the SV-7 Forward Camera exhibits metering capstan resonance.

This increased occurrence is probably related to the decreased load on the input drive capstan as the film speed is lowered. The drive capstan servos have a low gain switching resonance at 78 Hz, which is triggered by an external disturbance of sufficient amplitude to cancel the load on the capstan. In addition, the Twister Subassembly has a mechanical resonance at 83 Hz. The Drive Capstan Servo and the Twister then interact so that large variations of the Drive Capstan Summed Error occur at a dominant frequency of 78 Hz. The drive capstan servos excite the Twister via the film web and the Twister oscillation is coupled back to the drive servos during photography through the fine tension sensors.

Range E shows a frequency of occurrence greater than the general trend because the range includes the two Vx/h commands that bracket .044 second⁻¹. During photography, at a Vx/h of .044 second⁻¹, the frequency at which each of the drive capstan's six brushless motor windings is energized is 159.2 Hz (the second harmonic of 79.6 Hz). The match between the disturbance frequency and the winding energization frequency makes the servo more susceptible to excessive oscillation at this Vx/h.

The frequency of occurrence of Forward MCSE out-of-limits is plotted for the eight 15° scan sectors in Figure 2-22. Note particularly the much higher frequency of occurrence for the 0° to 15° sector.

The Forward optical bar scans from minus to plus degrees of scan. The zero crossing of the

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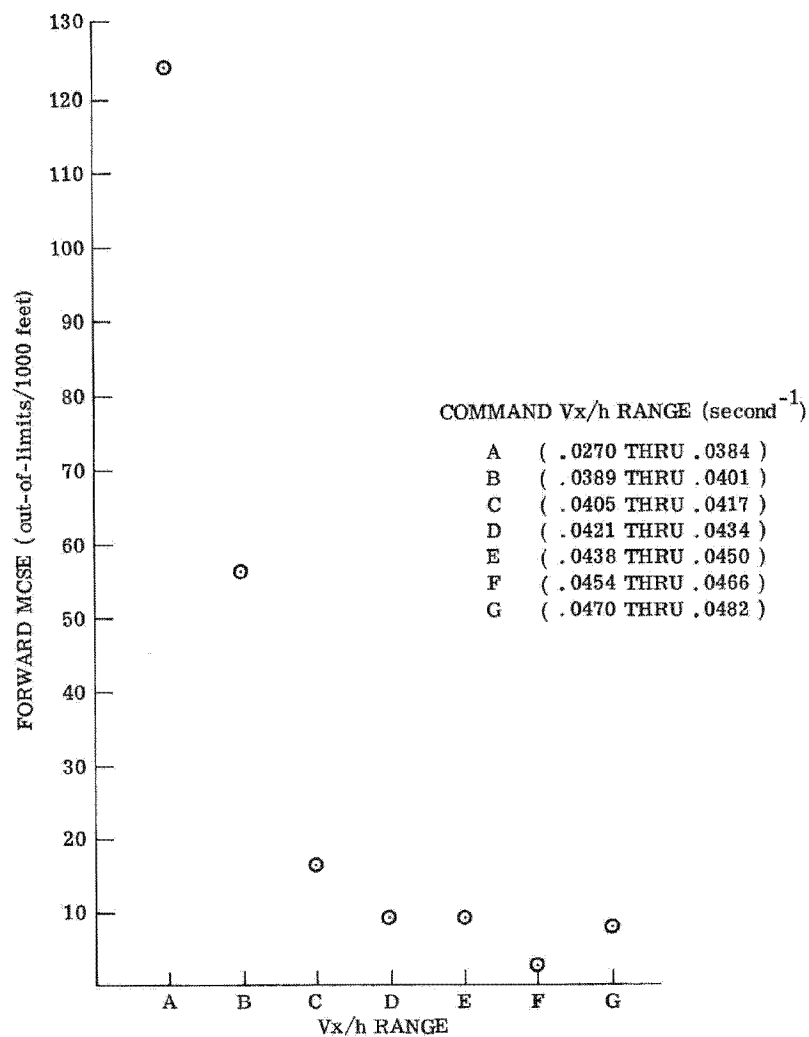
FORWARD METERING CAPSTAN SUMMED ERROR AUGIE OUT-OF-LIMITS PER
1000 PHOTO FEET VERSUS V_x/h RANGE

FIGURE 2-21

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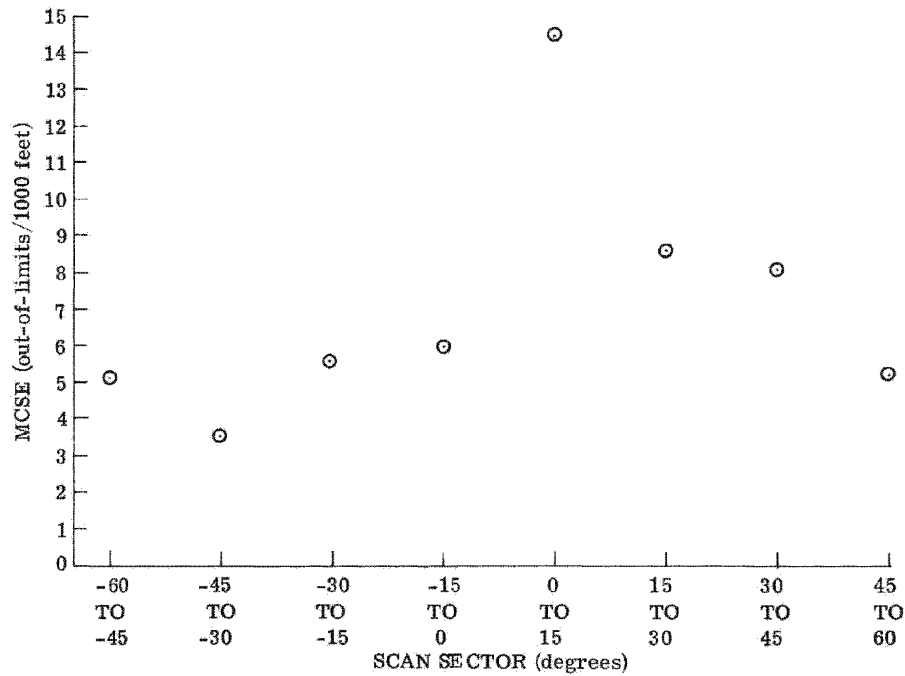
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FREQUENCY OF OCCURRENCES OF THE MCSE OUT-OF-LIMITS PER
1000 LIMIT-CHECKED FEET VERSUS 15° SCAN SECTORS

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FIGURE 2-22

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cross-track IMC velocity modulation term (ΔV_r) generally occurs just before scan nadir. This zero crossing introduces a slight disturbance into the drive capstan servos via the fine tension sensors. Most likely, the marked increase in the frequency of out-of-limit occurrences in the sector that starts at scan nadir is due to the zero crossing.

2.4.4 Microscopic Plus-Density Anomalies

Microscopic plus-density marks or "black spots" were found on processed footage from both supply rolls. Observations have confirmed that the spots ranged from about 1 to 12 microns across, with the majority falling in the 6 to 12 micron range. They appeared as either solid, circular, or semi-circular spots of medium-to-high density. Some spots appeared individually, while others occurred in closely spaced groups. The configuration of many of these groups, usually consisting of 2 to 4 spots within approximately .001" of each other, appeared to repeat in localized areas.

Spot checks under 100X magnification were made at 3 locations across the 6.6" width of each IOR from the 1207-1 Forward and Aft rolls. Occasional checks were also made on footage from the other three segments. In addition, samples of R-2 material from both 1207 supply rolls and samples of several other batches of 1414 were given viscous dual gamma and liquid processing. The latter were processed in a Versamat using MX641 Developer. The following are comments based on the results of these tests, plus other tests conducted by the film manufacturer.

A. The plus-density marks are composed of metallic silver.

B. A few individual, randomly spaced, solid, circular spots are evident in practically all the 1414 samples tested, both on the flight and non-flight film.

C. Groupings of plus-density marks, both circular and semi-circular, were observed on the 1207 orbital film, but were not seen on the R-2 samples from the same emulsion (1414-33) or samples from other emulsion batches.

D. The Forward Roll (233) exhibited significantly more markings than did the Aft (247).

Overall, the orientation of the groups of marks was found to be essentially random.

The observation that the groupings of marks appear to be confined to orbital film is considered significant. However, no viable cause-and-effect relationship has yet been established for either the individual or groups of marks which appear quite similar. Their formation may or may not be due to the same cause. BRIDGEHEAD shall continue to make spot checks on samples of future mission material to gain a better understanding of this phenomenon.

2.4.5 Frame Count Anomalies

2.4.5.1 Early Extra Aft Frames

Twice during this mission, the Aft Camera took one more frame than was commanded. The first occurred on Op 85, Rev 139 when 11 frames were taken although ten were commanded. The second

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was in Op 491, Rev 1143 where 14 frames were taken when 13 were commanded. In both, the extra Aft frame occurred at the start of the operation.

A seemingly unrelated Aft Camera early shutdown occurred during Preship Testing of SV-7 at SVIC. Here the shutdown of the Aft Camera occurred two frames after the Forward Camera instead of the normal three. The shutdown of the Aft Camera is controlled by logic in the System Command and Control (SCC) unit that counts three nadir pulses from the Forward Camera's optical bar encoder. The SV-7 Flight Readiness Report (BYE 15310-73) attributed the premature Aft shutdown to a noise pulse that was mistaken by the counter for a Forward Camera nadir pulse.

Since the same logic that determines the frame interval between the last frames of the Forward and Aft Cameras also controls the frame interval between the first frames of the two cameras, it seems likely that the preship frame count anomaly and the two orbital frame count anomalies have a similar cause. The fact that the ground event took place in Block I of the Redundant System Command and Control Digital Logic and the two orbital events took place in Block II indicates that the noise pulse source is probably outside the SCC Box.

2.4.5.2 Missing Aft Frames

During 1207-4, Op 528, Rev 1224 was programmed to be a four-frame stereo run. However, because of an error in command timing, four Forward but only one Aft frame were taken.

The Film Transport-off Command (FT-) was time-tagged to execute too soon after the first Forward Camera shutter-open. The error was attributed to 'TUNITY software for manual operations. To circumvent the problem the minimum number of frames was increased from four to five for subsequent manually loaded operations. This occurrence is unrelated to the early extra Aft frame anomalies. For the given command timing, the camera system performance was normal.

2.4.6 Supply Seal Door Sticking

Prior to vehicle launch, EM data indicated several times that the Forward Camera Supply Seal Door was occasionally sticking to the film during initial Film Transport start-up. Therefore, upon return of RV-1, the prelaunch film was divided for analysis as to severity and possible cause of the suspected sticking. The effort consisted of slitting a 790' length of film along the major axis and processing one-half of it. This gave visible locations of where the seal door had been clamped down on the film. The two film strips were realigned to determine if the seal door's presence could be visually detected on the non-processed film. Because door marks could not be detected on the non-processed film, it was concluded that the sticking did not mechanically damage the film.

2.4.6.1 Background

Other occurrences of film sticking to the seal door have been noticed during testing of SV-3,

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SV-7, and SV-9, and the causes of and solutions to this problem have been investigated. However, SSC has not been able to duplicate sticking in AVE configured seals during testing. The relatively minor amount of sticking in AVE equipment led to discontinuing this investigation, see reference PM-1492-X (BIF 007-0209-74) "Supply Seal Door Investigation".

The Supply Seal Door 621-5565 consists of a molded silicone rubber seal of GE SE4401U bonded to a clamping bar and support with RTV. In use, a nominal force of 117 pounds closes and clamps the seal against the film with a pressure of approximately 50 pounds/square inch. The sealing surfaces are coated with Dow Corning Primer S-2260 to remove the tacky or sticky surface characteristic of the seal. Primer S-2260 is normally used as a metal primer to promote adhesion to rubber. On silicone rubber the S-2260 creates a non-tacky surface with a low coefficient of friction.

The seals used on SV-1 thru SV-7 were manufactured by Gordon Rubber. The seals were coated at SSC with three coats of Primer S-2260. Effective with SV-8 the seals, manufactured by AGC Incorporated, were coated during assembly at SSC with ten thin coats of S-2260.

Three occurrences of sticking seals have been observed during in-air tests and all showed a slight deposit visible on the film in the stuck area. Deposits from the SV-7 and SV-9 were examined with an IR absorption spectrophotometer. Table 2-8 presents a history of the seal door sticking anomalies. It was determined that the seal rubber was isolated as the contaminant source and not the S-2260.

TABLE 2-8

SEAL DOOR STICKING HISTORY

SV	Number of Occurrences	Typical Seal Duration (days)	Visual Condition	Maximum Δ Tension
3	1	70	Light Deposit (Unknown)	ESD
7	6	2-3	Smear*	1 pound
9	Multiple	Up to 40	Slight Viscous Deposit*	ESD

NOTE: The asterisk (*) denotes that the analyzed deposit was similar to residue from the seal material.

The maximum tension in the forward direction is 4.25 pounds before ESD. However, the Supply motor has a minimum stall torque of 50 ft/lbs. At a maximum Supply diameter of 65.46" a tension of at least 18.3 pounds in the reverse mode is required to free a sticking condition. The strength of 1414 material is not a factor as it is typically 250 pounds.

2.4.6.2 Conclusions

A. There is no evidence that seal sticking is a major problem. In all cases of sticking with seals coated with Dow Corning S-2260, the sticking force was not high and is well below the maximum system torque capability and the material strength.

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B. The reason and cause for seal sticking is unknown at this time. In addition, it was impossible to duplicate seal sticking with test seals and clean 1414 material.

C. There is no evidence that the trace amounts of residue silicone deposited on clamped material in any way contributes to sticking or is otherwise detrimental.

D. Dow Corning S-2260 is presently the best known "anti-stick" coating for sealing surfaces. It adheres well to the silicone rubber, and even with considerable seal abuse it was not possible to create a sticking condition with clean 1414 material and the uncontaminated seal. S-2260 is far superior to another recommended primer, Chemlok 608.

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 throughout the mission on SCC II without anomalies or failures.

SCC I was not utilized during the active portion of the mission because of an unrepeatability short frame operation during preflight testing.

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 within the specification limits of .00054 radian/second.

2.5.4 Tracking

No tracking related anomalies occurred during Mission 1207.

Examination of the SVT index dots showed that both cameras experienced small downward (direction of untitled edge) shifts of .2 to .3 mm between ground testing and orbital operation. Since both cameras were tracking slightly high prior to launch, this resulted in very nearly nominal tracking on orbit. Neither camera experienced significant tracking shifts between mission segments. However, both cameras showed a gradual upward shift during the course of the mission so that, by the end of RV-4, each was tracking in a location similar to its prelaunch position. These changes can be seen in Figure 2-23. This figure shows the measured mean distance from film edge to the SVT dot for Horizontal Preship Testing and for each RV.

2.5.5 Instrumentation

All telemetry instrumentation performed properly throughout the mission, except for the Bulkhead and Core Pin Temperature Monitor for TU-2 of the Aft Camera. This temperature point had

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SVT DOT TRACKING DATA FROM 1414

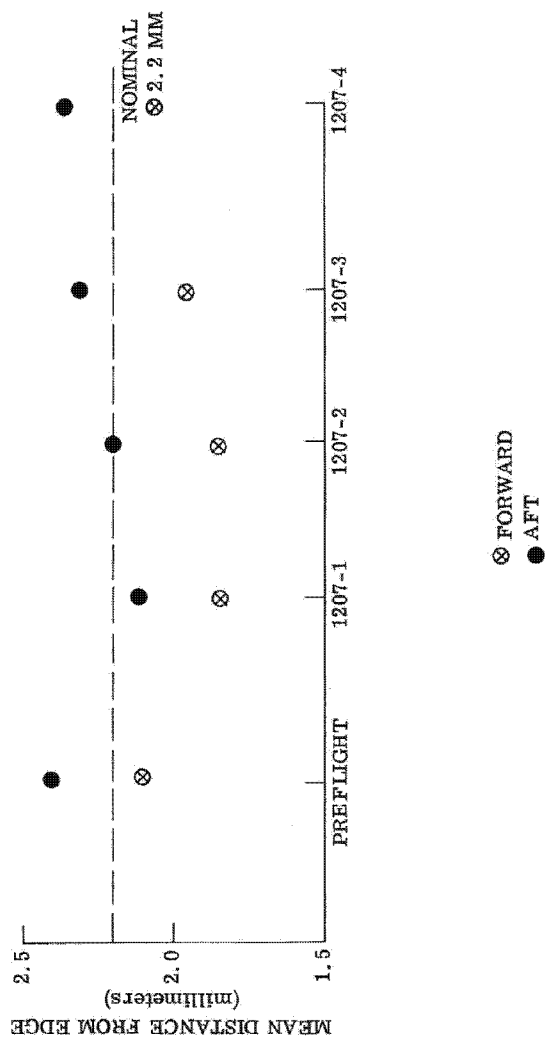


FIGURE 2-23

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been reading 68°F when the vehicle was on the pad and decreased slowly after lift-off to 54°F by Rev 405. Other points having the same power source indicated no peculiarities and no other sensors in the area indicated abnormal temperatures.

2.5.6 Pneumatics

The pneumatic system nitrogen reserve status for Mission 1207 is given in Table 2-9.

TABLE 2-9

PNEUMATIC SYSTEM NITROGEN RESERVE STATUS

Event	Tank A			Tank B			Total Reserve (lbs)
	Press (PSI)	Temp (° F)	Wt (lbs)	Press (PSI)	Temp (° F)	Wt (lbs)	
Lift-Off	3234	73	16.9	3262	72	17.1	34.0
End of Primary Mission (Rev 1200)	406	67	2.29	392	67	2.21	4.50

The computed PN+ use rate was a constant .025 lbs/minute throughout the mission. The pneumatics consumption history is graphically presented in Figure 2-24.

2.5.7 On-Orbit Thermal Performance

The data reported in the following subparagraphs describes the thermal environment for this Mission. Thermal control for SV-7 can be generally summarized as follows:

A. All SS temperatures were within design limits.

B. No excessive temperature changes occurred on the OBs as a result of a 90° roll maneuver conducted during the Solo phase of the mission.

2.5.7.1 TCA Environment

Table 2-10 is a summary of temperature levels, spatial distributions, and temporal variations for a typical orbital revolution in terms of thermal ICD (1420316A) requirements. Figure 2-25 shows typical time profiles of the parameters.

2.5.7.2 Optical Bar Temperature

T_{ref} is the average temperature indicated by four thermistors in the film path. T_{ref} was $70 \pm 2^\circ\text{F}$ throughout the mission. The equilibrium temperature level for both optical bars was approximately $68 \pm 2^\circ\text{F}$. Figure 2-26 shows an orbital profile of the OB temperatures.

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ESTIMATED PNEUMATICS SUPPLY VERSUS MISSION LIFE

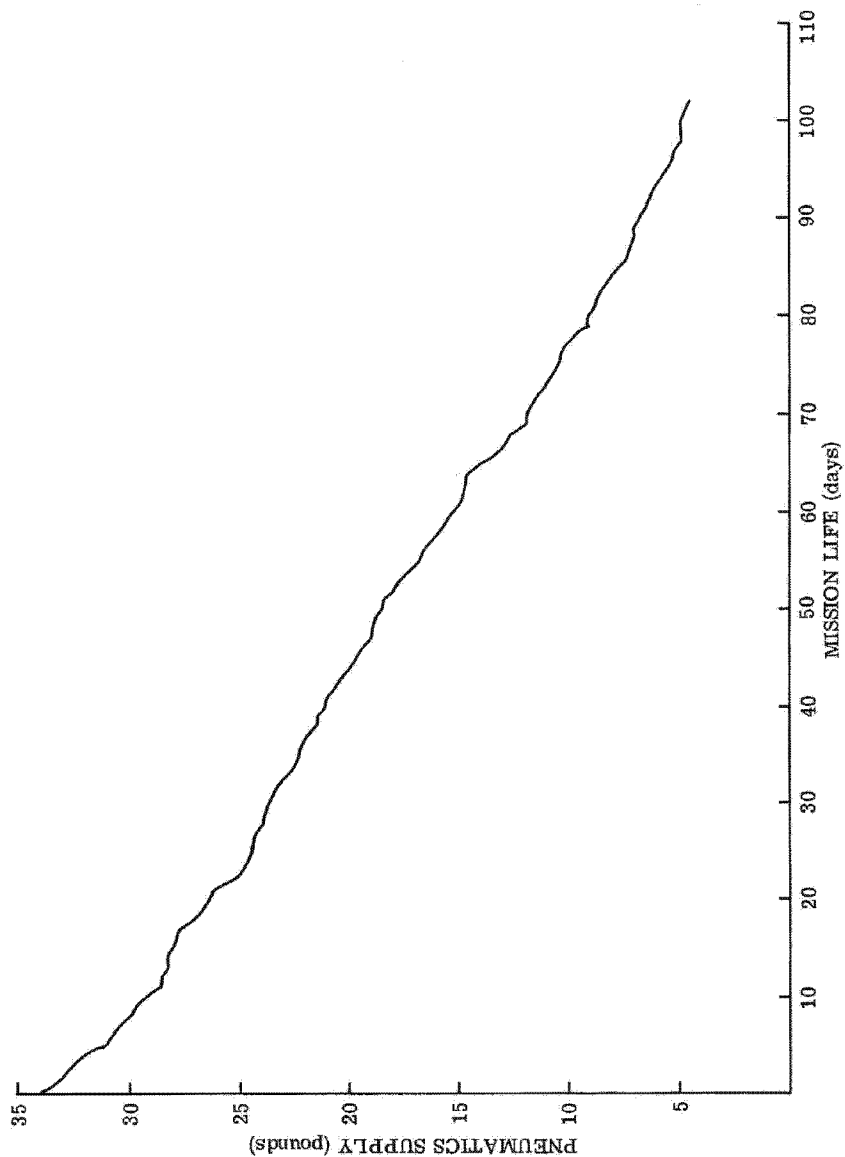


FIGURE 2-24

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TABLE 2-10

REV 358 TCA COMPARTMENT TEMPERATURES

Description	Designated Zone	Max Allowable	Flight Value
Temperature Level Index ($\bar{T}_{TCA}$)		70 ± 21	70
Zone I Mean Temperature	Not Applicable	NA	71
Zone II Mean Temperature		NA	69
Zone III Mean Temperature		NA	68
Zone IV Mean Temperature		NA	70
Forward Bulkhead		NA	71
Middle Bulkhead		NA	71
Variation of Mean Temperature Between Designated Zones	I to IV	9	0
	II to III	6	0
	I to II	4	2
	III to IV	4	2
	Bulkhead to Bulkhead	6	0
Spatial Variation of Time-Average Temperature Measurements at Locations within Designated Zone	I	11	2
	II	9	2
	III	9	2
	IV	11	2
	Forward Bulkhead	5	0
	Middle Bulkhead	17	0
Temporal Variation (Peak to Valley) of Temperature Measurement at any one Location within Designated Zone	I	46	16
	II	20	1
	III	20	1
	IV	46	16
	Forward Bulkhead	26	4
	Middle Bulkhead	57	14

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SATELLITE BASIC ASSEMBLY TEMPERATURE DATA, REV 358

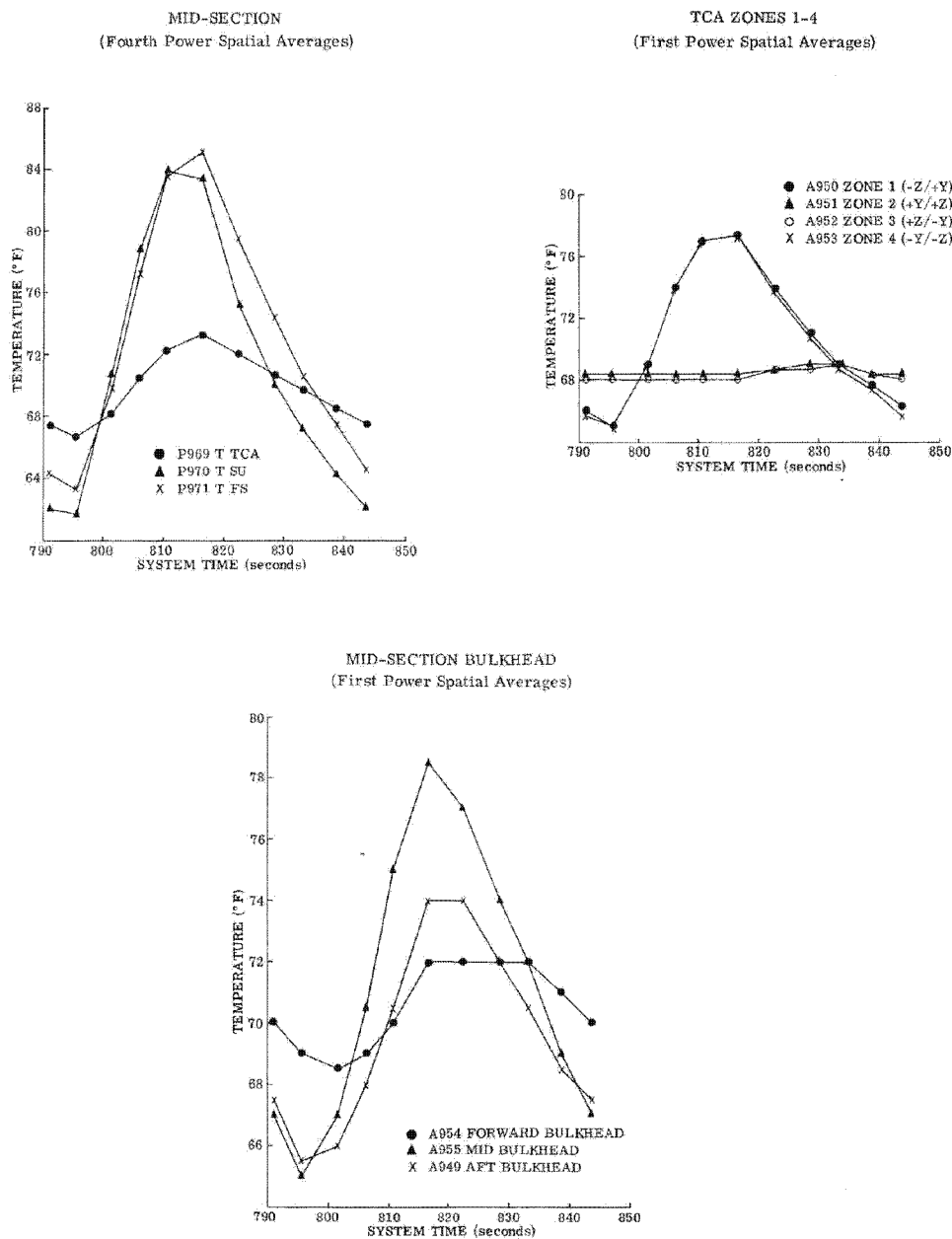


FIGURE 2-25

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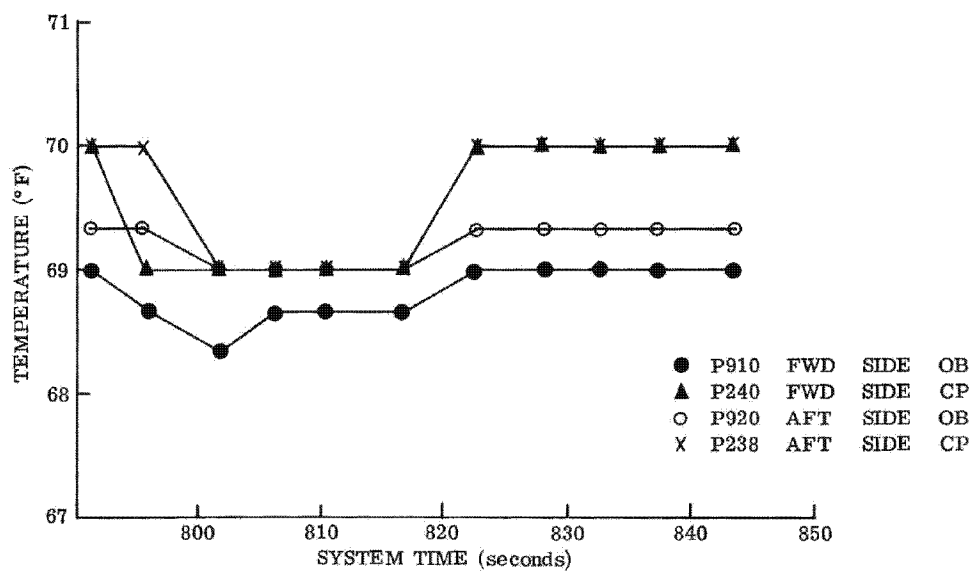
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SENSOR SUBSYSTEM TEMPERATURE DATA, REV 358



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FIGURE 2-26

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2.6 TUNITY FOR MISSION 1207

Message 840 for 91 HULA contained a 'TBALL selected operation (Op 59). This operation was in approximately 1° solar elevation and in a snow region that required a .875 stop snow bias. The desired command slit was .910"; however, 'TBALL computed and commanded .486 inches. Message 840 was rejected and Op 59 slits were altered to .910 inches. A Software Problem Report (SPR) was opened. It was discovered that 'TBALL was trying to compute the log of a negative number in its conversion of slit width routines from inches to stops.

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SECTION III

CAMERA PERFORMANCE

3.1 INTRODUCTION

Camera system performance for Mission 1207 was analyzed with the same general methodology utilized to evaluate the other HEXAGON missions. The basic areas within this methodology are focus, image motion compensation, resolution, comparison with chamber test data, exposure and radiation monitoring. On-orbit engineering tests were designed and executed to support the first four areas of investigation by SSC. The last two areas were addressed independently by BRIDGEHEAD. Resolution assessments in this report are set in perspective with preceding mission camera resolution data. Data regarding information content of the mission photography was acquired by NPIC via the new NIIRS technique. Although related to camera performance, this data is reported separately in Section V. An important procedural change relative to VEM analysis has been introduced with the Mission 1207 PFA work, and is explained in paragraph 3.1.1.

3.1.1 VEM Matrix Change

Mission 1207 marked the transition from the original 8-step DP VEM matrix to the finer incremented 25-step INSCAL matrix for focus determination during post flight performance analysis. A cross-calibration between the two matrices was performed. This permitted the new matrix to be interpreted in terms of 2:1 contrast tribar resolution and to be directly related to the original matrix. For clarification, all reference to the DP matrix (Matrix 1) signifies the 8-step matrix while the INSCAL matrix (Matrices 1-7) refers to the new 25-step matrix.

Originally, a cross-calibration for INSCAL Matrix 2 was performed by matching it directly against DP Matrix 1. This was accomplished at two contrast levels (1 and 3) by three observers. These points were averaged and plotted with INSCAL edge sharpness as the dependent variable, and 2:1 ON resolution as the independent variable, see Figure 3-1. The INSCAL matrix was found to be approximately seven levels sharper than the DP matrix. A linear extrapolation was used for this portion.

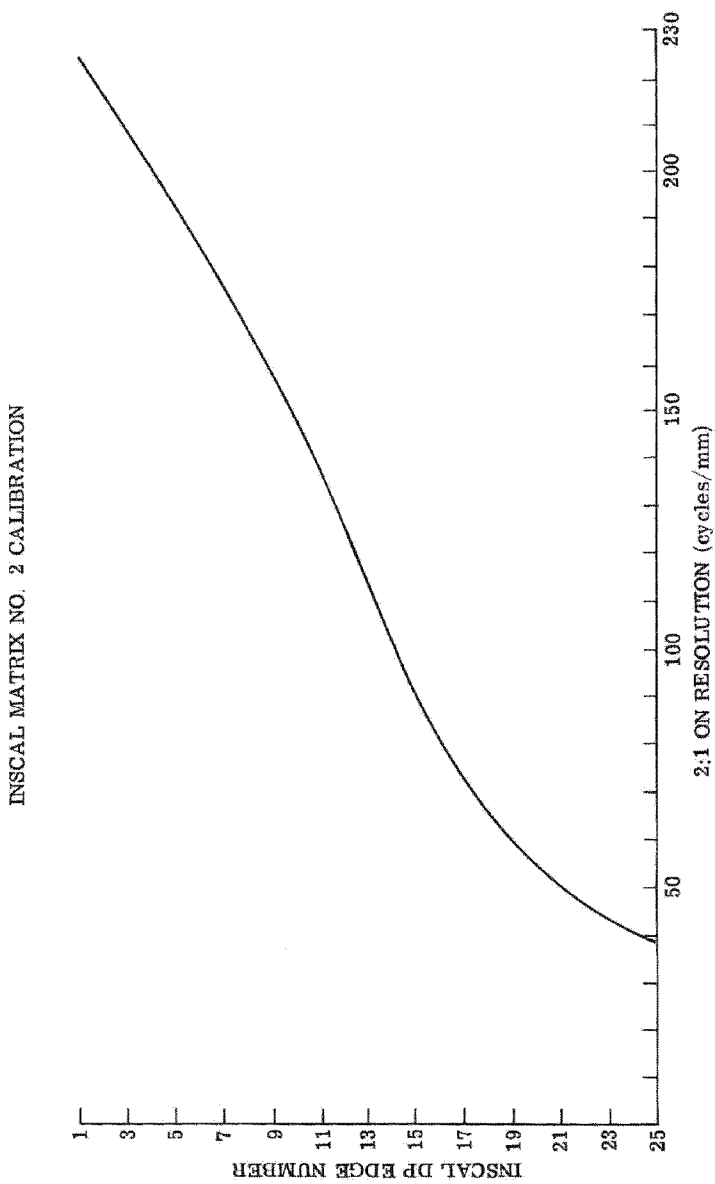
Since more than one INSCAL matrix is required, an additional cross-calibration was performed. This time, INSCAL Matrices 5, 6, and 7 were cross-calibrated using INSCAL Matrix 2 as the standard. Each of the 25 steps on Matrices 5, 6, and 7 were matched by three readers against Matrix 2 at three contrast levels (2, 4, and 6) using the same contrast levels on the standard matrix. A mean and standard deviation for the three readings were determined at each contrast level for each matrix. The average standard deviation for each matrix is an indication of reader variability and is equal to approximately .6 edge increments, equating to a variability of less than 10 cycles/mm.

The mean values for each contrast level were used for cross-correlating the sharpness levels

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FIGURE 3-1

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of the test and standard matrices. The calibration for each matrix at the three contrast levels in terms of Matrix 2 was fitted to a straight line using a least-squares linear regression. The fitted lines fall in very close proximity to a perfect 45° straight line. The correlation coefficients are for all practical purposes identical and equal to unity.

To determine the INSCAL Matrix 2 calibration applicability to the tested matrices, an RMS error was determined for each matrix at the three contrast levels. Each matrix error was characterized by averaging the contrast dependent errors. All of these computed errors were negligible.

In conclusion, Matrices 2, 5, 6, and 7 are the same and the calibration for Matrix 2 is applicable to all. To complete this exercise, Matrices 1, 3, and 4 need to be similarly calibrated.

3.2 SUMMARY

Camera performance analysis is summarized as follows:

- A. No focus change was required for either camera.
- B. The Forward Camera IMC parameters were set correctly. An on-orbit adjustment was made to the Aft Camera in-track velocity for 1414 Film; and also an error in the Aft Camera cross-track velocity for the SO-255 Film.
- C. Acquisition of 14 CORN 51/51 Tribar Targets on 1414 Film averaged 2.77' GRD and 141 cycles/mm RP normalized to 2:1 contrast. With no contrast normalization, the actual results average 2.24' GRD and 177 cycles/mm RP.
- D. Randomly sampled VEM resolution (2:1 contrast) from operational target complexes revealed identical performance for both cameras at 154 cycles/mm with a 95% confidence that the mean is between 147 and 160 cycles/mm.
- E. VEM resolution (2:1 contrast) analysis of major axis profiles ranges from 123 to 186 cycles/mm. The average performance for both cameras is 155 ± 15 cycles/mm over the full 120° scan format. Within $\pm 30^\circ$ of nadir, VEM resolution is 161 ± 13 cycles/mm for both cameras.
- F. There was no degradation in camera resolution performance on-orbit as compared to the chamber tests.
- G. Platen tilt was correctly set on both cameras.
- H. Effective field curvature as measured from mission engineering thru focus photography is relatively flat (on the order of 5 microns). This is comparable to Chamber D interferometric measurements from each optical bar, but is much less than photographic test measurements made with the camera in Chamber A-2 (on the order of 20 microns). At this time, the PFA Team does not understand the reasons for this discrepancy.
- I. As measured by VEM (2:1 contrast) resolution, the quality variability is 14% over the entire

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photographic format as randomly sampled throughout the entire mission for both cameras.

J. The Aft Camera in-track direction shows a "ramp" dependency of mean smear with scan angle which is not present in the other three cases.

K. Smear variability on-orbit as measured via smear slit image displacement was generally greater than that anticipated via sync flash measurements in the chambers. However, on-orbit variability was generally less than the original design budget values.

L. In general, there was virtually no mean smear on-orbit once the OAAA adjustment was made in RV-2. Smear variability tends to be on the order of .04 inch/second in-track and .08 inch/second cross-track for operational photography.

M. The attempt to measure system MTFs via microdensitometric analysis of the CORN deployed line targets was aborted due to acquisitions of insufficiently short exposure times.

N. Exposure differences between the Forward and Aft Cameras were corrected with a two count slit width bias ($-.06 \log E$). This change was applied to the Aft Camera during Op 138.

O. Both color films were assessed to be optimally exposed.

P. The 1414 Film was slightly overexposed ($.05 \log E$) relative to the present 1.0 mean scene criterion, but the aim is to be raised to 1.1 density.

Q. Use of the new three-step snow biasing technique showed a significant increase in the number of correctly exposed snow-surround frames. This replaced the former single-step (minimum depth of 4") criterion.

R. Exposure of sand-surround frames verified the desert polygon bias.

S. Analysis of vegetation-surround targets indicated that domestic scenes have larger brightness ranges than denied area scenes. Also, the Forward Camera tends to produce larger scene density ranges than the Aft Camera.

T. Microdensitometric measurements of CORN photometric patches provided estimated contrasts of six acquired tribars (nominally 5:1 on the ground) ranging from 3.02 to 4.90:1 at the image plane.

U. Radiation monitoring packets showed a gain of .22 gross fog on-orbit for 3401 Film only. Both the 1414 and SO-255 Films showed negligible gain in gross fog.

3.3 ON-ORBIT FOCUS ANALYSIS (1414)

3.3.1 Summary

As with Mission 1206, no on-orbit focus adjustment was required on either camera. The focus decision was made based on analysis of thru focus minor axis quality profiles generated by visual edge matching the 1207-1 thru focus engineering photography. Because this test was successfully executed, it was discontinued for the remainder of the mission.

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12073.3.2 Analysis Procedures

Nine thru focus operations were performed on the Forward Camera and six on the Aft; three Aft Camera operations (51, 68, and 79) were SO-255 engineering operations. The 1414 thru focus operations were performed to fulfill Engineering Test No. 1 requirements (Table 3-1), providing cumulative frames with platen offsets of 0, ± 8 , and ± 16 microns. To completely fulfill the engineering requirement, the culture was to be cloud free and spread across the entire format width within $\pm 20^\circ$ of scan nadir.

Minor axis profiles were generated for each camera at each of the five platen offsets in both the in-track and cross-track directions. Each camera was analyzed by a single reader/matrix combination.

Beginning with this mission, the format sampling was altered to provide data at the field positions tested in Chamber A-2.

Edges were matched in $1/2''$ cells centered at 0, ± 1 , ± 2 , $\pm 2.5''$ across the format. Seven edges in both directions were matched within a cell to provide a single averaged data point. Where possible, two minor axis profiles were generated at each platen position to more accurately characterize system performance.

3.3.3 Data Presentation

The image quality profiles and geometric mean for each of the five platen positions are shown in Figures 3-2 thru 3-4 for both cameras in both directions. The sign convention with respect to field position represents the film tilted edge as minus. Figure 3-5 presents the thru focus plots of average VEM resolution across the entire format as a function of platen position. These plots were derived from Figures 3-2 thru 3-4.

For the Forward Camera, determination of the optimum platen position from Figure 3-2, 3-4, and 3-5 is quite evident and is the nominal focus setting. The degradation in image quality as a function of platen offset is readily seen in both directions for both the ± 8 micron as well as the ± 16 micron offsets. Table 3-2 presents the 2:1 contrast Forward Camera VEM resolution as a function of field angle and relative defocus for all of the data plots in Figures 3-2 thru 3-5. In-track performance is essentially the same as that in the cross-track direction. The average performance level at nominal focus (133 microns) is 185 cycles/mm. However, this falls off at approximately 20 cycles/mm with a ± 8 micron defocus. With a ± 16 micron offset the quality loss is asymmetrical, ± 16 microns (away from the lens) producing a 30 cycles/mm loss, and -16 microns (toward the lens) producing a 60 cycles/mm loss.

The decision to retain the launch focus setting on the Aft Camera was not as straightforward as on the Forward Camera. Figures 3-3 and 3-4 present the data graphically while Table 3-2 presents the resolution data for these graphs. From these curves and Figure 3-5, it appears that the Aft Camera is less sensitive to focus change than the Forward Camera. The range of defocus from ± 8 to ± 16 microns shows a total resolution change of approximately 10 cycles/mm, which is negligible. Only the ± 16 micron

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TABLE 3-1

SUMMARY OF TEST 1 THRU FOCUS OPERATIONS FROM 1207-1

<u>OP</u>	<u>Scan Mode (degrees)</u>	<u>Frames</u>	<u>Location</u>	<u>Platen Offsets (microns)</u>	<u>Weather</u>	<u>Culture</u>	<u>Utility</u>	<u>Comments</u>
15	30/-15	6	Houston	0, +8, +16	Partial Cloud Covered	Excellent	Not Useful	Incorrect Exposure Bias
27	60/0	15	Atlanta	0, -8	Good	Excellent	Good	None
39	30/15	8	San Francisco	0, +8, -8, 16	Poor	Poor	Not Useful	None
51*	30/15	6	Los Angeles	0, -8, -16	Good	Excellent	Good	None
68*	30/15	6	Birmingham	0, +8	Good	Fair	Fair	None
79*	30/15	9	Seattle	0, -8, -16	Cloud Covered	Not Applicable	Not Useful	None
			Riverside/ San Diego	0, ±8, ±16	Good	Good	Good	None
105	30/-15	19	Paris	0, ±8, ±16	Good	Good	Good	None
115	30/-15	7	New York City	0, ±8, ±16	Cloud Covered	Not Applicable	Not Useful	None

NOTE: The asterisk (*) denotes that it was covered on the Forward Camera only.

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FORWARD CAMERA MINOR AXIS PROFILES

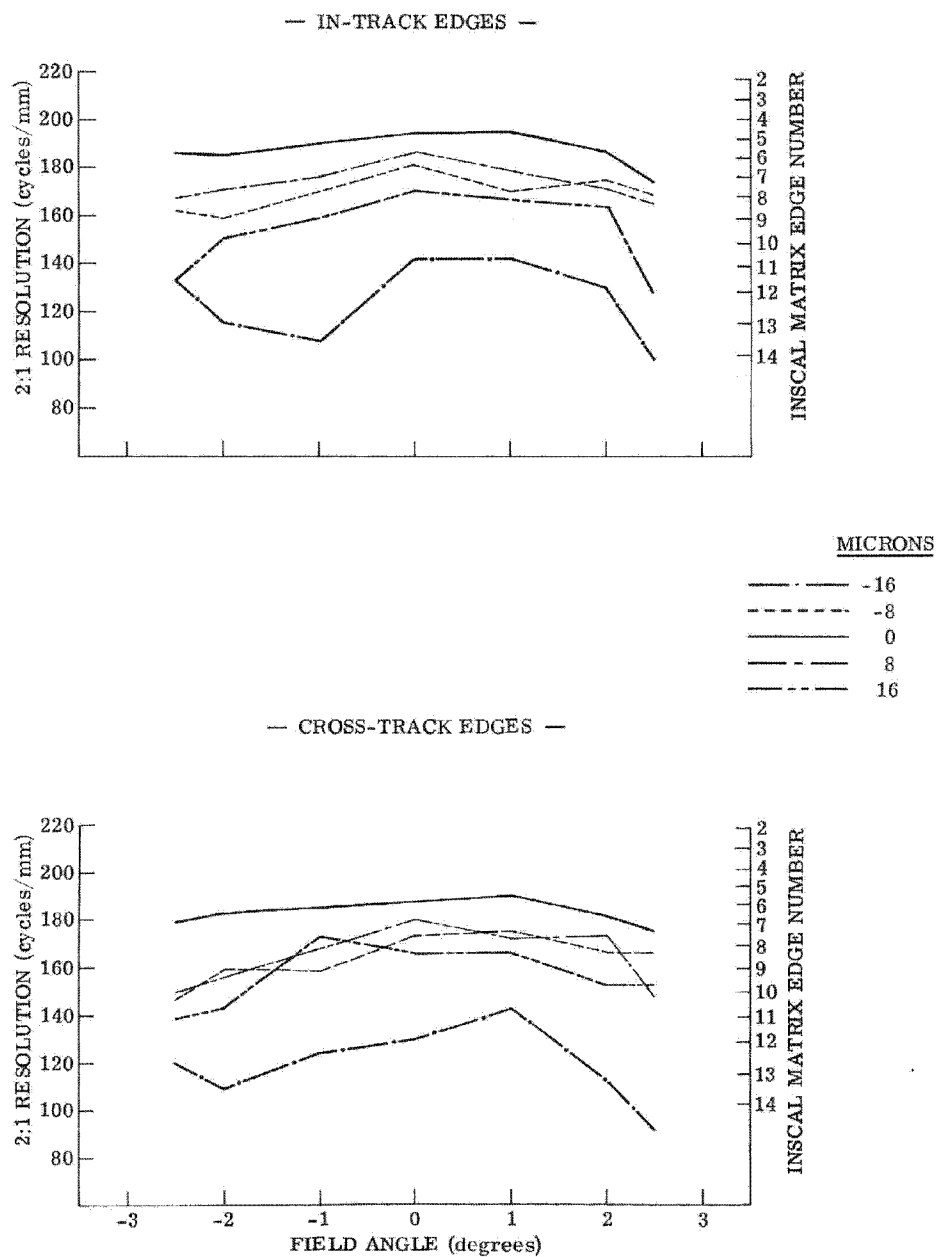


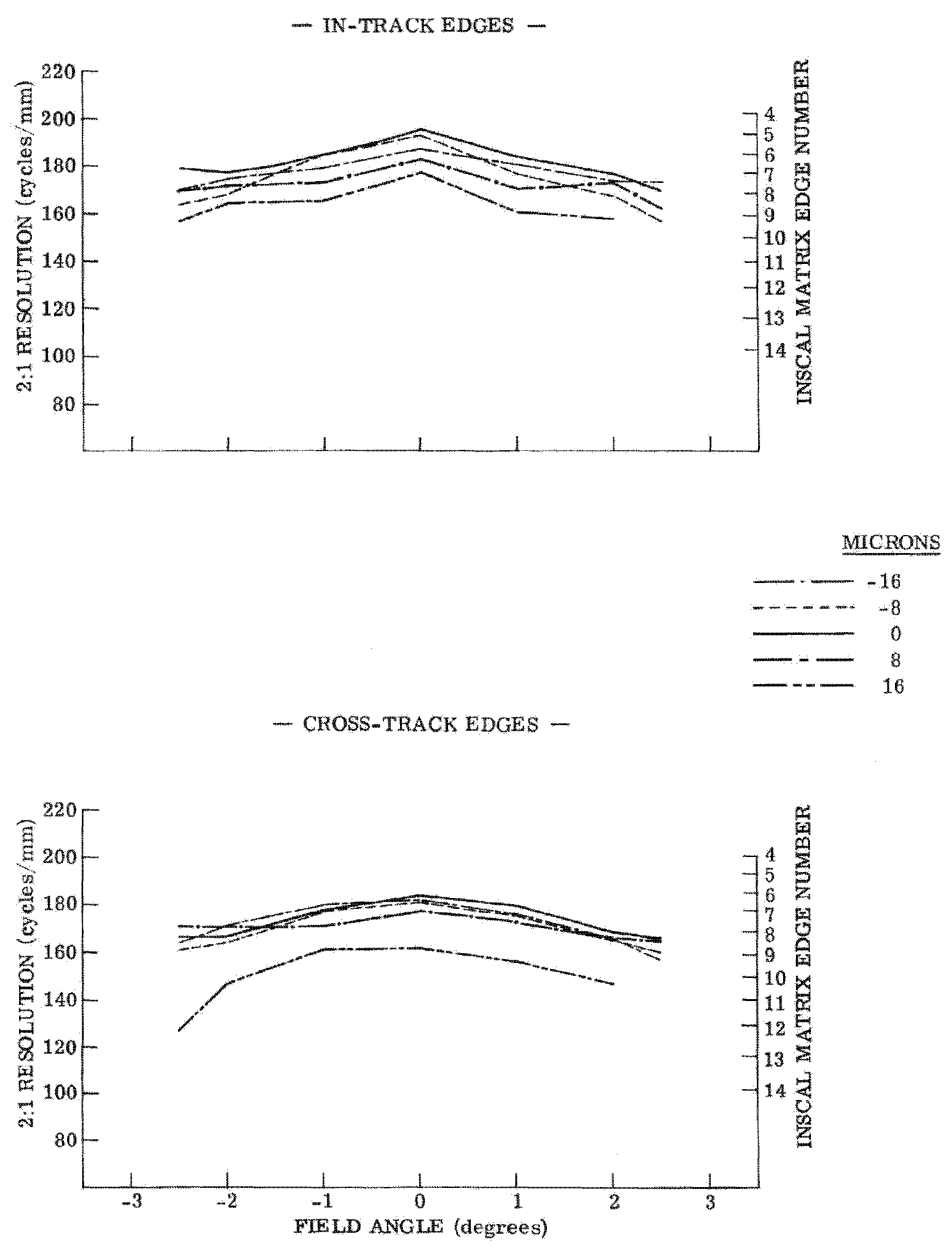
FIGURE 3-2

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AFT CAMERA MINOR AXIS PROFILES



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FIGURE 3-3

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THRU FOCUS GEOMETRIC MEAN MINOR AXIS PROFILES

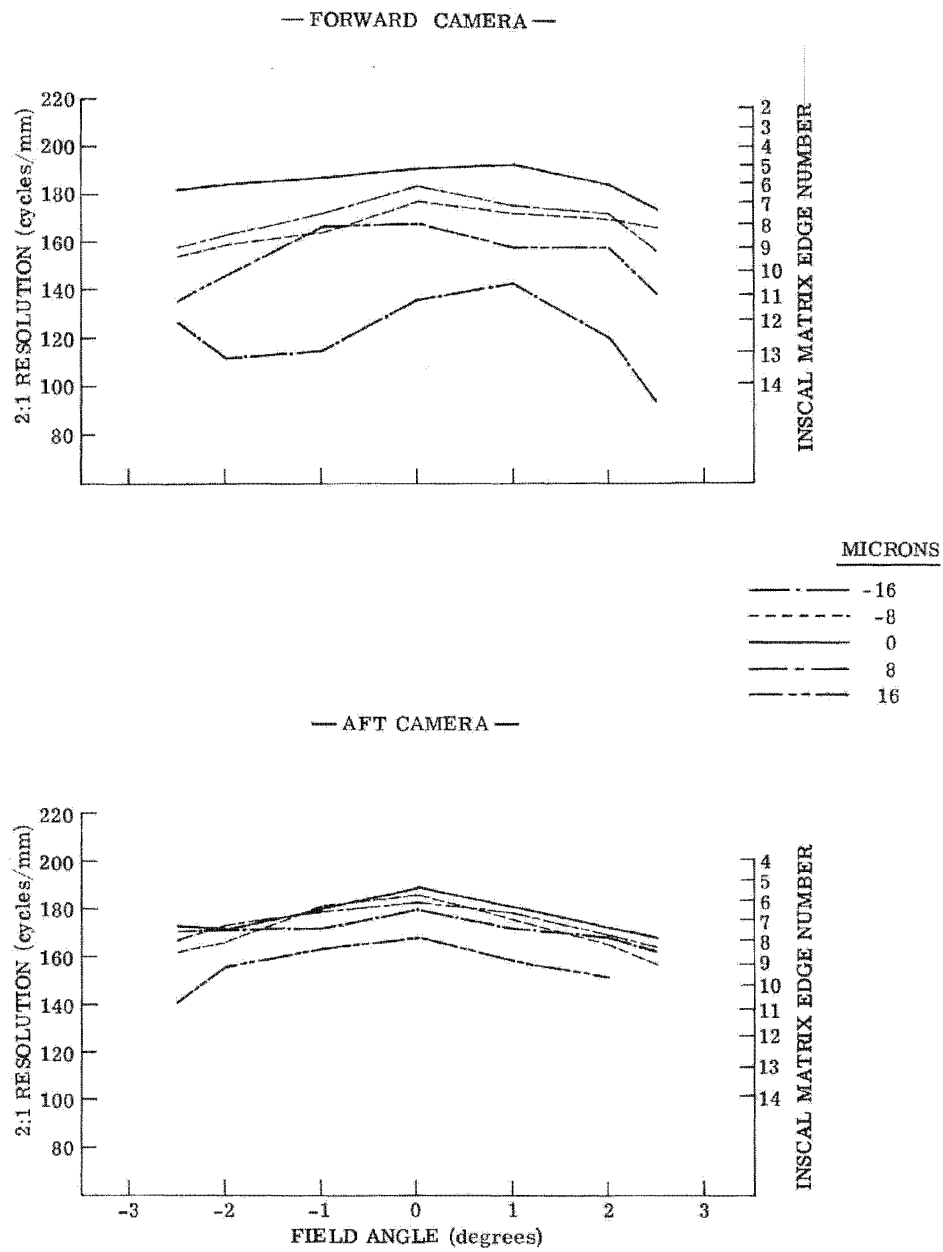


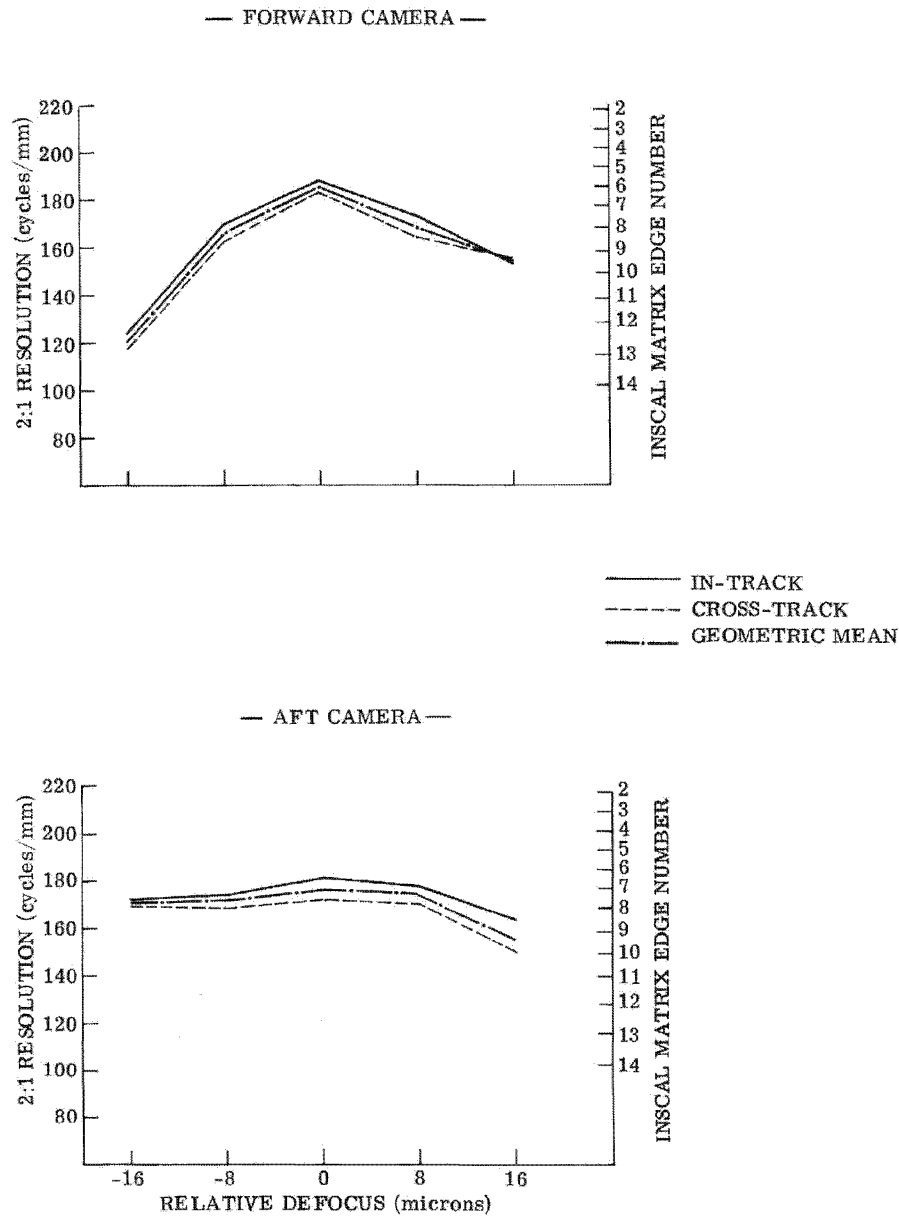
FIGURE 3-4

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AVERAGE PERFORMANCE ACROSS THE FIELD AS A FUNCTION OF DEFOCUS



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FIGURE 3-5

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TABLE 3-2

1207-1 MINOR AXIS THRU FOCUS SUMMARY

(cycles/mm)

— FORWARD CAMERA —

Relative Defocus (microns)	Field Angle (degrees)							Mean	Direction
	-2.5	-2.0	-1.0	0.0	1.0	2.0	2.5		
-16	133	115	107	142	130	99	124		
-8*	162	159	170	181	170	175	168	169	
0*	186	185	190	194	195	187	174	187	In-Track
8*	167	171	176	186	178	171	165	173	
16	132	150	159	170	166	164	127	153	
-16	120	110	124	130	143	112	90	118	
-8*	147	159	158	173	175	166	166	163	
0*	179	183	185	188	190	181	175	183	Cross-Track
8*	150	156	168	180	172	173	147	164	
16	139	143	173	166	166	152	152	156	
-16	126	112	115	136	143	121	94	121	
-8*	154	159	164	177	172	170	167	166	
0*	182	184	187	191	192	184	174	185	Geometric Mean
8*	158	163	172	183	175	172	156	168	
16	135	146	166	168	166	158	139	154	

— AFT CAMERA —

-16	170	172	173	184	171	173	163	172	
-8	164	168	185	193	177	168	157	173	
0	179	177	184	196	184	177	170	181	In-Track
8	170	175	170	187	181	174	174	177	
16	157	164	166	177	161	158	-	164	
-16	171	170	171	177	172	166	164	170	
-8	161	164	177	181	175	164	160	169	
0	167	166	177	183	179	168	166	172	Cross-Track
8	164	171	179	181	175	166	157	170	
16	127	147	161	161	156	147	-	150	
-16	171	171	172	180	172	169	164	171	
-8	162	166	181	187	176	166	158	171	
0	173	171	180	189	181	172	168	176	Geometric Mean
8	167	173	180	184	178	170	165	174	
16	141	155	163	169	156	152	-	156	

NOTE: The asterisk (*) denotes that there were two frames.

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defocus shows a substantial loss in performance. However, Table 3-2 shows the nominal focus performance to be slightly better across the field than at the +8 micron offset. Based upon this thru focus response and the slightly higher average geometric mean performance, the decision was made not to change focus. The nominal focus setting (37 microns) produced an average in-track and cross-track performance level of 176 cycles/mm.

3.3.4 RV-2 Nominal Minor Axis Profiles

No further thru focus tests were conducted during the second segment of Mission 1207. However, VEM measurements of system performance across the minor axis at nominal conditions were obtained for each camera; these are compared to the measurements made from the RV-1 photography, see Figures 3-6 and 3-7.

The field curvature and VEM resolution levels of both cameras are consistent with the measurements made from the RV-1 thru focus test. However, the overall level appears to have decreased on the Forward Camera by about 5 percent. As different readers were used for the two sets of measurements, this small shift does not imply any change in system performance. The Aft Camera measurements in each RV were performed by the same reader with no apparent shift in performance level between RVs.

3.3.5 Additional Observations

In addition to constituting the basis for the Mission 1207 focus decision, the data previously described leads to the following observations:

- A. The Forward Camera exhibits a steep thru focus curve while the Aft is very shallow. This difference in focus sensitivity between cameras is not evident in chamber test data. The discrepancy is discussed in detail in paragraph 3.6.2.
- B. Both in-track and cross-track performance of both cameras is equivalent.
- C. Peak average performance for both cameras is essentially the same, 185 cycles/mm on the Forward, and 176 cycles/mm on the Aft.
- D. Defocus toward the lens on the Forward Camera more seriously degrades imagery, and defocus away from the lens has a greater effect on the Aft Camera.

3.3.6 SO-255 Color Film

In RV-1, 4,984' of SO-255 Color Film was used in the Aft Camera. The filter was changed from equivalent W-12 to equivalent W-2E Type (Op 50), and focus was adjusted +30 microns (33 microns to 63 microns platen positions) to accommodate the transition to color film. Engineering Test No. 8 was a thru focus test with a range of ± 14 microns about the nominal position. Useful acquisitions totaled two frames at the 63 micron nominal and one frame each at the 49 and 77 micron platen positions.

Subjective analysis indicated that focus was set properly. Generally, the quality of the SO-255 photography at nominal focus ranged from Very Good to Poor with most imagery considered Good. The

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RV-1 TO RV-2 COMPARISON AT NOMINAL FOCUS FOR FORWARD CAMERA

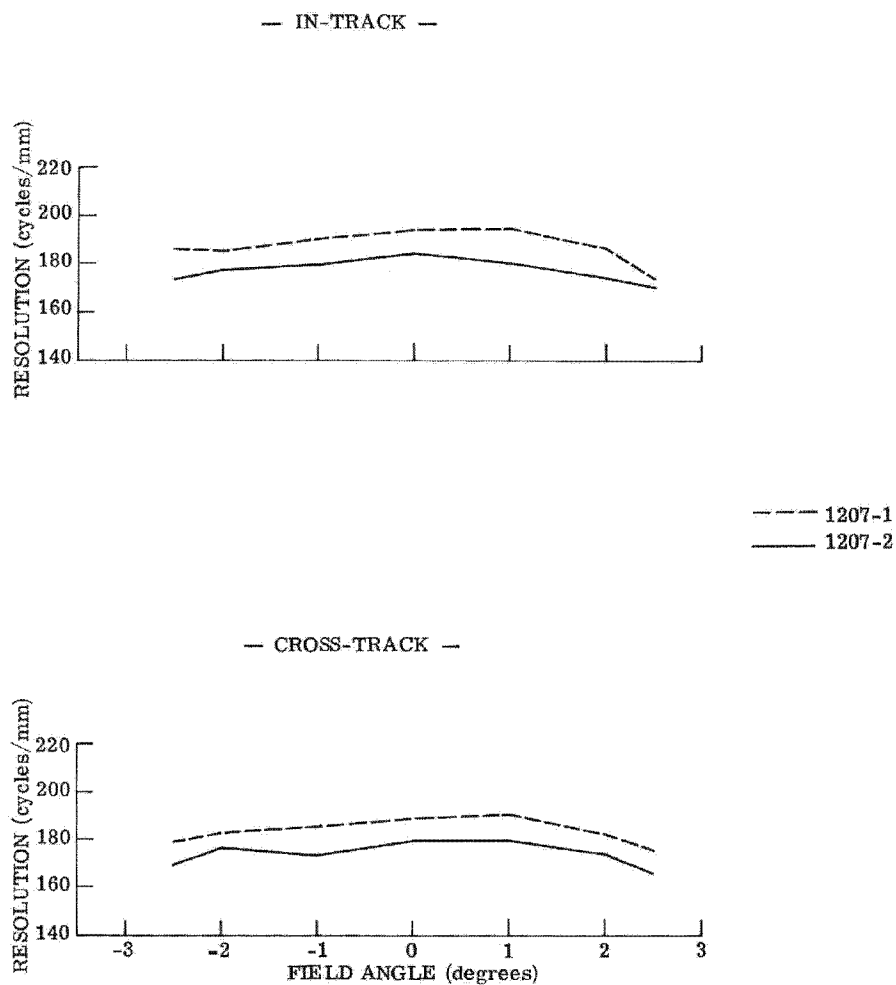


FIGURE 3-6

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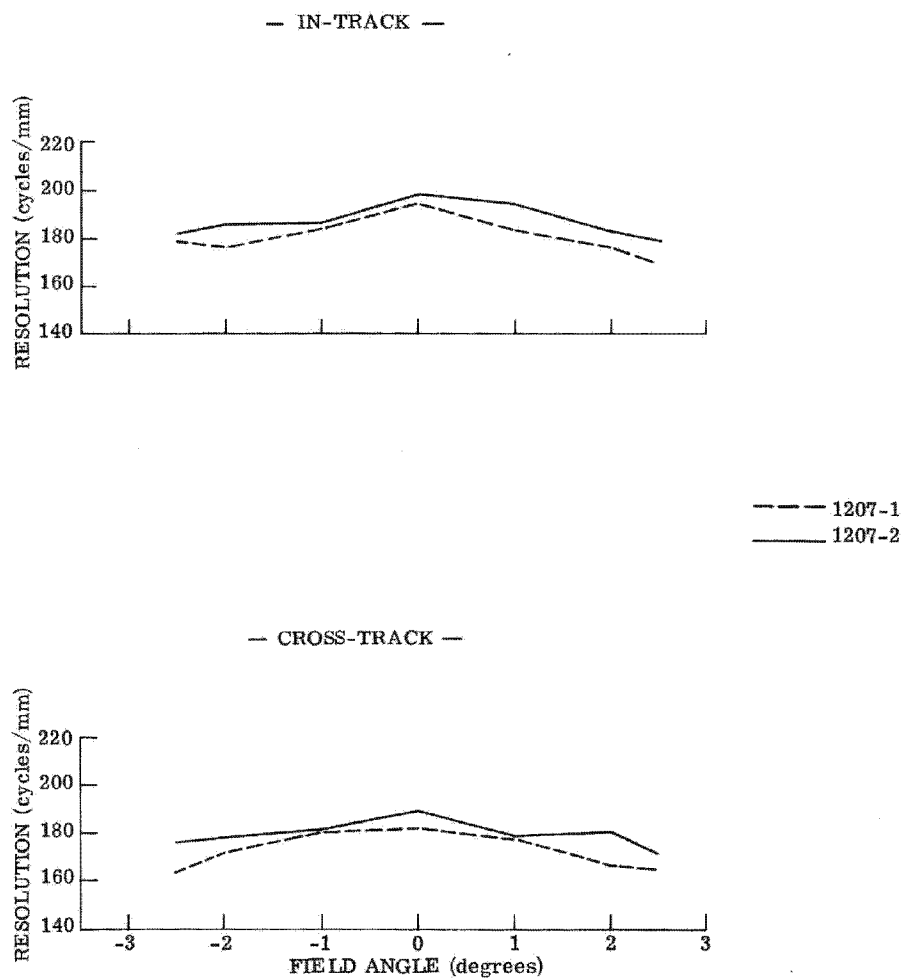
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RV-1 TO RV-2 COMPARISON AT NOMINAL FOCUS FOR AFT CAMERA



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FIGURE 3-7

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Very Good imagery is the best quality color photography acquired from the 1200 Series System to date.

3.4 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 $.015 \left(\frac{V_x/h}{.054} \right)$ and $.010 \left(\frac{V_x/h}{.054} \right)$ inches/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 for the OOAA. If this command step is different than the one being used, the data is further analyzed to determine 90% confidence limits for the zero smear command step. If the command step being used is more than one step away from the 90% confidence limits, a change in film speed is recommended. Before implementing the 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 amplified by approximately a factor of four. When this check confirms the regression analysis, the command step change is implemented.

3.4.1 Test 3A, Smear Slit Indication of OOAA Settings for 1414 Film

Mission Segment 1207-1 contained one photographic acquisition of Engineering Test 3A data (Op 95). As in Mission 1206, the test was conducted by inducing simultaneous OOAA biases in the in-track and cross-track directions. Biases of ± 16 and ± 23 OOAA command steps (approximately $\pm .2$ inch/second) were implemented for the cross-track and in-track directions respectively. The measured versus predicted double image displacements for each camera in both directions were plotted, and linear regression analyses performed, see Figure 3-8. The Forward Camera ordinate intercepts indicate that the film was slow by $-.017$ inch/second cross-track and fast (i.e., skew angle too large) by $.009$ inch/second in-track. This data originated entirely from Op 95 at a mean scan angle of -22 degrees. The ground test data (assuming linear interpolation between collimator data points) indicates that approximately a $-.010$ inch/second error is expected in the cross-track and $.019$ inch/second error in the in-track direction at -22° of scan. Hence, the residual errors would be $-.008$ inch/second cross-track and $-.010$ inch/second in-track. In addition, subjective analysis of smear slit imagery with no OOAA bias indicated that no adjustment was required.

For the Aft Camera, the original data set consisted of Op 95 data and indicated intercepts of $.003$ and $.041$ inch/second for the cross-track and in-track directions respectively, see Figure 3-8. The relatively large error in the in-track direction prompted the measurement of Op 87 imagery

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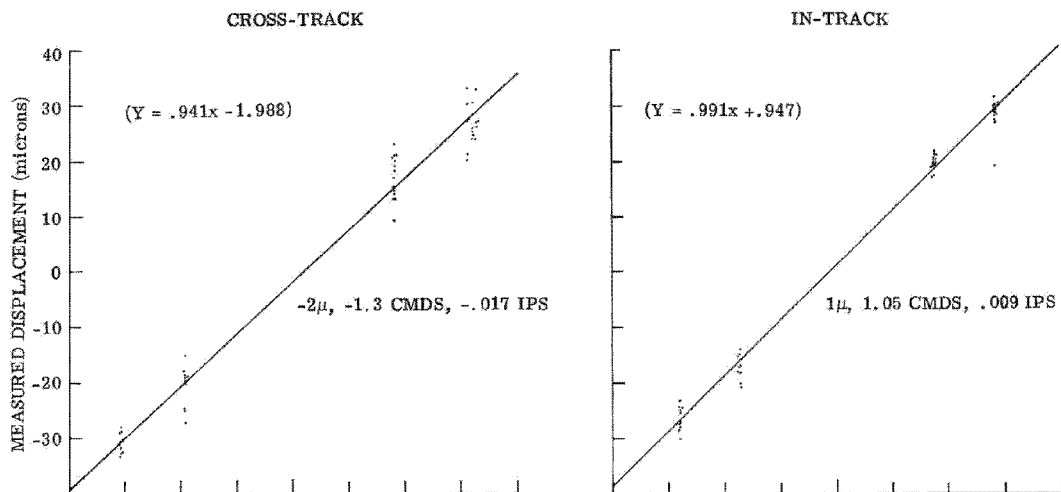
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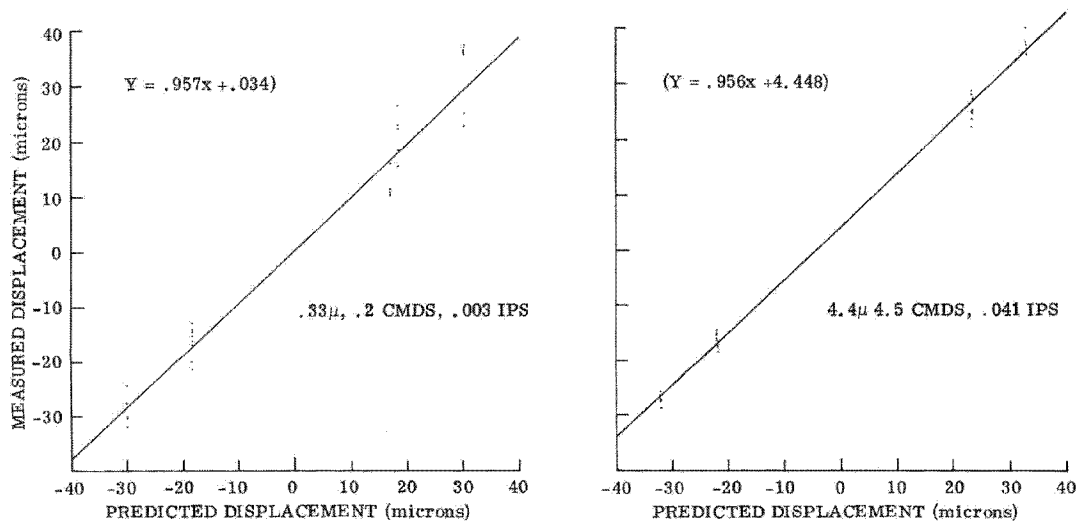
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MEASURED VERSUS PREDICTED DOUBLE IMAGE DISPLACEMENTS FOR OP 95

— FORWARD CAMERA —



— AFT CAMERA —



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FIGURE 3-8

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(acquired as Test 10) to increase the data base and yield additional insight into this error. Op 87 data yielded intercepts of .002 and .050 inch/second for the cross-track and in-track direction. The cross-track was evaluated to be set within one command step. The average intercept for the in-track direction was .045 inch/second, see Figure 3-9. The mean error derived from ground test data at -25° was .013 inch/second, indicating a residual error of .032 inch/second. Additionally, subjective analysis of unbiased smear slit imagery clearly indicated the in-track error. Hence, a -3 OAAA command step change (-.031 inch/second) was implemented on Op 132, Rev 282.

A total of 50 objects from the Forward Camera imagery and 89 from the Aft were measured in the in-track and cross-track directions from 1207-1.

In 1207-2, four additional Test 3A engineering operations (Ops 56, 166, 176, and 198) were acquired to verify OAAA settings. These resulted in an additional 85 data points for the Forward and 93 for the Aft Camera, see Figure 3-10. The Forward and Aft Camera intercepts exhibited excellent agreement with the first mission segment results. This agreement includes the three count correction to the Aft Camera in-track. Table 3-3 lists the ground test predicted error at the mean scan angle at which the orbital data was acquired. Since the cameras are adjusted to produce essentially zero mean error at 0° of scan, any ramps produce non-zero mean errors at scan angles other than zero. Table 3-3 also presents a comparison of the ground test errors to the orbital errors.

Except for the Aft Camera in-track OAAA setting, the settings made from ground test sync-flash data were within .01 inch/second mean smear residual error. The residual error on the Aft Camera in-track direction was determined to be .032 inch/second and was corrected on Op 132 by commanding a three OAAA step change.

3.4.2 Test 3B, Smear Slit Indication of Optimum OAAA Setting For SO-255

Test 3B on the Aft Camera for SO-255 Film was conducted similarly to Test 3A for the 1414 Film, with one acquisition achieved on Op 51, Rev 81. This operation was over Los Angeles and provided four frames of data ranging in scan from 10 to 20 degrees. Forty-one double image pairs were measured at the positive OAAA settings and 30 at the negative, see Figure 3-11. Linear regression analysis indicated that the in-track error was .009 inch/second fast. At the same time, however, the 1414 Film was assessed to be .032 inch/second fast. Therefore, an approximate -.022 inch/second difference existed between the 1414 and SO-255 setting for the Aft Camera in the in-track direction. Whether a real mean error difference exists between the two film types, or the difference is due to the small sample size (one op, four frames) is indeterminate.

The error in the cross-track direction was substantially larger. The measured displacement intercept indicated a mean error of -.05 inch/second (film too slow), with a 90% confidence of $\pm .005$ inch/second. A comparison of the 1207-2 results in the cross-track direction for the Aft Camera indicates

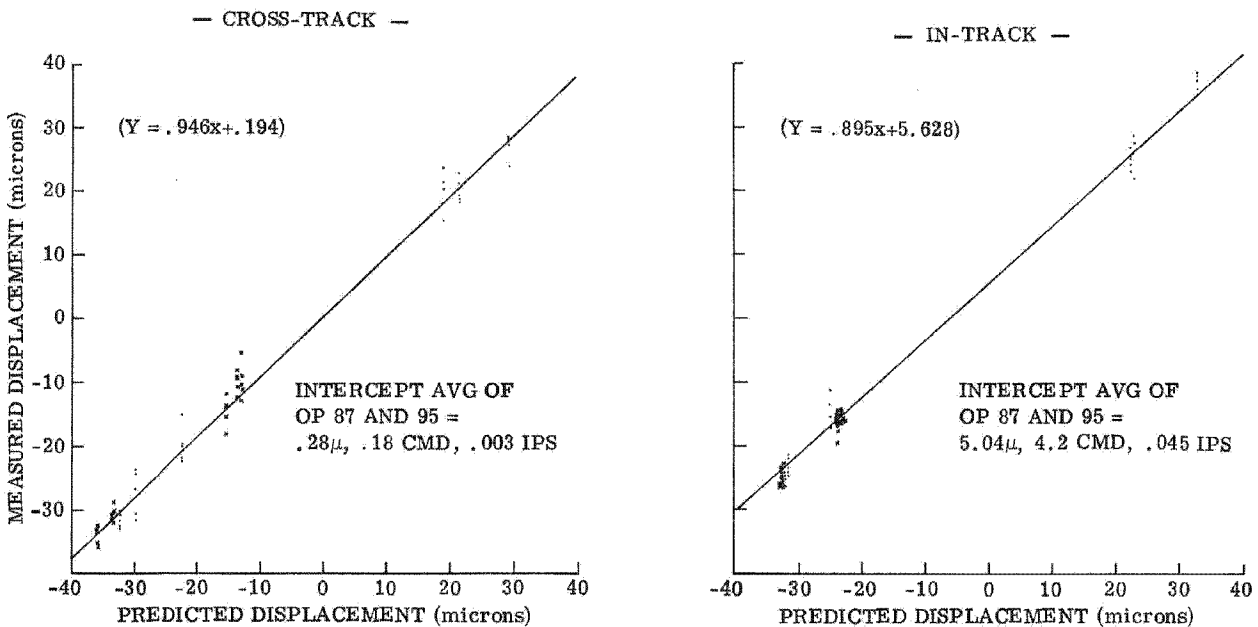
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MEASURED VERSUS PREDICTED DOUBLE IMAGE DISPLACEMENTS FOR
1207-1, AFT CAMERA, OPS 87 AND 95



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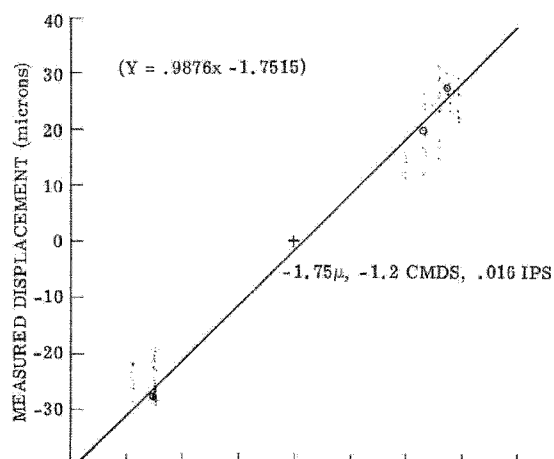
FIGURE 3-9

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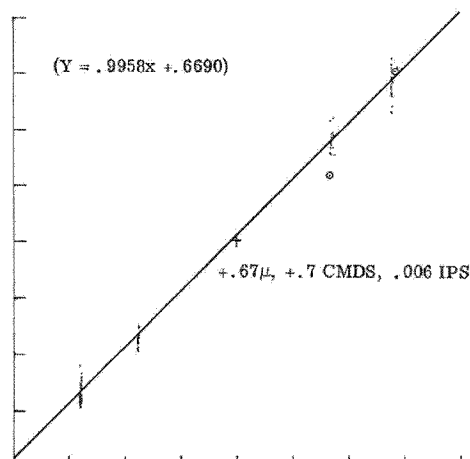
MEASURED VERSUS PREDICTED DOUBLE IMAGE DISPLACEMENTS FOR 1207-2

— FORWARD CAMERA —

CROSS-TRACK



IN-TRACK



— AFT CAMERA —

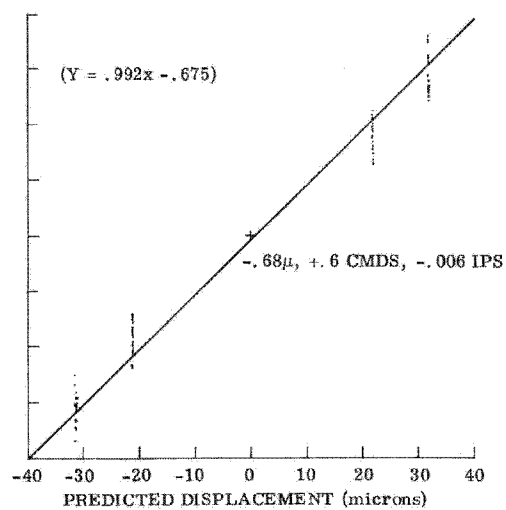
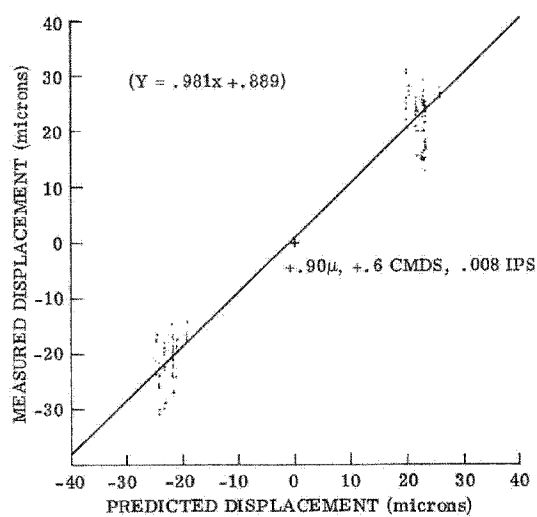


FIGURE 3-10

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TABLE 3-3

COMPARISON OF GROUND TEST VERSUS ORBITAL
SYNCHRONIZATION ERRORS

<u>Camera</u>	<u>Direction</u>	<u>Sync Error</u>	<u>1207-1</u>	<u>1207-2</u>	<u>1207-1(SO-255)</u>
Forward	In-Track	Ground Test	.019	.010	
		Orbital	.009	.006	N/A
		Residual	-.010	-.004	
	Cross-Track	Ground Test	-.010	-.006	
		Orbital	-.017	-.016	N/A
		Residual	-.007	-.010	
Aft	In-Track	Ground Test	.013	0	0
		Orbital	.045	-.006**	.009
		Residual	.032	-.006	.009
	Cross-Track	Ground Test	-.020	0	0
		Orbital	.003*	.008	-.050
		Residual	.023	.008	-.050

NOTES: 1. One asterisk (*) denotes the average intercept of Tests 3A and 10.

2. Two asterisks (**) denote that the value reflects the -.03 inch/second correction.

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MEASURED VERSUS PREDICTED DOUBLE IMAGE DISPLACEMENTS FOR 1207-1,
AFT CAMERA, OP 61, SO-255

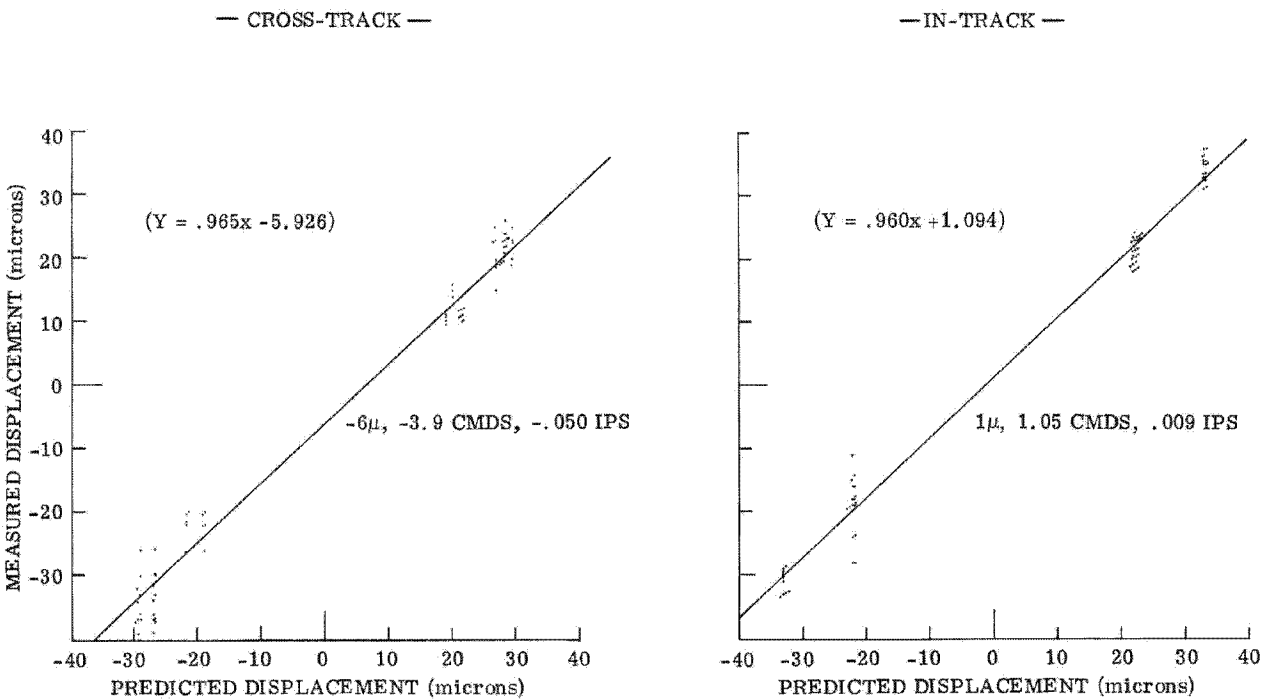


FIGURE 3-11

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that the mean error for the SO-255 Film relative to 1414 was $-.058$ inch/second. A flight setting of -16 command steps for SO-255 relative to the 1414 Film setting was based on both acceptance test data and OAAA calibration data. This is equivalent to $-.21$ inch/second, assuming a value of $.0133$ inch/second per step, which is the average of the $.052$ and $.044$ Vx/h test data. The measured synchronization difference between SO-255 and 1414 Films from Chamber A test data was $-.23$ inch/second for the Aft Camera. This was the average value for the Aft Camera of the tests performed (April 15 thru May 7, 1972). Differences between 1414 and SO-255 were noted as large as $-.26$ inch/second on the Aft Camera. Differences of $.06$ inch/second on SO-255 between the Forward and Aft Cameras were also observed. Additionally, a velocity difference of approximately $.02$ inch/second per $.1$ mil change in material thickness can be expected.

The spread in the test data on which the flight color film OAAA nominal is based, combined with the velocity to film thickness sensitivity and limited flight sample, could yield errors that when algebraically added amount to the measured $.058$ inch/second difference between the SO-255 and 1414 Films. However, the color film on 1206 was also found to be too slow by approximately $.04$ inch/second in the cross-track direction. In view of the 1206 and 1207 results, it is recommended that the 1208 color film cross-track setting be -14 counts relative to 1414 rather than -16 counts.

The $-.022$ inch/second difference between the 1414 and SO-255 setting for the Aft Camera in the in-track direction is of questionable validity. Neither ground nor orbital testing has yielded any such difference in the past, and there is no theoretical reason for the difference. Because of its uniqueness and the small sample size, the difference should not result in a new operational recommendation for 1208. It is recommended that the 1208 color film in-track setting be the same as the black and white film setting.

3.5 SYSTEM RESOLUTION PERFORMANCE

The following assessments of Mission 1207 camera resolution performance were carried out:

- A. Evaluation of CORN tribar targets. Results are only indicative, however, due to small sample size, and an unvalidated contrast normalization procedure.
- B. VEM resolution data generated in a highly controlled fashion for the purpose of input to the calculation of the mission evaluation score (MES). This provides a random format sampling for a reasonably realistic average performance characterization. However, only a small number of edges are selected for any given location, and any image quality patterns are detected as measurement noise only.
- C. Utilization of the VEM resolution data baseline profiles along the major axis (image quality as a function of scan angle) for each of the available scan modes. This approach provides sufficient data for confidence in determining mean levels, degree of noise, and the existence of quality patterns. However, there is a problem with anomalous arching (unexplained fall-off in VEM resolution at scan

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extremes) which could well be a measurement rather than a performance signature. Summarily, camera resolution performance assessment is a useful indicator but not a precise monitor of resultant mission image quality.

3.5.1 Tribar Acquisitions

Four mobile CORN tribar arrays were acquired with the Forward and three with the Aft Camera on 1414 Film during Mission 1207. In addition, there was one acquisition on SO-255 Color Film and one on FE-3916 Infrared Film. The targets were read by four readers and, except for the color film acquisitions, the resultant average resolution (GRD and cycles/mm) was normalized to what it would have been had the camera-incident tribar contrast been 2:1. Tribar normalization procedures for color film acquisitions have not yet been defined.

The contrast normalization procedure uses the MTF/AIM concept. An applicable optics polychromatic MTF is selected for a specific tribar acquisition dependent on camera, field angle, and platen position. The latter parameter determines effective defocus. This optics MTF is then multiplied by the best estimate linear smear MTF, as calculated from the film synchronization errors caused by the orbital fixed known smear at the target format position and the OAAA bias. The resultant system MTF is then multiplied by a frequency-independent constant determined from: (1) this MTF, (2) the 1414 Film AIM curve, and (3) the actual camera-incident tribar contrast. Actual tribar contrast input comes from microdensitometric measurements on the ON of the adjacent CORN Five-Step Gray Scale Target. At this point, the required parameters are known to the extent that the 2:1 normalized resolution is simply given by the intersection of the optics times smear times constant MTF with the 2:1 adjusted AIM curve. The entire MTF/AIM procedure is automated, by use of an Hewlett-Packard 9100B Programmable Calculator. The mobile CORN tribar data acquired on Mission 1207 together with 2:1 contrast normalizations is presented in Table 3-4.

Knowledge of camera-incident tribar contrast is probably the weakest link in the normalization procedure. Although contrast calculation is based on empirically derived conversion curves (the use of film as its own photometer) over small areas (~50 micron patches) and in the presence of large adjacency effects, it is prone to error. Concerning this, the accuracy of the tribar contrast determination method has not been verified with absolute reference data.

By design, the sample size of these acquired tribars is small. The purpose is to monitor actual tribar resolution (as opposed to resolution inference from VEM or NIIRS) rather than assessment of camera system performance as such. In this regard, Mission 1207 is similar to previous missions. The combined system GRD average geometric mean is 2.77' (141 cycles/mm) at 2:1 contrast on 1414 Film. The averages are 2.24' GRD and 177 cycles/mm film resolution with variable, actual contrast.

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TABLE 3-4

1207 MOBILE CORN TRIBAR DATA

— FORWARD CAMERA —

Op	Frame	Scan Angle (degrees)	Field Angle (degrees)	Photo Position (inches)	Measured Contrast	Geometric			Geometric			2:1 Adj In-Track (cycles/mm)	Cross-Track (cycles/mm)	GTD Cross-Track (cycles/mm)	Geometric Mean (cycles/mm)
						Mean (line)	In-Track (line)	Cross-Track (line)	Mean (line)	In-Track (cycles/mm)	Cross-Track (cycles/mm)				
22	003	24.0	2.0	137	3.80	2.58	2.3	2.9	2.17	176	146	144	118	139	139
69	003	5.3	-1.3	137	3.02	2.19	2.3	2.4	2.38	184	156	158	135	191	191
188	004	1.5	-5	137	4.37	1.85	2.3	2.5	2.45	208	185	157	138	147	147
529	002	-21.4	-2.2	137	5.90	1.99	2.3	3.0	2.63	214	187	174	137	184	184

— AFT CAMERA —

Op	Frame	Scan Angle (degrees)	Field Angle (degrees)	Photo Position (inches)	Measured Contrast	Geometric			Geometric			2:1 Adj In-Track (cycles/mm)	Cross-Track (cycles/mm)	GTD Cross-Track (cycles/mm)	Geometric Mean (cycles/mm)
						Mean (line)	In-Track (line)	Cross-Track (line)	Mean (line)	In-Track (cycles/mm)	Cross-Track (cycles/mm)				
22	004	25.2	.4	133	3.02	2.45	2.7	3.1	2.89	177	166	148	139	143	143
69	003	6.1	2.0	55	NA	2.59	2.3	3.6	2.84	151	132	141	101	123	123
188	004	1.5	-2.5	53	3.56	2.37	2.4	3.6	2.84	182	127	150	101	123	123
519	003	-20.6	.7	33	3.60	2.14	2.3	3.0	2.63	211	173	159	137	152	152
700*	002	6.0	-6	63	NA	5.49	2.3	3.0	2.63	72	82	87	137	152	152

NOTE: The asterisk (*) denotes a memo run.

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12073.5.2 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 targets. The resultant data serves primarily as input to the mission evaluation score (MES). The approach here offers a characterization of system performance as a function of camera, direction, and mission segment as well as a method of comparison between missions using the same operational target complexes.

The total frequency distribution of matches is output onto a single 120° frame format, see Figure 3-12. The numerals in the figure indicate the field/scan angle locations of the edge data as well as the number of samples taken at each of the sampled positions; sample size varies from one to six edge matches at a given location. The fact that distribution over the format is uniform demonstrates that the VEM/MES data represents a random average response of edge sharpness in the images of typical intelligence target complexes.

The data for Mission 1207 in terms of equivalent 2:1 contrast VEM resolution is given in terms of mean values together with their respective 95% limits, see Table 3-5. This data is presented in-track, cross-track and geometric mean on a per segment basis. Two observations are immediately possible from this data: (1) in-track resolution is consistently higher than cross-track resolution, and (2) the mission averages for the two cameras are equivalent.

Geometric mean VEM resolution was plotted to show chronological trend comparison, see Figure 3-13. For each camera, the mean as bounded by the 95% confidence level limits is plotted on a logarithmic scale. A statistical analysis of mission VEM/MES data shows a slight indication of a degradation of Forward Camera performance with time. No such correlation was found on the Aft Camera.

Previous mission VEM/MES data places Mission 1207 into historical perspective. Mean VEM resolution data compared for the five most recent missions on a per segment basis shows only a moderate (~ 30 cycles/mm) range of resolution levels, see Table 3-6. For the Forward Camera, the range is from a low of 140 cycles/mm (1204-4) to a high of 170 cycles/mm (1205-4). The range is similar for the Aft Camera, a low of 141 cycles/mm (1204-2) to a high of 169 cycles/mm (1205-4).

A more detailed examination of mission averages shows plots of the means as bounded by their 95% confidence limits for each of the ten cases, see Figure 3-14. From this, it is apparent that 1205 was the most superior while Missions 1203, 1204, 1206, and 1207 were similar, especially for the Forward Camera. Thus, from the random sample approach, Mission 1207 rates equivalent to previous Good quality missions. Comparable data is not available for the first two missions.

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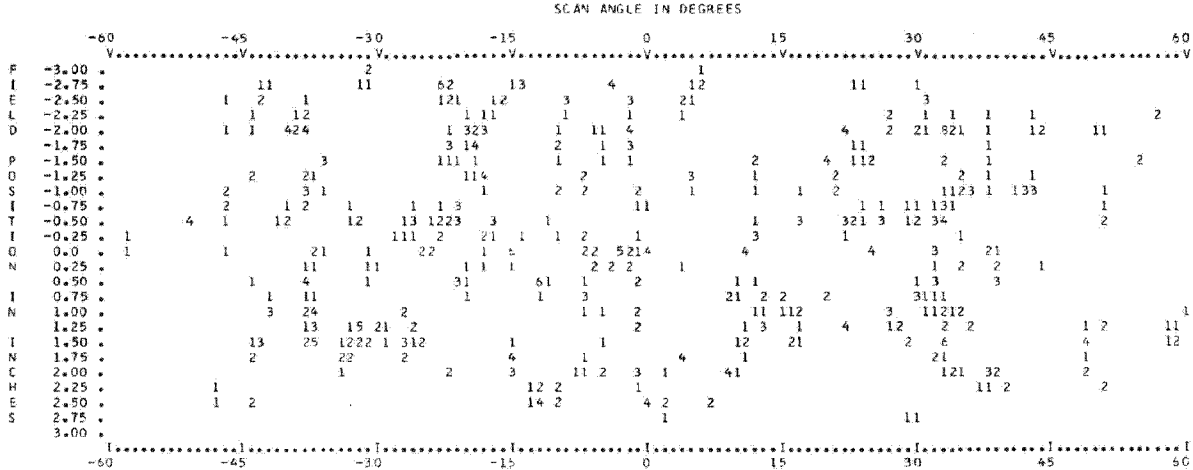
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VISUAL EDGE MATCHING

TOTAL FREQUENCY DISTRIBUTION OF READINGS BY SCAN ANGLE AND FIELD POSITION FOR MISSION 1207

THE FREQUENCY OF OBSERVATIONS AT EACH FIELD POSITION AND SCAN ANGLE IS INDICATED BY A NUMBER OF 1 TO 9, OR A LETTER OF A TO Z (FOR FREQUENCIES OF 10 TO 35 RESPECTIVELY) OR AN * FOR FREQUENCIES OVER 35. IF NO OBSERVATIONS WERE MADE AT A POINT, THE POSITION IS LEFT BLANK. IF THE FIELD POSITION OF AN OBSERVATION WAS LESS THAN -3.0, IT IS SET TO -3.0. THE UPPER LIMIT IS THEN CHECKED AGAINST A MAXIMUM OF 3.0 AND SET TO THAT IF A LARGER NUMBER IS FOUND. SIMILARLY, THE UPPER AND LOWER LIMITS OF THE SCAN ANGLE ARE CHECKED.



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FIGURE 3-12

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TABLE 3-5

VEM/MES RESOLUTION SUMMARY

(cycles/mm)

Mission Segment		Forward Camera			Aft Camera		
		In-Track	Cross-Track	Geometric Mean	In-Track	Cross-Track	Geometric Mean
1207-1	(1)	158	149	155	162	148	155
	(2)	163	155	159	167	155	161
	(3)	169	161	163	173	161	166
1207-2	(1)	155	144	150	158	132	145
	(2)	162	151	156	164	140	151
	(3)	168	158	162	170	147	156
1207-3	(1)	154	137	146	150	141	147
	(2)	160	145	152	156	148	152
	(3)	166	153	158	162	156	157
1207-4	(1)	143	133	138	156	142	149
	(2)	151	143	146	162	149	155
	(3)	160	154	155	167	155	160
Mission Averages	(1)	153	141	147	157	141	149
	(2)	159	149	153	162	148	155
	(3)	166	157	160	168	155	160

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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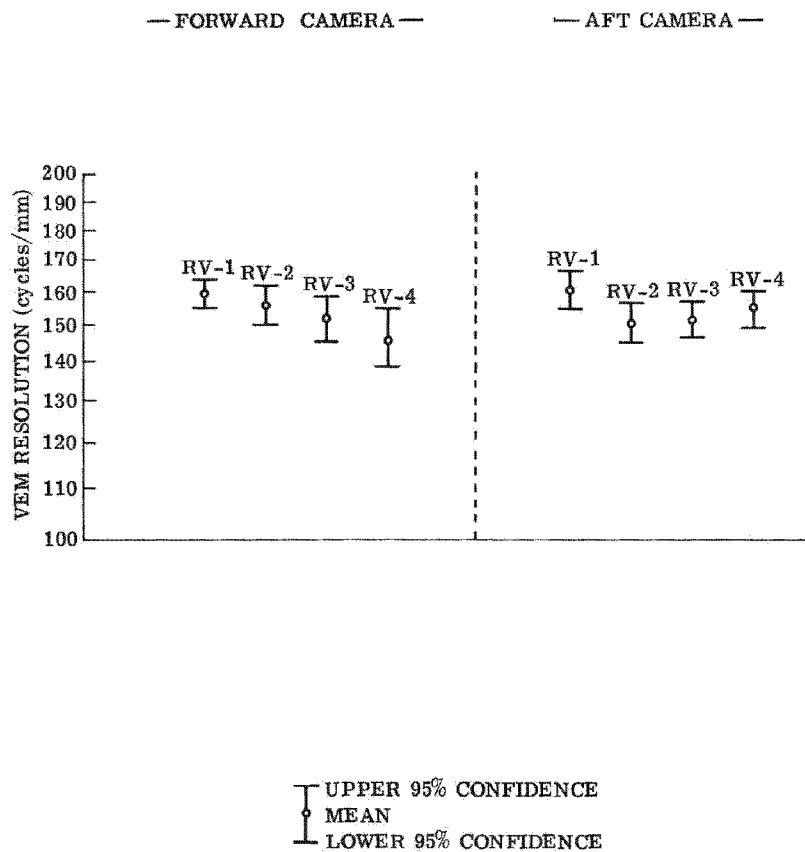
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COMPARISON OF GEOMETRIC MEAN RESOLUTION BY MISSION 1207 SEGMENTS



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FIGURE 3-13

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MISSION AVERAGE GEOMETRIC MEAN VEM RESOLUTION

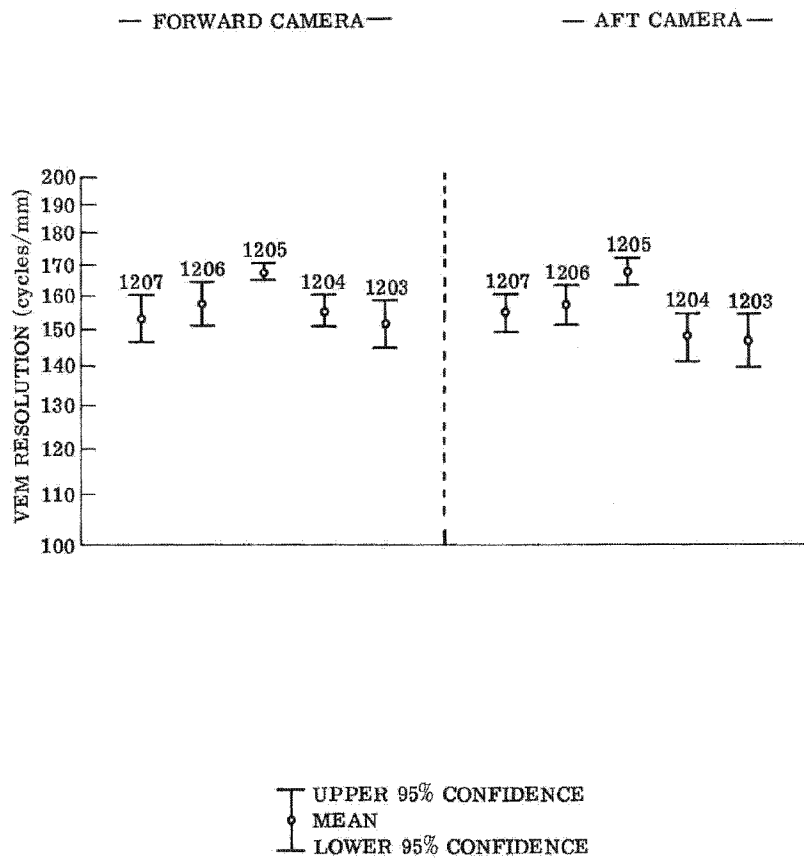


FIGURE 3-14

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TABLE 3-6

HISTORICAL COMPARISON OF MEAN RESOLUTION LEVELS AT 2:1 CONTRAST
(cycles/mm)

— Forward Camera —

Mission Segment	Mission				
	1207	1206	1205	1204	1203
RV-1	159	159	162	167	156
RV-2	156	159	168	159	148
RV-3	152	158	169	153	149
RV-4	146	152	170	140	153
Average	153	157	167	155	152

— Aft Camera —

RV-1	161	154	164	161	147
RV-2	151	160	168	141	145
RV-3	152	155	168	145	148
RV-4	155	160	169	144	146
Average	155	157	167	148	147

NOTE: The values are the geometric mean of the in-track and cross-track measurements.

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

- A. Sampling has been uniformly distributed over the full format.
- B. In-track resolution is slightly higher than cross-track.
- C. The two cameras have essentially equal performance.
- D. A small degradation in image quality with time is indicated on the Forward Camera but not on the Aft Camera.

E. For overall average resolution, Mission 1207 performed at 154 cycles/mm which is comparable to Missions 1206, 1204, and 1203, but inferior to Mission 1205.

3.5.3 Major Axis Quality Profiles3.5.3.1 General

Visual edge matching was used to characterize the image quality of Mission 1207 photography along the center line of scan, i.e., the major axis. Results of these measurements show, as they have with previous missions, an intermittent tendency of a falloff in resolution away from nadir that appears to be scan mode dependent. Generally these losses are slight but there is no clear-cut system or measurement

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process related explanation as yet. The anomalous image quality profiles do not represent any serious degradation to overall mission performance but do represent an area of concern.

3.5.3.2 Analysis Procedures

Major axis profiles were obtained for 12 of the 14 possible combinations of scan length and scan center used during this mission. Only the 30° scans centered at $\pm 15^\circ$ and 0° were measured; data from previous mission has shown that this is sufficient to characterize the 30° scan mode operations. Generation of the major axis profiles was started by the PFA Team at BRIDGEHEAD and later completed at AFSPPF.

Each of the profiles is composed of a series of VEM measurements made within a defined measurement cell; these cells were spaced at 15° increments along the major axis for each of the modes tested, see Table 3-7. The size of the measurement cell used was 3" in scan by 1" ($\pm 1/2$ " about 0° of field) in field.

TABLE 3-7
MEASURING CELL LOCATION USED IN MAJOR AXIS VEM ANALYSIS
(degrees)

Scan Mode (degrees)		Cell Locations In Scan									
Length	Center										
120	0	-60	-45	-30	-15	0	15	30	45	60	
	-15	-60	-45	-30	-15	0	15	30			
90	0		-45	-30	-15	0	15	30	45		
	15			-30	-15	0	15	30	45	60	
	-30	-60	-45	-30	-15	0					
	-15		-45	-30	-15	0	15				
60	0			-30	-15	0	15	30			
	15				-15	0	15	30	45		
	30					0	15	30	45	60	
	-15			-30	-15	0					
30	0				-15	0	15				
	15					0	15	30			

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Each profile data point associated with a cell is the average of 18 VEM readings, nine edge matches by each of two readers. The nine readings per reader were required to be taken from a minimum of three different frames to avoid any bias that could result from a single frame sampling. Table 3-8 shows the range of resolutions measured for each family of curves as well as the percent change that this range constitutes. See Tables 3-9 and 3-10 for the average VEM determined resolution for each of the measurement conditions.

TABLE 3-8

RESOLUTION RANGE MEASURED BY VEM FOR EACH SCAN MODE
(cycles/mm)

Mode (degrees)	Forward Camera						Aft Camera					
	In-Track			Cross-Track			In-Track			Cross-Track		
	Max	Min	$\Delta\%$	Max	Min	$\Delta\%$	Max	Min	$\Delta\%$	Max	Min	$\Delta\%$
120	178	155	13	172	140	19	183	169	8	183	170	8
90	182	134	26	178	126	29	185	125	32	181	138	24
60	186	137	26	178	131	26	172	141	18	171	130	24
30	178	147	17	179	146	18	171	133	22	170	123	20

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

3.5.3.3 Data Analysis

Because of the similarity of curve shapes with in-track and cross-track edge orientations in the data base, major axis quality profiles are presented as geometric mean VEM resolution for quality profiles of the Forward and Aft Cameras respectively, see Figures 3-15 and 3-16. A composite response is also provided in the form of the mean and the minimum and maximum resolutions measured at each scan angle.

Both cameras exhibit similar characteristics for each of the four modes. The full 120° scan is essentially flat, with minor losses at $\pm 60^\circ$ Forward only. The most severe resolution falloff with increasing distance from center is with the three 90° scans. Slight and irregular losses characterize the 60° scans. For the short 30° scans, the data for any given profile is closely grouped, but the quality levels vary with scan center. All of the measured VEM resolution, averaged together for each scan angle cell, show a gradual and nearly symmetrical resolution loss with increasing scan angle from nadir. However, the range of resolution measured at any one scan angle encompasses the mean resolution of almost every other cell. In summary, the "arching" anomaly is neither totally absent nor totally present.

Another view of this same data is that the 12 profiles for each camera are mapped onto

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TABLE 3-9

SUMMARY OF VEM DETERMINED RESOLUTION FOR FORWARD CAMERA

(cycles/mm)

— In-Track —

Scan Mode (degrees)		Scan Angle (degrees)												
Length	Center	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60
120	0	159	172		176	176		173	178		177		175	155
	-15	137	149		145	154		152	154		150			
90	0		135		159	174		179	179		158		134	
	15				149	176		182	181		180		148	137
	-30	140	144			162		172						
	-15		150		152	163		163	147					
60	0				143	157		159	163		137			
	15					160		172	186		161		150	
	30							176	168		163		154	153
	-15				160	176		178						
30	0					158		168	155					
	15							158	147		150			
164 + 12*														

NOTE: The asterisk (*) denotes mean and standard deviation $\pm 30^\circ$ scan.

— Cross-Track —

120	0	149	166		171	172		171	166	168		159		140
	-15	126	127		154	159		149	153	148				
90	0		133		155	167		175	171	157		130		
	15				154	175		178	177	175		146		126
	-30	132	146		158	154		164						
	-15		150		147	159		164	147					
60	0				138	149		158	149	131				
	15					157		171	178	162		153		
	30							163	156	160		153		151
	-15				160	179		178						
30	0					158		165	156					
	15							150	146	148				
160 ± 11														

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TABLE 3-10

SUMMARY OF VEM DETERMINED RESOLUTION FOR AFT CAMERA

(cycles/mm)

— In-Track —

Scan Mode (degrees)		Scan Angle (degrees)												
Length	Center	60	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
120	0	169	170	171	171	171	183	173	173	173	173	173		173
	-15	145	160	167	167	183	181	172	149					
90	0		162	160	168	168	185	182	149	111				
	15			148	157	169	185	168	153	125				
	-30	142	156	159	163	154								
	-15		141	147	172	169	163							
60	0			152	160	172	163	157						
	15				151	142	171	139	141					
	30					170	167	158	150	144				
	-15			140	133	136								
30	0				166	171	156							
	15					145	146	145						

162 + 14

— Cross-Track —

120	0	170	171	172	173	183	174	173	174	174
	-15	141	159	166	181	178	169	146		
90	0		138	164	169	177	171	138	91	
	15			143	148	166	177	166	149	119
	-30	143	154	150	150	159				
	-15		130	152	171	160	160			
60	0			137	163	168	157	148		
	15				147	150	161	145	140	
	30					163	162	155	145	131
	-15			127	123	132				
30	0				167	170	150			
	15					140	156	142		

158 + 14

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FORWARD CAMERA MAJOR AXIS PROFILES

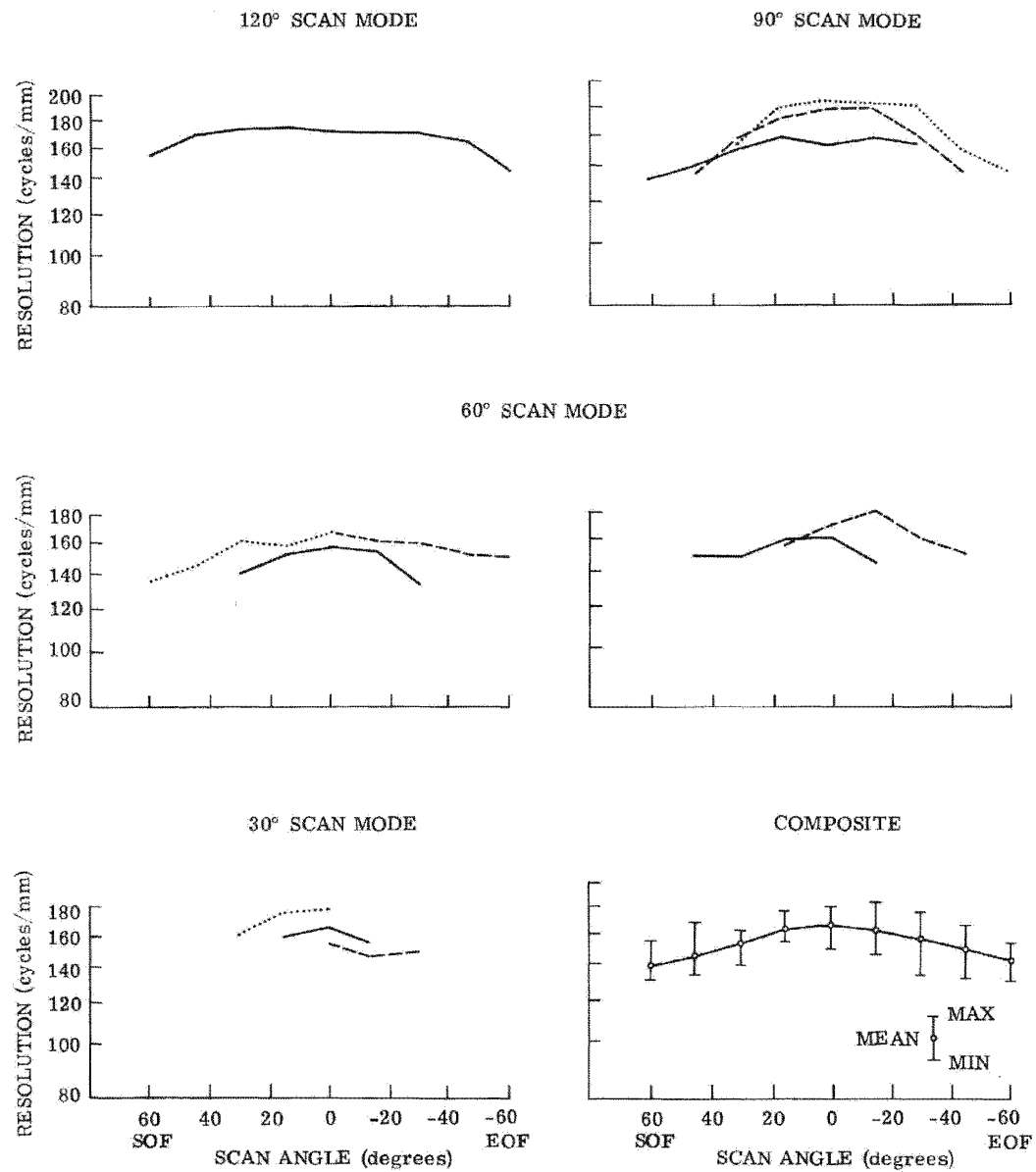


FIGURE 3-15

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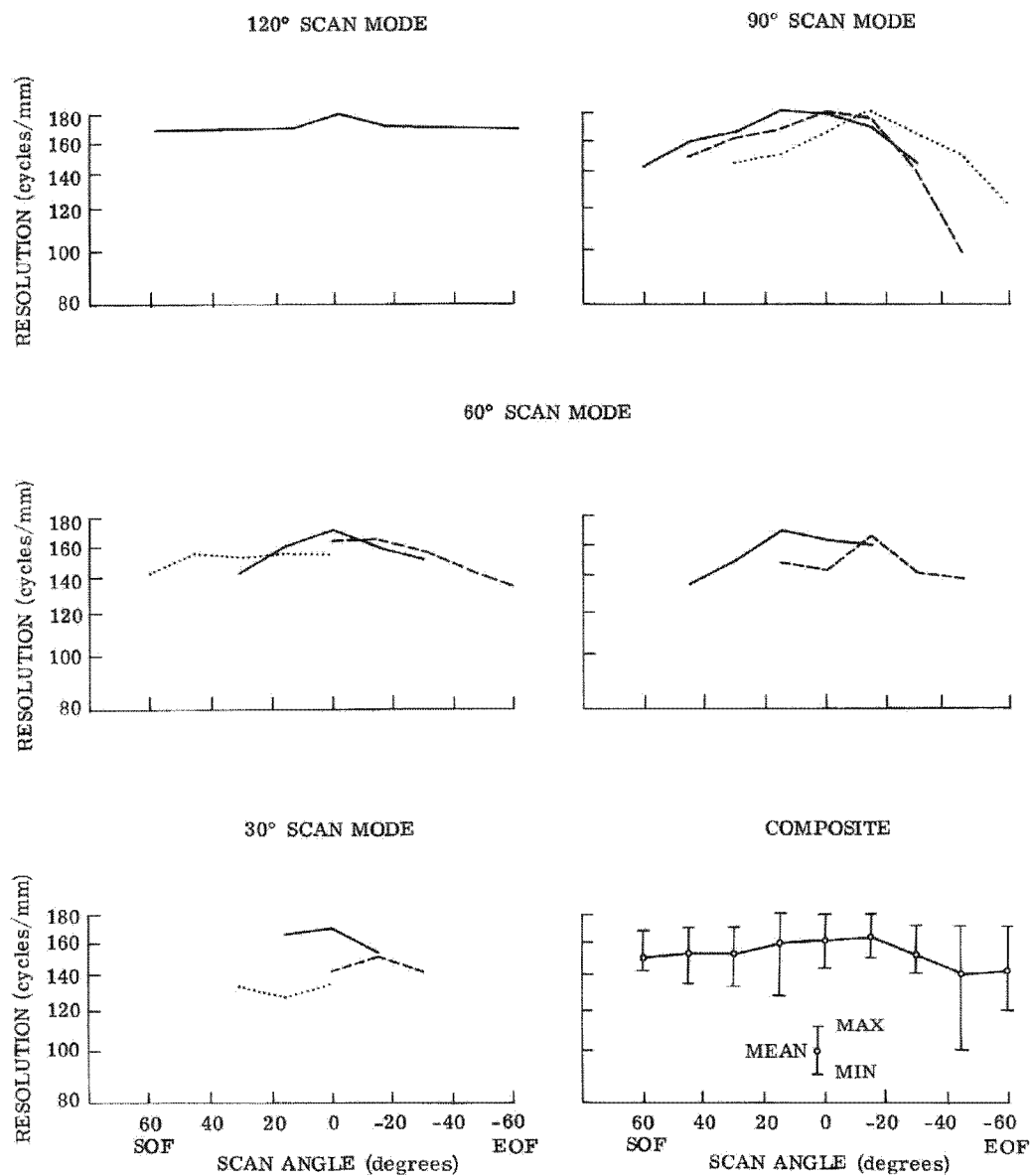
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AFT CAMERA MAJOR AXIS PROFILES



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FIGURE 3-16

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representative frame formats as high points, equal resolution and suppressed resolution locations, see Figures 3-17 and 3-18. The one cell exhibiting peak resolution for that profile is located by an "H". For both cameras, the high point is contained within $\pm 15^\circ$ of nadir. Cells that are left blank are considered to be within the measurement noise level (9% or less) of the peak resolution for that profile. Suppressed resolution, which is a reduction of 10% or more from peak for each profile, cells are located by "L" designations. For both cameras, one third of the total cells measured have at least 10% lower resolution than the peaks. In all cases, the low points are either zero, one or two cells in from either end. These points are about equally balanced between start and end-of-frame. Although the low spots for a given scan format are restricted to the ends, on an absolute scan angle basis, no scan angle including nadir is free from a low spot sample.

Although VEM resolution is sometimes suppressed at the format ends, most of the data is at a reasonably uniform resolution level and peak resolution is never located beyond $\pm 15^\circ$ of nadir.

The major axis data is shown in another way in Figure 3-19. In this comparison, the angles indicate distance from center format and not absolute scan angle. The data for each profile is normalized to center format and averaged to compare the four scan modes. The differences in peak resolution level and rate of resolution loss with scan angle are slight but distinguishable.

3.5.3.4 Recommendation

An in-depth study of the Mission 1207 major axis quality profiles is addressing this apparent anomaly. Sample cell areas from which many of these VEM measurements were made have been chipped out of the DP rolls. Mounted as 2 1/4" x 2 1/4" slides and coded for identification, these 118 chips of clear weather culture will be further analyzed. The first phase of this study will be for the original readers to VEM these chips again. This data, when compared to the original data, should reveal whether or not normally generated major axis profiles contain a subjective bias with respect to format location. The second study phase will be to perform other quality assessments of the chips grouped into absolute scan angle categories. With scale and obliquity held constant, it should be possible to determine objectively whether or not there is a system-induced format location factor influencing image quality. It is recommended that this study be carried to completion.

3.6 LABORATORY VERSUS ORBITAL PERFORMANCE

During ground testing, several aspects of camera performance are ascertained; resolution, optical field curvature, platen tilt, quality variability, and image motion are assessed in environmental test chambers. In flight, the engineering tests designed to fine-tune focus and image motion compensation yield a data base that allows for a comparison of operational performance to laboratory test results.

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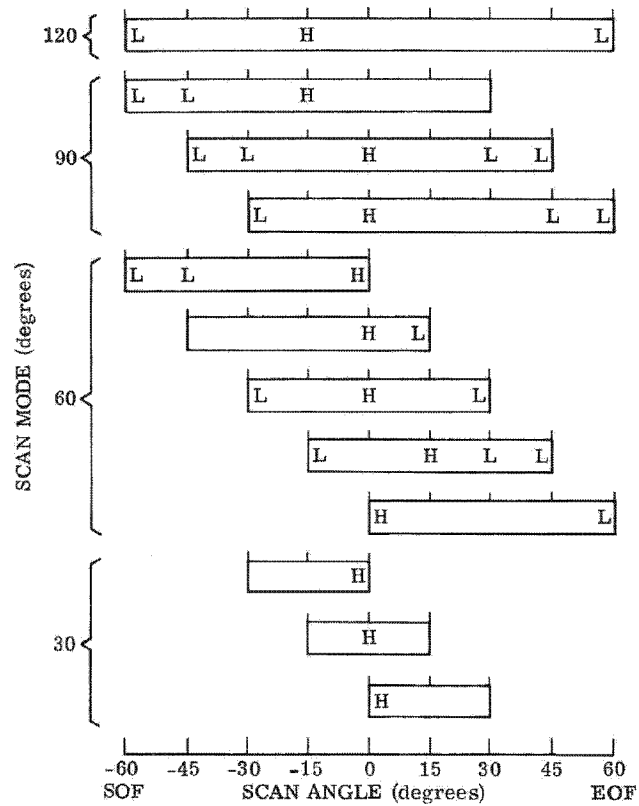
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SCAN MODE FORMAT QUALITY FOR FORWARD CAMERA



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FIGURE 3-17

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SCAN MODE FORMAT QUALITY FOR AFT CAMERA

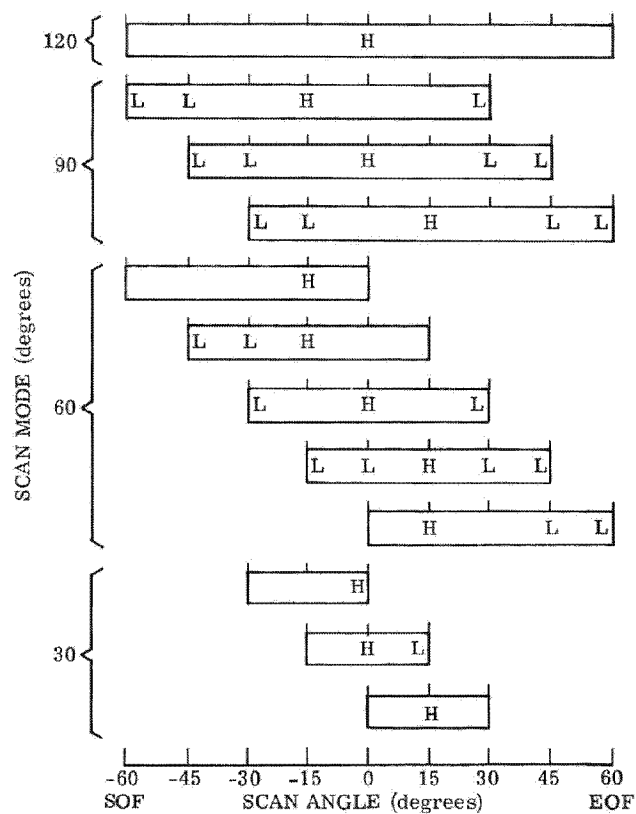


FIGURE 3-18

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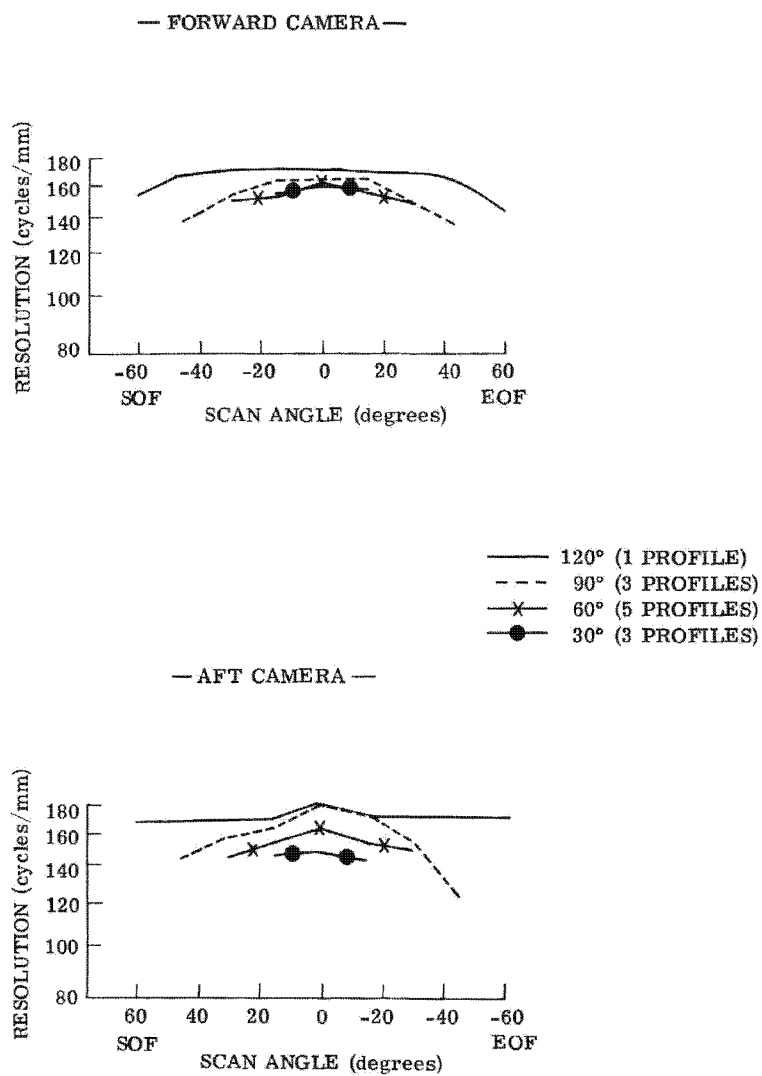
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COMPOSITE OF MAJOR AXIS PROFILES NORMALIZED TO CENTER FORMAT



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FIGURE 3-19

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12073.6.1 Resolution

Resolution is determined by exposing 2:1 contrast tribar targets onto 1414 Film during camera testing in Chamber A-2; these results are presented in the SV-7 Readiness Report (BYE 15310-73). On-orbit, the thru focus runs are used to establish an equivalent 2:1 contrast resolution by use of visual edge matching. Since there was no focus change on SV-7, a comparison between flight and ground test resolution can be made by comparing the prelaunch profile of resolution across the field with that of the minor axis VEM at equivalent platen positions, see Table 3-11. The conclusion can be drawn that no degradation in resolution performance occurred between ground and orbit, and, if anything, resolution was slightly improved. However, this conclusion should be tempered with the fact that the on-orbit sample size is relatively small compared with ground test data.

TABLE 3-11

2:1 CONTRAST MEASURED RESOLUTION COMPARISON BEFORE AND AFTER LAUNCH
(cycles/mm)

-- In-Track --

Field Angle (degrees)	Forward Camera			Aft Camera		
	Lab Tribar Test	Orbit VEM	Difference (%)	Lab Tribar Test	Orbit VEM	Difference (%)
-2.5	192	186	- 3	172	179	4
-2	172	185	8	194	177	- 9
-1	174	190	9	176	184	5
0	167	194	16	181	196	8
1	165	195	18	204	184	-10
2	183	187	2	181	177	- 2
2.5	152	174	14	134	170	27
Average	172	187	9	178	181	2

-- Cross-Track --

-2.5	176	179	2	146	167	14
-2	152	183	20	160	166	4
-1	167	185	11	164	177	8
0	158	188	19	164	183	12
1	159	190	20	176	179	2
2	151	181	20	156	168	8
2.5	120	175	46	128	166	30
Average	155	183	15	156	172	10

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3.6.2 Optical Field Curvature

To estimate the effective field curvature in mission photography, it is necessary to use the VEM minor axis profile data taken from the 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 through the available data points, see Figures 3-20 and 3-21. 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 3-22.

The final assessment of on-orbit field curvature is not as precise as it should be due to the limited number of thru focus samples. Although impractical due to acquisition conditions and material consumption, it is recommended that the number of frames providing minor axis profile data at each platen position be increased to improve this precision. The Mission 1207 data indicates a flat field.

From Figure 3-22, this on-orbit estimate is in apparent disagreement with the preflight test measurements, which indicate approximately 25 microns of effective field curvature. However, its agreement with Chamber D determined field curvature is quite good. The reason for poor agreement with Chamber A-2 results is not presently known; however, 20 microns field curvature could certainly be ascertained by VEM on operational photography. The degree of agreement of Chamber D with on-orbit curvature is not known due to uncertainties in the sample size; however, on-orbit results are more like Chamber D than Chamber A-2. Furthermore, this figure shows there is little if any platen tilt in SV-7.

3.6.3 Quality Variability

Variability in image quality throughout the mission, as a function of camera and direction, can be characterized by the ratio of standard deviation to mean resolution from the VEM/MES data baseline.

The VEM data shows that the cross-track variability is somewhat greater than in-track and generally, the overall variability in the VEM/MES sampling is on the order of 14 percent. A comparison of the on-orbit measured variability to the preflight testing is made in Table 3-12. Readiness test data shows an average variability of 8% in Chamber A-2. The 6% increase on-orbit can be attributed to: (1) the less precise methodology from product imagery, (2) the full distribution over the format rather than the fixed nadir point location, and (3) a possible increase of smear variability during the mission.

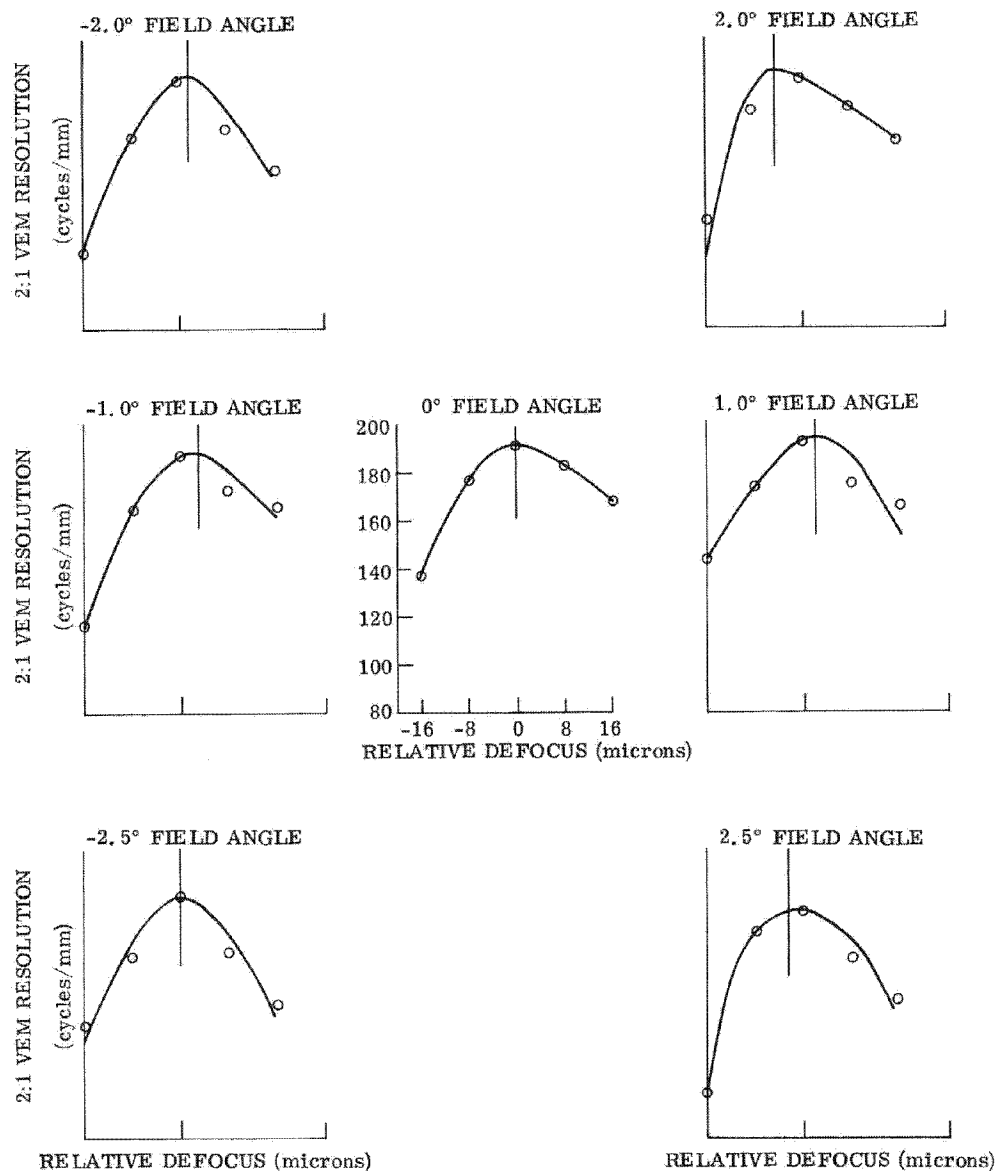
The fact that quality variability measured from flight photography is normally greater than that measured from chamber test tribars is confirmed in Table 3-13. On the average, Readiness test variability is characteristically 8 or 9 percent. The VEM/MES indicated variability for four of the most recent missions is characteristically 12 or 14 percent. Some increase in variability is to be expected since laboratory testing does not include all the error sources that the camera system experiences on-orbit, e.g., vehicle rates, vehicle attitude, command errors, etc. The only exception to this trend is Mission 1205 which exhibited no increase in variability on-orbit. From this point of view, Mission 1207 variability

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12071207-1 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 3-20

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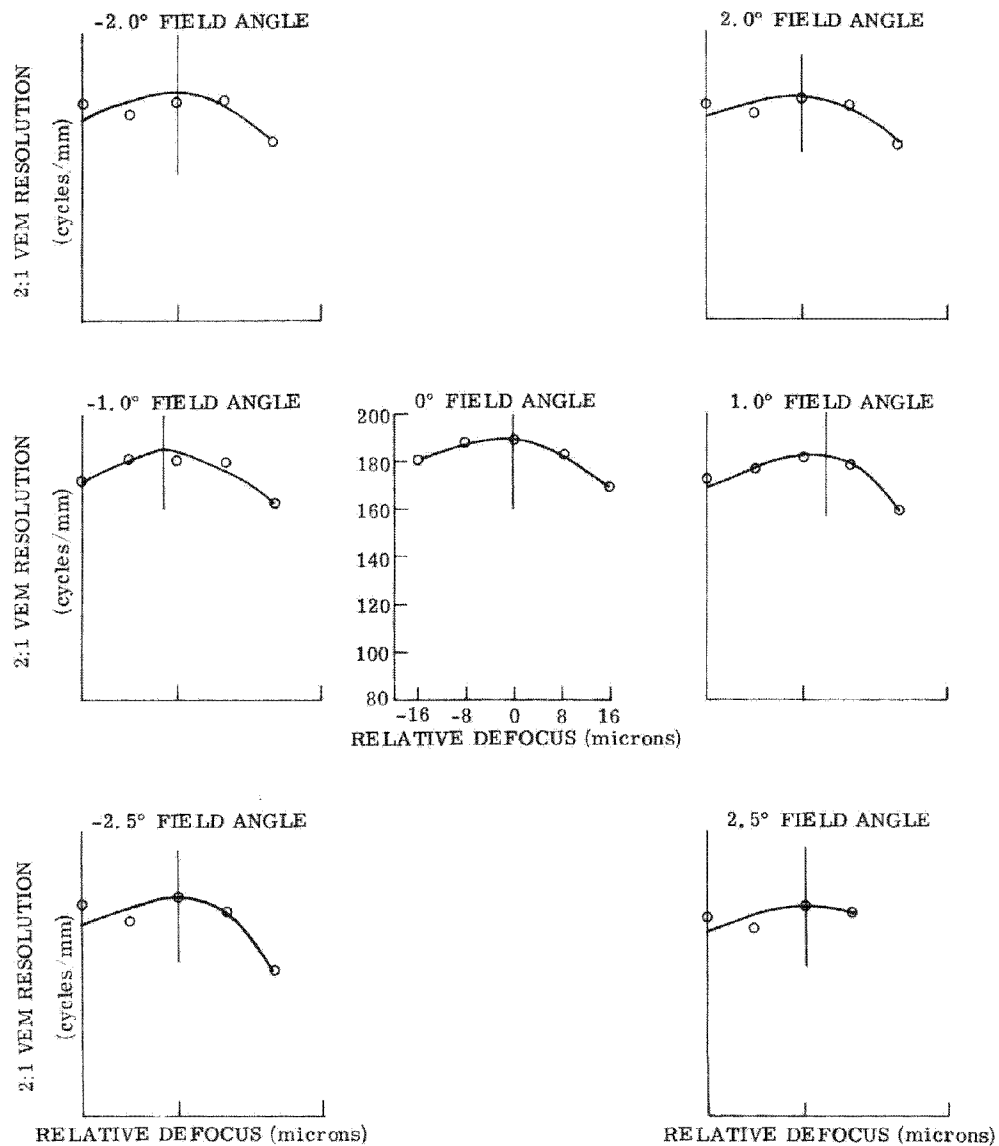
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1207-1 AFT CAMERA ON-ORBIT THRU FOCUS GEOMETRIC MEAN RESOLUTION
AS A FUNCTION OF FIELD ANGLE



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

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FIGURE 3-21

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FIELD CURVATURE ASSESSMENT COMPARISONS

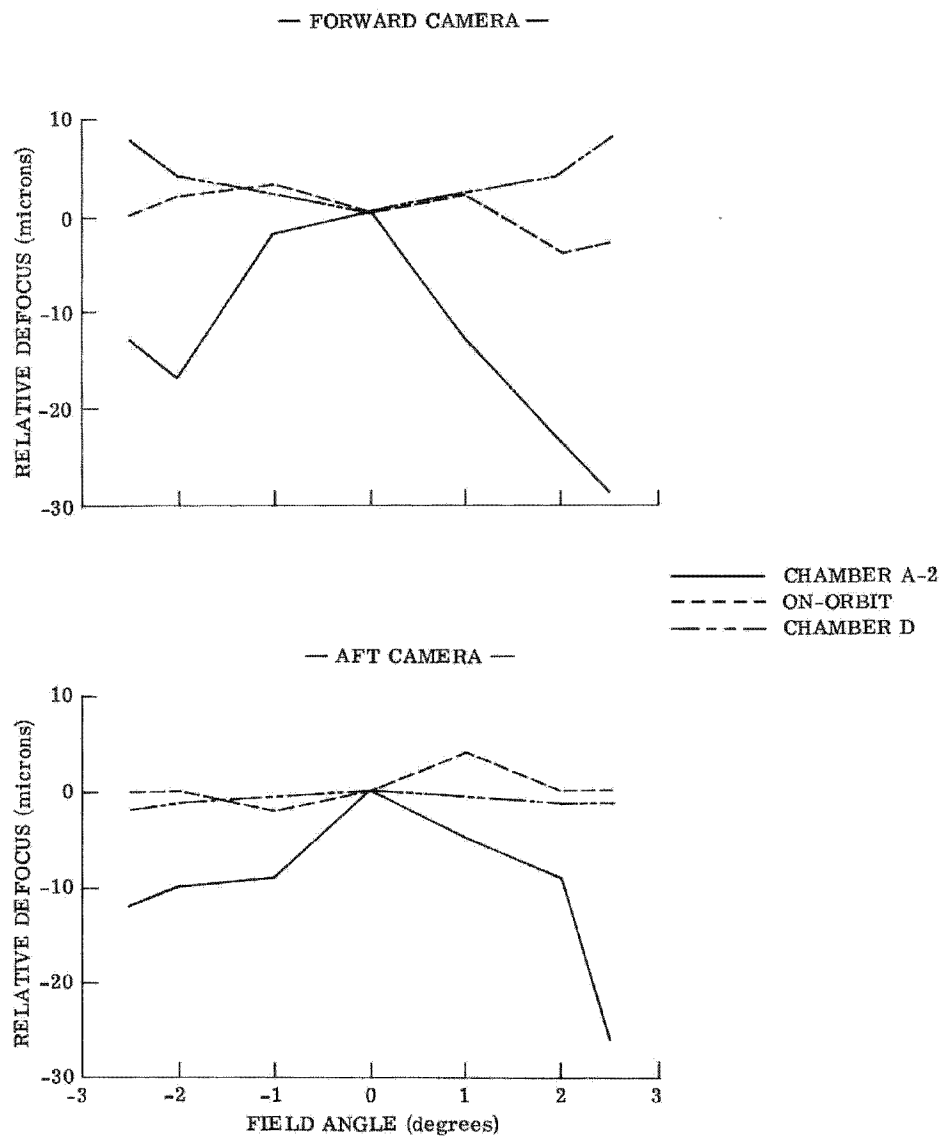


FIGURE 3-22

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TABLE 3-12

IMAGE QUALITY VARIABILITY AS DETERMINED FROM VEM RESOLUTION
(cycles/mm)

Mission Segment	Forward Camera				Aft Camera			
	In-Track		Cross-Track		In-Track		Cross-Track	
	Average Resolution (R)	Standard Deviation(σ)	Average Resolution (R)	Standard Deviation (σ)	Average Resolution (R)	Standard Deviation(σ)	Average Resolution (R)	Standard Deviation(σ)
1207-1	164	<u>+17</u>	155	<u>+18</u>	167	<u>+16</u>	155	<u>+20</u>
1207-2	162	<u>+19</u>	151	<u>+22</u>	164	<u>+18</u>	140	<u>+22</u>
1207-3	160	<u>+17</u>	145	<u>+26</u>	156	<u>+18</u>	149	<u>+22</u>
1207-4	151	<u>+26</u>	143	<u>+33</u>	161	<u>+18</u>	149	<u>+20</u>
$\frac{\sigma}{R}$	$\frac{20}{159} = 0.126$		$\frac{25}{148} = 0.169$		$\frac{18}{162} = 0.111$		$\frac{21}{148} = 0.142$	
Variability (%)	12.5		16.9		11.1		14.2	
Average Variability (%)	14.7				12.6			

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is comparable to past mission performance.

TABLE 3-13

MISSION VERSUS CHAMBER QUALITY VARIABILITY

Mission	PFA Edge Data			Ch A-2 Tribar Data		
	Forward	Aft	Average	Forward	Aft	Average
1207	15	13	14	7	9	8
1206	14	11	13	8	7	8
1205	7	9	8	8	8	8
1204	10	14	12	9	9	9
1203	14	13	14	7	10	9

NOTE: The values are the percent ratios of standard deviation to mean VEM resolution.

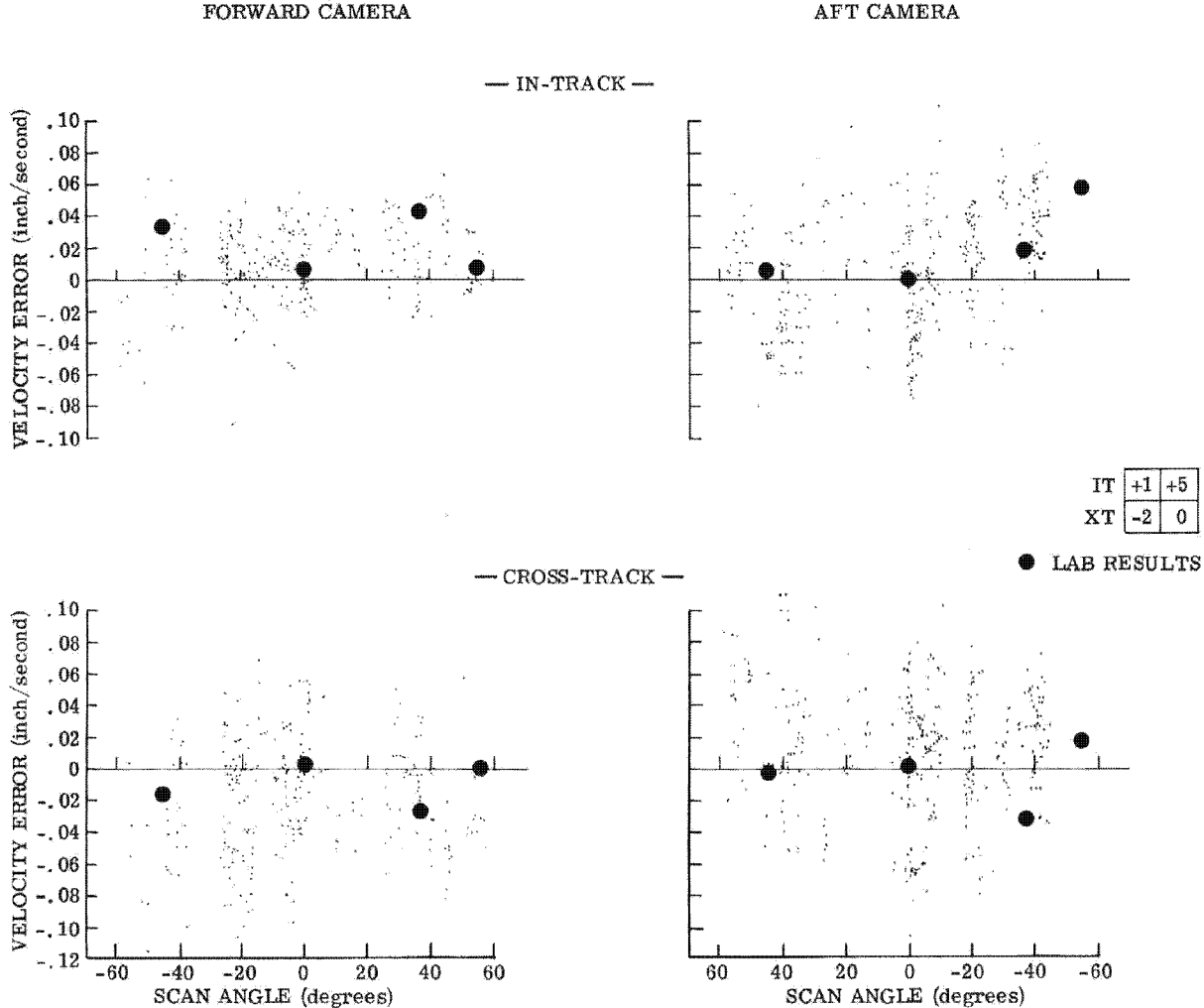
3.6.4 Smear as a Function of Scan Angle (Test 10)

3.6.4.1 General

The objective of Test 10 is to: (1) assess smear as a function of scan angle, and (2) correlate on-orbit measured velocity errors with chamber test sync-flash derived errors at four discrete locations in the panoramic format. To accomplish this, photography is acquired at scan angles greater than 35° with known OAAA biases (approximately $\pm .2$ inch/second from the nominal orbital settings). The displacement between double image pairs is compared to the predicted displacement, the difference being the resultant error. Test 3A data is processed identical to and merged with the Test 10 data to obtain data points within $\pm 20^\circ$ of 0° scan, hence yielding velocity error information across the entire format. The Aft Camera in-track data prior to Op 132 is adjusted to reflect the -2 command step change implemented to OAAA effective in that operation. A total of 12 operations were performed for Tests 3A and 10.

In the plots of velocity error as a function of scan angle, each data point results from the average of three repeated measurements of the same object in the in-track and cross-track directions, see Figure 3-23. For the Forward Camera, approximately 240 objects were measured from 11 operations, while the Aft Camera data was obtained from 10 operations and consists of approximately 290 objects. Also plotted in this figure is the ground test predicted on-orbit velocity error on-axis at each of the four collimator locations. These data points are the algebraic sum of the most current Chamber A and Chamber A-2 sync-flash indicated velocity error, gravity induced image motion, reticle rotation, and OAAA adjustments prior to launch. These data points represent the predicted on-orbit performance and are directly comparable to the on-orbit smear slit derived values. A positive value is indicative of film which is moving too fast, or at too large a skew angle.

VELOCITY ERROR AS A FUNCTION OF SCAN ANGLE FROM TEST 10



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FIGURE 3-23

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The data plotted in Figure 3-23 was segmented in scan increments of 20° (excluding scan angles greater than 50°) and the mean and two sigma values were computed for each data set, see Table 3-14. Additionally, for each camera, a comparison was made of expected versus actual on-orbit variability. The anticipated values for on-orbit variability were obtained by combining the ground test measured data with the anticipated on-orbit errors due to random and fixed unknown error sources. The budgeted values for five first order error contributors to on-orbit smear (vehicle yaw, roll, pitch, yaw rate, and Vx/h command), which account for 80% of the on-orbit (external to the sensor) error, were used, see Table 3-15.

TABLE 3-14

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 -30	Mean	.010	-.02	.038	.022
	2 σ	.046	.08	.050	.052
-30 to -10	Mean	.007	-.02	.016	.004
	2 σ	.044	.08	.052	.086
-10 to +10	Mean	.009	-.01	-.001	.009
	2 σ	.046	.06	.076	.078
+10 to +30	Mean	.025	-.02	.022	.007
	2 σ	.034	.06	.076	.074
+30 to +50	Mean	.016	.03	-.022	.017
	2 σ	.048	.06	.058	.084
Overall	Mean	.013	-.02	.007	.012
Average	2 σ	.044	.06	.062	.074

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TABLE 3-15

COMPARISON OF OVERALL SMEAR VARIABILITY TWO SIGMA

(inch/second)

<u>Camera</u>	<u>Direction</u>	<u>Ground Test</u>	<u>Anticipated On-Orbit</u>	<u>Measured On-Orbit</u>	<u>Budgeted Values</u>
Forward	In-Track	.022	.030	.044	.044
	Cross-Track	.045	.047	.060	.071
Aft	In-Track	.028	.035	.062	.047
	Cross-Track	.035	.038	.074	.071

NOTE: The following are the definitions of these values:

- (1) Ground Test = Most current chamber measured values.
- (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).

3.6.4.2 Forward Camera In-Track Direction Error

The Forward Camera data in the in-track direction is the least variable of the four data sets ($2\sigma = .044$ inch/second), as is the ground test data ($2\sigma = .022$ inch/second). The data indicates a mean error of approximately $+.013$ inch/second (skew too large). This is consistent with the Test 3A results based on linear regression analysis. There are no indications of any ramps from the on-orbit data, see Figure 3-23 and Table 3-14. The 37° and 45° collimators do not agree with the orbital indications.

3.6.4.3 Forward Camera Cross-Track Direction Error

The cross-track direction is noticeably more variable than the in-track and hence more difficult to assess mean level changes in velocity error. This increased variance is also supported by the chamber data. In general, the mean level appears to be biased in the negative direction by approximately $.02$ inch/second. Linear regression analysis of Test 3A data yields the same offset. The change in mean level error as a function of scan is constant, as is the two sigma variance of $.06$ inch/second. The slight increase in the mean error at $+40^\circ$ of scan ($-.03$ inch/second) agrees with the adjusted 37° Collimator indication of $-.04$ inch/second.

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12073.6.4.4 Aft Camera In-Track Direction Error

The Aft Camera in the in-track direction is more variable than the Forward Camera. Both the chamber and orbital data indicate a positive ramp. No data was measurable on the Aft Camera past 45° of scan; however, at approximately -40°, both the orbital and chamber data indicate a mean error of approximately .04 inch/second. At positive scan angles, the chamber data indicates essentially zero error, while the orbital data out to 50° of scan would indicate a ramp of lesser magnitude than on the negative side of scan (i.e., a dogleg).

On Mission 1206, a ramp existed on the Aft Camera in-track direction at positive scan angles; no data existed at negative scan angles. The data correlation was again evident on this 1206 data. The 45° Collimator did not evidence good correlation with the orbital data.

3.6.4.5 Aft Camera Cross-Track Direction Error

The cross-track two sigma is approximately $\pm .074$ inch/second, and the mean indicates no apparent ramps or doglegs. In general, the overall mean smear level from orbital data is .012 inch/second. The 37° Collimator differs considerably in both magnitude and sign ($-.03$ inch/second) from the orbital indicated mean error at that scan angle (.02 inch/second)

3.6.4.6 Conclusions

The following conclusions were drawn:

A. With the exception of the Aft Camera in-track direction, there appears to be no variation of mean smear with scan angle, although there are small DC errors. The Aft Camera in-track direction exhibits a clear ramp (or slight dogleg) that increases with distance into scan, see Figure 3-23. This phenomenon was also present on Mission 1206.

B. The anticipated on-orbit variability was less than that measured in all cases. The Forward Camera, measured two sigma in both directions, was only .01 inch/second greater than would be predicted by taking the root sum square of the chamber ground test data with the on-orbit budgeted values for the random plus fixed unknown errors, see Table 3-16. The Aft Camera in both directions was greater, .03 inch/second, see Figure 3-23.

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TABLE 3-16

GROUND TEST SMEAR VARIABILITY TWO SIGMA

(inch/second)

Camera	Direction	Collimator (degrees)			Average
		0	55	37	
Forward	In-Track	.026	.018	.020	.022
	Cross-Track	.044	.042	.053	.045
Aft	In-Track	.036	.019	.023	.028
	Cross-Track	.034	.030	.044	.035

C. Except for the Aft Camera in-track direction, the on-orbit measured variability was less than the original SV design budget values for fixed unknown plus random errors. The Aft Camera in-track was .015 inch/second in excess of the budget.

D. A comparison of the on-orbit versus laboratory collimator indicated mean errors is made in Table 3-17. The conclusions are as follows:

(1) The 0° Collimator exhibits excellent correlation, as would be expected since the sensor is essentially tuned for zero smear at 0° scan.

(2) The 45° Collimator exhibits good correlation in the cross-track, but not in the in-track on either camera.

(3) The Aft Camera 37° Collimator in the cross-track direction leads to a totally different conclusion than the orbital results; i.e., a significant dogleg as opposed to no mean change with scan.

TABLE 3-17

COMPARISON OF ON-ORBIT MEAN SMEAR TO
CHAMBER COLLIMATOR INDICATED VALUES

(inch/second)

Camera	Direction	Collimator (degrees)			
		45	0	37	55
Forward	In-Track	Coll/On-Orbit +.033/+.010	Coll/On-Orbit +.006/+.009	Coll/On-Orbit +.043/+.016	Coll/On-Orbit +.006/+.006
	Cross-Track	-.016/-.02	+.003/-.01	-.025/-.03	.000/-.03
Aft	In-Track	+.006/-.022	-.001/-.001	+.019/+.038	+.058/*
	Cross-Track	-.003/+.017	+.004/+.009	-.032/+.022	+.018/*

NOTES: 1. Positive value in all cases indicates film too fast or skew angle too large.

2. The asterisk (*) denotes that no data is available.

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12073.6.4.7 Recommendation

On Missions 1206 and 1207, the initial conclusions as to proper on-orbit OAAA settings were tempered with the chamber ground test indicated values of mean smear at the collimator scan positions. Additional data on Mission 1208 will be analyzed to establish a level of confidence as to which is the best Test 3A data to be used in setting the OAAA.

3.6.5 Op 145 Smear Variability

Variability of the image quality was noted on 1207-2. A 60° scan at -15° center consisting of 113 frames from Op 145 was acquired in clear weather and utilized for both quantitative and qualitative smear evaluation. The smear slit imagery indicated a variability on both the Forward and Aft Cameras. The smear appeared to occur randomly in the in-track, cross-track and at times in both directions simultaneously. The typical duration of a disturbance was approximately 1" from the point where the imagery was first observed to appear doubled to the point where doubling disappeared.

An investigation of the smear slit imagery examined sources external to and internal to the Sensor Subsystem. A study was performed to see if there was any correlation to the vehicle thruster firings. The test was run as follows:

For Op 145, a Calcomp plot was obtained of the shutter open/close measurements on the Forward and Aft Cameras and the eight vehicle thruster telemetry measurements. From this information, it was possible to isolate those frames of photography that contained thruster firings. An attempt was made to correlate vehicle thruster firings with the disturbed imagery by: (1) examining the smear slit imagery of those frames of photography that included thruster firings, and (2) examining frames of photography that occurred at least several frames later from the last thruster firing. No disturbed imagery could be observed at the time of or slightly after the thruster firings. In the majority of cases, this was due to lack of culture in the smear slits. The converse was also true. The best example was Frame 034 on the Forward Camera, which evidenced obvious image doubling at -12° of scan in both the in-track and cross-track directions. The nearest previous thruster firing occurred between Frames 026 and 027, approximately 16 seconds earlier.

Error sources internal to the Sensor Subsystem capable of causing the characteristics smear noted were investigated. Measurements were made on a limited number of smear slit images from Op 145

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where image doubling was observed. The peak image displacements observed were generally equivalent to a velocity error of approximately .08 inch/second cross-track, and slightly less (approximately .05 inch/second) in-track. In general, the peak magnitudes observed on Op 145 are to be expected in light of the Test 10 data, and is probably typical of the majority of operations in this mission. The most probable origin, based on the occurrences, characteristic, and magnitudes is the algebraic sum on a random basis of known small errors in the system.

3.6.6 Line/Lens MTF

As with the previous three missions, Engineering Test No. 6 was run to determine on-orbit optical bar MTFs from deployed mobile CORN Line Targets. The objective was to compare the operationally-derived MTFs with preflight chamber-derived MTFs, both techniques using line impulse analysis. From this analysis, it is hoped to find whether or not the optical bar's operational performance is degraded.

Analysis of previous missions did not fully resolve this question due to uncertainties in microdensitometric procedures and data processing. In-track and cross-track line targets were again deployed and recorded across the web during this mission. Lines were acquired in stereo mode on Op 198, Frames 010 thru 012, at nominal platen and OAAA settings. However, the exposure times which were 1.9 milliseconds for the Forward and 1.3 milliseconds for the Aft induced some image smear. This is undesirable when attempting to isolate system modulation response, and represents an out-of-specification condition for the test.

Additional lines were acquired on Op 253, Frames 010 thru 012, at .5 milliseconds exposure time; unfortunately, these lines were not useful due to a billowing and twisting of the targets caused by high winds. Since a valid analysis could not be drawn from this data, this investigation was terminated. It is planned that this test will be conducted during Mission 1208.

3.7 EXPOSURE ANALYSIS3.7.1 Summary

Microdensitometric analysis performed on the Mission 1207 black and white imagery indicated a slight overexposure (.05 log E) relative to the present criterion of 1.0 mean scene density. However, the acquisitions were subjectively rated Good. Since the point of peak subjective quality appears to coincide with a density of between 1.0 and 1.2, as does the point of peak black and white film resolution, it is recommended that the black and white mean density aim be raised to 1.1.

Exposure differences between the Forward and Aft Cameras were corrected with a two count exposure bias (-.06 log E) which was applied to the Aft Camera during Op 138.

Both Color Films, SO-255 and FE-3916 IR, were considered to be correctly exposed by subjective and limited microdensitometer analysis. No change in exposure criteria is recommended.

Use of the new three-step snow biasing technique showed a significant increase in the number of

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correctly biased snow-surround frames over what would have resulted with the former single-step (4" or more) criterion. The average snow scene was .05 log E closer to the mean density of optimum exposure (presently considered 1.0) than would have been attained using the old bias. Slight underexposure of three frames (11%) did occur from errors associated with the snow bias, two were traceable to command errors and one was a criterion failure.

Analysis of sand-surround frames indicated that the present desert polygon bias is sufficient when applied. It may be necessary to modify the format criteria that governs its use, since too many frames fail to meet the criteria and yet in fact require the bias.

Data from Mission 1207 vegetation-surround acquisitions was added to that of previous 1200 Series missions to study scene log E range as a function of scene location, camera, and time of year. Consistent with prior analyses, the data indicates that domestic scenes have larger scene log E ranges than denied area scenes and that the Forward unit generally is larger than the Aft. Scene range was found to decrease sharply in the summer and maximize in the fall. Mission 1207 had the largest log E range observed so far.

The effective contrast to the system of the CORN tribar resolution targets was estimated by backing out the micro edge effects of the five-step gray scales and determining their relative log exposure via microsensitometry.

Scene data from this and other previous missions is presently being analyzed to determine the solar altitude range for which vertical surface irradiances are more appropriate than horizontal irradiances for generating HEXAGON exposure recommendations.

3.7.2 Exposure Recommendation

3.7.2.1 Basic KSCOPE Exposure Recommendation

A. Black and White

The basic exposure time versus solar altitude recommendation for each camera was computed for 1414 with the appropriate filters, using the radiometric acquisition model KALEIDOSCOPE, see Figure 3-24. These basic recommendation curves were based on the criterion of acquiring a typical urban/industrial area with vegetation-surround such that the scene mean exposure is placed at 1.0 density.

Based on the exposure analysis of RV-1, the Aft exposure recommendation was decreased by two counts (-.06 log E). This new recommendation was instituted on Op 138. It is shown as a dashed line in Figure 3-24.

B. Color

The basic exposure recommendation for SO-255 and FE-3916 was generated by KSCOPE and is plotted in Figure 3-25. The two count exposure change (-.06 log E) implemented on Op 138 is shown by the dashed curve. The recommendation for both films was based on the aim of exposing urban areas on

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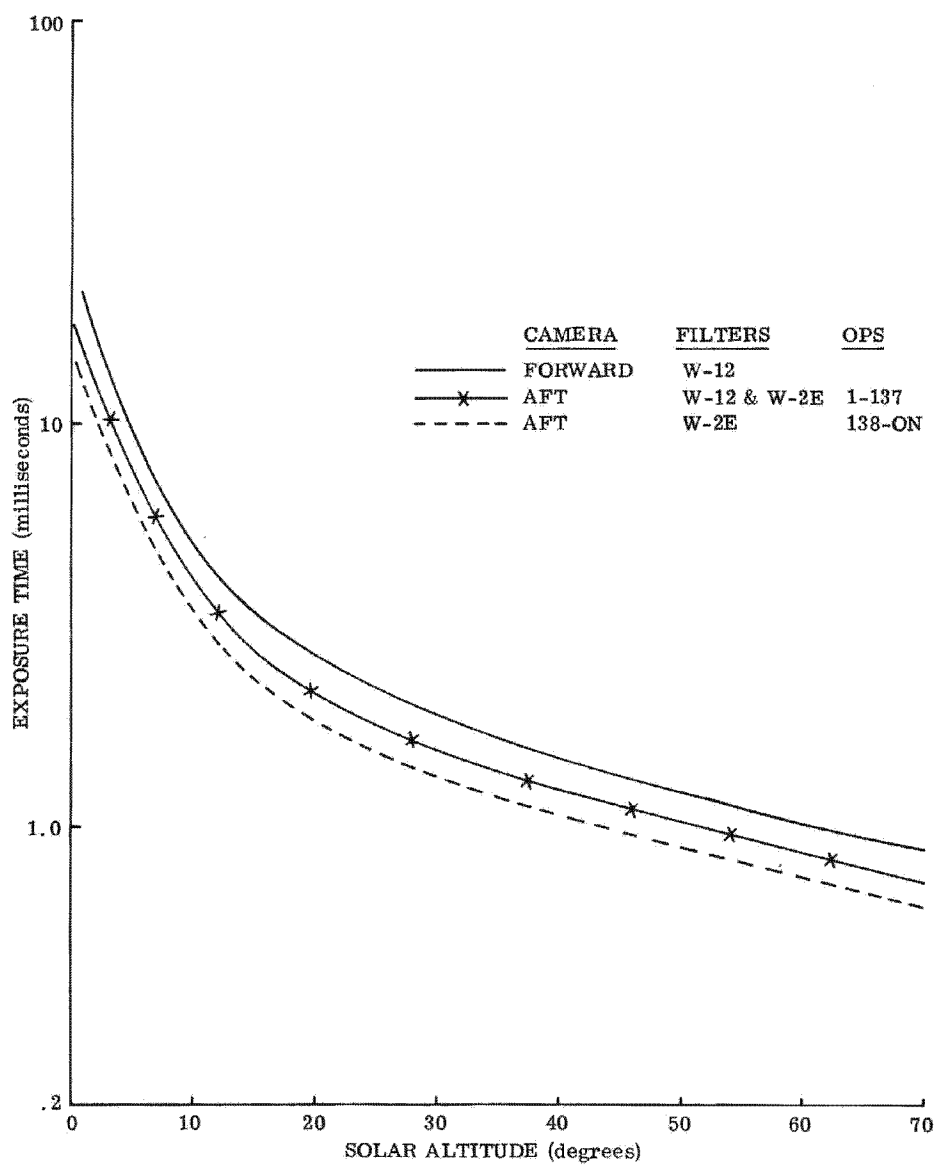
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EXPOSURE RECOMMENDATION FOR 1414 FILM



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FIGURE 3-24

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EXPOSURE RECOMMENDATION FOR SO-255 AND FE-3916 FILMS

(Aft Camera, Filter W-2E)

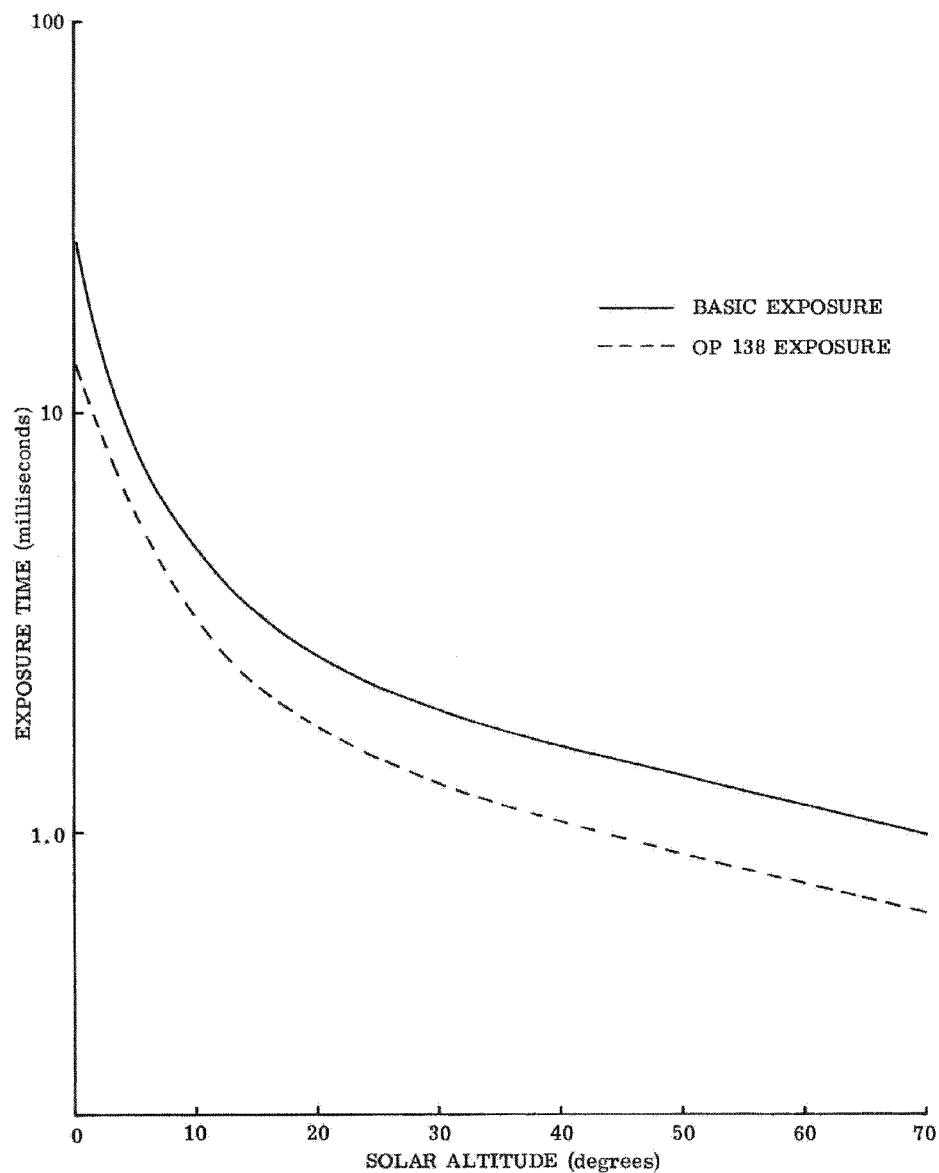


FIGURE 3-25

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their respective green sensitive layers at a 1.5 density.

3.7.2.2 Special Exposure Biases

A. Snow

A new three-level snow bias was introduced that increased with increased reported snow depth within the planned acquisition area. The bias (exposure decrease) for each reported snow depth is presented in Table 3-18.

TABLE 3-18

NEW EXPOSURE BIAS FOR SNOW COVERAGE AREAS

<u>Snow Depth (inches)</u>	<u>Normal Exposure Bias</u>
Less than 1	0
1 - 4	-.13 log E
4 - 10	-.26 log E
More than 10	-.36 log E

B. 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 U.S.

3.7.3 General Description of Analysis

3.7.3.1 Microdensitometry

All frames selected for basic exposure analysis were raster scanned with a 15.3 micron aperture on the GAF-650 Microdensitometer. A minimum of 1,500 contiguous points were collected from each sample, digitized, and processed in the computer. Calibration of the microdensitometer was achieved with the macro characteristics curve exposed on the 1B Sensitometer and processed with the mission. Program "HISTO" was used to statistically analyze the scan data in terms of parameters meaningful for exposure analyses, i.e., mean density, cumulative frequency plots, etc. Microdensitometry done in support of a CORN target contrast analysis was performed on the Mann-Data Microdensitometer employing a 2 micron aperture.

3.7.3.2 Frame Selection

For all but special analyses, the imagery was selected for microdensitometry by two criteria: (1) areas to be scanned must be cultured (urban/industrial areas, military bases, etc.), and (2) there must be no obvious cloud obscuration.

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The choice of frames for exposure analysis was usually made by the Exposure Evaluation Team. Some selection of frames was also initiated by the PFA Team when noting an apparent exposure anomaly requiring investigation. A total of 69 acquisitions were examined. These were broken down by camera, film type, and terrain type as shown in Table 3-19.

TABLE 3-19

1207 ACQUISITION EVALUATION BREAKDOWN

<u>Film</u>	<u>Camera</u>	<u>Vegetation - Surround</u>	<u>Snow - Surround</u>	<u>Sand - Surround</u>
1414	Forward	18	21	9
	Aft	7	7	2
SO-255	Forward	0	0	0
	Aft	2	2	1
FE-3916	Forward	0	0	0
	Aft	2	0	0

3.7.3.3 Log E Analysis

The exposure for each acquisition was rated on its log E deviation ("Total Delta log E") from the aim criterion of mean urban/industrial scene density of 1.0 (1414), or 1.5 (SO-255/FE-3916). This deviation can be attributed to two factors. The first is deviation from recommended exposure time, 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 negative signifies an algorithm creating underexposure.

3.7.4 General Exposure Analysis of Black and White Record3.7.4.1 Mission Density Profiles

Figures 3-26 thru 3-28 contain the density profiles of all urban areas scanned. Each profile gives the maximum, mean, and minimum densities of a microdensitometer scanned urban area, whose op and frame numbers appear adjacent to the profile. The maximum and minimum densities are defined as those points in the scene density distribution at which 95% of the points are lower than the maximum 95 percentile and 5% of the points are lower than the minimum 5 percentile.

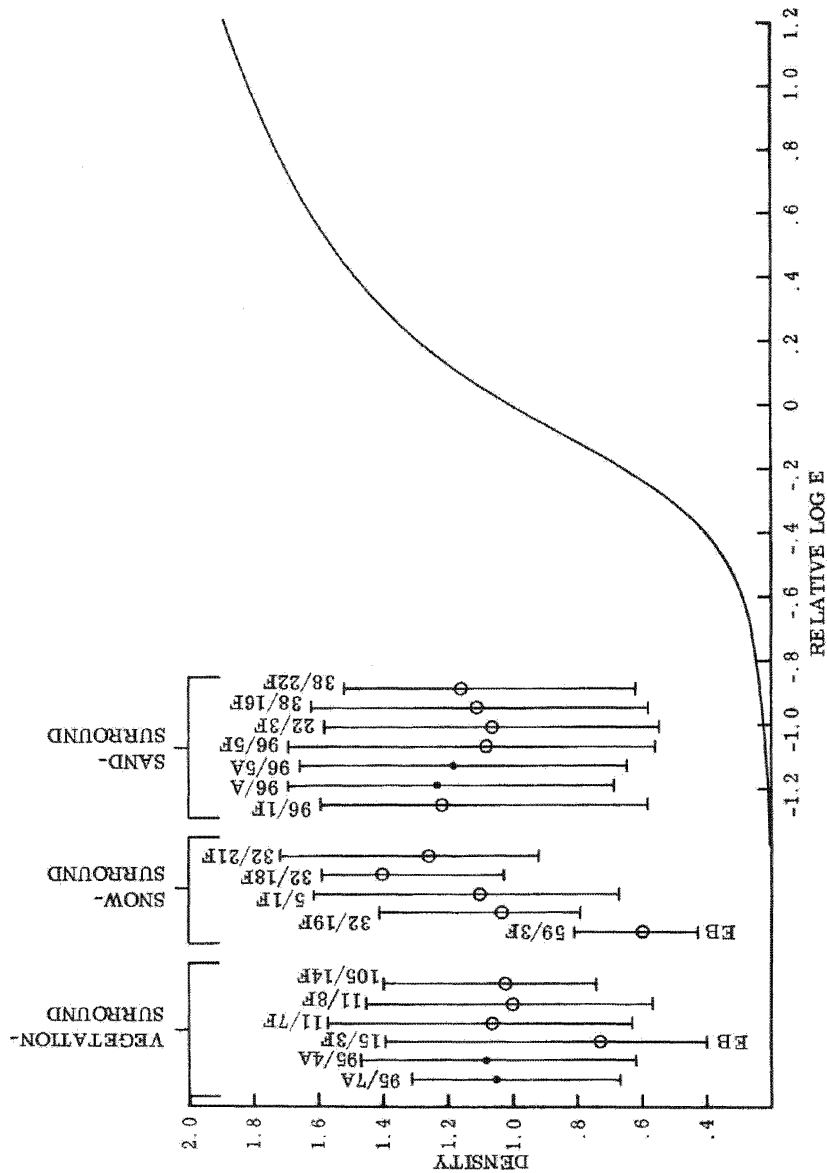
The density profiles, besides giving scene density data, give information on the type of

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1207-1 DENSITY PROFILE
(1414 Film)



NOTE: EB means that erroneous bias was applied.

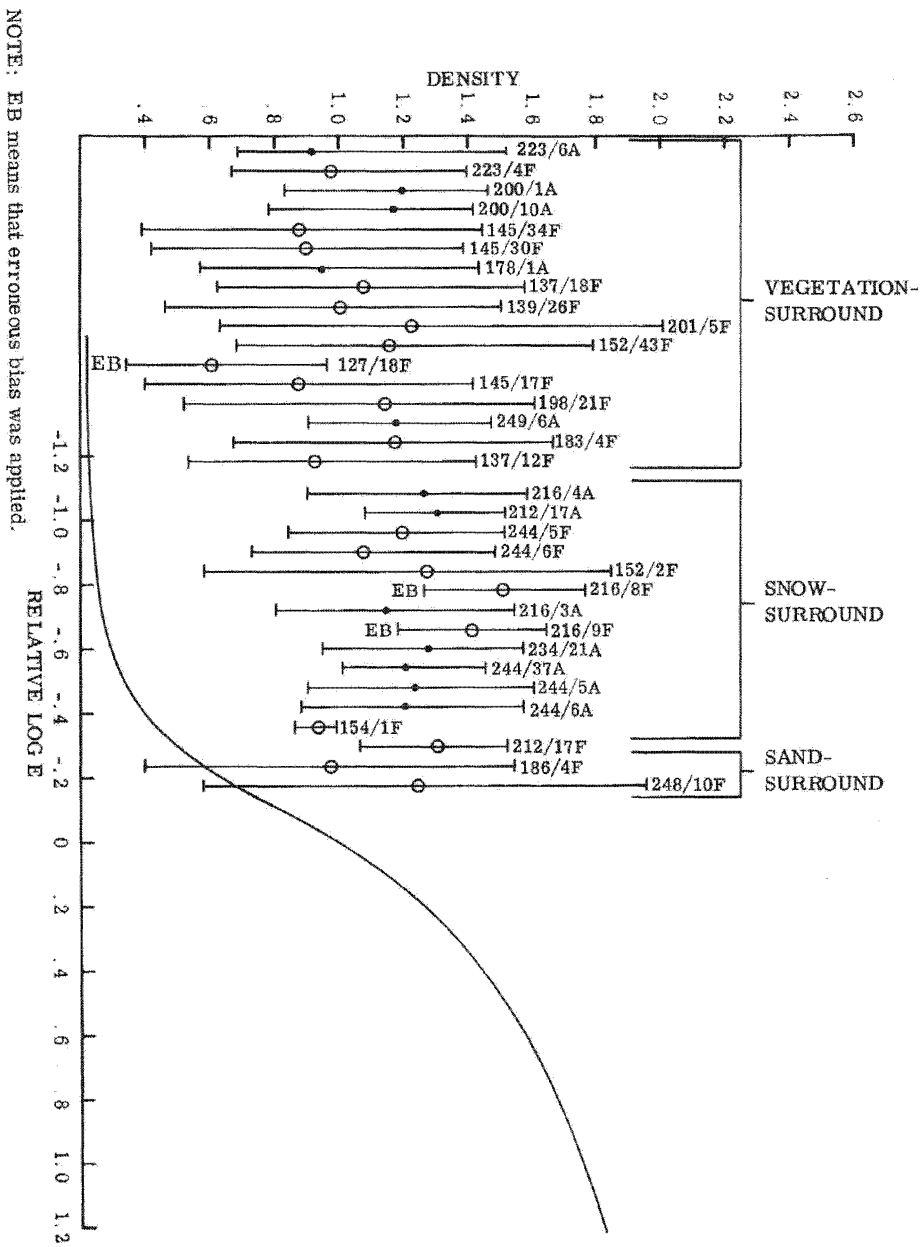
FIGURE 3-26

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1207-2 DENSITY PROFILE
(1414 Film)



NOTE: EB means that erroneous bias was applied.

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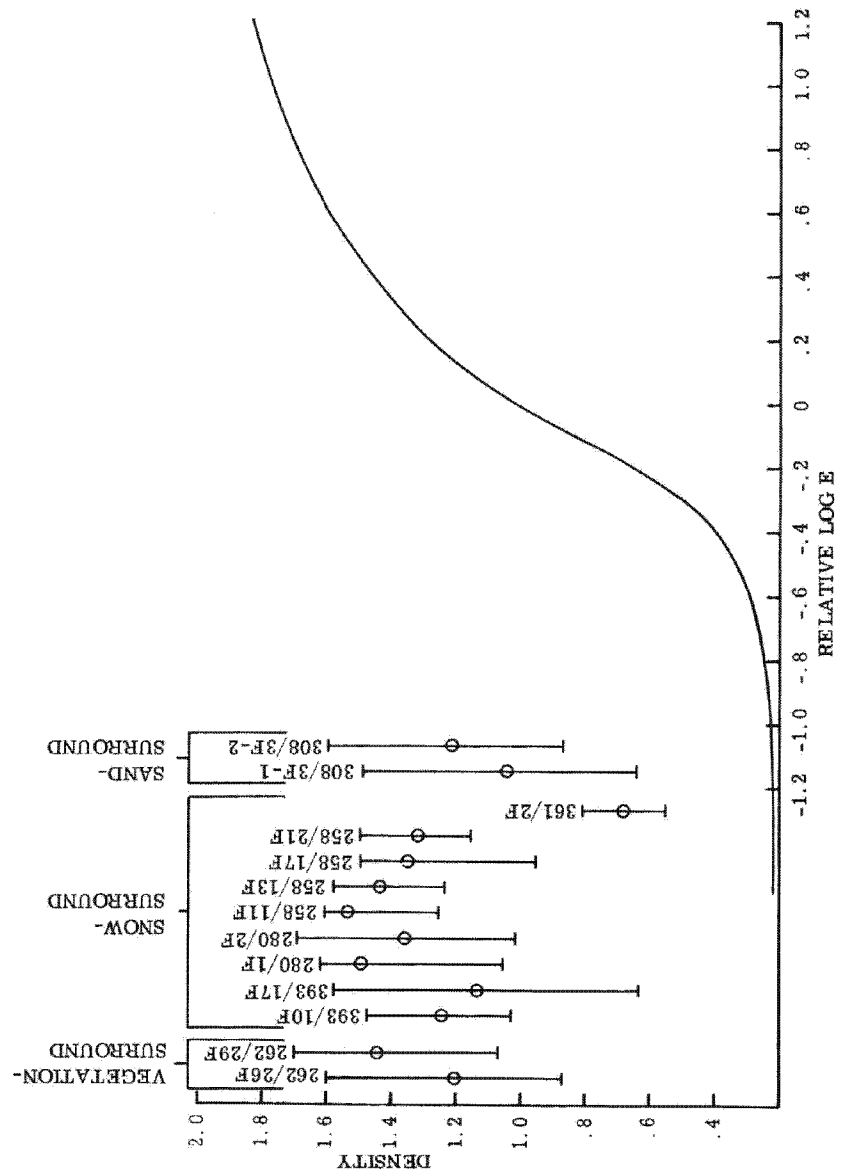
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1207-3 DENSITY PROFILE
(1414 Film)



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FIGURE 3-28

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terrain adjacent to or contained within the scanned areas. Notes, appearing on each profile, indicate when an acquisition was given an incorrect exposure bias. A process curve, typical of that mission part, appears on each profile as an aid in determining the relative exposures of the individual acquisitions.

3.7.4.2 Evaluation of Basic Recommendation

The evaluation of the basic recommendation was made from the analyzed raster scan data of 23 of the 25 vegetation-surround acquisitions. The remaining two were given erroneous snow biases and were underexposed. Table 3-20 gives the measured mean exposure statistics of the 23 acquisitions. For convenience of analysis the "camera" and "algorithm" errors have been calculated relative to the initial recommendation of 1207. Both of these errors have been plotted for the average maximum, mean, and minimum statistics on Figures 3-29 and 3-30.

TABLE 3-20

URBAN SCENE MEAN EXPOSURE ERRORS FOR 1414 FILM

Type Surround	Camera	Number	Total	Δ Log E Error	
				Camera	Algorithm
Vegetation	Forward	16*	.05	.01	.04
	Aft (Op 1-137)	3	.01	-.04	.05
	Aft (Op 138 on)	4	.08	-.04	.12
	Forward	20	.17	-.19	.36
Snow	Aft (All after Op 137)	7	.17	-.21	.38
	Forward	9	.12	-.11	.23
Sand	Aft	2	.13	-.07	.20

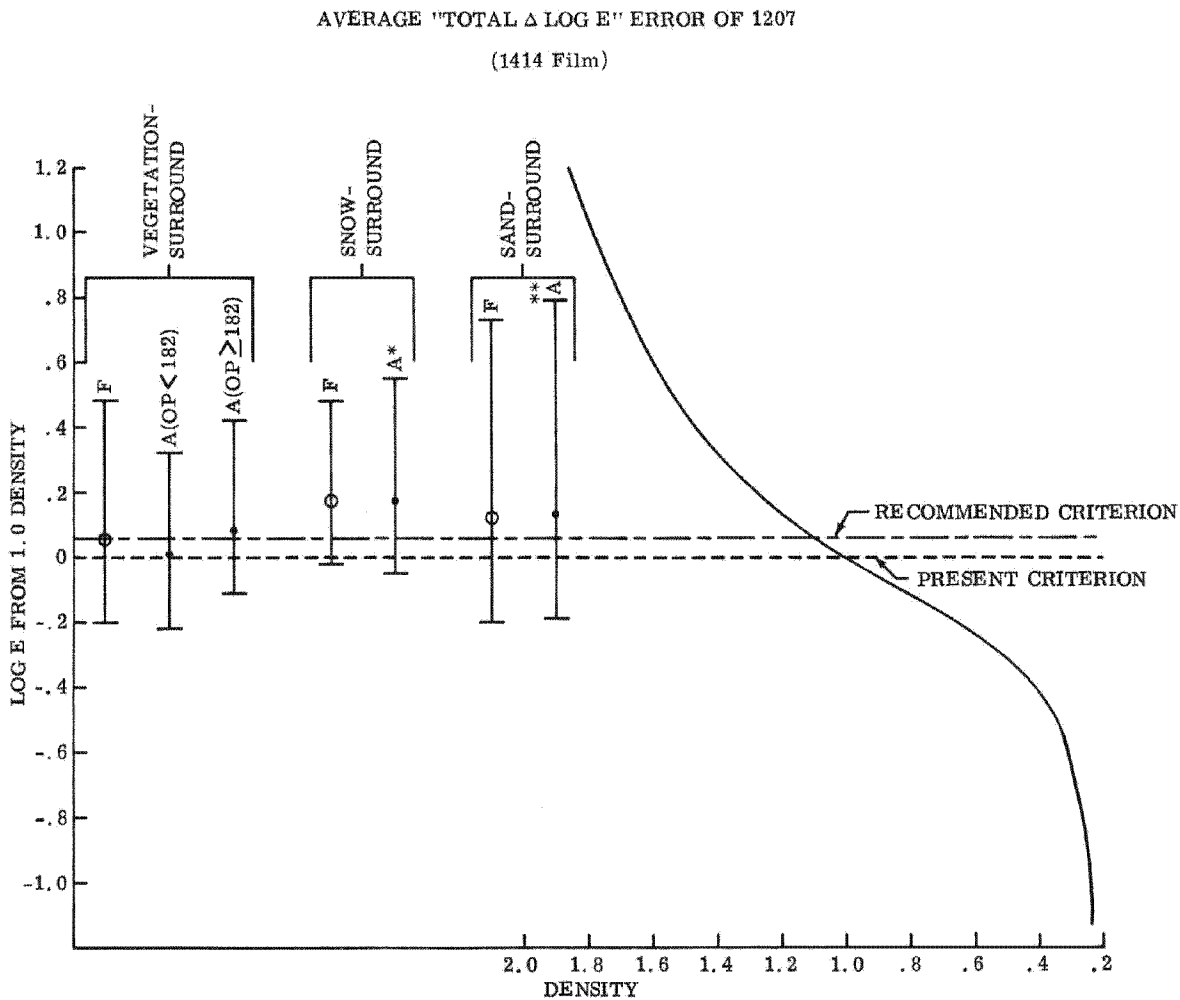
NOTE: The asterisk (*) means that this value does not include the two frames with erroneous snow bias.

The vegetation-surround imagery was judged to be well exposed. The average "Total Log E" for both units over the entire mission was .05 log E which reflects an overexposure compared to the aim criterion. The .05 log E corresponds to approximately 1.08 density. Since this amount of overexposure has been found on many missions for which the overall subjective imagery rating was Good, an increase of the exposure criterion to a mean density of 1.10 is being recommended for subsequent missions. Note how well the Mission 1207 vegetation-surround acquisitions were exposed relative to the recommended criterion by comparing their exposure statistics to the dotted line labeled "recommended criterion" in

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NOTES: 1. The asterisk (*) denotes that all acquisitions examined were after Op 182.
2. The double asterisk (**) denotes that all acquisitions examined were before Op 182.

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FIGURE 3-29

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AVERAGE "ALGORITHM Δ LOG E" ERROR OF 1207 URBAN AREA ACQUISITIONS
(1414 Film)

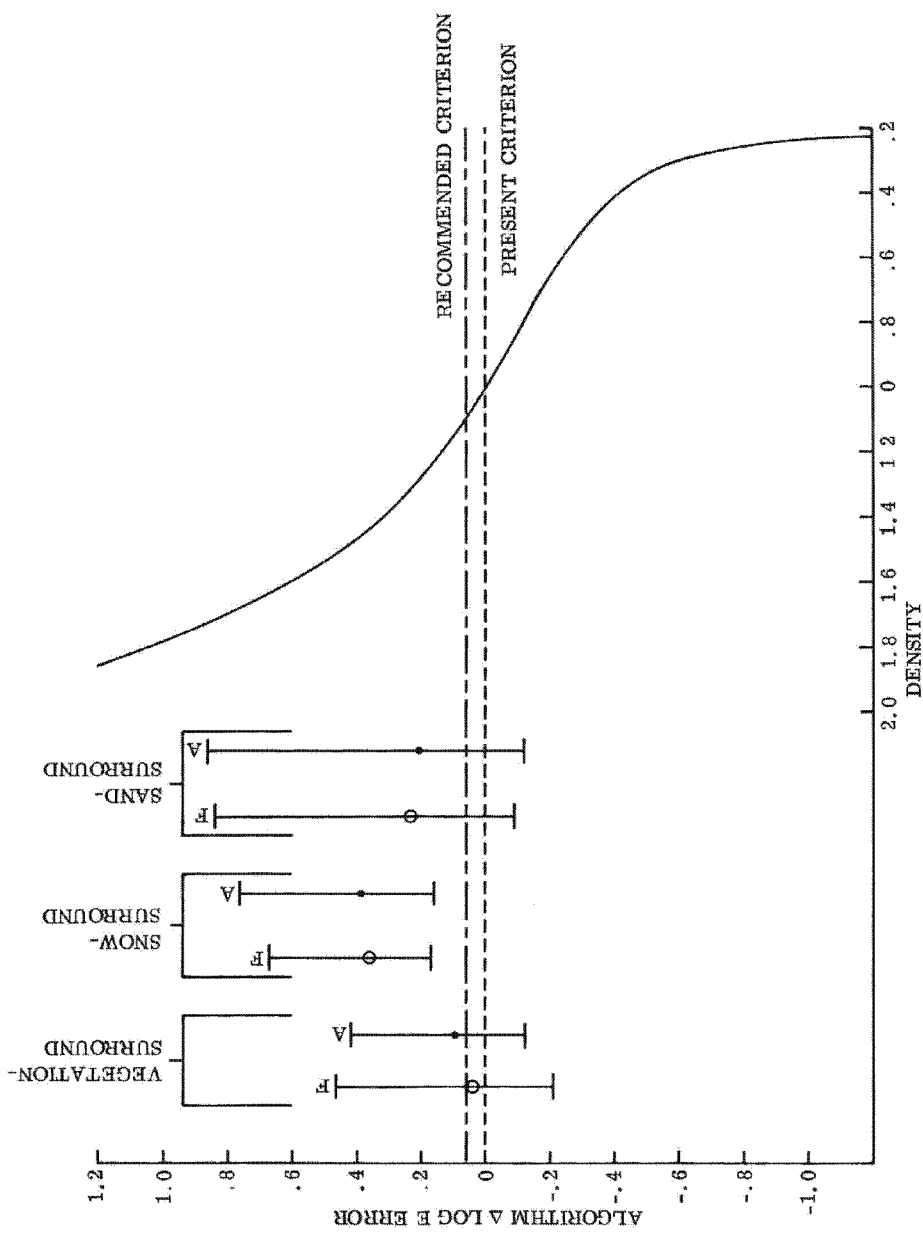


FIGURE 3-30

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Figures 3-29 and 3-30.

Analysis of the first part of the mission disclosed a larger algorithm error for the Aft Camera than the Forward, although the mean densities for each were similar. It should be noted that these results are based on just a few samples. Since the imbalance between Forward and Aft has been noted on all missions including 1207, and generally causes higher density levels on the Aft, a two count bias ($-.06 \log E$) was recommended and implemented on Op 138. This resulted in nearly equal mean scene densities between Forward and Aft Cameras.

The reason for the imbalance of algorithm error between Forward and Aft units is probably a function of the difference in percentage of sunlit areas seen by the two units. The Aft sees generally front-lighted areas and little shadow compared to the Forward which sees back lit areas with high shadow content. As of this time, the KSCOPE model does not have the ability to differentiate between them for exposure recommendation purposes.

3.7.4.3 Evaluation of Special Snow Exposure Bias

In general, snow-surround acquisitions were judged to be as good or better than on previous missions using other snow biasing techniques. This was also supported by the statistical analysis made on these acquisitions.

The new snow biasing routine relies on close coordination between snow reporting, weather satellite albedo measurements, and the exposure command software. The snow depth to exposure bias relationship used in Mission 1207 was set up to insure that snow-surround acquisitions were biased to a mean density as close as possible to, but not below 1.0. This was done while at the same time insuring that malfunctions of the biasing routine (including bad reporting of data) did not cause underexposure. Ideally, all snow acquisitions would have the same total log E error, regardless of snow depth, when using this bias routine.

A total of 29 snow related urban area acquisitions were examined during the analysis of 1207. The "Total log E" error of each of these acquisitions has been plotted as a function of exposure bias on Figure 3-31. The figure shows each snow bias step as a band which includes the slit granularity (approximately $\pm .06 \log E$). Table 3-21 demonstrates how well the snow biasing routine worked, based on its aim, for each of the four snow prediction/snow occurrence situations.

The first and last cases in Table 3-21 represent correct biasing decisions. For the acquisitions examined, correct decisions were made 76% of the time. Of these samples, 2 were underexposed due to an implemented exposure bias of more than the snow bias limit. These were considered to be underexposed because of an unknown system error and were not considered as a snow bias caused underexposure. Thus, there was only one sample from a correct biasing decision that had underexposure traceable to the bias.

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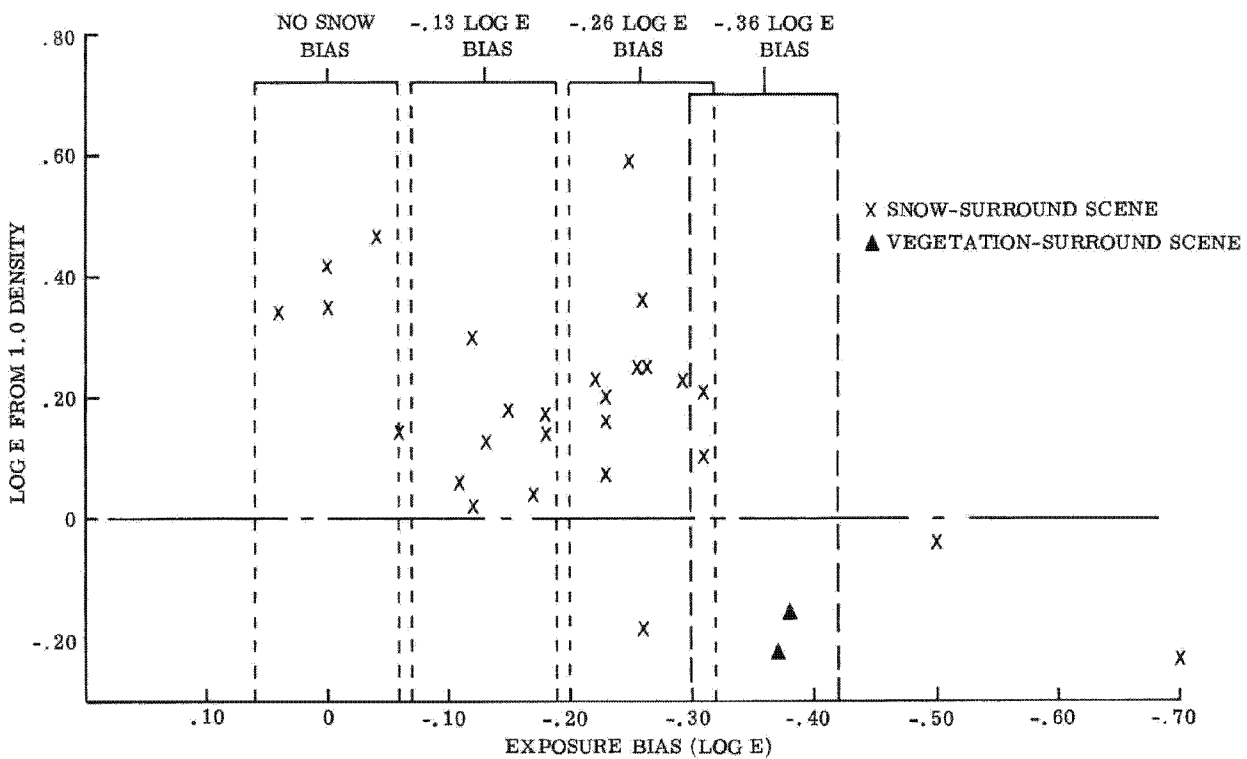
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RELATIVE EXPOSURE OF SNOW RELATED 1207 URBAN AREA ACQUISITIONS



NOTE: The bias categories are based on the criterion presented in Table 3-18.

FIGURE 3-31

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TABLE 3-21

NEW SNOW BIASING ROUTINE ANALYSIS SUMMARY

Type Error	Snow Predicted	Snow Present	Samples	No. Correctly* Exposed	Number Underexposed
-	Yes	Yes	22	19	3*
-	Yes	No	2	0	2
β	No	Yes	5	5	0
-	No	No	-	-	-

NOTE: The asterisk (*) denotes that "No. Correctly Exposed" by the present snow bias criterion means the number of scenes whose mean density is equal to or greater than 1.0.

Of the two sets of incorrect biasing decisions represented, the samples were the only set resulting in underexposure. These acquisitions were vegetation scenes erroneously given a snow bias. The " β error" resulted in no bias being applied to a snow scene when it would undoubtedly have been beneficial. This, however, did not result in underexposure. Thus of the seven acquisitions with incorrect biasing decisions examined, 5 (71%) were correctly exposed according to the snow bias aim criterion.

Although the snow biasing routine is geared to minimize underexposure, complete evaluation of it must also include a look at how close it came to optimum exposure. Table 3-22 shows the average 5% minimum, mean, and 95% maximum "as exposed" log E relative to 1.0 density for the 27 snow-surround samples. This table also presents a hypothesis of what these statistics would have been with the old snow bias routine and with no snow bias. In addition, it shows the predicted two sigma maximum 95% and minus two sigma minimum 5% points to demonstrate the worst conditions likely to be encountered.

TABLE 3-22

COMPARISON OF SNOW BIAS ROUTINES

TOTAL Δ LOG E ERROR

	No Bias	Old Bias (4" or over)	New Bias (incl β error)
2 σ Max 95%	1.15	1.01	.96
Avg 95%	.68	.54	.49
Avg Mean	.37	.23	.18
Avg 5%	.15	.01	-.04
-2 σ Min 95%	-.25	-.39	-.44

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Figure 3-32 superimposes these statistics on a typical mission process curve to demonstrate the improvement of the new 3-step bias. With this biasing routine, not only was the average mean above the 1.0 mean density minimum 95% of the time, but it was closer (.18 log E above) to the optimum 1.0 density than the other criteria. In addition, a statistical analysis of the typical snow scene distribution indicates that the minus two sigma minimum 5% point will be well above base fog (.36 density).

The stepped snow bias does not lend itself to the traditional mean algorithm error analysis. However, the analysis can find mean snow scene "Algorithm Δ log E" statistics in Table 3-20 and Figure 3-30. These sources show that an average bias of -.30 log E (1 stop exposure decrease) is appropriate for correct exposure.

3.7.4.4 Evaluation of Special Sand Exposure Bias

A total of 11 sand-surround acquisitions were evaluated, although not all were given the recommended -.15 log E sand bias. The acquisitions given the bias (6 on the Aft) were generally better exposed than those without it.

The exposure statistics presented in Table 3-20 show an average total Δ log E of .15, indicating a slight overexposure. However, this is indicative of some frames not being given the bias. The average algorithm error of .22 log E indicates the prescribed -.16 log E bias was appropriate where applied. This would leave a projected total error of .07 log E, which would be accounted for by the new recommended exposure criterion of 1.1 density.

3.7.5 General Exposure Analysis of Color Records

3.7.5.1 Mission Density Profiles

Figures 3-33 and 3-34 contain the density profiles of the color acquisitions analyzed on 1207. Figure 3-33 represents the urban scene statistics of three SO-255 frames while Figure 3-34 represents two acquisitions on the Color IR Film, FE-3916.

3.7.5.2 Evaluation of Basic Recommendation

Both the exposures of SO-255 and FE-3916 were judged to be good although little micro-densitometry data is available. Table 3-23 gives the measured mean scene data upon which the exposure recommendation evaluation is based. Note that the total errors of each film (Δ log E relative to 1.5 density) were as a result of differing recommendations. The SO-255 was exposed according to the initial recommendation, while the FE-3916 was exposed according to the two count bias.

The measured .08 "Total Δ log E" error for the SO-255 indicates that slight underexposure for the color is not harmful. The -.07 log E algorithm error is based on only two samples, but this does not seem to warrant adding two more counts of underexposure to the SO-255 as was done with the 1414. The same conclusion is made with respect to the FE-3916 material based on virtually identical exposure values.

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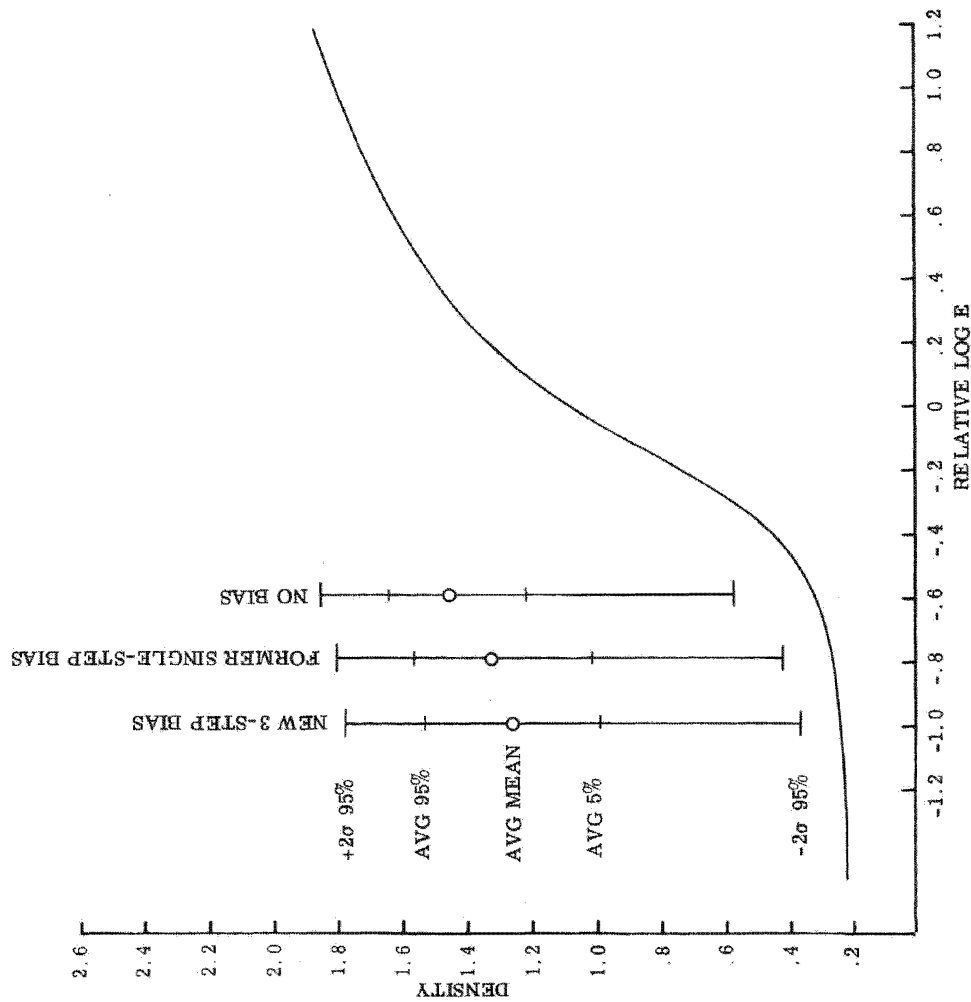
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COMPARISON OF SNOW BIASING TECHNIQUES USING SNOW SCENE

DENSITY DATA FROM MISSION 1207



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FIGURE 3-32

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1207-1 DENSITY PROFILE
(SO-255 Film)

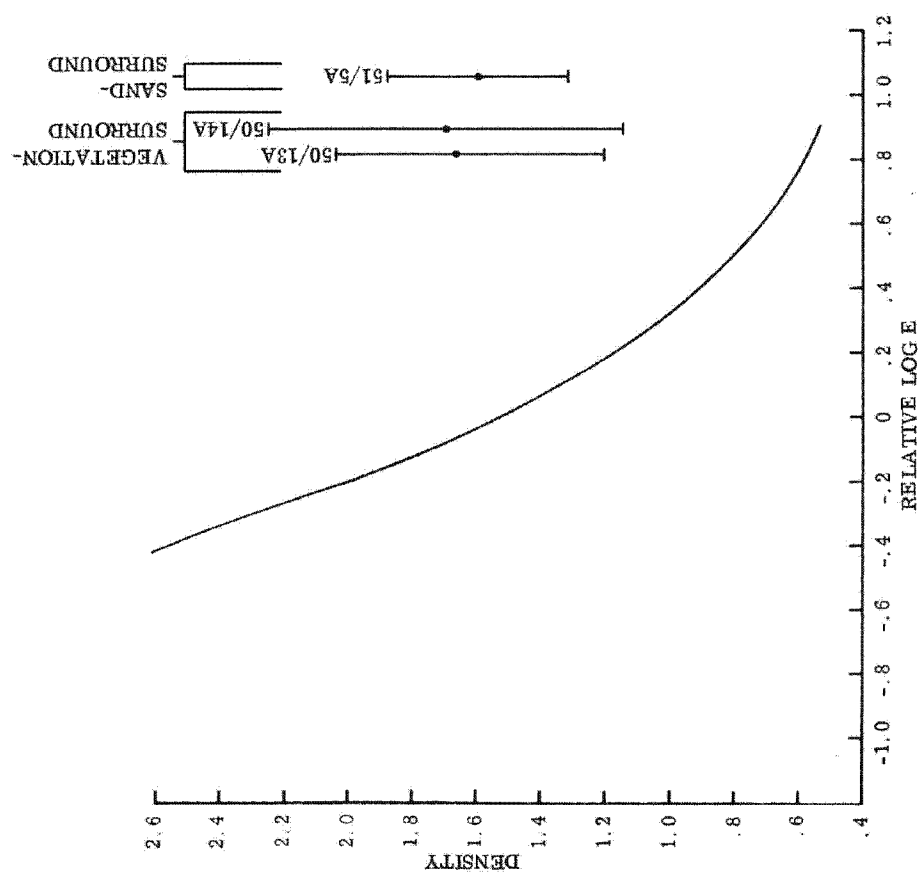


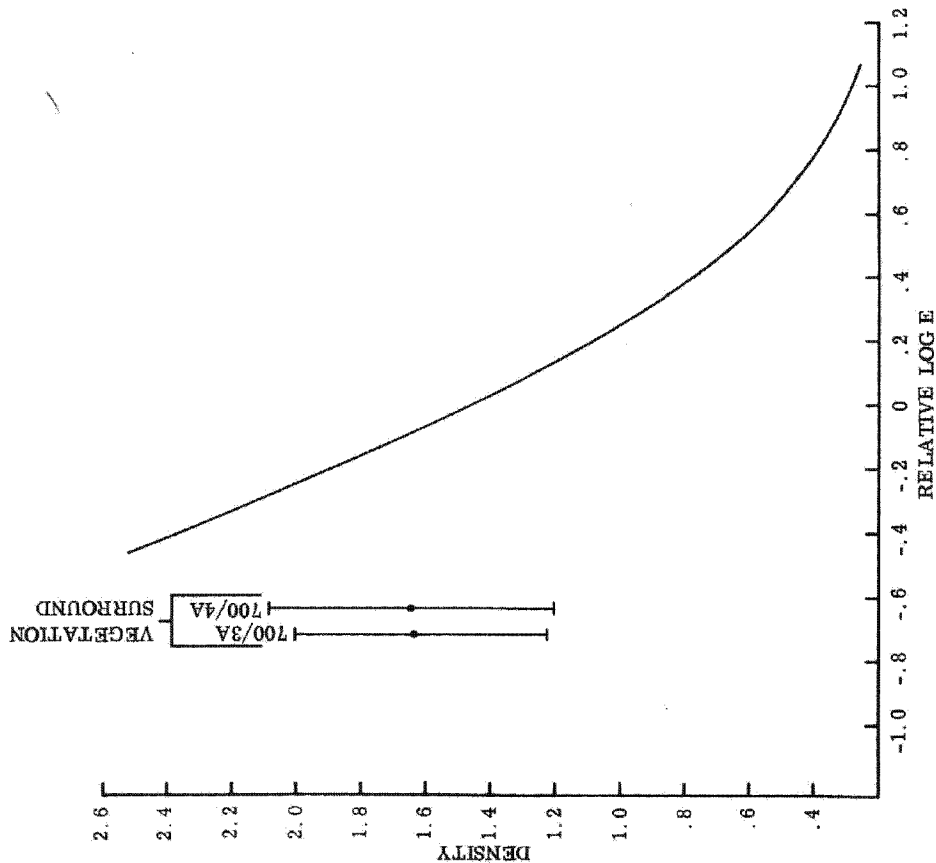
FIGURE 3-33

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1207-4 DENSITY PROFILE
(FE-3916 Film)



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FIGURE 3-34

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TABLE 3-23

URBAN SCENE MEAN EXPOSURE ERROR FOR
SO-255 AND FE-3916 FILMS

Type Surround	Film	Camera	No.	Log E Error		Algorithm
				Total	Camera	
Vegetation	SO-255	Aft	2	-.08	-.01	-.07
	FE-3916	Aft	2	-.07	-.01	-.06
Sand	SO-255	Aft	1	-.03	-.05	-.02

3.7.5.3 Evaluation of Sand Bias

Only one desert polygon acquisition of SO-255 was examined. This is not sufficient data to base the adequacy of the bias for SO-255 Film. The urban area traced was within the CONUS polygon, but no sand bias had been made because the entire frame format was not within the polygon. The exposure was good despite the absence of the bias, mainly because the actual exposure time was on the low side of the slit granularity (-.05 log E camera error). However, the difference in algorithm error between the vegetation and sand acquisitions is evidence of the sand effect. In this instance, the frame would have been adversely affected by an additional sand bias.

3.7.6 Special Analyses3.7.6.1 CORN Target Contrast Analysis

The CORN target contrast analysis was undertaken to establish the film plane contrast of the CORN display tribars. In the HEXAGON System, the tribar images are too small to scan accurately, so the contrast of the tribars (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 using the Mann-Data Microdensitometer. The recorded microdensities were plotted versus their nominal reflectance. Microdensities for background and bar nominal reflectances of tribars were then determined by interpolation. These microdensities were then converted to macrodensities using an empirically derived relationship, and then to relative exposure values from which the contrast was calculated.

Table 3-24 gives the estimated macro contrasts of each Mission 1207 tribar measured. All contrasts measured were high and indicative of clear atmospheric conditions.

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TABLE 3-24

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

<u>Mission Segment</u>	<u>Camera</u>	<u>Op</u>	<u>Frame</u>	<u>Measured Contrast</u>
1207-1	Forward	22	003	3.80
1207-1	Aft	22	004	3.02
1207-1	Forward	69	003	*
1207-2	Forward	186	004	4.37
1207-2	Aft	186	004	3.55
1207-3	Forward	529	002	4.90
1207-3	Aft	529	003	3.60

NOTE: The asterisk (*) denotes that the contrast on this frame was well above the ground contrast of the tribars.

3.7.6.2 Urban Scene Log Exposure Range Comparison

During 1205, the log E range of vegetation-surround urban scenes were examined as a possible correlate with subjective appraisals of 1200 Series imagery and the time of year. The 1207 scene data was added to previous 1200 Series mission data in an effort to more clearly describe seasonal scene range relationships.

The scene range data has been broken down into categories of mission, camera, and scene location (domestic or denied). The data is tabulated in Table 3-25 and has been graphed as a function of the month of the year in Figure 3-35.

TABLE 3-25

MEASURED URBAN SCENE LOG E RANGES

<u>Mission</u>	<u>Month</u>	<u>Camera (Filter)</u>	<u>Domestic Areas</u>		<u>Denied Areas</u>	
			<u>Number</u>	<u>Log E</u>	<u>Number</u>	<u>Log E</u>
1201	June	Fwd (W-2E)	21	.45	11	.39
		Aft (W-12)	13	.31	8	.28
1202	January	Fwd (W-12)	No data		2	.64
		Aft (W-2E)	No data		4	.56
1203	July	Fwd (W-12)	1	1.05	6	.53
		Aft (W-2E)	2	.72	7	.42

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TABLE 3-25 (CONT'D)

Mission	Month	Camera (Filter)	Domestic Areas		Denied Areas	
			Number	Log E	Number	Log E
1204	October	Fwd (Clear)	11	.64	1	.51
		Aft (W-12)	3	.70	5	.55
1205	March	Fwd (Clear)	10	.65	7	.43
		Aft (W-12)	7	.60	8	.44
1206	September	Fwd (W-12)	11	.58	21	.57
		Aft (Clear)	19	.63	22	.53
1207	November	Fwd (W-12)	6	.72	10	.69
		Aft (W-2E)	4	.54	3	.54

In general, the data indicates that the scene contrast of the Forward Camera is greater than that of the Aft. The exceptions to this are 1204, the denied areas of 1205, and the domestic areas of 1206. Since no filter was present in the Forward Camera for 1204 and 1205, the observed decrease in contrast could have resulted from even a moderate haze condition. As for 1206, since a large proportion of the acquisitions were in or near designed desert polygons, the haze condition can be presumed to be insignificant. Therefore, one should not expect the Aft Camera to record a lower scene contrast just because a clear filter was used. A closer look at the scene contrast range of the 1206 acquisitions does not show any significant difference between Forward and Aft Cameras.

The log E range of the domestic urban area imagery was found to be greater than that of the denied areas. This log E range superiority now seems to be uniform for the entire year. In all cases where the log E was measured significantly higher, the imagery was subjectively rated better.

3.7.7 Conclusions/Recommendations

A. The basic 1414 algorithm error relative to the initial recommendation was .04 log E for the Forward and .09 log E for the Aft. This imbalance was corrected by a two count exposure bias (-.06 log E) applied to the Aft Camera during 1207. It is recommended that this two count bias be continued for the Aft unit when exposing black and white film.

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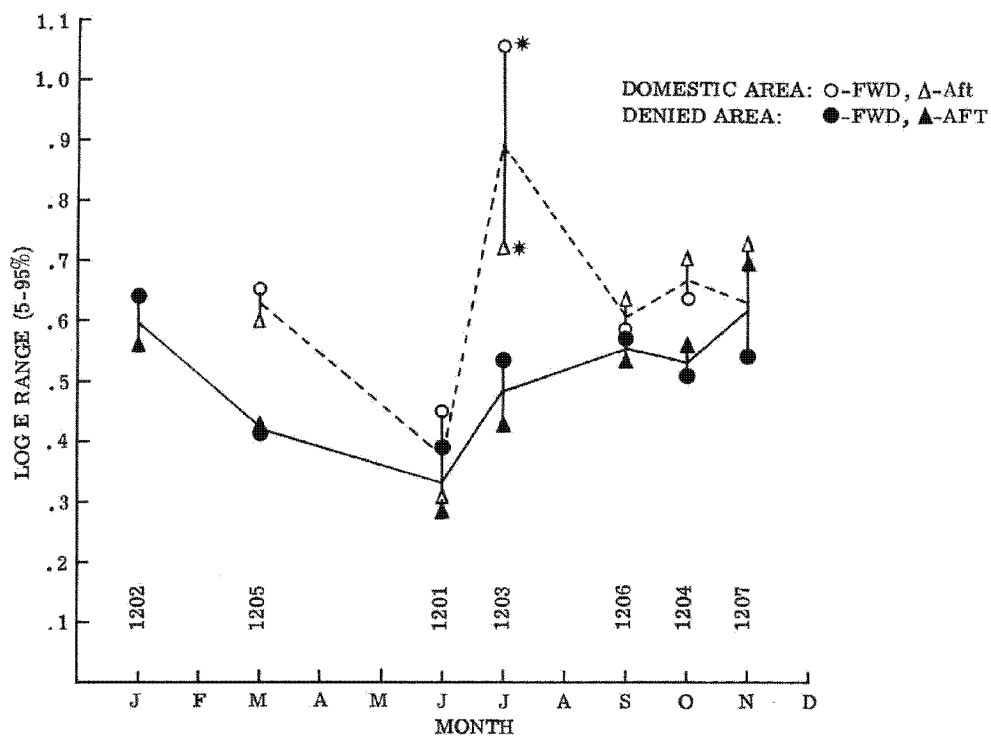
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SCENE LOG E RANGE AS A FUNCTION OF TIME OF YEAR



NOTE: The asterisk (*) denotes that there was very limited data.

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FIGURE 3-35

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B. The 1414 imagery was rated Good by subjective evaluation. In consideration of this rating and data showing that peak resolution occurs between a density of 1.0 and 1.2, it is recommended that 1.1 density be used as the new exposure aim criterion.

C. Exposure of the SO-255 and FE-3916 was rated Good by subjective appraisal. Limited microdensitometer data concurred with the visual appraisal. No change in exposure is recommended for the SO-255 and FE-3916 Color Films.

D. The new three-step snow bias was found to be an improvement over the old single-step bias. The average scene is exposed .05 log E closer to the optimum density criterion with a very small percentage of scenes (11%) resulting in underexposure attributable to the biasing technique. It is therefore recommended that the new bias routine be continued.

E. The -.15 log E sand bias was found to be appropriate when applied. Of the 11 sand frames analyzed, six were totally within desert polygons and were given the bias. No change in bias is recommended, although a redefinition of the desert polygon for determining implementation may be advisable. Presently, many desert frames remain unbiased and overexposed when the major portion of the format is within the desert polygon.

F. Scene range data, plotted as a function of time of year, indicates: (1) increased scene range in the fall months, (2) generally larger scene range with the Forward unit, and (3) a larger scene range for domestic areas. Subjective image quality was found to be higher where the scene range was significantly larger.

3.8 RADIATION MONITORING PACKETS (RMP)

3.8.1 Summary

Radiation Monitoring Packets (RMP) of the 3401, 3414, and SO-255 Films were carried in all RVs of Mission 1207 for the purpose of monitoring ambient radiation. The method of handling the packets, their ground controls, processing, and analysis of results were the same as indicated in the Mission 1206 PFA Final Report, TCS-363515-73. Gross fog at the end of the mission was .34 for 3401 Film, representing an increase of .22 of the orbiting packets over the ground controls. For 3414 Film, gross fog was negligible. Gross fog on SO-255, represented by a lowering of density, was also negligible.

Using a 37% longer time base than Mission 1206 (104 days versus 76 days), a revised prediction of gross fog on 3401 Film after 180 days would be approximately .50 instead of .66. The previous prediction of .31 fog density after 180 days for 3414 remains the same. A change in fog density after 180 days with SO-255 is not indicated.

Packet controls for each RV were included as recommended in the 1206 Report. Comparison of

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the four packet controls to the zero controls show them to virtually the same.

Two packets were carried on each RV of Mission 1207. As far as the RMPs are concerned, Mission 1207 was a virtual repeat of Mission 1206.

The format having been established and the analytical details discussed in the previous report, this section will deal with the results and omit details of methods employed in the analysis.

Processing of the packets was the same as with Mission 1206. There was one small difference between 1206 and 1207. With Mission 1206, a packet control sensitometric film strip, which was kept at the launch site, was returned to BRIDGEHEAD with the first RV only. However, with 1207, a packet control strip was returned with each of the four RVs. The distribution of the packets can be seen in Table 3-26.

TABLE 3-26

DISTRIBUTION OF FILM PACKETS

	<u>RV-1</u>	<u>RV-2</u>	<u>RV-3</u>	<u>RV-4</u>
Packet A	X	X	X	X
Packet B	X	X	X	X
Packet Control (at launch site)	C	C	C	C
Zero Control (at BRIDGEHEAD)	C	C	C	C
WCFO	C			

NOTES: 1. C represents a type of control.
2. X represents on-board film.
3. A sensitometric film strip was forwarded from WCFO to BRIDGEHEAD immediately after being received. There it was frozen and processed with the RMPs of the first RV.

3.8.2 Analysis Results

As with Mission 1206, analysis was hampered by non-uniformity in the processing of the small strips of all three films. All were evaluated with respect to gross fog and change in gradient.

3.8.2.1 Gross Fog Analysis for the Black and White Record

Table 3-27 shows gross fog densities for the 3401 and 3414 Films. The term "Delta Day" refers to the elapsed time in days from launch to date of processing. Figures 3-36 and 3-37 are plots of the data in Table 3-27.

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CHANGE IN GROSS FOG OF 3401 FILM WITH DELTA DAYS

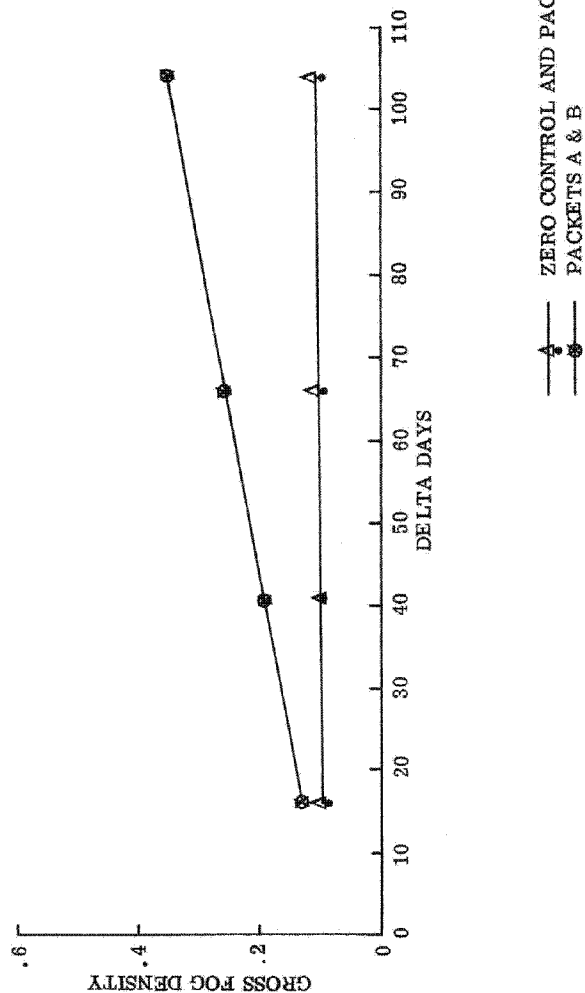


FIGURE 3-36

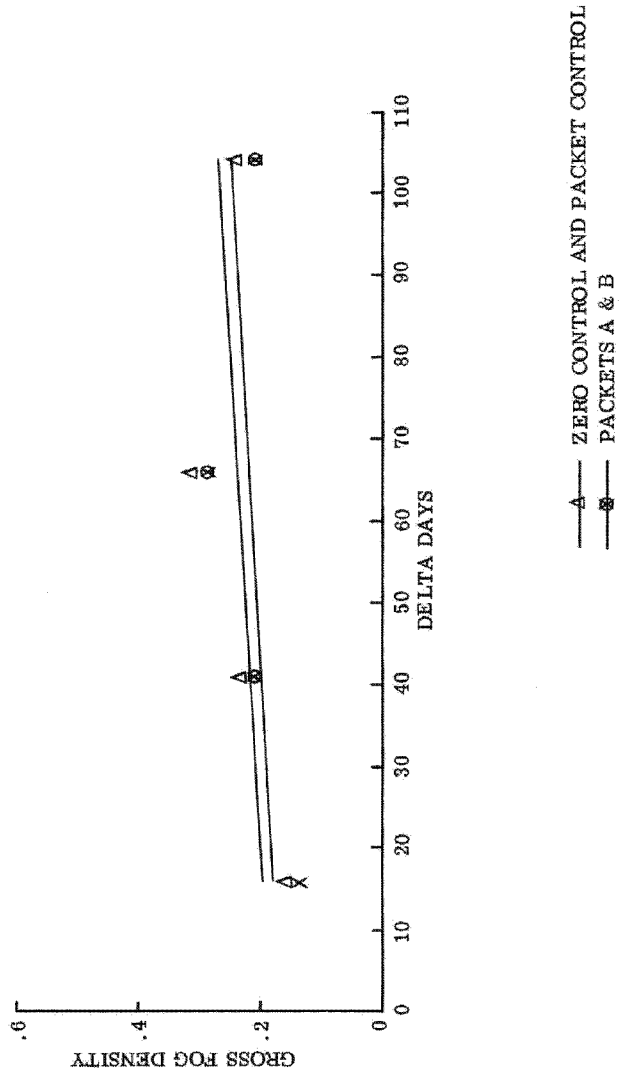
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CHANGE IN GROSS FOG OF 3414 FILM WITH DELTA DAYS



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FIGURE 3-37

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TABLE 3-27

SUMMARY OF GROSS FOG FOR 3401 AND 3414 FILMS

— 3401 Film Type —

<u>RV</u>	<u>Delta Day</u>	<u>Zero Control</u>	<u>Packet Control</u>	<u>Packet A</u>	<u>Packet B</u>	<u>WCFO</u>
1207-1	16	.09	.10	.13	.13	.10
1207-2	41	.10	.10	.19	.19	
1207-3	66	.10	.11	.26	.26	
1207-4	104	.12	.09	.34	.36	

— 3414 Film Type —

1207-1	16	.16	.14	.16	.16	.13
1207-2	41	.21	.21	.23	.23	
1207-3	66	.29	.28	.31	.31	
1207-4	104	.21	.21	.24	.21	

Change in the gross fog density of 3401 Film appears to be linear with an increase in delta days. There is no apparent change in gross fog with 3414 Film. Processing variations have masked any fog density changes.

3.8.2.2 Gross Fog Analysis for SO-255 Record

Process controls for SO-255 were better for this mission than for 1206. Tabulation of gross fog is given in Table 3-28.

TABLE 3-28

GROSS FOG FOR SO-255 FILM

<u>RV</u>	<u>Delta Day*</u>	<u>Zero Control</u>	<u>Packet Control</u>	<u>Packet A</u>	<u>Packet B</u>	<u>WCFO</u>
1207-1	16	2.68	2.96	2.78	2.81	2.98
1207-2	41	3.10	3.18	3.12	3.17	
1207-3	66	2.96	3.00	3.08	3.10	
1207-4	104	2.94	3.02	3.11	3.14	

NOTE: The asterisk (*) denotes that the delta days were actually greater for SO-255 than for the black and white films, being 20, 53, 82, and 122 days for RVs -1, -2, -3, and -4, respectively. The packets were frozen immediately upon their return to BRIDGEHEAD and processed later as a matter of convenience. However, the delta days are effectively the same for all the films.

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Figure 3-38 is a plot of the SO-255 fog. No significant change in gross fog over the duration of the mission is evident. If there is any trend in fog, it is lost in the noise.

3.8.2.3 Effect of Radiation Fog on Gradient

The gradient was calculated in the same manner as in the Mission 1206 Report except in the case of SO-255 where a density of 1.5 was selected instead of a density of 1.0 used for the black and white films. Plots of gradients for 3401, 3414, and SO-255 Films are shown in Figures 3-39 thru 3-41. The plots show a trend to a lower gradient with an increase in delta days in the case of 3401. Any trends that might occur with 3414 and SO-255 are masked by the noise.

3.8.3 Recommendations

This data supports the conclusions reached in the Mission 1206 Report. It is apparent that the RMP project has served its purpose and that there is little to be gained by continuing this type of detailed evaluation. Therefore, it is recommended that the RMP Program be continued but the film evaluation be conducted only as required.

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CHANGE IN GROSS FOG OF SO-255 FILM WITH DELTA DAYS

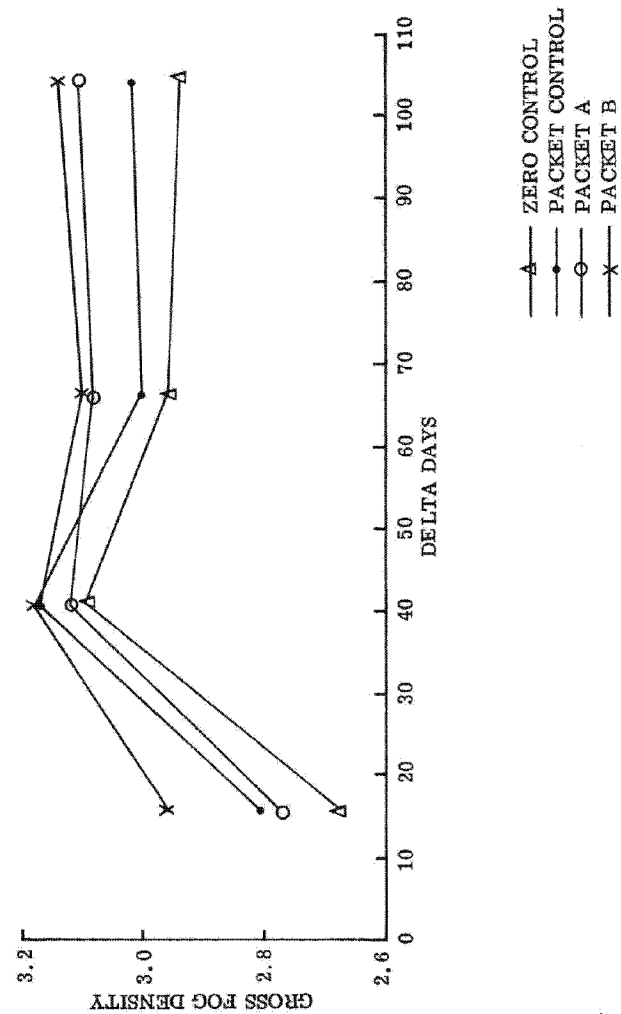


FIGURE 3-38

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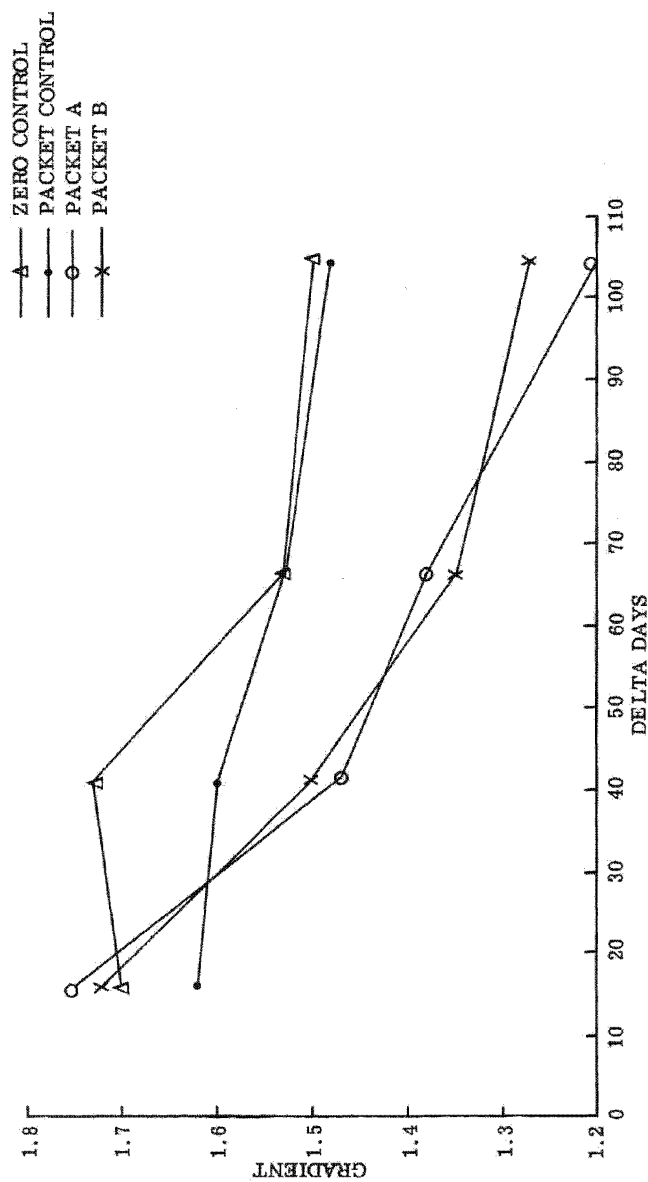
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CHANGE IN GRADIENT FOR 3401 FILM



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FIGURE 3-39

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CHANGE IN GRADIENT FOR 3414 FILM

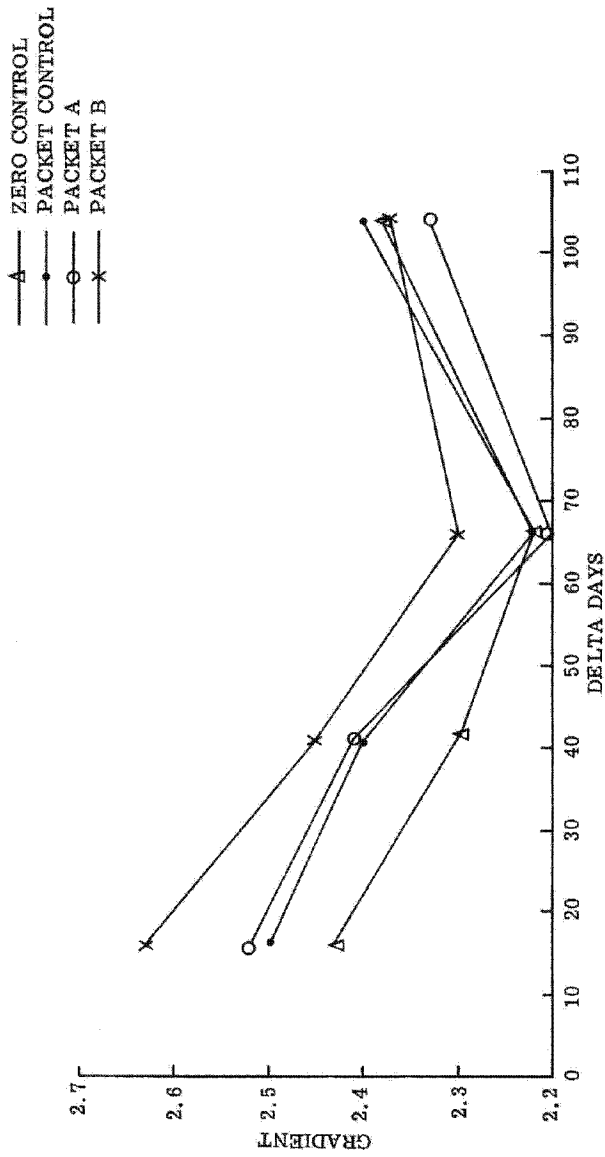


FIGURE 3-40

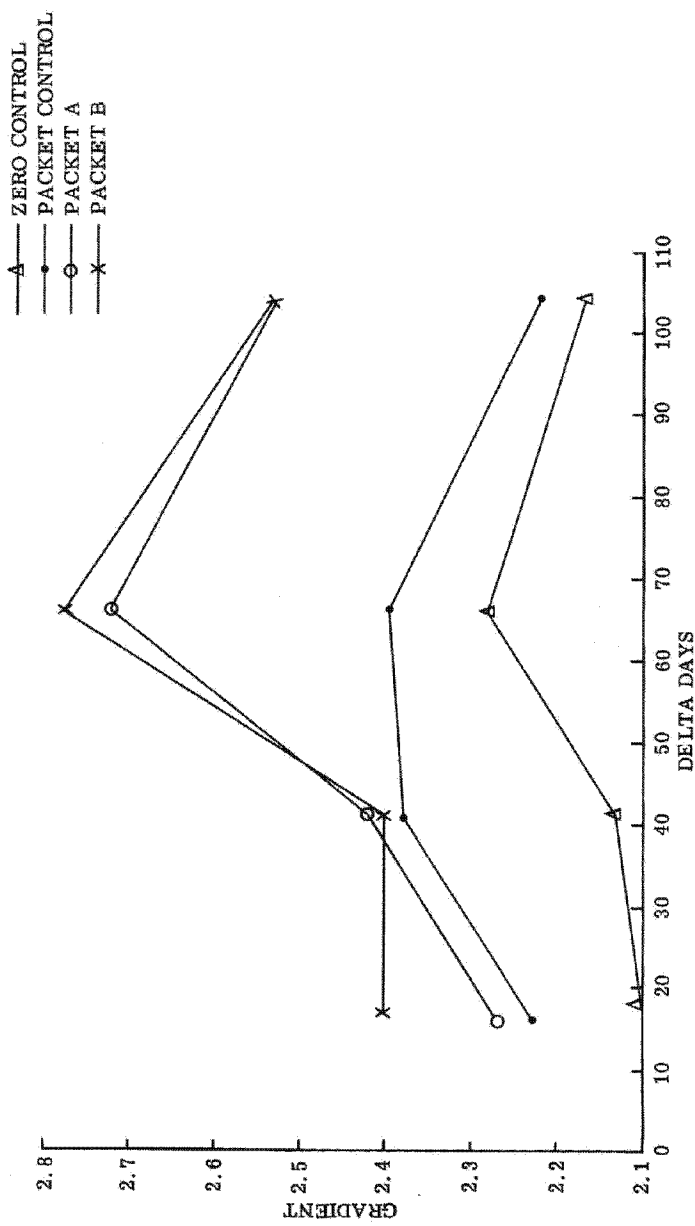
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CHANGE IN GRADIENT FOR SO-255 FILM



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FIGURE 3-41

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SECTION IV

PROCESSING, REPRODUCTION, AND DUPLICATE IMAGE QUALITY

4.1 INTRODUCTION

This section discusses defilming, processing, titling, and reproduction of the Mission 1207 Forward and Aft Camera original records, and the results of the NPIC evaluation on duplicate image quality. All production operations were accomplished at BRIDGEHEAD except for the Target Complex and Priority 3 customer requirements from the black and white original negative (ON). This work was done at AFSPPF.

Studies of resolution transfer and original negative granularity are presented for the black and white film. The experimental black and white second generation duplicate positive (DP) used by BRIDGEHEAD on 1207-4 is evaluated. Also included is a sensitometric study of the special high contrast duplicate positives.

Mission 1207-1 marked the introduction of a new color duplicating film for preparing contact color duplicate positives from color reversal originals. This material is designated Aerial Color Print Film SO-287. For image assessment comparison studies, additional copies of several selected operations from 1207-1 were made available using previously employed High Definition Ektachrome Film SO-356. Resolution transfer, tone reproduction, color balance, and subjective quality were evaluated for the SO-356, SO-287, and the green record duplicate positive copies.

There was also 501' of Color Infrared (IR) Film FE-3916 successfully acquired on 1207-4. Analysis of this imagery consisted of resolution transfer, tone reproduction, and color balance.

4.2 SUMMARY

Defilming of all RVs was accomplished without any major difficulty, even though festooned, tangled film was present in all but RV-1. The core locking pins did not shear in RV-1. Processing and reproduction of the black and white portion of this mission was accomplished without incident. Second generation DPs on 1207-4 were printed on experimentally modified Redondo Printers. High contrast duplication methods were utilized to provide both entire part and special target oriented duplications.

Processing and reproduction of the color original positives (OP) from Mission 1207 were accomplished without incident. The color portion of 1207-1 contained the conventional SO-255 Color OP Film, and 1207-4 contained Color Infrared (IR) OP Film, FE-3916. A new Color DP Film (SO-287), which was given a special reversal process, was used to prepare the color DP copies. A green record derivative black and white from SO-255 and a red record derivative black and white from FE-3916 were also prepared.

A resolution transfer analysis of the black and white duplicate copies from Mission 1207 show an insignificant loss for both the BRIDGEHEAD and AFSPPF second generation DPs at the 175 cycles/mm

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level on the ON, and an 89% transfer at 200 cycles/mm. The second generation duplicate negative (DN) and third generation DP show 88% and 82% transfer respectively, at the same two ON resolution levels. The ON granularity shows no change from past missions.

The experimental second generation DP system used by BRIDGEHEAD on 1207-4 is a good replacement for that used previously. A sensitometric study of the SO-192 high contrast DP system used at BRIDGEHEAD showed that only if the microdensity range of the ON scene was less than .80, could the high contrast system reproduce all the density levels. This agreed with the BRIDGEHEAD system reproduction curves derived by means of macrodensitometry.

The SO-287 Color DP resulted in substantial improvements in image quality and resolution transfer characteristics. Tribar resolution analysis from the single CORN target acquired on 1207-1 showed that the SO-287 DP provided 85% transfer compared to 65% when using SO-356. Subjective image assessment collaborated the improved image quality results obtained through the CORN analysis. A paired comparison between the two color DPs showed that the SO-287 was superior in the following areas: (1) sharpness, (2) small and large object detection, (3) object recognition, (4) highlight detail, and (5) overall information content. The green record DP shows no significant resolution loss.

The SO-287 DP supplied to the PIs was found to be poor for both tone reproduction and color balance in shadow areas. The highlight density detail was better on the SO-287 than the SO-356, and much better than that of the green record DP.

Resolution transfer loss from the FE-3916 IR Color Film was insignificant for both the color DP and red record DP. This is due to the lower resolution capability of the FE-3916 and the higher resolution quality provided by the SO-287 Color DP. The red record DP was found to be better in tone reproduction for both highlights and shadows than the color DP. The color balance of the SO-287 made from the FE-3916 was generally good to excellent. A special pre-flashing technique was implemented for adjusting system sensitometry to provide improved tone reproduction of the color DPs from 1207-4 versus those from 1207-1.

4.3 RECEIPT AND DEFILMING

4.3.1 Mission Segment 1207-1

The RV/TU arrived at the BRIDGEHEAD processing site in good condition at 1045 EST, 25 November 1973. A small amount of particulate was collected from the inside of the dome. A greasy substance was present on the inside of both cannister retaining rings about 1.5" into the cannister wells. Both core locking pins were engaged and intact. Film was well centered and well stacked on both rolls. Tag ends of 3,080' on the Forward and 6,032' on the Aft were removed and processed immediately for PFA Team evaluation. The Forward Camera film weighed 227.7 pounds and the Aft film weighed 230.3 pounds.

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12074.3.2 Mission Segment 1207-2

The RV/TU arrived at the BRIDGEHEAD Processing Facility in good condition at 0945 EST, 18 December 1973. Both core locking pins were engaged but sheared. Approximately 90' of Forward and 104' of Aft film had spilled from the stacks. The loose film was adhering to the sticky tape used to capture particulate contamination in the RV. Emulsion pickoffs, which were most probably caused when the film was pulled from the tape, occurred on Op 249, Frames 001 thru 003 of the Forward Camera and on Op 249, Frame 010 of the Aft Camera. The damage caused a loss of imagery. This film was respooled onto the TU by hand to permit subsequent defilming by normal procedures. The Aft Cluster Roller Assembly was still threaded with film. Except for the spillage, both rolls were well stacked and well centered on the TU cores.

The tail 7,636' of the Forward and 7,646' of the Aft rolls were removed for immediate processing to expedite high priority acquisitions.

A small amount of particulate was collected from the RV dome. Both cannister wells contained a sticky substance which has been identified as thermally conductive grease used to prevent electronics overheating.

The Forward Camera film weighed 203.3 pounds and the Aft weighed 203.7 pounds.

4.3.3 Mission Segment 1207-3

The RV/TU arrived at BRIDGEHEAD in good condition at 1645 EDT, 14 January 1974. A small amount of debris and a yellow EP-20 connector dust cap were found in the RV dome. Both core locking pins were engaged, but sheared. Approximately 100' of the Forward and 110' of the Aft film had spilled from the stacks. The Forward film was wrinkled and jammed under the builder roller. These portions were spooled back onto the stacks by hand to permit normal despooling.

Three instances of mis-stacking were noted in the Aft stack. In each case, the mis-stack was approximately 1/8" to the inboard side. The first occurrence was about 1" from the outside of the roll and continued for about 1/2" into the stack. Profile measurements made at the start of this mis-stack (5,920' from tail) showed no unusual condition. The second mis-stack began approximately 2" from the outside and continued for 1/2" of depth. The third began approximately 4 1/2" from the outside and continued for approximately 3/4" of depth. At the start of this mis-stack, a film tear was discovered extending 2 7/8" into the web from the untitled (outboard) edge.

The tail 5,927' of the Forward and 5,917' of the Aft rolls were removed for immediate processing to expedite high priority acquisitions.

Stack profile measurements were also taken on each stack after the spilled film was removed. The Aft film was well centered on the TU core, while the Forward was offset slightly to the outboard side. A drop of oil found inside the RV dome was sampled for analysis and reported by BRIDGEHEAD.

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The Forward Camera film weighed 228.3 pounds and the Aft weighed 228.7 pounds.

4.3.4 Mission Segment 1207-4

The RV/TU arrived at BRIDGEHEAD at 0935 EDT, 21 February 1974. A small amount of debris was found in the RV dome. The aft side of the shipping container had a 6" long x 1/4" deep dent. The reinforced channel iron spanning the diameter of the shipping container cover was also damaged on one side.

The aft side antenna on the RV bulkhead was broken off at the base. The cause is unknown and the antenna was not with the RV. A small amount of grease or oil was found on some of the bolt heads in the core area. Samples were taken for spectrographic analysis and reported to the community by BRIDGEHEAD message.

The film cutters were closed and no film was entrapped in the cutters. Both core locking pins were engaged, but sheared. There were 230' of IR Film from the Aft and approximately 150' of the Forward film found spilled in the dome. Portions of the IR material were stuck to the dome particulate tape resulting in the emulsion being pulled off of the Op 697 interop runout (IOR). On the Forward side, the film was jammed between the stacks and wrapped around the core of the drive motors. There were 36' removed for off-line repair and handling. The damaged film was all camera run-out and contained no imagery.

The Aft stack had a 1/16" mis-stack to the outboard edge approximately 2" from the core, while the Forward stack had a 1/16" mis-stack to the outboard edge approximately 3/4" from the core. Centering of both stacks was good.

The Forward Camera film weighed 184.6 pounds and the Aft weighed 185.4 pounds.

4.4 PROCESSING AND TITLING4.4.1 Mission Segment 1207-1

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

TABLE 4-1

1414 PROCESSING DATA, RV-1

	<u>Forward Camera</u>	<u>Aft Camera</u>
Processor	Yardleigh 5	Yardleigh 6
Developer	19DNV	19DNV
Operational Frames:		
30° Scan	313	187
60° Scan	1,019	803
90° Scan	1,554	1,236

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TABLE 4-1 (CONT'D)

	Forward Camera	Aft Camera
120° Scan	298	198
Totals	3,184	2,424
Footage:		
Preflight	1,928 *	1,657
Flight	27,036	20,761
Manufacturing Splices	19	18 **

NOTES: 1. The asterisk (*) means that only 508' were processed. The remaining footage was held unprocessed at BRIDGEHEAD for "Prelaunch-Stick" testing.

2. The double asterisk (**) means that this value includes the black and white-to-material change detector (MCD) and MCD-to-black and white transition splices.

Table 4-2 presents the processing data for the SO-255 original positive.

TABLE 4-2

SO-255 PROCESSING DATA, RV-1
(Aft Camera)

Processor	Grafton
Process Chemistry	E-26-8
Operational Frames:	
30° Scan	127
60° Scan	199
90° Scan	293
120° Scan	8
Total Frames	627
Footage	4,984
Manufacturing Splices	5*

NOTE: The asterisk (*) means that this value includes the color-to-MCD and MCD-to-color splices.

Processing of the color OP on the Grafton Processor was accomplished without interruption. However, magenta spots similar to those noted on the color OPs from Mission 1206 were also observed on this mission. BRIDGEHEAD is continuing its testing program to determine the exact cause of this defect.

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12074.4.1.1 Optical Titling

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

4.4.1.2 Manual Titling of the Color Film

Incorporated in the Grafton Processor is an exposing source for flashing the title side of the film web. The processed image is cyan in color, to facilitate manual titling using the UNIMAK Film Titler.

4.4.2 Mission Segment 1207-2

Table 4-3 presents the processing data. There was no color film in RV-2.

TABLE 4-3

1414 PROCESSING DATA, RV-2

	<u>Forward Camera</u>	<u>Aft Camera</u>
Processor	Yardleigh 5	Yardleigh 6
Developer	19DNV	19DNV
Operational Frames:		
30° Scan	466	466
60° Scan	1,557	1,557
90° Scan	1,082	1,082
120° Scan	214	214
Totals	3,319	3,319
Footage	26,015	26,077
Manufacturing Splices	15	17

4.4.2.1 Optical Titling

There was 99.7% of the Forward film completely and accurately titled. However, a frame mark detection problem in the Optical Titling System resulted in only 91.4% of the Aft frames being completely and accurately titled.

The problem occurred in Op 142 and after repeated attempts to re-establish synchronization, a cut was made at the head of the processor in the IOR between Ops 146 and 147. After corrective action was taken, the balance of the film was titled without further incident.

4.4.3 Mission Segment 1207-3

Table 4-4 presents the processing data. There was no color film in RV-3.

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TABLE 4-4

1414 PROCESSING DATA, RV-3

	<u>Forward Camera</u>	<u>Aft Camera</u>
Processor	Yardleigh 5	Yardleigh 6
Developer	19DNV	19DNV
Operational Frames:		
30° Scan	1,109	1,109
60° Scan	1,408	1,407
90° Scan	1,356	1,358
120° Scan	<u>108</u>	<u>108</u>
Totals	3,981	3,982
Footage	28,982	29,036
Manufacturing Splices	18	19

The Aft film was cut in the IOR between Ops 268 and 269 because of a minor processing streak. Investigation revealed that a break in the gasket material which seals the developer cut off section of the processor was allowing water to drip on the base of the film. Processing was resumed after the leak was repaired.

4.4.3.1 Optical Titling

There were 97.7% of the Forward and 97.2% of the Aft frames completely and accurately titled by the Optical Titling System.

Both Forward and Aft tag ends were cut at the heads of the processors because an electrical interface malfunction in the Optical Titling System caused synchronization problems. After corrective action was taken, processing/optical titling was resumed and completed.

4.4.4 Mission Segment 1207-4

Table 4-5 presents the processing data for the original negatives.

TABLE 4-5

1414 PROCESSING DATA, RV-4

	<u>Forward Camera</u>	<u>Aft Camera</u>
Processor	Yardleigh 5	Yardleigh 6
Developer	19DNV	19DNV
Operational Frames:		
30° Scan	2,189	2,172
60° Scan	1,223	1,174
90° Scan	401	402

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TABLE 4-5 (CONT'D)

	<u>Forward Camera</u>	<u>Aft Camera</u>
120° Scan	<u>65</u>	<u>56</u>
Totals	3,878	3,804
Footage	23,429*	22,875
Manufacturing Splices	13	16**

NOTES: 1. The asterisk (*) means that this value does not include 36' of severely damaged film from the tail of the roll. This segment of film did not contain any imagery (10.7' Versamat processed, 25' unprocessed).

2. The double asterisk (**) means that this value includes the black and white-to-MCD splice.

Table 4-6 presents the processing data for the FE-3916 Color IR original positives.

TABLE 4-6

FE-3916 PROCESSING DATA, RV-4

(Aft Camera)

Processor	MP ²
Process Chemistry	E-31-3
Operational Frames:	
30° Scan	22
60° Scan	49
90° Scan	0
120° Scan	<u>0</u>
Total Frames	71
Footage	501
Manufacturing Splices	1*

NOTE: The asterisk (*) means that this is the IR-to-MCD splice.

A machine cut was made during the processing of the color IR original on Op 694 because creases and wrinkles were observed on the pre-mission process control film. These were due to a misaligned splice on one of the pre-mission sensitometric control strips. The creases and wrinkles were confined to the process control materials and did not affect the mission record. The processor was then recertified and processing was completed without further incident.

4.4.4.1 Optical Titling

Over 99% of the frames in the black and white portion were completely and accurately titled

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by the Optical Titling System.

4.4.4.2 Manual Titling of the Color IR Film

The title side of the film web was flashed to give a light cyan color off-line before processing. The flashed edge permits manual titling using the UNIMAK Film Titler.

4.4.5 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 to obtain optimum sensitometry for that particular batch of flight film. The mission rolls are then processed under these adjusted conditions with additional sensitometric strips attached. Sensitometric curves from these strips are shown in Figures 4-1 thru 4-4 for each RV and are most representative of the sensitometry of the flight film.

4.5 REPRODUCTION AT BRIDGEHEAD4.5.1 Breakdown

After processing, the original camera film was "broken-down" according to the Geographic Area covered. For Mission 1207, 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 Negatives4.5.2.1 Geographic Area Duplicate Positives

All of the regular DP copies of complete composite rolls for customers in Priorities 1 and 2 (NPIC, DIA, Hqs/IAS and SAC) were prepared using Kodak High Resolution Aerial Duplicating Film (Estar Base) SO-192, processed in the viscous mode to provide a system sensitometry suitable for reproduction of entire composite rolls. Figure 4-5 shows the system sensitometry for RV-1, RV-2, and RV-3 while Figure 4-6 shows the sensitometry for RV-4. Redondo Printer settings were selected to return the ON densities of each op/area part between .40 and 1.80, except on RV-4 where the improved sensitometry permitted an upper limit of 2.00, with small tolerances for system variability.

On RV-4, all DPs were printed on experimentally modified Redondo Printers. These modifications permitted the exploitation of certain spectral characteristics of 1414 and SO-192 to achieve an improved sensitometry and limited contrast adjustment. Experimental work is continuing to refine the technique and simplify printer control.

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. Table 4-7 presents a summary of the required multiple printing for 1207.

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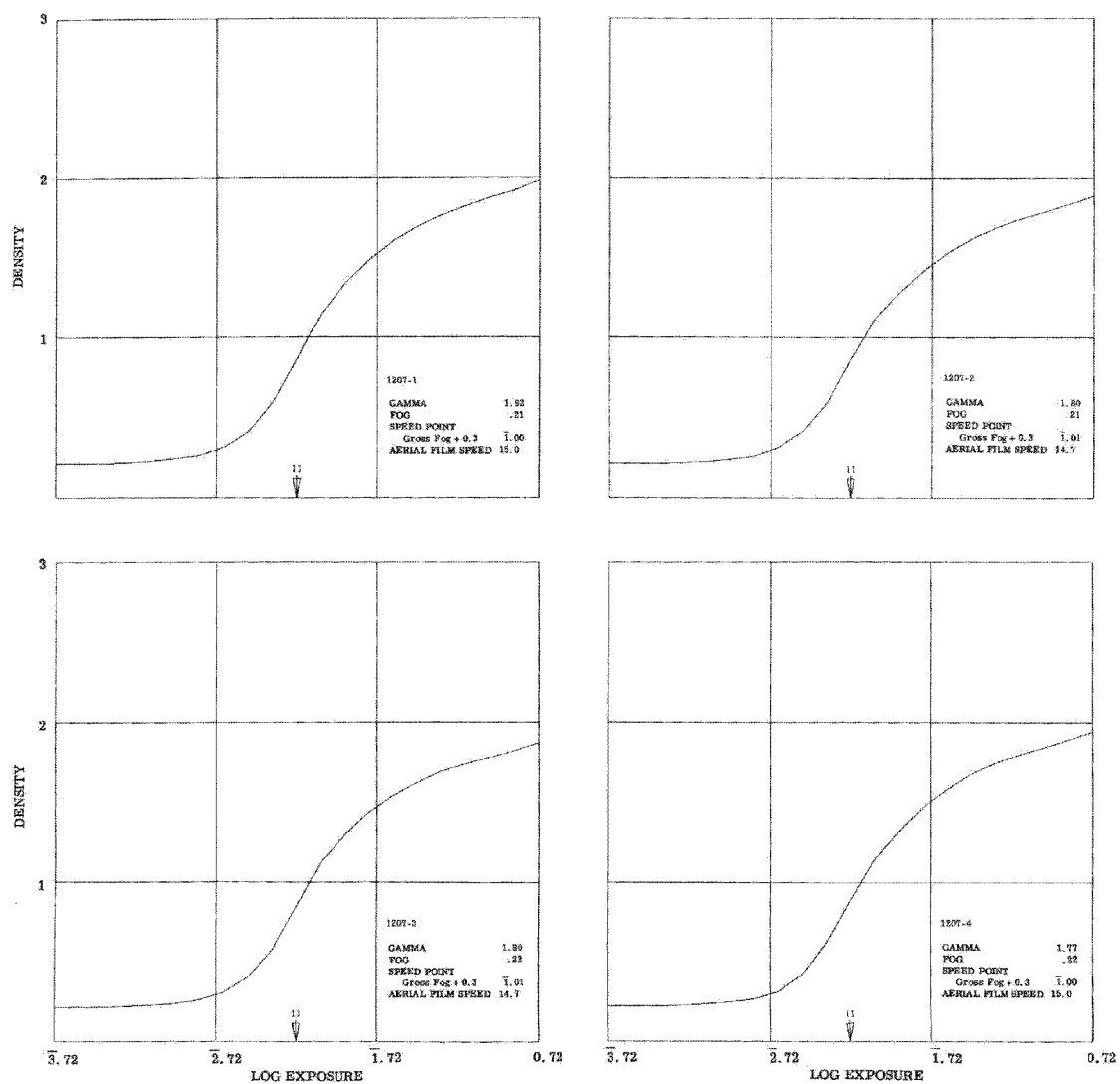
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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-33

FORWARD CAMERA



NOTE: Exposure Data:

Sensitometer	1B
Filter	Daylight
Time	1/25 second
Log E ₁₁	1.22

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FIGURE 4-1

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SENSITOMETRIC CURVES FROM MISSION MATERIAL, FILM TYPE 1414-33

AFT CAMERA

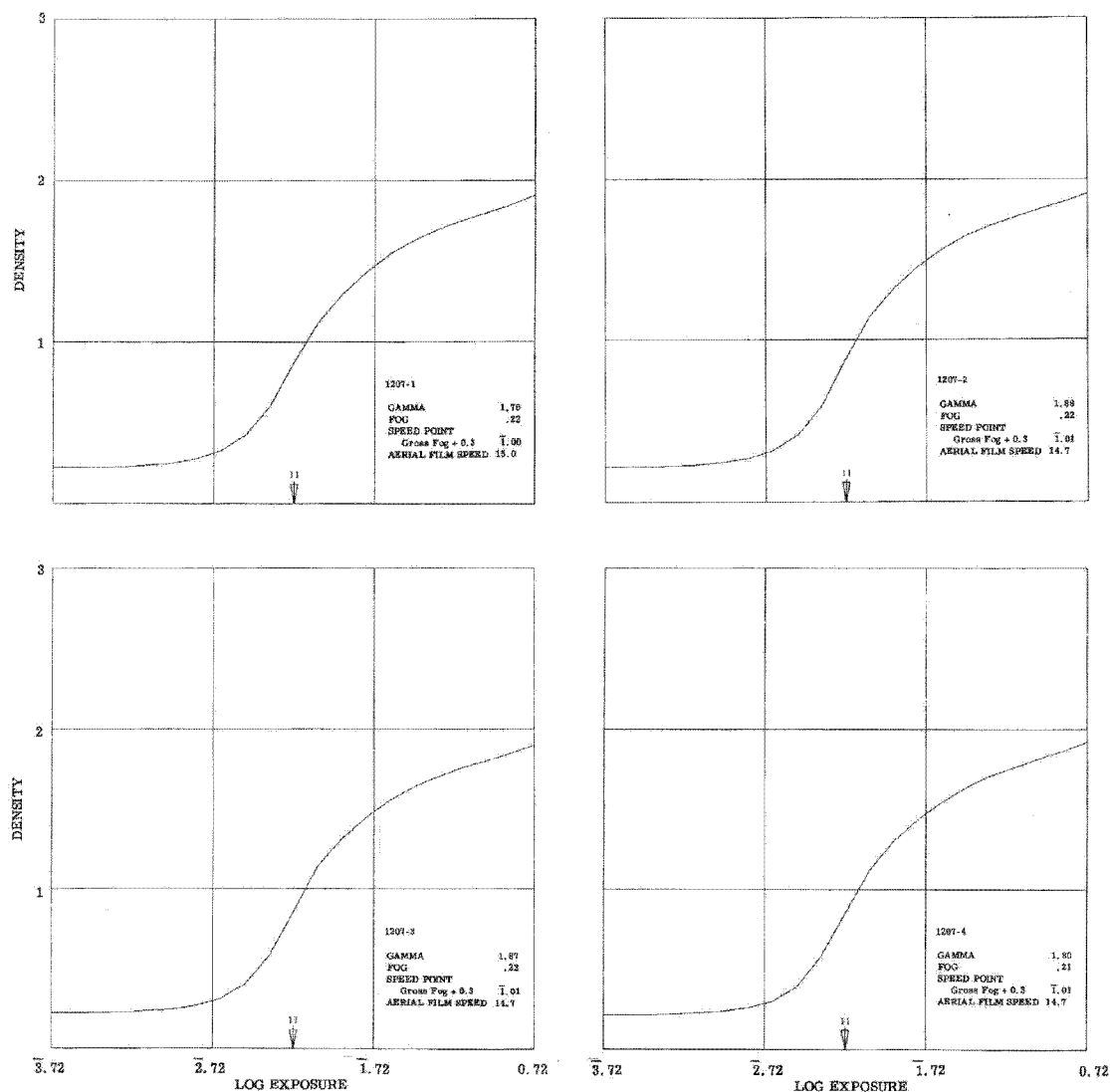


FIGURE 4-2

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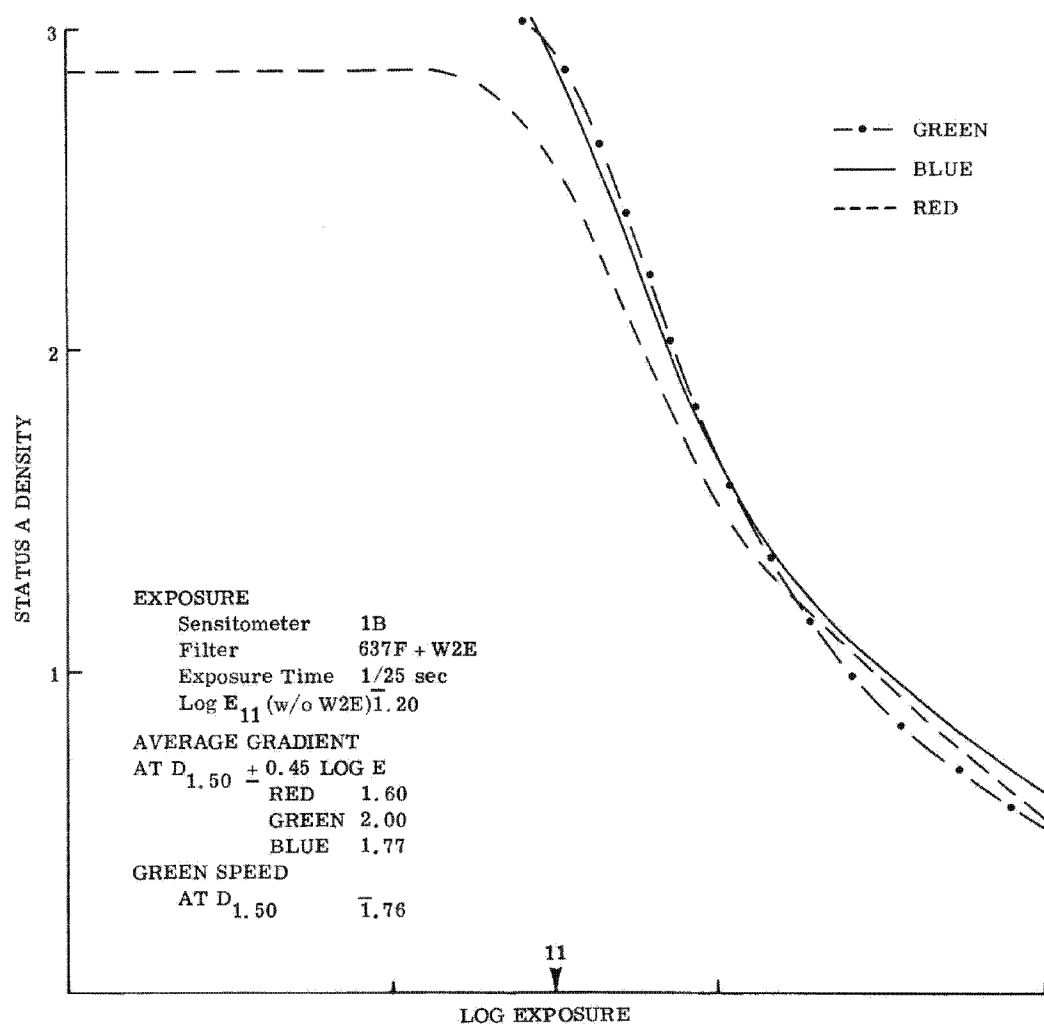
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POST FLIGHT ANALYSIS REPORT

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SENSITOMETRIC CURVES FROM 1207-1 AFT CAMERA, FILM TYPE SO-255-112



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FIGURE 4-3

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SENSITOMETRIC CURVES FROM 1207-4 AFT CAMERA, FILM TYPE FE-3916

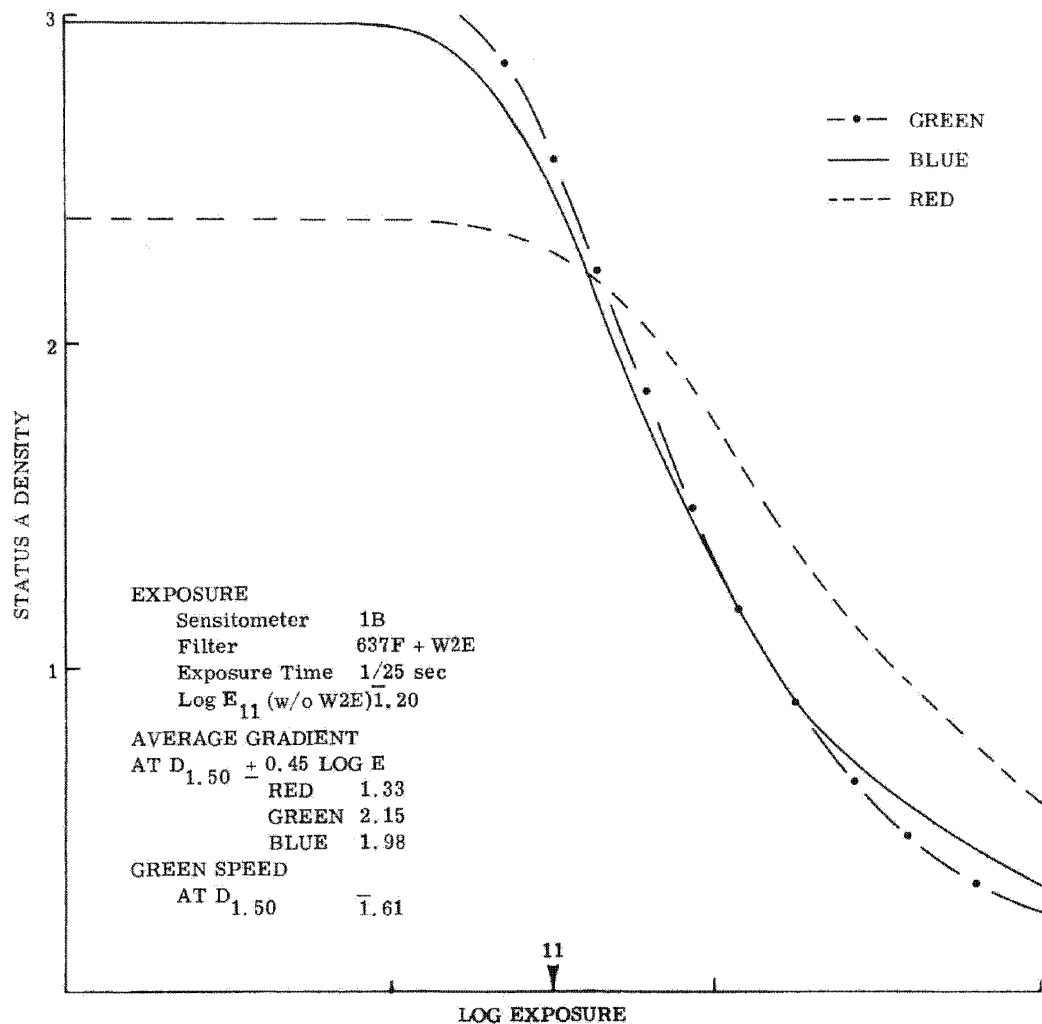


FIGURE 4-4

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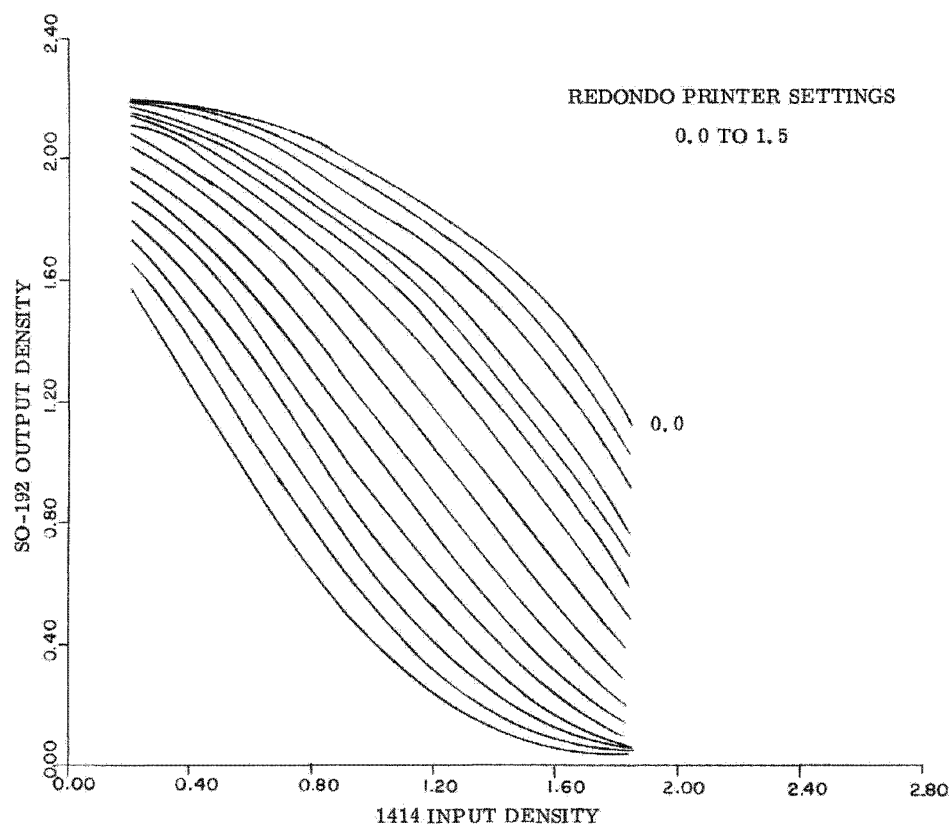
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SYSTEM REPRODUCTION CURVES FOR RV-1, RV-2, AND RV-3



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FIGURE 4-5

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POST FLIGHT ANALYSIS REPORT

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SYSTEM REPRODUCTION CURVES FOR RV-4

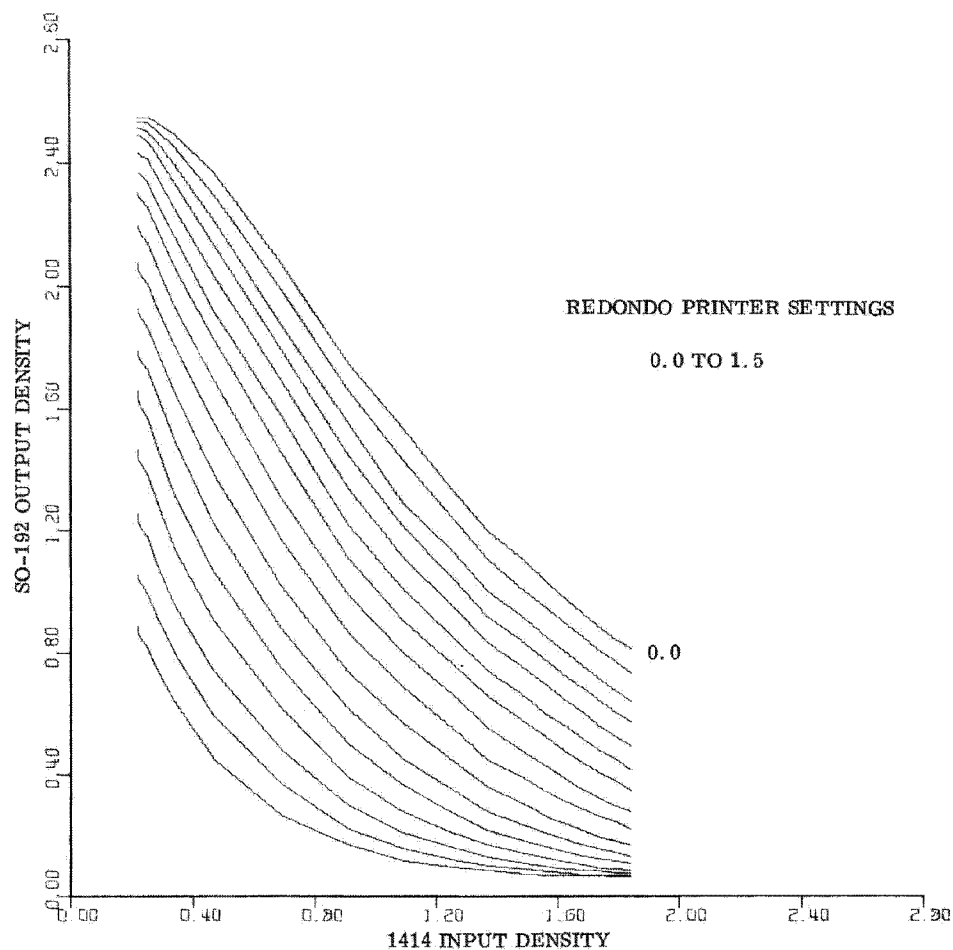


FIGURE 4-6

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POST FLIGHT ANALYSIS REPORT

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TABLE 4-7

BRIDGEHEAD DUPLICATE POSITIVE MULTIPLE PRINTING SUMMARY

(percent)

<u>Mission Segment</u>	<u>Operational Parts Multiple Printed</u>
1207-1	13.0
1207-2	6.7
1207-3	8.3
1207-4	1.0

In addition, the following number of complete op/area parts were reproduced at higher than normal contrast for better reproduction of low contrast areas on the original negative, see Figure 4-7. These copies were shipped instead of the normal contrast copies. Table 4-8 lists a summary of high contrast parts.

TABLE 4-8

BRIDGEHEAD HIGH CONTRAST PRINTING

(number of parts)

<u>Mission Segment</u>	<u>High Contrast Op/Area Parts</u>
1207-1	11
1207-2	12
1207-3	1
1207-4	13

A larger 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.

4.5.2.2 Geographic Area Duplicate Negatives

All DN 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 4-8. The advanced printers for continuous exposure control (formerly known as Cayuga Scanning Printers) were used for printing most of the duplicate negatives. Intensity of the scanning printer lamp is modulated within frames to return the Dmin to .40. In a few instances of "subject failure," the Dmax then exceeds the upper limit

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SYSTEM REPRODUCTION CURVES USED FOR HIGH CONTRAST MULTIPLE PRINTING

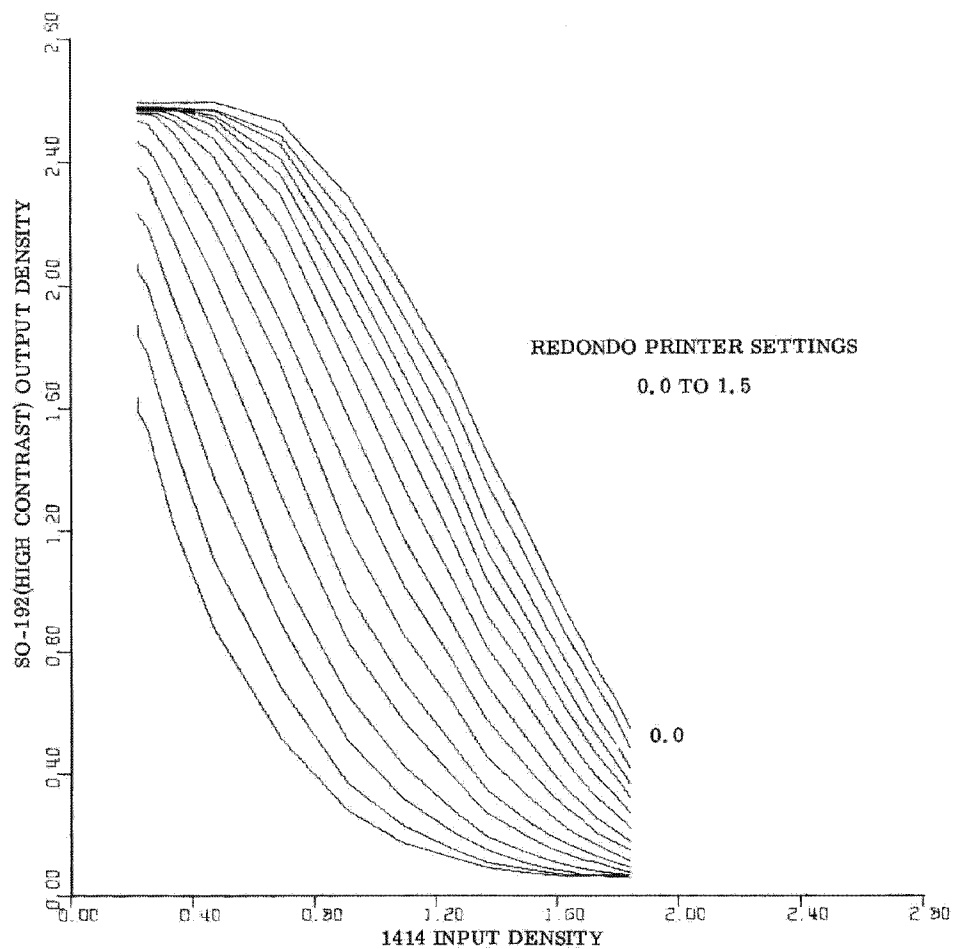


FIGURE 4-7

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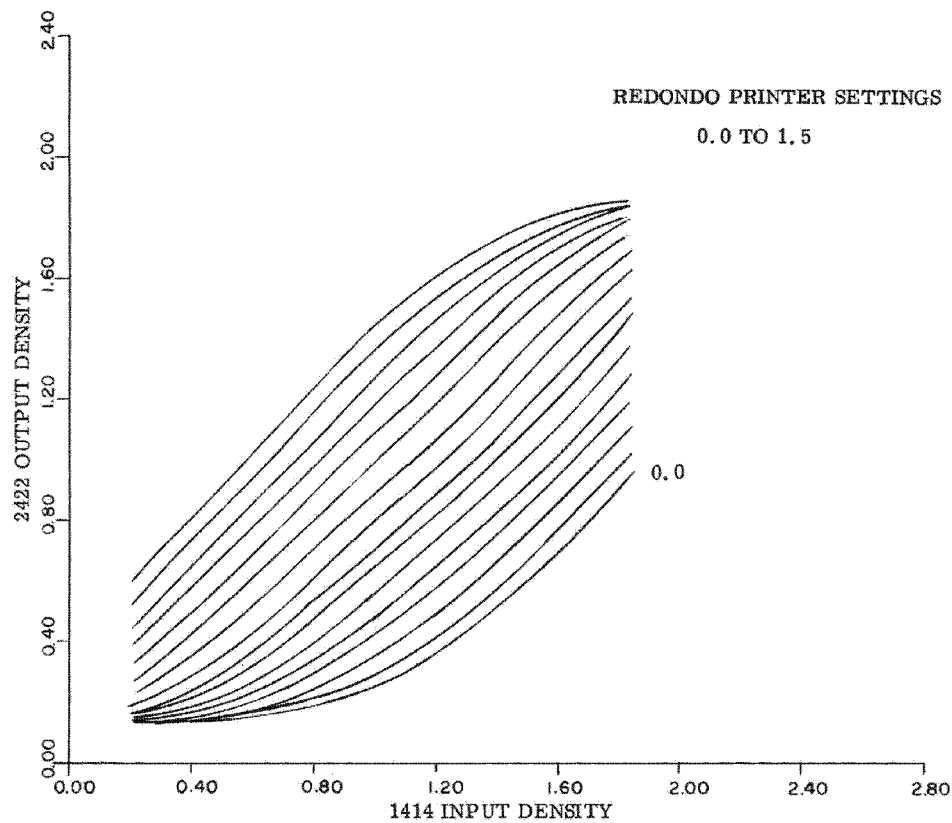
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SYSTEM REPRODUCTION CURVES USED FOR DUPLICATE NEGATIVE PRODUCTION



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FIGURE 4-8

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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)

<u>Mission Segment</u>	<u>Operational Parts Multiple Printed</u>
1207-1	8.3
1207-2	2.5
1207-3	0.0
1207-4	0.0

All Target Complex DN copies were prepared using the same film sensitometry and printers as the Geographic Area DNs; however, the printing criteria for the Target Complex DNs is to return the mean density of the ON to density of 1.10 on the DNs.

4.5.2.3 Machine-Cut Duplicates

To provide DP copies for PFA and NPIC Team evaluations as quickly as possible, machine-cut copies were prepared. These copies are printed before each machine-cut (approximately 1,300 of ON) is broken down into Geographic Area parts. Each entire machine-cut was printed onto SO-192 using the Cayuga-type Scanning Printer. After the PFA and NPIC Teams were finished with these copies, they were shipped to NPIC and DMATC, respectively.

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 films providing different contrast levels for expanding the ON density range were used. These films were Kodak Minicard Film 6451 and Kodak High Resolution Aerial Duplicating Film SO-192 (processed to high contrast). The system sensitometry for this application is shown in Figures 4-7 and 4-9.

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 1207.

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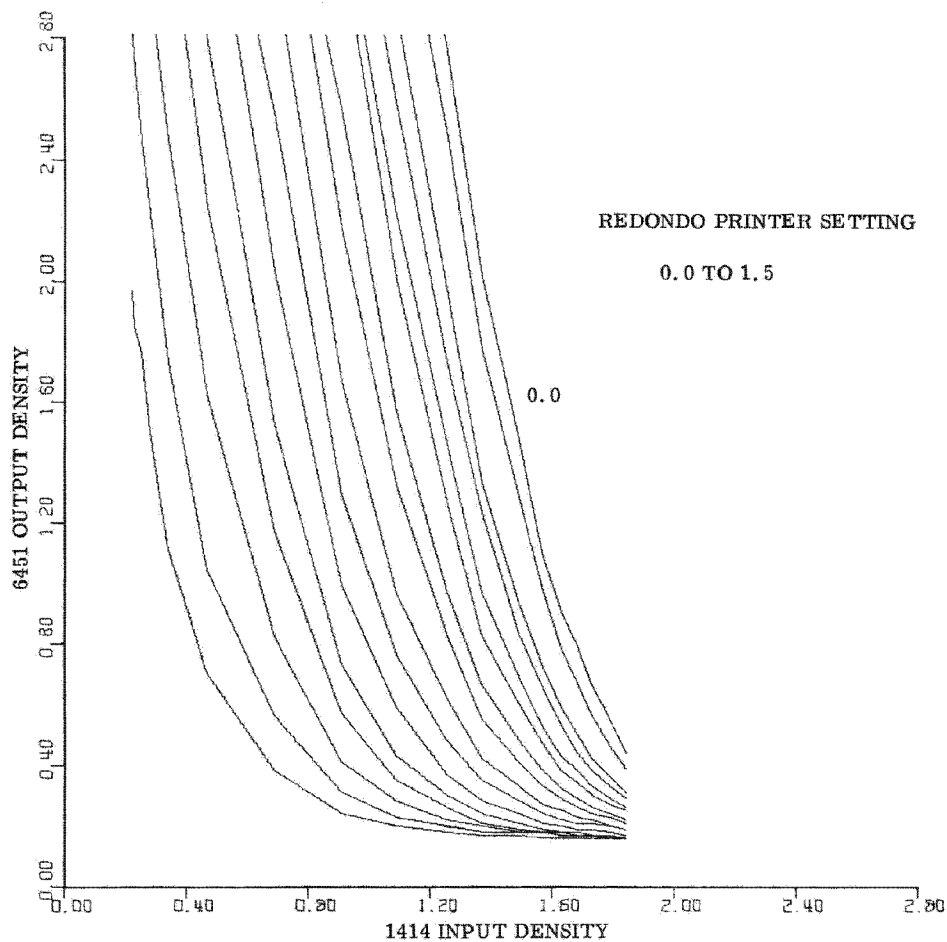
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SYSTEM REPRODUCTION CURVES USED FOR SPECIALIZED DUPLICATION



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FIGURE 4-9

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TABLE 4-10

SPECIALIZED DUPLICATION

(units)

	<u>1207-1</u>	<u>1207-2</u>	<u>1207-3</u>	<u>1207-4</u>
Single Prints (6.6" x 12")				
6451	5	4	7	9
SO-192 (High Contrast)	18	14	28	15
Both 6451 and SO-192	1	5	-	-
Complete Op/Area Parts				
6451	-	4	12	-
SO-192 (High Contrast)	12*	8	12	-

NOTE: The asterisk (*) means that this value includes three units of black and white from the color OP.

4.5.3 Duplication of Color Original Positives

4.5.3.1 Black and White From Color

The production of second generation master green record black and white internegatives from the SO-255 Color Original Positive was accomplished on the Framingham Printer (equipped with a liquid-gate assembly) using a Wratten 16 Filter in the printing aperture. Kodak Minicard Film 6451, viscous processed to a low contrast, was used for preparing the internegative. The system sensitometry is shown in Figure 4-10.

The production of the red record internegatives from the FE-3916 Color IR Original Positive was accomplished on the Rainbow Printer. This printer was converted from an additive color printer to a 3000 watt tungsten light source printer and spectrally-shaped with a Wratten 16 Filter in the printing aperture to provide red record (magenta dye layer) printing. A variant of Minicard Film 6451, designated SO-182, was used for the production of the master black and white internegative. The photographic properties of 6451 and SO-182 are identical. However, SO-182 incorporates small matte particles in the emulsion to minimize the formation of newton rings in contact printing without using a liquid gate system. The system sensitometry for this internegative is shown in Figure 4-11.

Third generation DP copies from the red record black and white internegatives were made on SO-192 using Redondo Printers, specially equipped 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 red record internegative onto the full range of SO-192, see Figures 4-12 and 4-13. Table 4-11 lists the contrast levels used during 1207-1 and 1207-4.

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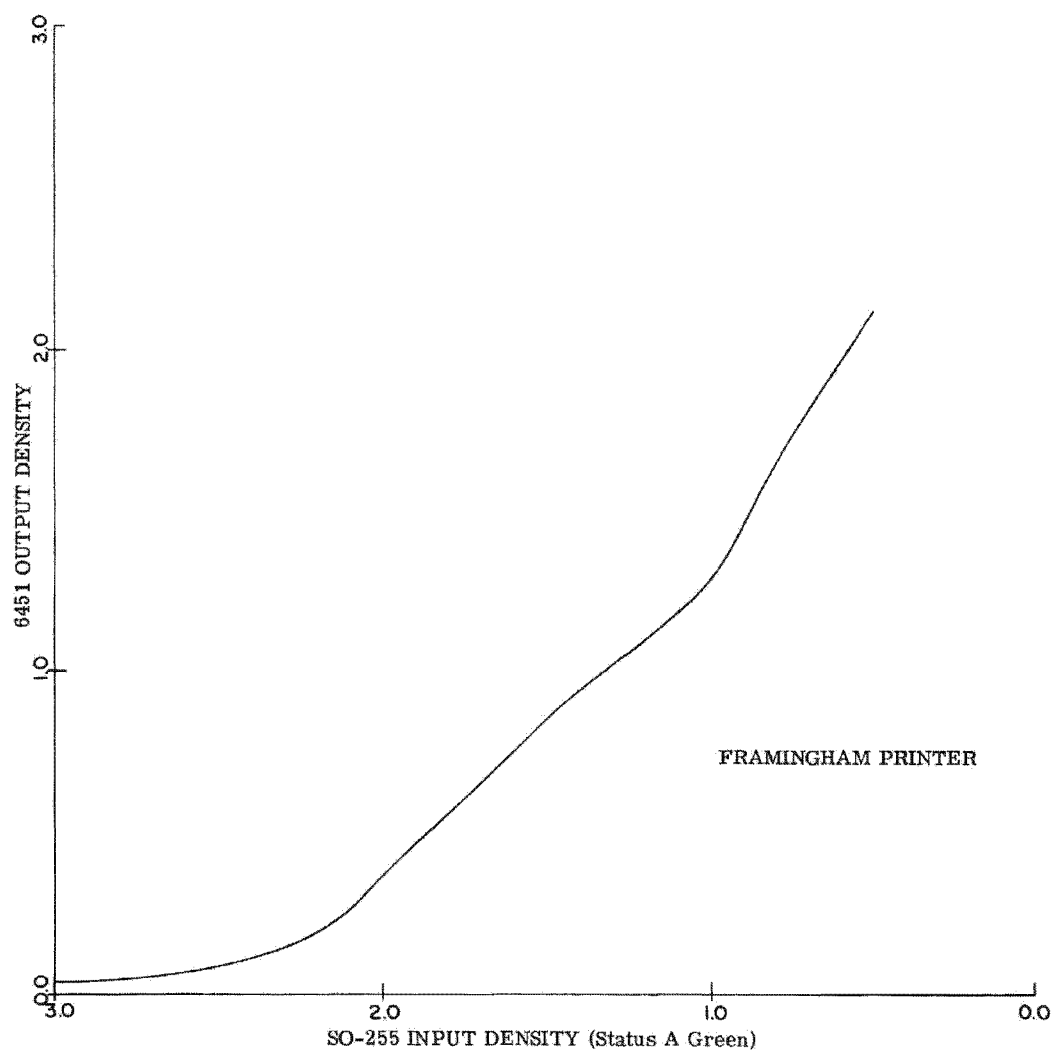
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SYSTEM REPRODUCTION CURVE FOR SECOND GENERATION INTERNEGATIVE



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FIGURE 4-10

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SYSTEM REPRODUCTION CURVE FOR INTERNEGATIVE

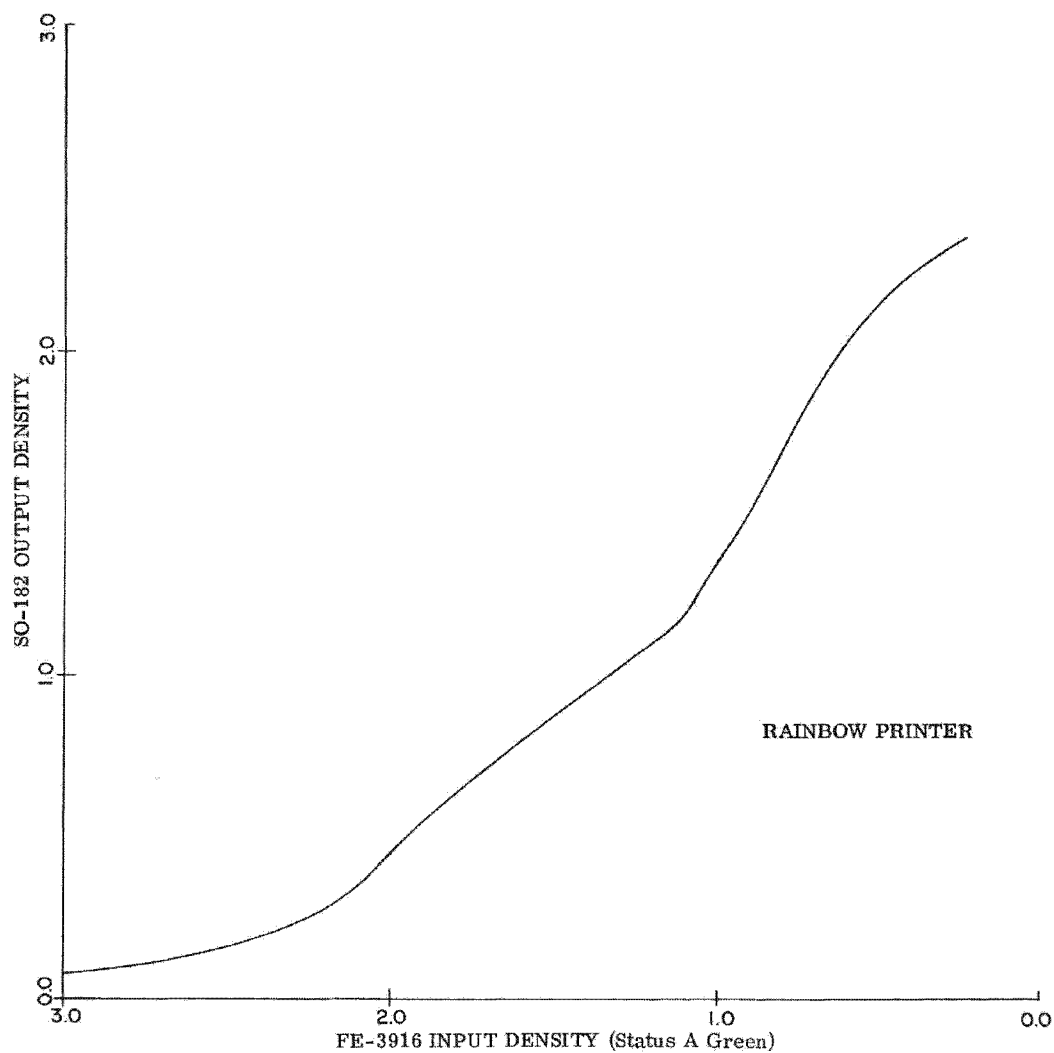


FIGURE 4-11

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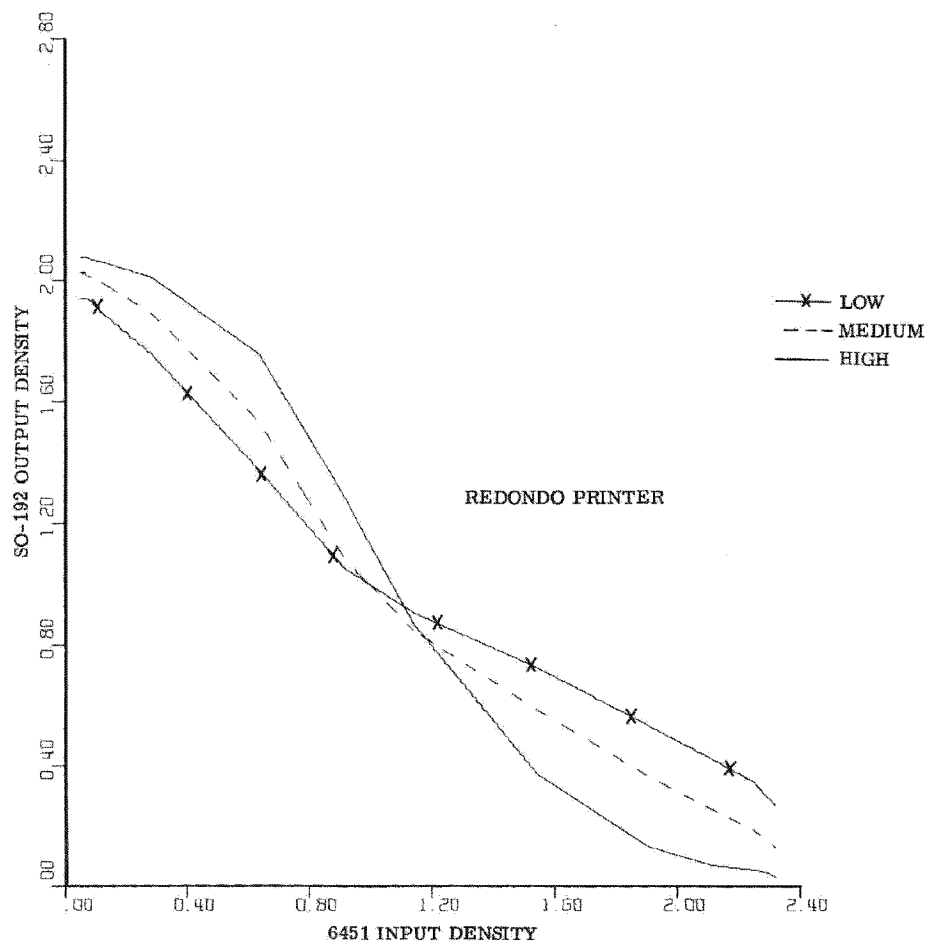
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POST FLIGHT ANALYSIS REPORT

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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION DUPLICATE POSITIVES



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FIGURE 4-12

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POST FLIGHT ANALYSIS REPORT

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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION DUPLICATE POSITIVES

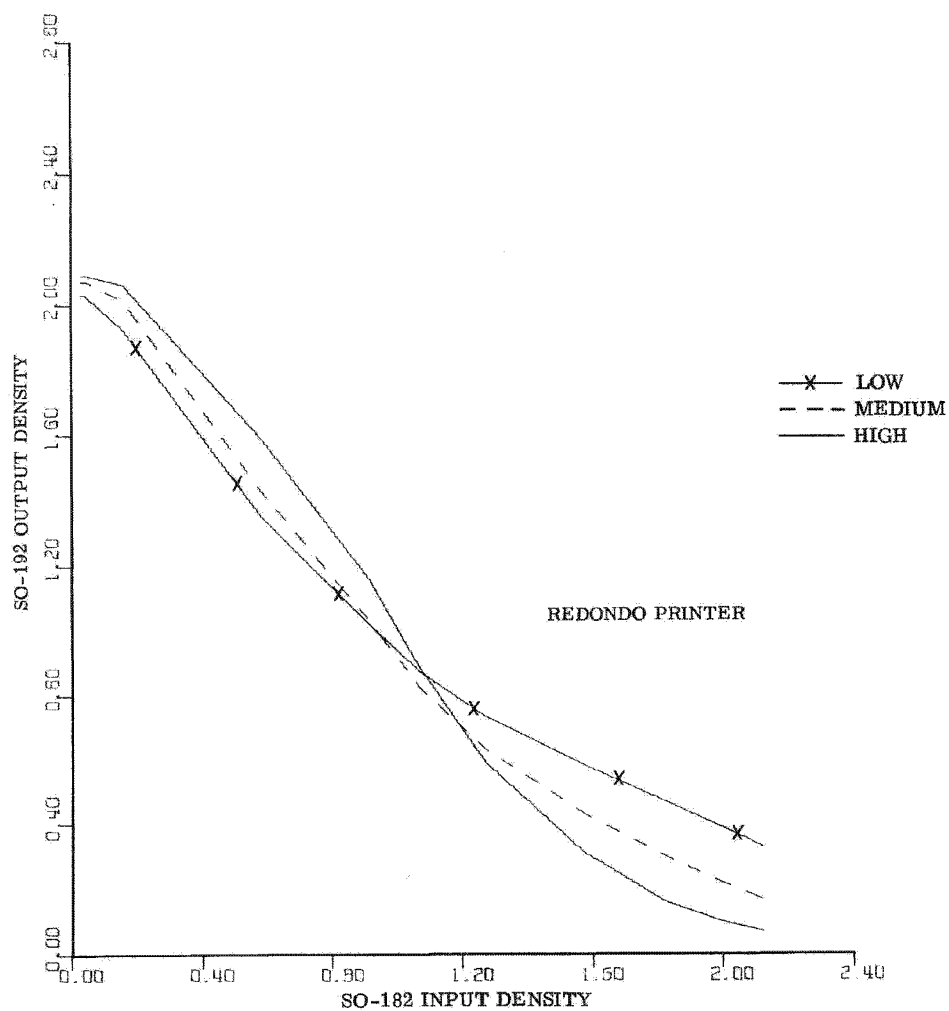


FIGURE 4-13

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TABLE 4-11

CONTRAST LEVELS AT LOW, MEDIUM, AND HIGH

Contrast	Mission 1207-1		Mission 1207-4	
	Parts	(%)	Parts	(%)
Low	38	(68)	2	(29)
Medium	12	(27)	4	(57)
High	2	(5)	1	(14)

Third generation DNs were also prepared from the black and white internegatives using 2422, see Figure 4-14.

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

Since Mission 1202-4, color DP copies from SO-255 color originals have been routinely made using High Definition Ektachrome Film SO-356. The image quality and resolution transfer of the SO-255/SO-356 contact duplicating system has been inherently limited by the spatial quality of SO-356 Color Reversal duplicating film. Aerial Color Print Film SO-287 together with an experimental reversal process (designated E-87-2) was used operationally during Mission 1207 to prepare all color DP copies.

The production of all color DP copies was accomplished using the additive Rainbow Printer. System sensitometry representative of the reproduction of the SO-255 onto Aerial Color Print Film SO-287 used during Mission 1207-1 is shown in Figure 4-15.

Production of all color DP copies from the color IR film were also prepared on Aerial Color Print Film SO-287. To adjust the system reproduction contrast, selective layer pre-flashing of the color print film was performed. This method effectively lowers the upper scale maximum densities and reduces individual layer contrasts. The system sensitometry for these color DP copies are shown in Figure 4-16.

As a result of contact printing the color OP onto SO-287, artifacts similar to newton rings were formed. These artifacts, magenta in hue, were observed on the 1207-4 color DPs in large uniform mid and highlight density areas. Product development efforts are being investigated to minimize the formation of this mottle pattern during contact printing.

4.5.3.3 Color Internegatives

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

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SYSTEM REPRODUCTION CURVES FOR THIRD GENERATION DUPLICATE NEGATIVES

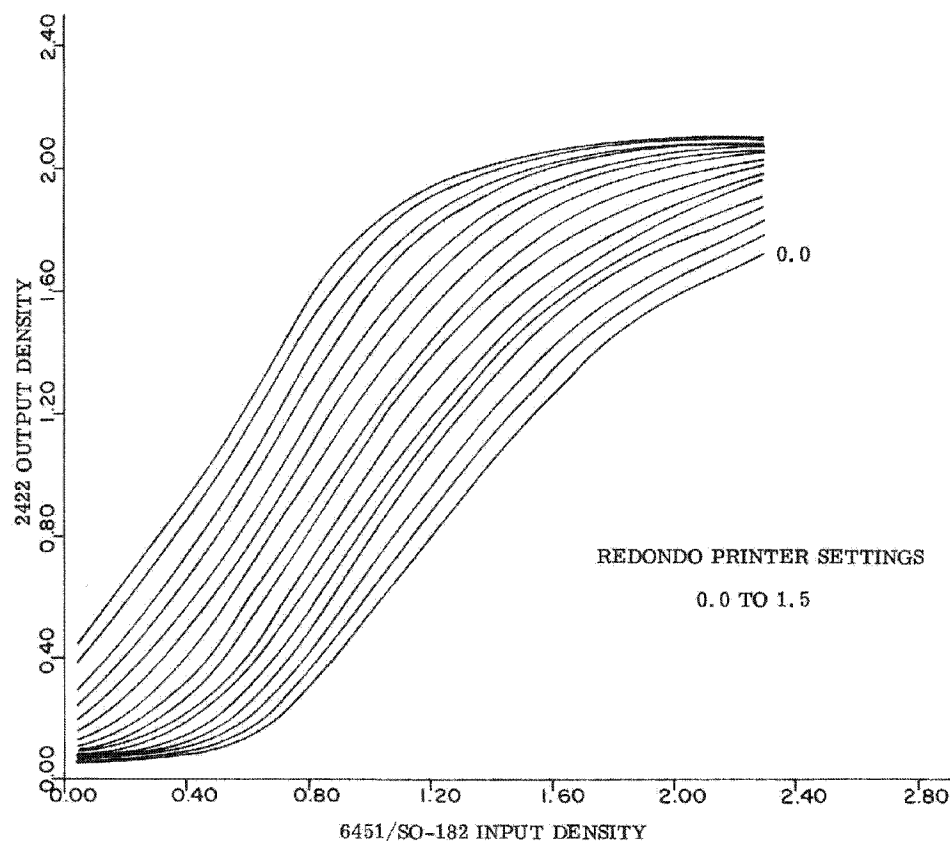


FIGURE 4-14

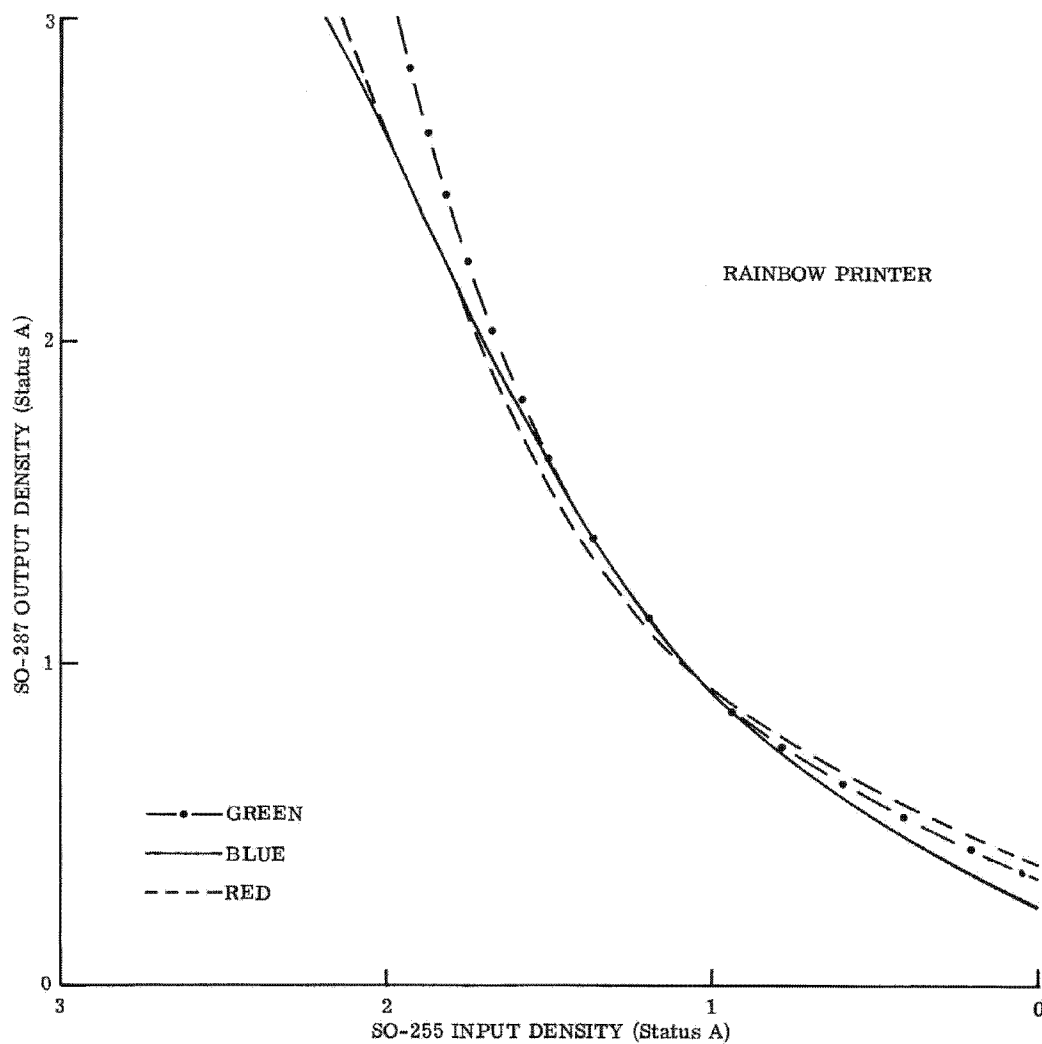
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SYSTEM REPRODUCTION CURVES FOR COLOR DUPLICATE POSITIVES



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FIGURE 4-15

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SYSTEM REPRODUCTION CURVES FOR IR COLOR DUPLICATE POSITIVES

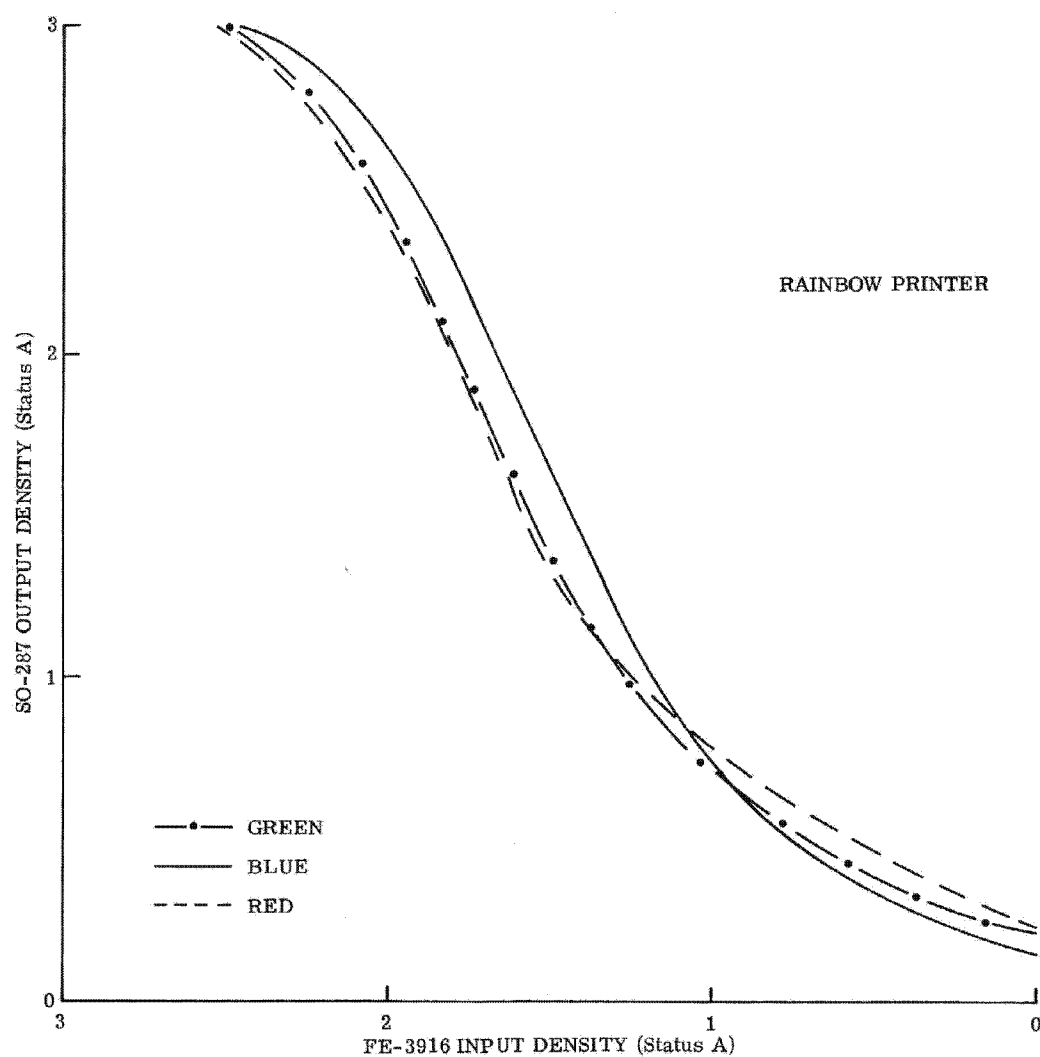


FIGURE 4-16

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The density and color balance of the internegatives are evaluated by means of a Video Color Analyzer, densitometry, and by the production of enlarged "proof" prints onto Ektacolor paper.

4.5.4 Total Footages

The total duplicate footage shipped from BRIDGEHEAD for Mission 1207 is summarized in Table 4-12.

TABLE 4-12

DUPLICATE FOOTAGE SUMMARY

(feet)

Mission Segment	Black and White		Black and White from Color	Color Duplicate Positives	Color Internegs
	Geographic Area & Machine Cuts	Specialized Duplication			
1207-1	840,624	6,155	139,176	26,092	4,604
1207-2	960,152	6,476	-	-	-
1207-3	1,122,827	8,172	-	-	-
1207-4	<u>792,877</u>	<u>174</u>	<u>12,862</u>	<u>3,108</u>	<u>564</u>
Totals	3,716,480	20,977	152,038	29,200	5,168

4.6 REPRODUCTION AT AFSPPF4.6.1 General

Reproduction at AFSPPF consisted of duplicating both Target Complexes and Geographic Areas. Target Complexes are smaller areas of interest within the Geographic Areas. Select frames from operations over these Target Complexes were identified by the Exploitation Subcommittee (EXSUBCOM) of the COMIREX and reproduced by Target Complex number. All master negatives for Target Complex reproductions on Mission 1207 were prepared at BRIDGEHEAD on the Advanced Printers. These printers produce single-copy density corrected negatives on 2422 Direct Reversal Film. After Priority 1 and 2 production requirements were completed at BRIDGEHEAD, the ON was sent to AFSPPF for completion of the Priority 3 Geographic Area requirements.

4.6.2 Target Complex Duplication

Operations over the same Target Complex were assembled in composite rolls up to a maximum of 150 feet. Each composite roll contained only one numbered Target Complex. Customer copies were reproduced as third generation duplicate positives on Kodak High Resolution Aerial Duplicating Film (Estar Base) SO-192. Special reproduction system sensitometry was used in printing SO-192 from 2422. The SO-192 was spray processed to a low gamma standard, see Figure 4-17.

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SYSTEM REPRODUCTION CURVES

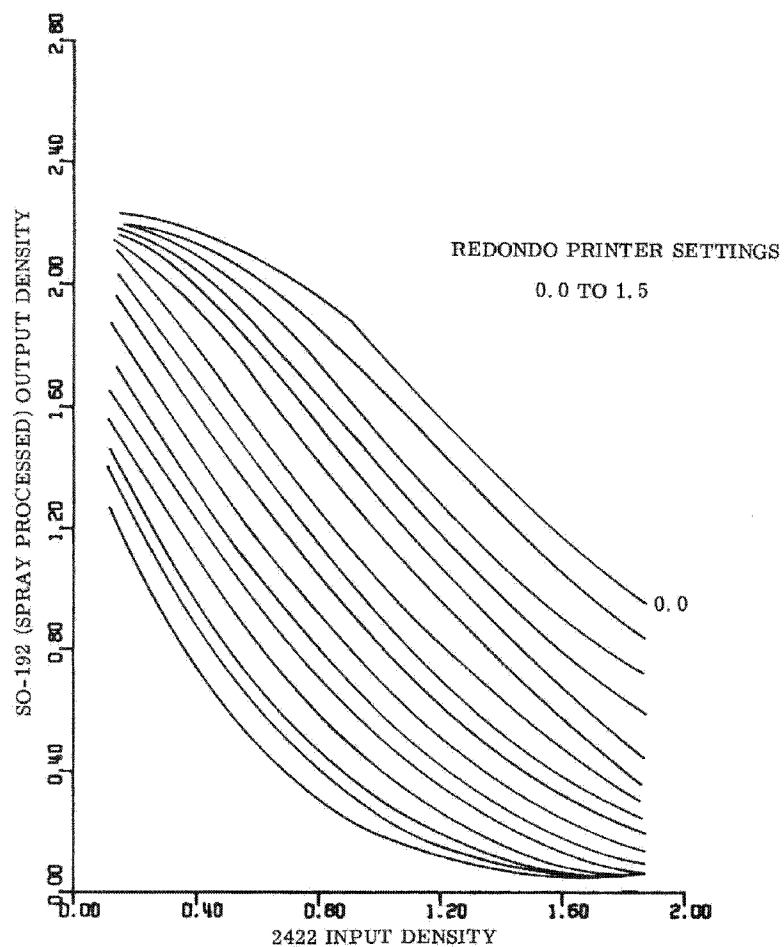


FIGURE 4-17

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12074.6.3 Regular Duplication4.6.3.1 Duplicate Positives

Geographic Area duplicate positives for Priority 3 customers were prepared using SO-192 processed in the spray mode to provide system sensitometry, see Figure 4-18. 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.

TABLE 4-13

AFSPPF DUPLICATE POSITIVE MULTIPLE PRINTING SUMMARY
(number of parts)

<u>Mission Segment</u>	<u>Operational Parts Multiple Printed</u>
1207-1	22
1207-2	17
1207-3	33
1207-4	7

4.6.3.2 Duplicate Negatives

All DN copies for Priority 3 customers were prepared using Kodak Direct Duplicating Aerial Film (Estar Base) 2422 processed in the spray mode to provide system sensitometry, see Figure 4-19. Redondo Printer settings were selected to return the original negative minimum densities to like densities for each op/area on the duplicate negative.

4.6.4 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 1207.

4.6.5 Total Footages

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

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SYSTEM REPRODUCTION CURVES

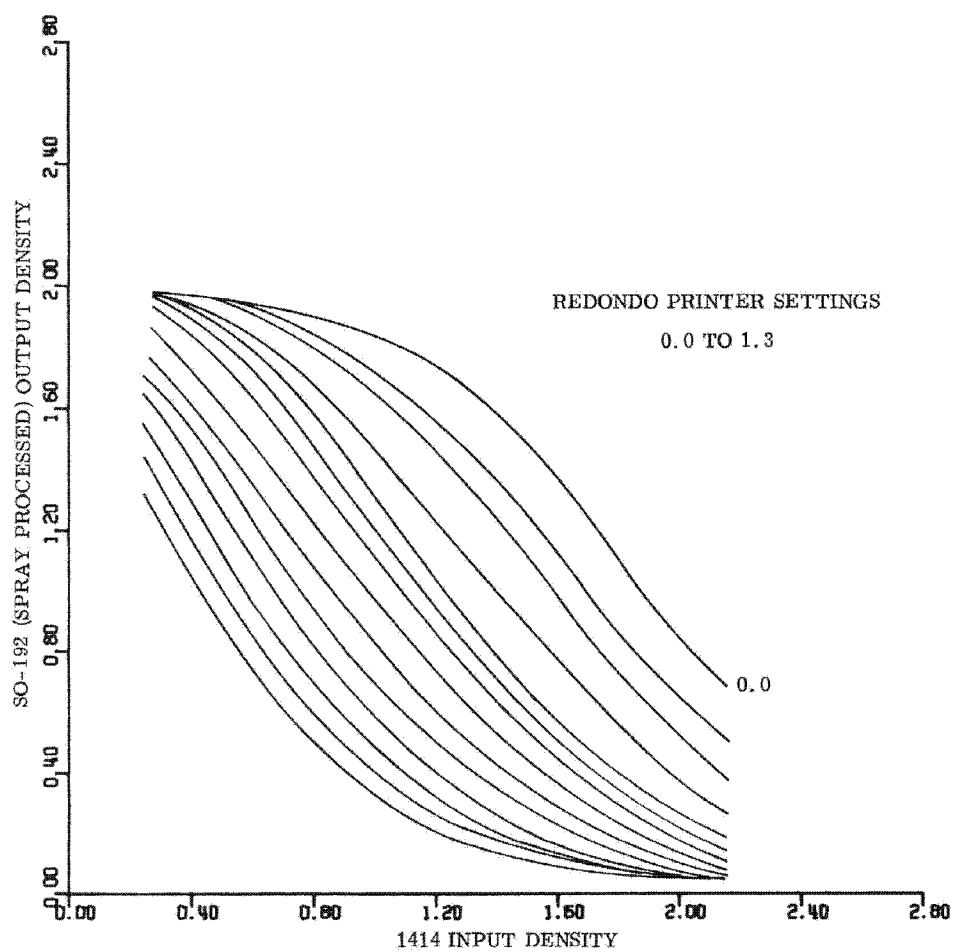


FIGURE 4-18

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4-33

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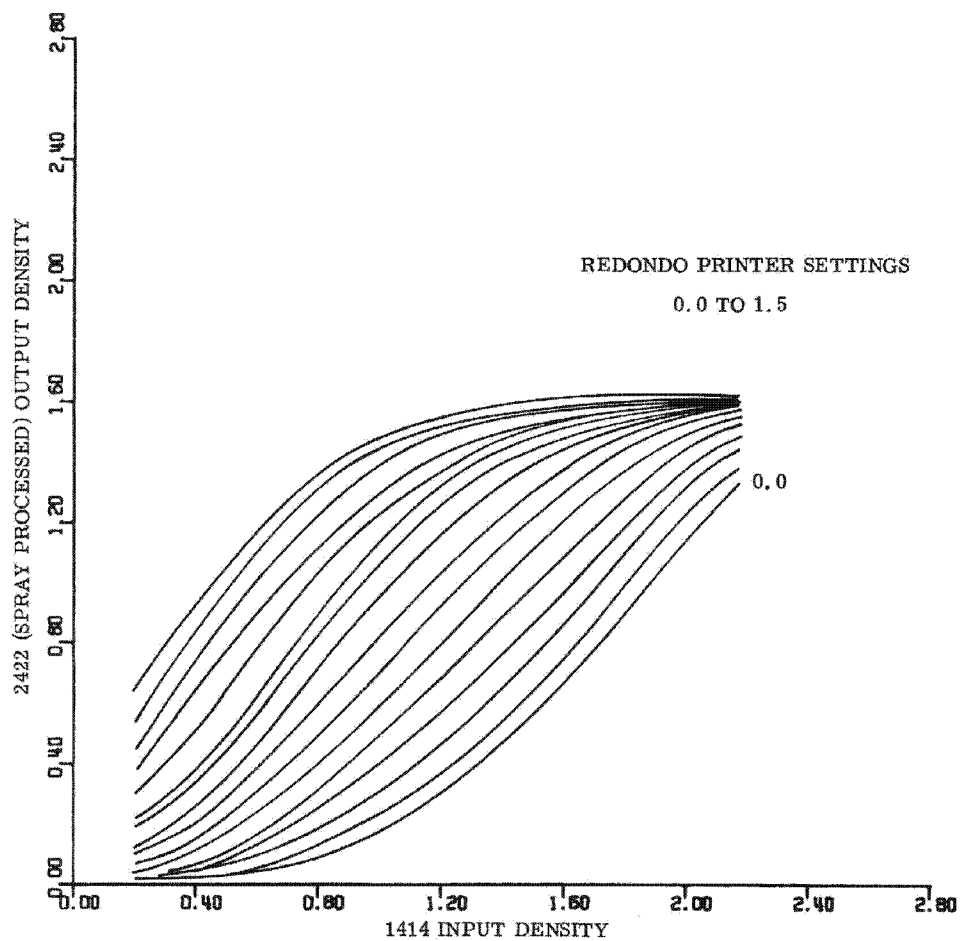
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SYSTEM REPRODUCTION CURVES



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FIGURE 4-19

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TABLE 4-14

AFSPPF DUPLICATE FOOTAGE SUMMARY

(feet)		
<u>Mission Segment</u>	<u>Target Complex</u>	<u>Geographic Area</u>
1207-1	82,405	582,713
1207-2	88,960	619,296
1207-3	122,566	718,878
1207-4	68,713	505,408
Total	362,644	2,426,295

4.6.6 Customers

The following is a listing of customers for 1207 material divided into those who required Geographic Area coverage and those who specified Target Complex coverage.

4.6.6.1 Geographic Area Coverage (Priority 3)

ARMY/SPAD	FICEUR
ARMY/MID	FICLANT
NISC	FICPAC
PACAF/548	USAFE/497
USASSG	CANADA
AF/FTD	DMAAC
UK	
AUSTRALIA	

4.6.6.2 Target Complex Coverage (All Priorities)

NPIC	NISC
DIA	AF/FTD
SAC	USFK
SAMSO	FICLANT
CANADA	USASSG

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4.7 BLACK AND WHITE IMAGE QUALITY STUDY

4.7.1 Resolution Transfer Study

The CORN tribar data collected from the ON, 2DP (BH), 2DP (AFSPPF), 2DN (BH), and the 3DP (AFSPPF) for the HEXAGON missions since 1202 was re-analyzed in this study. A regression analysis procedure was used to compare the resolution transfer, first for all missions given each generation duplicate, and secondly, for the four duplicate generations given each 1200 mission. A simpler, but just as adequate, power function mathematical model was used for this regression. This new model calculates the duplicate resolution change in cycles/mm, i.e., duplicate resolution value minus ON resolution value, regressed as a first order linear function of the ON resolution value. A factor (either mission or generation) was considered significant only when the probability of its coefficients being different from zero exceeded 95 percent.

Figure 4-20 presents the results of the regression analysis for the 2DP (BH) copy. For the 2DP (BH), there is no significant difference between each mission pair (1202/1203, 1204/1205, and 1206/1207). It was also noted that there is no pattern evident in the relationship of the missions.

The results of the regression analysis for the 2DP (AFSPPF) copies are also shown in Figure 4-20. Note that the data from Missions 1205, 1206, and 1207 is the same.

Figure 4-21 shows the same analysis for the 2DN (BH) copies. Note the improvement in resolution transfer from Mission 1202 to 1203, and then to 1204 thru 1207. The data from Missions 1204 thru 1207 show no differences from each other, and are similar in transfer to the two second generation duplicate positives.

Figure 4-21 shows the results obtained for the 3DP (AFSPPF) copies which are made from the 2DN (BH). Missions 1202 and 1203 are equivalent, and an improvement is seen in resolution transfer for Missions 1204 and 1205. Finally, for Missions 1206 and 1207, even though the 2DN (BH) had similar losses to 1204 and 1205, the 3DP (AFSPPF) copies showed large resolution losses.

Figure 4-22 and 4-23 show the results of the second type of regression analysis, where the four generations are compared for each HEXAGON mission. Ninety-five percent confidence intervals are shown about the best estimate of the functions. The ordering of the generations with respect to resolution loss are generally consistent. The two second generation DPs are very close together, except for Mission 1205, where there is an unexplainable low resolution loss in the 2DP (BH). The 2DN (BH) and 3DP (AFSPPF) show larger resolution losses for each given mission than the two second generation duplicate positives.

Table 4-15 summarizes the resolution transfer results at four different ON resolution levels encountered on the duplicates.

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REGRESSION ANALYSIS UTILIZING SECOND GENERATION DUPLICATE POSITIVE

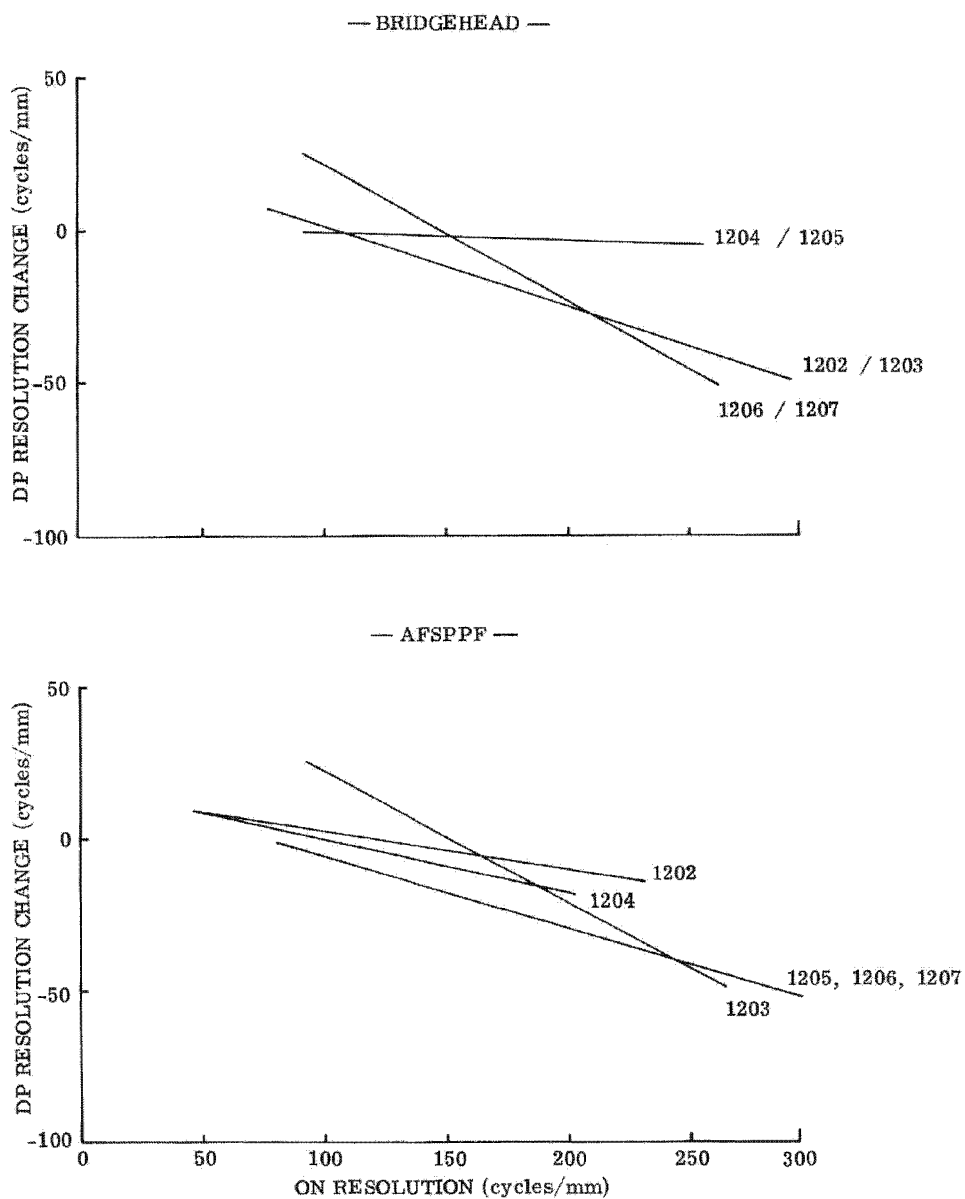


FIGURE 4-20

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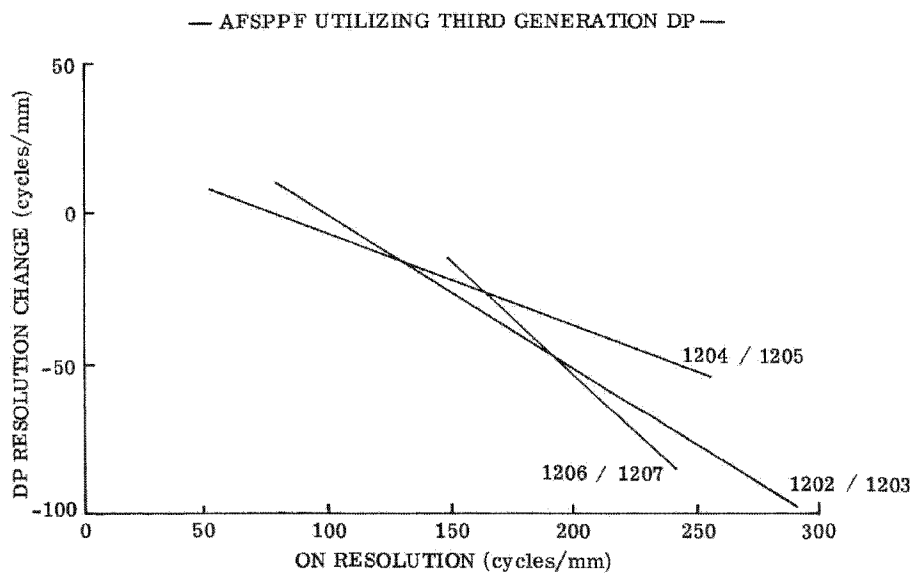
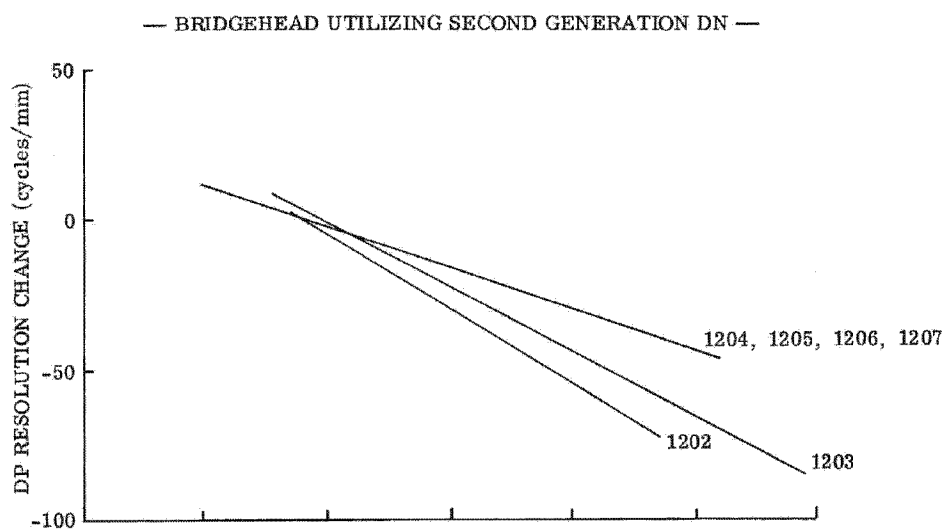
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REGRESSION ANALYSIS



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FIGURE 4-21

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REGRESSION ANALYSIS OF RESOLUTION TRANSFER ON MISSIONS 1202, 1203, AND 1204

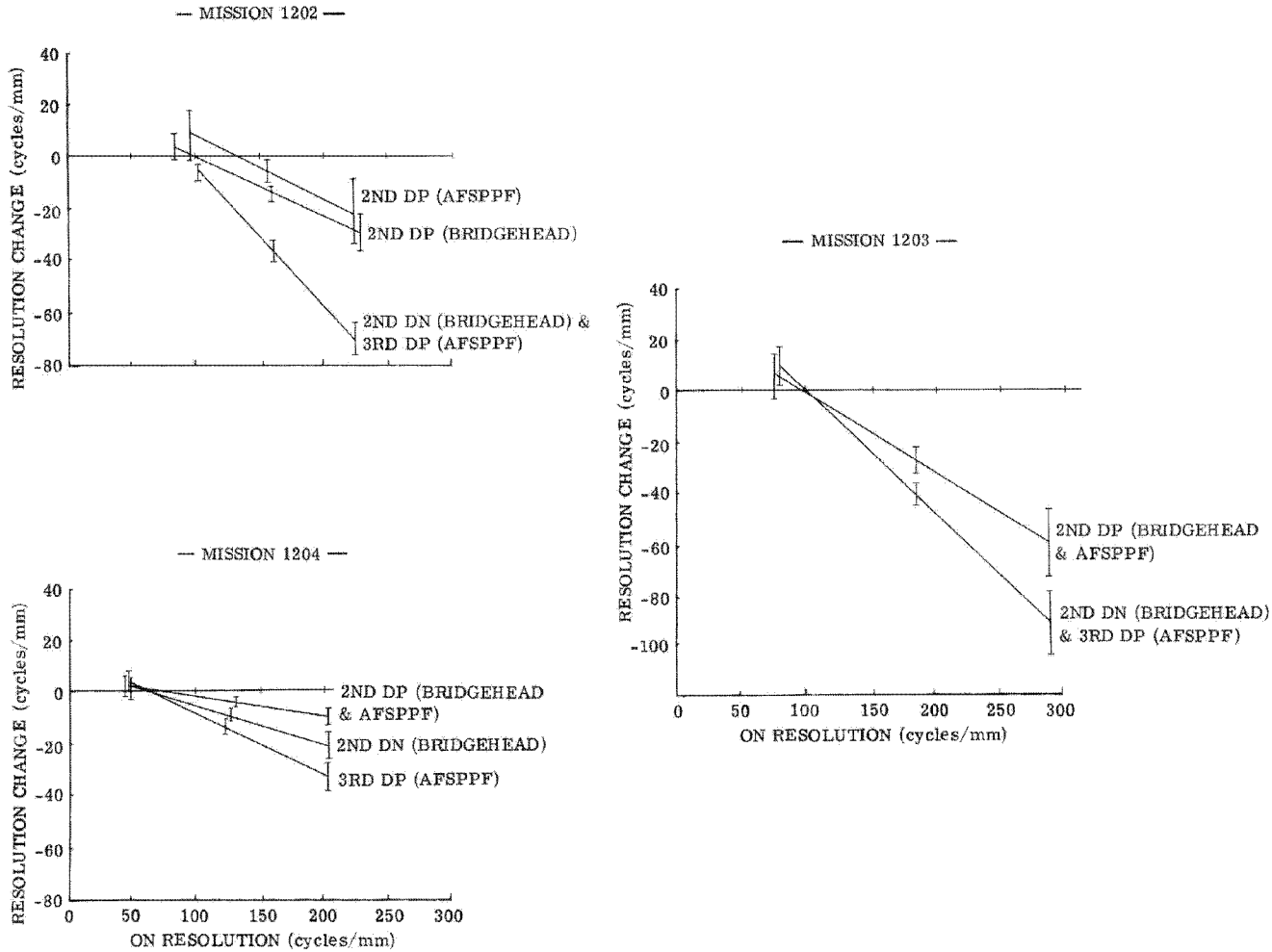


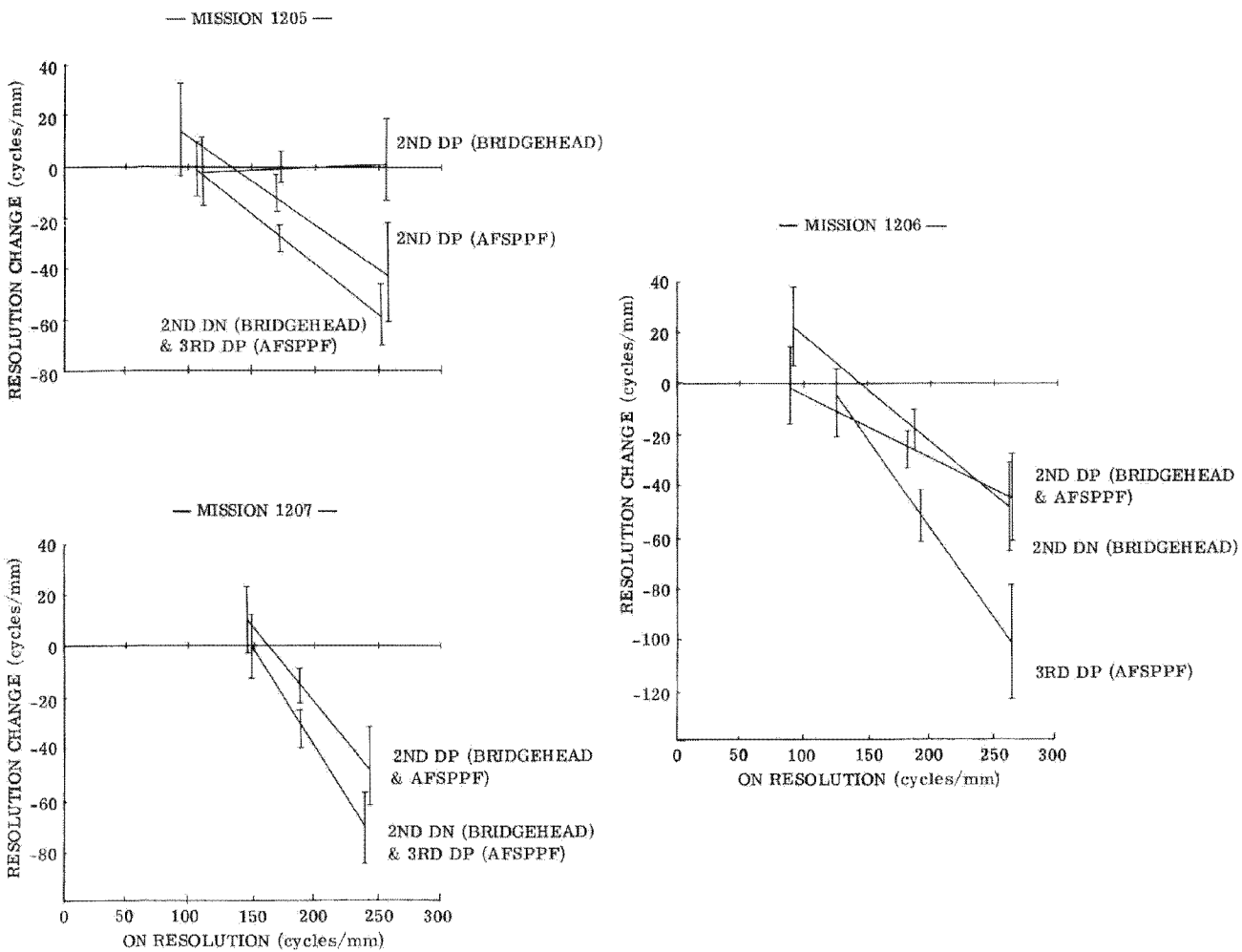
FIGURE 4-22

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REGRESSION ANALYSIS OF RESOLUTION TRANSFER ON MISSIONS 1205, 1206, AND 1207



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FIGURE 4-23

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TABLE 4-15

SUMMARY OF RESOLUTION TRANSFER
(percent change)

Generation (Facility)	ON Resolution (cycles/mm)			
	150	175	200	225
2DP (BH)	+6	-4	-11	-16
2DP (AFSPPF)	+6	-4	-11	-16
3DP (AFSPPF)	-2	-12	-18	-26
2DP (BH)	-2	-12	-18	-26

As shown in Table 4-15, the two second generation DPs show no difference in resolution transfer from each other. Also, the second generation DN and third generation DP show no difference from each other.

4.7.2 Granularity Analysis

A thorough re-analysis of the granularity data collected from all HEXAGON missions was undertaken. The data was derived from microdensitometer traces of the 50' CORN target gray panels. A two micron circular aperture was used for all traces. All the ON granularity versus density data was considered at one time using a stepwise regression analysis procedure "blocking". Using a first order linear mathematical model, it was found that the granularity data from 1202 was different from 1203, and both of these missions were different from Missions 1204 thru 1206 (which can all be considered the same). Figure 4-24 shows the resultant three regression curves with 95% confidence intervals about them.

Taking data from 1202 and Missions 1204 thru 1206 as best characterizing the granularity of the ON mission material up to this mission, Figure 4-25 shows the characteristic response curve of this data compared to the data derived from Mission 1207. There is no significant difference in the Mission 1207 ON granularity data and this characteristic response curve.

4.7.3 Evaluation of the Experimental Second Generation Production4.7.3.1 Duplicate Positive System

On 1207-4, all second generation DPs from BRIDGEHEAD were printed on experimentally modified Redondo Printers. Prior to this change, NPIC evaluated selected operations acquired on 1207-3 which were reproduced on: (1) both SO-192 which was normal gamma viscous processed and the modification, and (2) SO-192 which was printer optically reduced in contrast and then high gamma viscous processed. The following is the result of this evaluation.

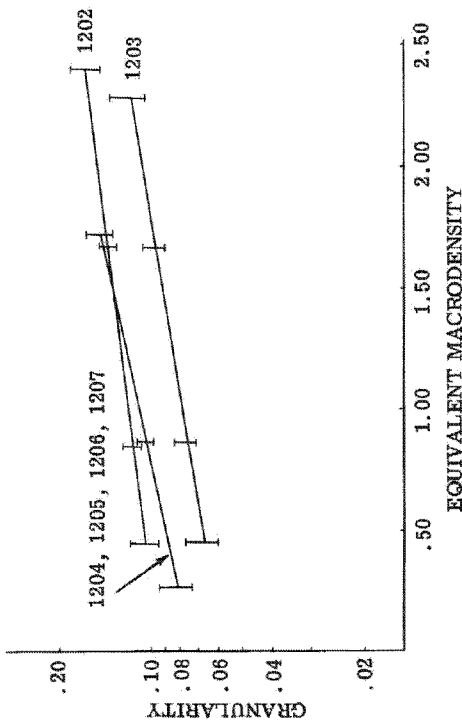
The tone reproduction of the experimental DP system is similar to the old DP system, except for more density in the highlight areas. Figure 4-26 shows the "ON density in/DP density out" data for the

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ORIGINAL NEGATIVE GRANULARITY FOR MISSIONS 1202 THRU 1207



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FIGURE 4-24

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ORIGINAL NEGATIVE GRANULARITY FOR MISSION 1207

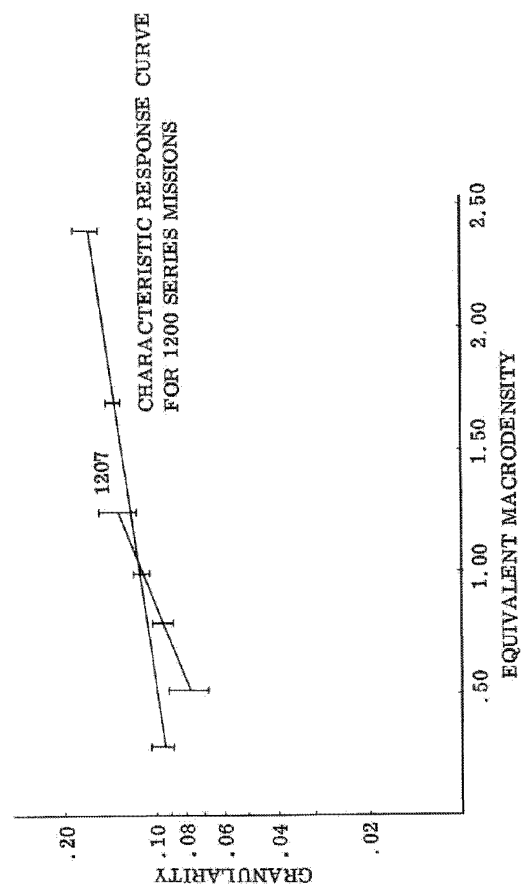


FIGURE 4-25

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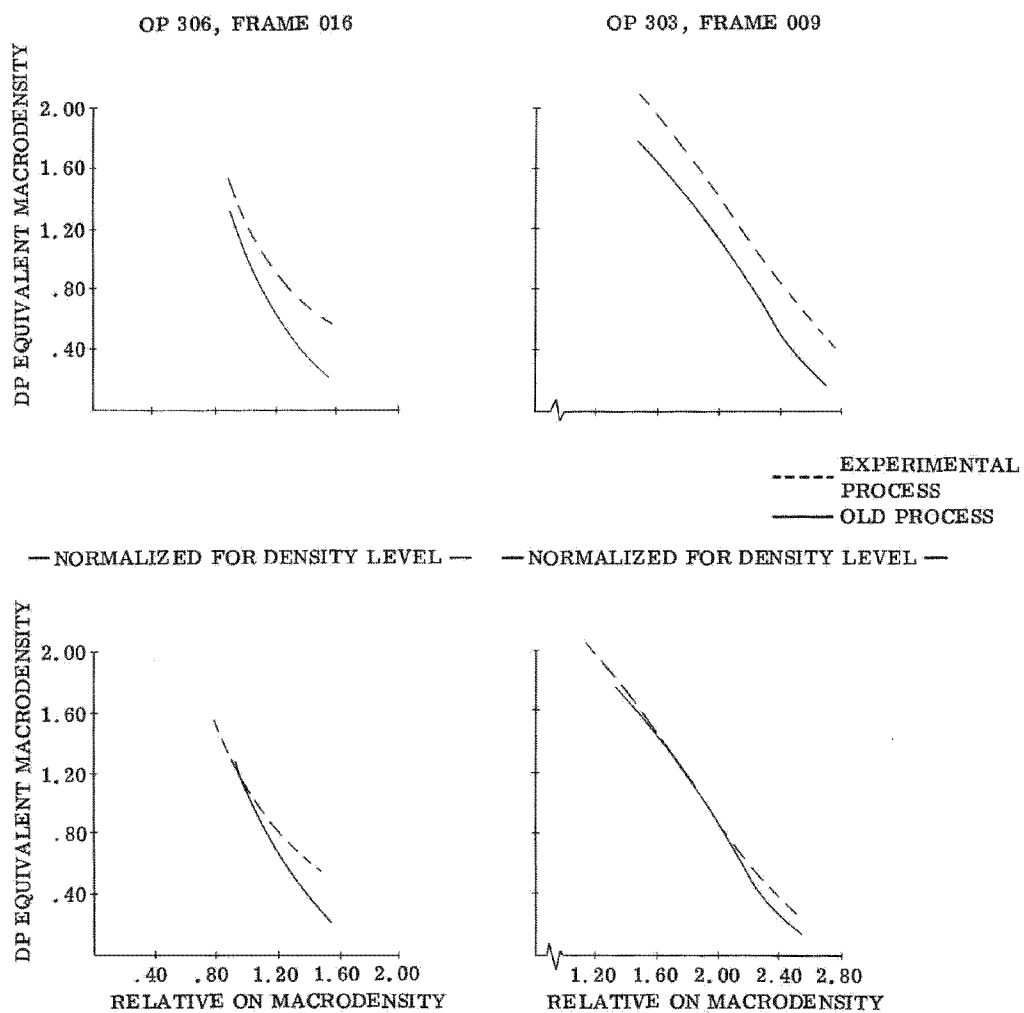
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AFT CAMERA DENSITY COMPARISONS BETWEEN THE OLD AND EXPERIMENTAL 2ND DP
(BRIDGEHEAD) DUPLICATING SYSTEMS

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FIGURE 4-26

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two DP copies. The two lower graphs show the same data, but equalized for printer level setting. Note that the shadow areas (high DP densities) are very similar. The highlight areas (low DP densities) tend to have more density. This has been seen visually to lessen highlight "blooming" on the duplicate positives.

Final detail, of course, is a major concern with any reproduction DP system. A modification in the chemistry and optical printing, as was done here, raises the question of any fine detail reproduction change. Both photointerpreters and experienced photo technologists compared and found no differences in the fine detail structure of the two DP systems.

Based on the acceptability of the tone reproduction and fine detail reproduction of the experimental DP system, as well as favorable photointerpreter comments, this experimental DP system will be implemented as the standard 2DP (BH) reproduction system at BRIDGEHEAD.

4.7.4 Sensitometric Study of Special High Contrast Duplication Positives

In an effort to obtain the maximum information from the ON for the photointerpreter, it is sometimes necessary to expand the tonal range of the ON by using a high contrast SO-192 DP system to produce an "in place of" or an "in addition to" DP. Until 1207-4, the normal DP system was SO-192 Film processing in a normal gamma chemistry. The high contrast DP is SO-192 processed in a high gamma chemistry. Raster scans were made at NPIC using a Mann Trichromatic Microdensitometer with a 1 x 40 micron scanning aperture of a number of target areas specially selected from Mission 1207-1. The ON, a normal contrast DP, and a high contrast DP made for this study were traced. Their density statistics were compared to each other and also to the statistics derived from the sensitometric step wedge exposures.

Figures 4-27 thru 4-29 show three intelligence target areas which were traced. Figures 4-30 thru 4-32 show the "ON density in/DP density out" data derived from their normal and high contrast copies. These curves were obtained by matching the cumulative distributions of ON density values to the reciprocal distribution of DP density values. Two and one half percent of the lowest and highest of the ON density values were excluded from the plots. Table 4-16 lists the useful density ranges (95% of the ON density values) for the ONs and their duplicate positives.

TABLE 4-16

DENSITY RANGES

Op	Frame	Camera	Original Negative	Useful Density Range	
				Normal DP	High Contrast DP
73	009	Forward	0.38	0.43	0.88
74	003	Forward	0.86	0.96	1.58
98	007	Forward	1.63	1.10	1.73

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TONE REPRODUCTION CURVES FOR LOW CONTRAST SCENE

(Forward Camera, Op 73, Frame 009)

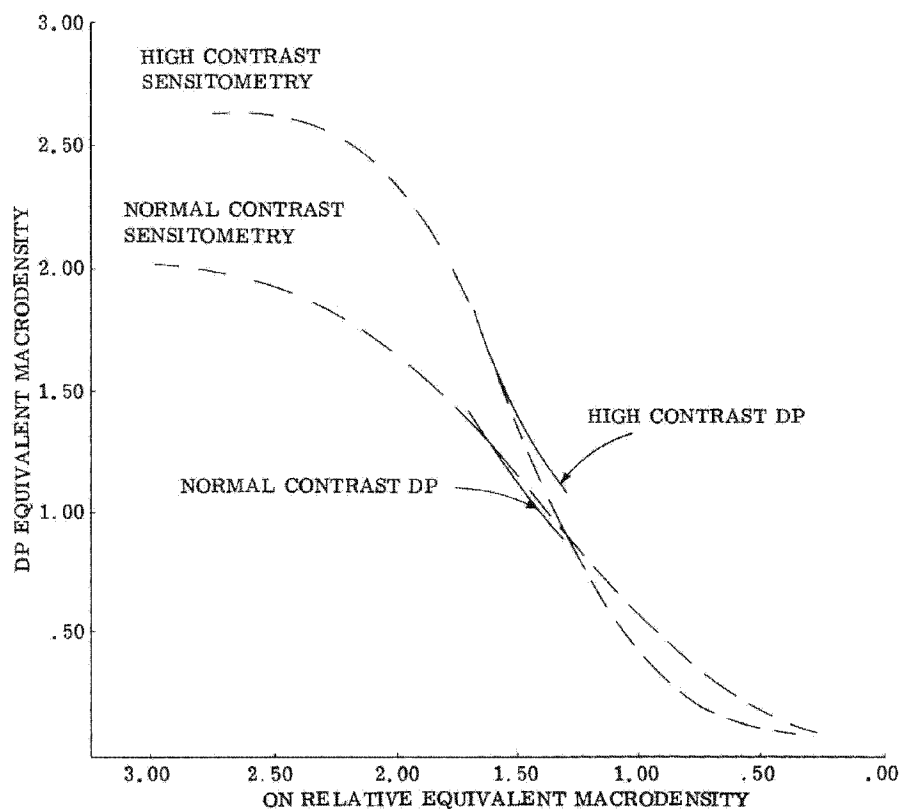


FIGURE 4-30

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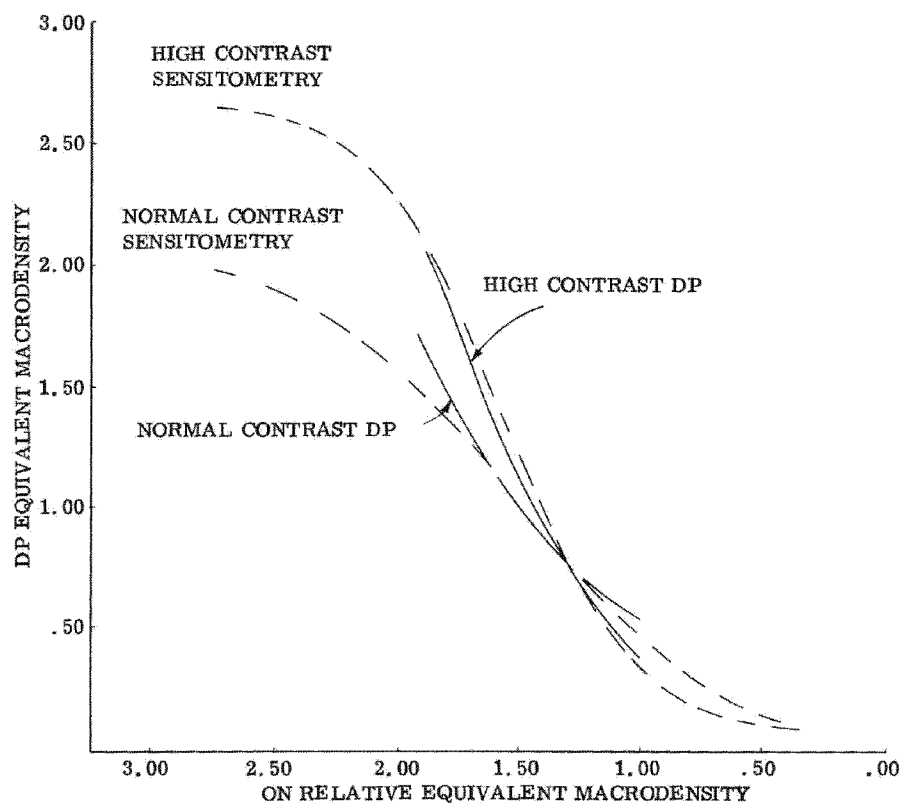
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TONE REPRODUCTION CURVES FOR NORMAL CONTRAST SCENE

(Forward Camera, Op 74, Frame 003)



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FIGURE 4-31

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TORE REPRODUCTION CURVES FOR HIGH CONTRAST SCENE
(Forward Camera, Op 98, Frame 007)

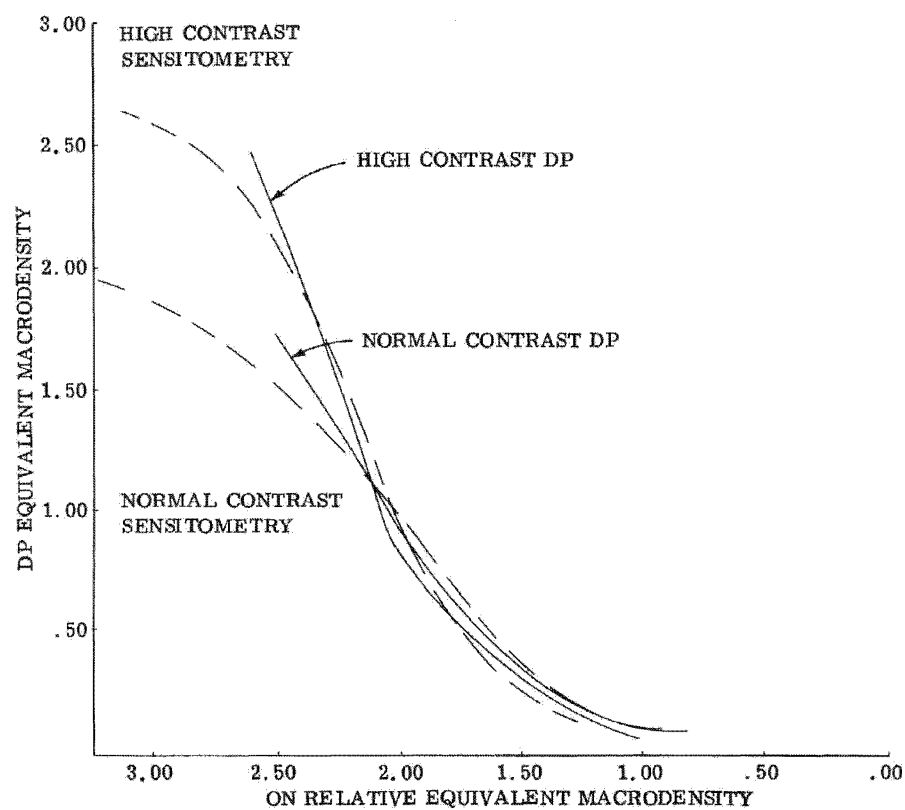


FIGURE 4-32

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The following observations can be made from the density plots in Figures 4-30 thru 4-32 and the data in Table 4-16.

A. The sensitometric "ON density in/DP density out" (and consequently the corresponding macrodensity film printer "system curves") are good indicators of the microdensity distributions derived from actual intelligence target imagery.

B. The ON frames with small density ranges, e.g., .38 for Op 73 Forward Frame 009, do benefit from high contrast duplication, as shown both by visual comparison and by their density statistics.

C. The ON frames with large density ranges, e.g., 1.63 for Op 98, Forward Frame 007, are degraded by high contrast duplication. The density values of the high contrast DP continues far above the maximum density values of 1.80 specified in the NPIC Photographic Reproduction Guidelines, TCS-5752/73. Also, the highlight areas of the scene fall into the "toe" portion of the "ON density in/DP density out" curves, and these density areas may be compressed more than on the normal contrast DP.

D. As a first approximation, an ON microdensity range of .80 appears to be the maximum that can be reproduced on a high contrast SO-192 DP without losing density tones. This agrees well with the BRIDGEHEAD system reproduction curves.

4.8 COLOR IMAGE QUALITY STUDY

4.8.1 Conventional Color

4.8.1.1 Resolution Transfer

Three experienced resolution readers using a threshold resolution criteria read the one 51/51 Tribar Target acquired on 1207-1. The SO-255 OP, SO-356 DP, SO-287 DP, and the black and white green record DP copies were read. There was a substantial improvement in the resolution transfer of SO-287 over the SO-356 DP. The SO-287 Color DP provided 85% transfer compared to 65% when using the SO-356 Color DP (for a color OP input of 141 cycles/mm). The 14% loss for the SO-287 is still considered significant. The green record DP showed no significant loss in resolution transfer.

4.8.1.2 Tone Reproduction

Many photointerpreters complained of an inability, or at least a great difficulty, in seeing some targets on the color DP that were themselves dark (in shadow) or acquired at low sun angles. In addition, some PIs found that lighter objects contained more detail in the SO-287 than the green record DP. For these reasons, six targets were selected for densitometric analysis that were considered difficult to reproduce. Three targets containing subtle highlight detail in the color OP were traced with a 6 micron diameter circular aperture on the OP, SO-356 Color DP, SO-287 Color DP, and the green record DP. Figures 4-33 thru 4-35 illustrate the highlight target (Target 1) which was traced. Three targets were

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also selected that contained subtle shadow detail. These types of subtle shadow detail targets were traced with a 1 x 40 micron slit, with the exception of Target 5, which was traced with a 6 micron diameter circular aperture. These targets were also traced on SO-255, SO-287, and SO-356. Figures 4-36 thru 4-38 illustrate what Target 5 looked like on the different duplicate positives. A visual filter was used for all traces to approximate the visual tone differences that the PI saw when looking through all three layers. Table 4-17 lists the density data derived from these traces. Figure 4-39 illustrates the resultant curves on the Five-Step Gray Scale CORN Target "color OP input/DP output" density data.

The results of the comparison of the tone reproduction films, using the data in Table 4-17, are:

- A. No reproduction retains all the highlight density detail contained in the color OP.
- B. The SO-287 DP provides improved highlight density discrimination over the SO-356 DP or the green record DP.
- C. The green record DP retains less highlight density detail than the SO-287 DP or the SO-356 DP, which may be a result of printing density level.
- D. The green record DP retains more shadow density detail than the SO-287 or SO-356 DPs.
- E. The SO-287 and SO-356 DPs are similar for shadow density detail; however, the SO-287 DP densities are significantly higher than the SO-356 DP. This requires a greater amount of light for the PI to see shadow detail in the SO-287 DP than is presently available in his viewing table.

From these observations, it is concluded that for the PI to get maximum tonal information from 1207-1 imagery, he should have used the SO-287 Color DP for highlight areas and the green record for shadow areas. It is therefore, recommended that:

- A. SO-287 shadow density levels be lowered. It should be noted that this was effectively performed for reproducing the 1207-4 color IR original positive.
- B. Highlight contrast of the SO-287 DP should be maintained at its present level, or raised slightly to improve highlight density detail.

If these two recommendations are successfully implemented, the SO-287 Color DP would have a tone reproduction better than the current green record DP system. In addition, the resolution of SO-287 DP could match the green record DP resulting in an overall color DP of greater exploitation value than the green record DP.

4.8.1.3 Color Balance

Figure 4-40 and 4-41 show system reproduction curves for 1206-4 and 1207-1. Mission 1206-4 had the best representative color fidelity of any HEXAGON color mission segment to date. These system curves illustrate the differences in the resultant color balance of the two DPs. Both have

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TABLE 4-17

TONE REPRODUCTION OF ACTUAL OBJECTS

— TARGET 1 (Highlight Area) —

<u>Film</u>	<u>Subject Density</u>	<u>Background</u>	<u>Density Difference</u>
SO-255	1.10	.65	.45
SO-287	.55	.40	.15
SO-356	.70	.60	.10
Green Record DP	.23	.18	.05

— TARGET 2 (Highlight Area) —

SO-255	1.15	1.55	.40
SO-287	.72	1.00	.28
SO-356	.84	1.10	.26
Green Record DP	.35	.60	.25

— TARGET 3 (Hazy Area) —

SO-255	1.10	.70	.40
SO-287	1.35	1.02	.33
SO-356	1.25	1.07	.18
Green Record DP	.83	.25	.58

— TARGET 4 (Shadow Area) —

SO-255	2.52	2.70	.18
SO-287	3.50	3.00	.22
SO-356	2.80	3.72	.20
Green Record DP	1.55	2.05	.50

— TARGET 5 (Shadow Area) —

SO-255	2.35	2.50	.15
SO-287	3.45	3.65	.20
SO-356	2.90	3.10	.20
Green Record DP	1.75	2.10	.35

— TARGET 6 (Hazy Area) —

SO-255	1.22	1.27	.05
SO-287	1.29	1.36	.07
SO-356	1.30	1.38	.08
Green Record DP	.74	1.00	.26

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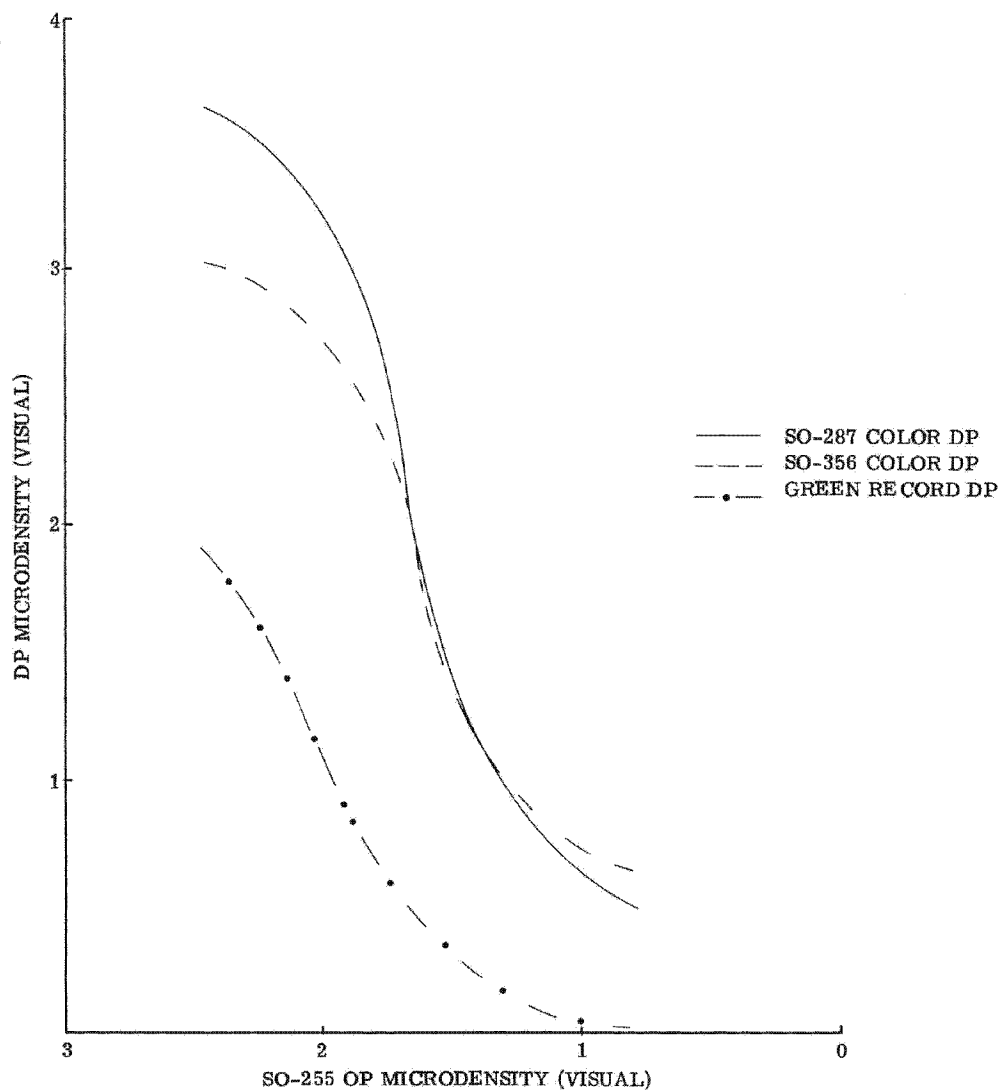
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ORIGINAL POSITIVE/DUPLICATE POSITIVE TONE REPRODUCTION CURVES

FROM FIVE-STEP GRAY SCALE

(Aft Camera, Op 69, Frame 003)



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FIGURE 4-39

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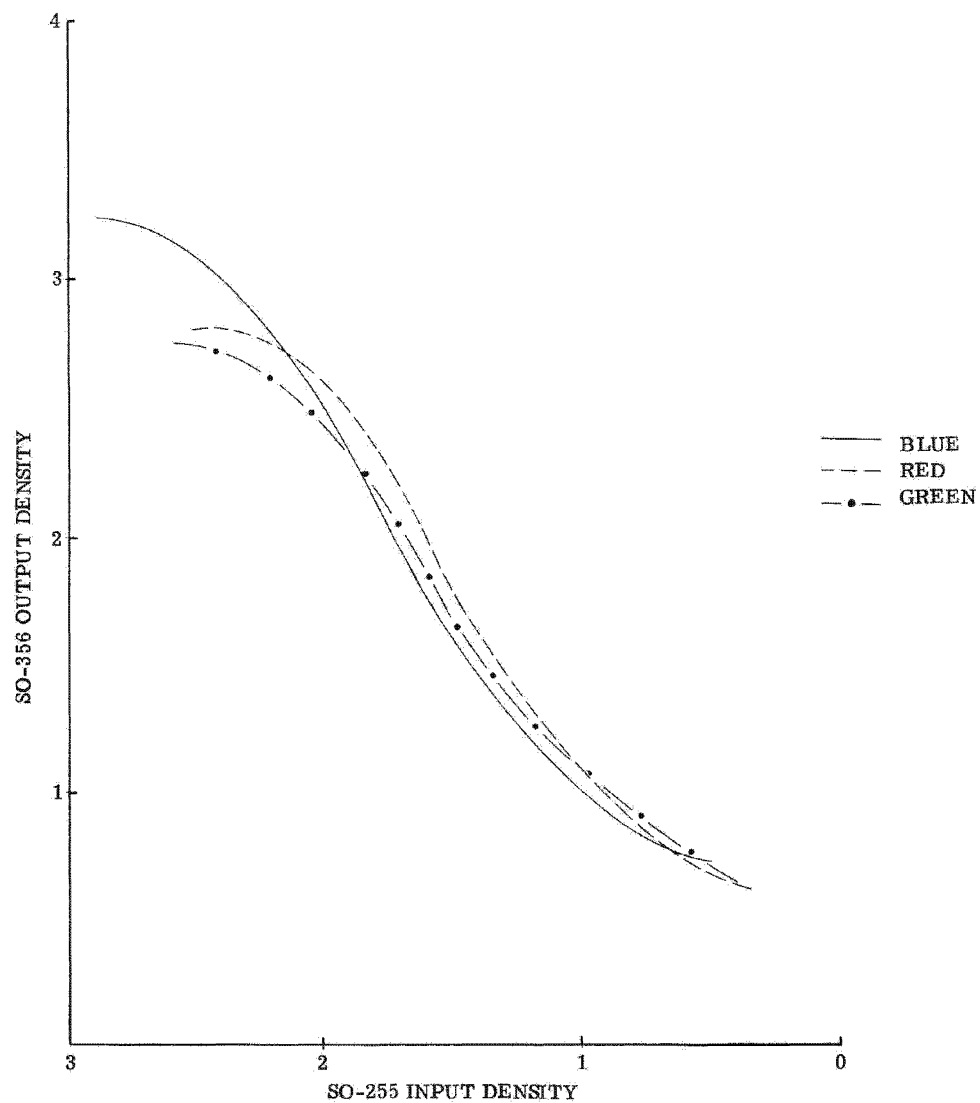
MISSION SEGMENT 1206-4 SYSTEM REPRODUCTION CURVES FOR
SO-255 ONTO SO-356

FIGURE 4-40

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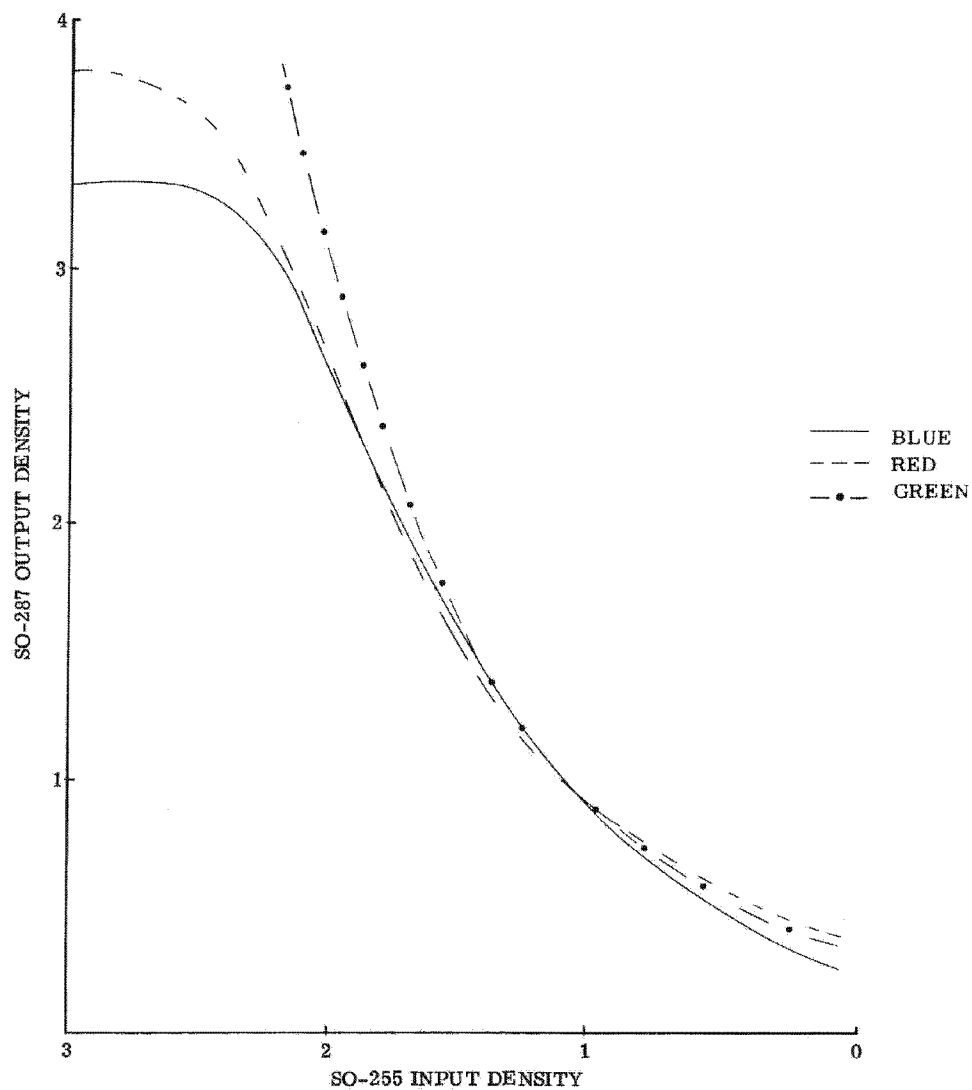
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MISSION SEGMENT 1207-1 SYSTEM REPRODUCTION CURVES FOR
SO-255 ONTO SO-287

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FIGURE 4-41

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individual layer contrast mismatches. The SO-287 Color DP, however, has a much greater contrast mismatch in the shadow area. The green sensitive layer shadow slope is too high compared to the red and blue sensitive layers. The printing of the color DP for neutral highlights, and the high green contrast caused the shadow areas to appear "purplish". The highlight areas of the curves are more nearly parallel for 1207-1 compared to 1206-4. This indicates that the SO-287 DP reproduces neutral highlights more accurately than the SO-356 DP.

4.8.1.4 Subjective Assessment

To see if the 1207-1 resolution data is truly representative of the capabilities of SO-287 for PI related tasks requiring high resolution, a sampling of operational imagery was selected for a paired comparison test between the SO-287 and SO-356 Color DPs. From this study, it was concluded that the SO-287 Color DP was superior to SO-356 in the following areas: (1) small object detection, (2) large object detection, (3) recognition, and (4) detection in highlights.

For the task of detection in shadows, both color DP copies were considered poor. The higher density level of SO-287 was thought by the PIs to be degrading factor with the scope/viewer equipment used in this test.

Color fidelity for both SO-287 and SO-356 was considered poor. The SO-287 DP shadows were found to be excessively purple; however, the highlights of SO-287 were found to be nearly neutral.

4.8.2 Infrared Color

There were 501' of Color Infrared Film Type FE-3916 acquired in 1207-4. SO-287 was the duplication material used for making color DPs using the special pre-flashing system to adjust system reproduction. The black and white internegative material was SO-182. The internegative was printed from the red record layer (magenta dye layer) onto SO-192. The black and white copies from the FE-3916 DP are, therefore, termed red record duplicate positives.

4.8.2.1 Resolution

Three experienced resolution readers using a threshold criteria, read the 51/51 Tribar Target acquired on the 1207-4 IR material. The color OP, the color DP, and the red record DP copies were all read.

The two reproduction systems provided no significant loss in resolution transfer. This was attributed to the lower spatial quality, i.e., resolution level, of the IR color OP and the high spatial qualities of the two reproduction systems.

4.8.2.2 Color Balance

The color balance of the FE-3916 OP was an overall cyan. Figure 4-4 shows that the slope of the red sensitive layer color OP is lower than either the green or IR sensitive layers. This process sensitometry compensates for the high IR ground reflectance, and may have resulted in the overall cyan cast.

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4.8.2.3 Tone Reproduction

Four targets were selected which were considered difficult to reproduce because of either subtle highlight or subtle shadow detail. These targets were traced on a Mann Trichromatic Microdensitometer using a 6 micron circular aperture and employing the visual filter. The targets were traced on both the SO-287 DP and the red record DP. Figures 4-42 thru 4-45 illustrate two of the targets which were traced. Table 4-18 presents the resultant density data.

TABLE 4-18

TONE REPRODUCTION OF ACTUAL OBJECTS

<u>Target</u>	<u>Duplicate Positive</u>	<u>Subject</u>	<u>Density Background</u>	<u>Density Difference</u>
1	Infrared	0.80	0.60	.20
	Red Record	0.60	0.35	.25
2	Infrared	0.65	0.60	.05
	Red Record	0.50	0.40	.10
3	Infrared	2.00	1.70	.30
	Red Record	1.25	1.75	.50
4	Infrared	2.30	2.50	.20
	Red Record	1.25	1.60	.35

It can be noted from the data that the red record DP was slightly better than the SO-287 DP for reproducing both highlight and shadow detail. The improved highlight/shadow density reproduction of the red record DP is a result of the change in print density level criteria implemented during 1207-4.

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SECTION V

EXPLOITATION SUITABILITY

5.1 INTRODUCTION

This section contains an evaluation of the exploitation suitability of Mission 1207. Included in the evaluation is an analysis of the black and white, color, and IR color acquisitions.

An analysis is also included which compares the intersected ground positions derived from data base attitude as reported in the MPR and nominal attitude.

Mission 1207 marked the introduction of the revised version of the National Imagery Interpretability Rating Scale (NIIRS). A primary purpose of the NIIRS is to obtain from the photointerpreters a judgment as to the interpretability of an acquired image. The NIIRS was used by NPIC photointerpreters to rate over 7,000 targets on Mission 1207. NIIRS data as a function of the different acquisition conditions of weather, photo scale, obliquity, and solar elevation were analyzed. Although there was a large variability in the NIIRS ratings for a given acquisition condition, averaging did establish a trend between interpretation suitability of the imagery and the acquisition conditions.

5.2 SUMMARY

5.2.1 Black and White

PI comments indicate that the suitability of the black and white photography from Mission 1207 was average. The NIIRS ratings have confirmed the relationship of the interpretability of a photograph and the basic acquisition conditions of weather, photo scale, obliquity, and solar elevation.

5.2.2 Color

The introduction of color duplicate positive Film Type SO-287 has resulted in an improvement in the exploitation capability from this type of reproduction. The most significant factor in this improvement was attributed to improved resolution. The image quality of the color DP is still lower than the black and white DP. Many of the PIs, however, still state that occasional color coverage of their targets is beneficial. The following problem areas were noted by photointerpreters: (1) poor tone reproduction and (2) poor color fidelity. The PIs engaged in the wheat yield study were unable to use the SO-287 for their readout; therefore, a copy was made utilizing SO-356 for this purpose.

No noticeable differences were noted between the 1206 and 1207 green record duplicate positives. The percentage of PIs favoring the green record over the color DP was lower than previous missions employing color because of the resolution improvements.

For military intelligence related targets, the PIs expressed two concerns relative to the infrared (IR) color DP: (1) poor resolution and (2) poor acquisition conditions. The PIs engaged in the wheat study preferred the IR over the black and white DP.

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12075.2.3 Geodetic Positioning

An evaluation of MPR attitude data again indicated that data base attitude was a better estimator of vehicle orientation than nominal attitude.

5.3 INTERPRETABILITY

5.3.1 Black and White Interpretation Suitability

The quality of the 1207 imagery has been assessed for intelligence purposes by a new version of the method known as the National Interpretability Rating Scale (NIIRS). The previous manner of rating imagery as Excellent, Good, Fair, or Poor was replaced by the initial version of the NIIRS on Mission 1203, and by the expanded version on 1207.

In applying the NIIRS, the photointerpreter is asked to assign a rating number based on what tasks he can do and which items he can see. The acquisition conditions encountered are taken into account in making this judgment. Every image does not necessarily contain the information needed to do all, or perhaps even any, of the specific tasks. It may not even contain any of the specific items of intelligence interest mentioned in the scale. When these specific items of intelligence are not present in the image, the photointerpreter assigns a rating by judging what tasks he thinks he could do or what items he thinks he could see on imagery of that quality.

The NIIRS categories range from 0-9 and are related to objective measures of image quality. A 0-rated image is unsuitable for photointerpretation due to obscurity, degradation, or very poor resolution. The correlation between NIIRS ratings of operational imagery by experienced photointerpreters and GRD is currently under study.

The photointerpreter rates the imagery with the aid of a manual which includes a series of standard images and descriptive terms relating to intelligence exploited from photography of different quality. Table 5-1 lists examples from the manual which describe the type of intelligence that can be derived from different quality photography of naval targets.

TABLE 5-1

NIIRS CRITERIA FOR NAVAL TARGETS

(Partial Listing)

<u>Rating</u>	<u>Interpretability Criteria</u>
1	Detect a port facility by identification of piers and warehouses.
2	Identify a large ship at a port; identify a drydock at a port.
3	Identify a ship as either a cruiser or destroyer by relative size and hull shape.

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TABLE 5-1 (CONT'D)

<u>Rating</u>	<u>Interpretability Criteria</u>
4	Identify a KRESTA I by the helicopter platform flush with the fantail; identify a KRESTA II by the raised helicopter platform (one deck level above fantail and flush with main deck).
5	Detect RBV installations, major electronics, and surface-to-air missile launchers on a KARA CLGM.
6	Identify a ROMEO-Class submarine by the presence of the cowlings for a snorkel induction and the snorkel exhaust; identify a WHISKEY-Class submarine by the absence of the cowlings and exhaust.
7	Identify the general configuration of an SSBN/SSGN submarine sail, to include relative placement of bridge, periscope(s), and main electronics/navigation equipment.
8	Identify the configuration of major components (screens, feeds, and mounts) of larger electronics equipment on a KRESTA II (e.g., components of HEAD NET C, HEAD LIGHT A or B, and TOP SAIL) and identify smaller electronics by type
9	Identify in detail on a KINDEN DDGS the configuration of torpedo tubes and AA gun mountings (including gun details).

Although these specific items are not in all naval scenes, the PI is able to relate these types of quality to all naval targets. There are similar guides for air, ground, missile, and electronic type targets.

Table 5-2 presents the overall percentages of targets per NIIRS category for each RV of Mission 1207. Note that there were no targets rated 0, 7, 8, or 9, and that most of the photography from Mission 1207 was rated between 2 and 5. Figures 5-1 and 5-2 are examples of 2 and 5 rated imagery from the NIIRS manual.

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TABLE 5-2

SUMMARY OF NATIONAL IMAGE INTERPRETABILITY RATINGS
(percent)

Rating	1207-1	1207-2	1207-3	1207-4	1207 Average
1	0.2	0.5	0.2	0.5	0.3
2	4.6	8.3	7.1	8.0	6.7
3	39.6	40.3	32.3	40.1	37.1
4	43.2	39.2	48.6	43.2	44.3
5	12.3	11.3	11.5	8.0	11.3
6	0.1	0.2	0.3	0.1	0.3

Approximately 10,000 targets of all priorities are read out in stereo by NPIC for each 1200 Series mission. Due to software and time constraints, only the Priority A and B OAK Targets have been used for suitability evaluation in the past. The number of Priority A and B OAK Targets rarely exceeded 2,000. However, aided by the longer on-orbit lifetime and new analysis computer programs, a NIIRS rating evaluation was accomplished on approximately 7,000 targets from 1207. These are stereo readouts of OAK and OAK Supplement Targets. Due to the fact that the targets evaluated are stereo readout, no comparison of Forward and Aft Cameras was possible. The NIIRS is not system or requirement dependent like the old Excellent, Good, Fair, and Poor method. Due to this change in rating the photography, a comparison of the NIIRS of 1207 to the Excellent, Good, Fair, and Poores of past missions was not attempted. However, it should be noted that when the PIs were asked to subjectively compare 1207 to other missions, most considered it to be average.

The location of targets is such that some operations have a higher concentration of targets than others. This must be kept in mind when comparing the NIIRS ratings to camera performance trends, which sometimes deal only in film distribution and not target distribution. Figure 5-3 shows the distribution of targets and film for the mission as a function of geographic latitude. It can be seen that there are latitudes where a small percentage of the exposed film produced a significant portion of the priority targets from the mission. Photography from 35°N to 40°N latitude was responsible for 9% of the exposed film and 32% of the priority targets.

In the following sections, a comparison will be made between the NIIRS values and the target acquisition conditions of weather, obliquity, scale, and solar elevation. This is done in order to confirm the basic relationships that are thought to exist between acquisition conditions and exploitation suitability.

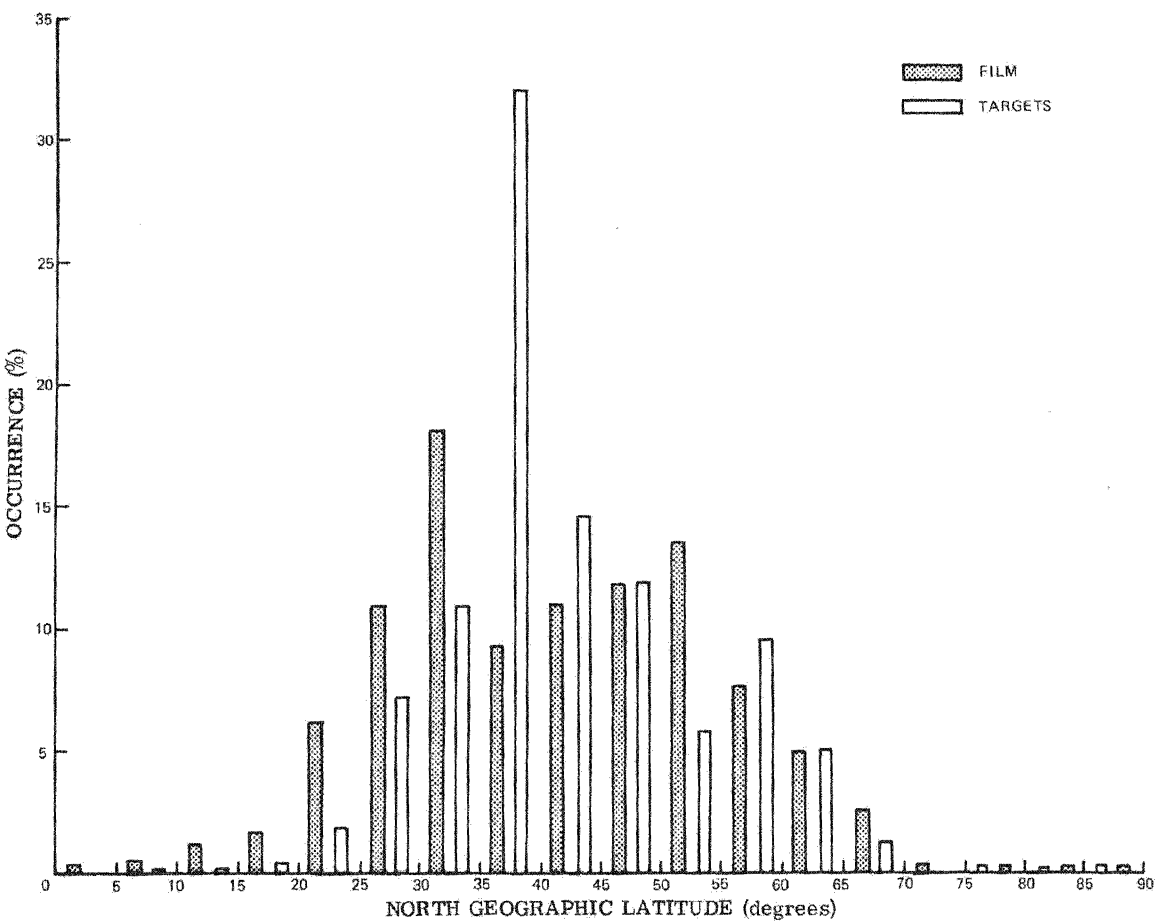
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GEOGRAPHIC LATITUDE DISTRIBUTION OF TARGETS AND FILM USAGE FOR MISSION 1207



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FIGURE 5-3

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5.3.1.1 Weather Versus NIIRS

As in previous 1200 Series missions, weather was one of the major quality degradation factors. Using the NIIRS data, imagery of similar weather categories was pooled together to find what effect these degrading factors have on interpretability. The targets were divided into four basic categories: (1) clear weather, (2) cloud cover, (3) haze, and (4) snow. The average NIIRS values for targets of these categories are presented in Table 5-3. The total of the percentage figures exceeds 100% because some targets are included in more than one category.

TABLE 5-3
AVERAGE NIIRS RATING FOR ALL WEATHER CATEGORIES

<u>Weather Condition</u>	<u>Average NIIRS Rating</u>	<u>Targets (%)</u>
Clear	3.7	88
Snow	3.2	19
Clouds	3.1	12
Haze	2.8	7

The percentage of targets affected by these degrading factors cannot be compared to those of past missions, as a different population of targets were sampled. There is nearly a full NIIRS increment between the average rating for clear targets and the average for haze reported targets.

The degrading factors of clouds and snow have been well established in the past. The clouds obscure the target or create contrast problems. Snow too, can obscure the area of interest, and can cause exposure problems.

5.3.1.2 Scale and Obliquity Versus NIIRS

Another much studied acquisition condition is the combined effect of obliquity and scale on a target. Although there is variability in the NIIRS values, there is a trend showing that larger scale imagery is preferred by the PIs. This variability is caused, in part, by the number of factors which affect the imagery. In addition to changes in scale and obliquity, the photography is influenced by geographic location, solar elevation, target type, etc.

Table 5-4 shows the average photo scale and average obliquity of Mission 1207 targets as a function of NIIRS ratings. Only clear weather targets were used in order to eliminate the effects of clouds, haze, and snow.

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TABLE 5-4

NIIRS RATING VERSUS AVERAGE OBLIQUITY AND AVERAGE SCALE
FOR CLEAR WEATHER TARGETS ONLY

<u>NIIRS Rating</u>	<u>Average Obliquity (degrees)</u>	<u>Average Scale</u>
2	24	128,000 : 1
3	23	125,000 : 1
4	20	123,000 : 1
5	19	122,000 : 1
6	18	121,000 : 1

Although there is a clear trend for increasing NIIRS rating to be associated with decreasing obliquity and larger scale, Table 5-4 presents the data only in terms of averages. The variability in obliquity and scale within each category of NIIRS rating is large, and of course, a number of 5 and 6 ratings occurred at obliquities beyond 28° and scale values exceeding 137,000:1. A more precise understanding of the effect of obliquity and scale will be possible only after the NIIRS ratings from several missions are pooled, and targets which are common except for obliquity or scale are compared to one another.

5.3.1.3 Solar Elevation Versus NIIRS

Table 5-5 lists the average NIIRS ratings for targets at different solar elevations.

TABLE 5-5

SOLAR ELEVATIONS VERSUS AVERAGE NIIRS RATING

<u>Solar Elevation (degrees)</u>	<u>Average NIIRS Rating</u>
0 - 5	2.93
5 - 10	3.25
10 - 15	3.53
15 - 20	3.71
20 - 25	3.63
> 25	3.92

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When the solar elevation becomes low, exposure times must be increased to compensate for a loss of illumination. The longer exposure times increase the amount of smear in the imagery. This smear becomes more noticeable when exposures are taken at approximately 10° or lower solar elevation.

There is a strong correlation between snow cover and solar elevation. The snow is most prevalent at northern latitudes where the sun is lowest. Although the snow cover can, on occasion, enhance an image, it is generally a degrading factor. This is very evident in Table 5-3.

The presence of long shadows can be either good or bad. When the area of interest is in the shadow of another object, the detail can be difficult to detect. However, the presence of shadows can also help in the detection and recognition of objects. For some target types, particularly electronics, the shadow can be more important in determining shape and size than the object itself.

When the sun is very low, many targets do not receive direct lighting. This condition, which generally occurs below 10°, lowers the contrast of the target area.

As stated earlier, the distribution of targets and film is different. The most northern areas with lowest sun, generally have the lowest targets. Much of this coverage is for satisfying annual or 18 month search requirements. Twenty percent of the film was acquired at solar elevations below 15°; however, only 8% of the targets were in that segment.

Mission 1207, being a winter mission, contained a number of photographic operations which were acquired under low solar elevation conditions. Many of these operations were judged to be of limited value to the PIs due to the increase in smear, snow cover, low contrast, and long shadows. These factors combine in different ways to affect the information derived from the imagery.

5.3.1.4 Geographic Area Breakdown

An analysis of interpretability ratings by geographic area provides insight into the utility of Mission 1207. Seasonal weather conditions and changes in intelligence priorities affect the distribution of coverage and the interpretability of the imagery of different countries.

There are four general areas which usually account for most of the priority targets read out from a 1200 Series mission. These areas are: USSR, China, Southeast Asia, and the Middle East.

Table 5-6 lists these areas and the distribution of targets for Mission 1205 thru 1207.

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MISSION TARGET DISTRIBUTION
(percent)

Geographic Area	1205	1206	1207
USSR	40	39	22
China	22	21	36
Middle East	10	8	28
Southeast Asia	26	30	6

The most significant change to note is that of the increased target percentage for the Middle East and the decrease for Southeast Asia.

Table 5-7 summarizes the NIIRS ratings of the four major geographic areas.

TABLE 5-7
NIIRS RATING VERSUS COMIREX GEOGRAPHIC AREA

Geographic Area	Area Code	NIIRS Rating (Percentage of Total)						Total Number Targets	Average NIIRS
		1	2	3	4	5	6		
USSR	A	1	14	30	47	8	1	679	3.52
	B	1	9	23	44	28	0	222	4.04
	C	0	9	32	37	22	0	399	3.72
	D	0	8	38	40	13	0	266	3.55
	N+O	0	20	29	50	0	0	24	3.27
									Avg 3.65
China	E	0	10	34	45	10	0	543	3.52
	L	0	3	22	55	20	0	1335	3.92
	M	0	3	60	35	1	0	712	3.31
									Avg 3.67
Middle East	G	0	4	48	44	3	0	1930	3.43
	H	1	1	39	56	3	0	76	3.59
									Avg 3.44
Southeast Asia	F	2	15	28	34	22	0	429	3.62

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The following sections deal with the use and suitability of photography in each major COMREX geographic area.

A. USSR (Areas A, B, C, D, N, O)

The rating of targets for this large geographic area varied considerably. The northernmost areas (N and O) had the lowest average NIIRS rating (3.27) of any area. Area B which includes a large portion of the Volga River Valley and the Caspian Sea was rated high, having an average of 4.04.

Most of the PI concerns centered around the small scale, snow cover, and haze.

B. China and North Korea (Areas E, L, M)

Interpretability of these areas was also variable. The northeast area of China (Area L) was among the best of the Mission with 75% of its targets rated 4 or better. Some PIs stated that clear weather coverage from 1207-3 and 1207-4 was the best 1200 Series mission coverage to date. Overall, coverage from Areas E, L, and M combined, was average for the mission.

C. Middle East and Northern Africa (Areas G, H)

Historically, photography of this area has been predominately Fair. This trend has continued for this mission. Over 90% of the targets from this area were rated 3 or 4 on the NIIRS. Most targets in this area are surface-to-air missiles and ground order-of-battle. These targets are small and often camouflaged, taxing the resolution capability of 1200 Series mission imagery.

D. Southeast Asia (Area F)

The coverage of Southeast Asia was much less than that of past missions. Southeast Asia suffers from some of the same problems as the Middle East, many small, hidden targets. In addition, the weather in this area is often poor.

5.3.2 Color Interpretation Suitability5.3.2.1 Interpretability of the Color Duplicate Positive

Previous 1200 Series missions containing color film have shown that the inherent loss of fine detail from the original positive to the color duplicate positive is a major problem for interpretability of many types of targets. The DP resolution losses for past missions have been as high as 35 percent. SO-287 color duplicating material was introduced on Mission Segment 1207-1. SO-287 replaced SO-356 and resulted in a significant reduction (14%) in resolution loss. With this change, NPIC PIs found a definite improvement in interpretation of the 1207-1 color DP.

Some PIs found that the color DP was as good, and in some cases better, than the green record DP. Consequently, the color DP from 1207-1 received more use than previous color photography. When asked for a choice between the color and the black and white DPs, the vast majority of NPIC PIs still favored the black and white copy with its higher resolution and edge sharpness. However, a number of

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PIs strongly felt that occasional color coverage of their targets is beneficial. Examples of some targets benefiting from color in 1207-1 are presented in the following paragraphs:

A. A target received a classification change from Unidentified to Probable, exclusively through the added dimension of color. The target, a mining pit, was located and associated with a mining refinery plant through the detection of material dropping from trucks on route from a mining pit to the refining plant. In an effort to determine what material was being mined, INSITE analysis of the mining pit and the ore pile located at the refining area was requested by NPIC. From the color DP, it was thought that the material being mined might be a toxic material. However, with the INSITE data it was concluded that the material was not toxic, and most probably was aluminum ore (Bauxite).

B. Another example was areas which were thought to be film anomalies on the black and white coverage. However, it was shown on the color coverage that these items were not film anomalies, but flares. Further study showed that these objects were associated with aircraft located in flight in that area indicating possible training exercises were in progress.

C. There was an example of the location of a probable airplane that was initially missed on the black and white DP but detected on the color DP. However, the difference between these two types of coverage was so subtle that once the target was detected, recognition could not be made with 100% confidence. The photo technologists at NPIC investigated the difference using the original positive as well as the black and white DP. They agreed that the object was detected better on the color, but had extreme difficulty in recognizing it as an airplane.

D. In one target area, cratering and rock slide activity were easily discernible in the color. Also, the PI was able to get a better idea of the composition of the soil in which a nuclear event took place. At another target area, color was helpful in the examination of the coolant water out-flow in determining if a reactor unit was, in fact, in full operation. Color made it easier to differentiate snow/earth/water areas at the out-flow.

As mentioned earlier, the PIs encountered problems associated with tone reproduction and color fidelity. Many of the PIs complained of the inability, or at least great difficulty, in seeing some of their targets, i. e., targets that were themselves dark, acquired in shadows or at low sun angles. No problems were encountered with interpreting the lighter objects. This indicates that while the highlight areas were being recorded properly for interpretation, the shadow areas and to a lesser degree the mid-tones were recorded/reproduced in the color DP with excessive contrast resulting in dark shadows. This information was given to BRIDGEHEAD, who in turn began an investigation into methods of reducing the contrast of the SO-287.

The other problem with the color DP concerned color fidelity. The PIs complained

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of excessively purplish shadow areas. The majority of PIs admitted that poor color balance did not detract from interpretability for most of their targets; however, some expressed opinions that it was more difficult to relate to an object in terms of its color.

For PIs engaged in the wheat yield study, the color fidelity was clearly inadequate and unacceptable. The PIs pointed out that they could not distinguish crops nor areas which were planted or fallow. Since these types of targets are generally dark, the excessive contrast of the SO-287 only added to the poor interpretability. Because of this problem a special SO-356 copy was provided for production readout. This copy was better than the SO-287 in terms of color fidelity and tone reproduction but was not considered to have color fidelity equivalent to 1206-4. To date, Mission 1206-4 has produced the closest color balance to what is needed for best interpretation of this type of target.

5.3.2.2 Interpretability of the Green Record Duplicate Positive

The majority of the PIs surveyed concerning the interpretability of the green record DP saw no noticeable difference between Missions 1206 and 1207. Most found the green record DP less sharp and more grainy than the black and white DP. When asked to compare the green record with the color DP, a division in preferences resulted. Some judged the green record sharper and said it contained more fine detail. Some favored black and white/green record stereo viewing over black and white/color stereo. Typical reasons given for these preferences included: (1) a loss in resolution by the color DP, (2) lack of color requirements, (3) inability to perceive color when mixing black and white and color, and (4) the comparatively higher density of the color DP. The PIs covering the Middle East and other desert areas favored the green record DP because it provided better separation of sand colored tanks against sand backgrounds.

On the other hand, some PIs judged the color DP to be slightly better than the green record DP. These PIs agreed that the resolution of the color DP was less than the green record, but felt the color had better highlight density detail and offered the benefits of color contrast and color signatures. It appears that these benefits of color were enough for some PIs to compensate for the narrower resolution gap between the green record and color than for previous missions.

As mentioned before, PIs noticed that the highlight density differences of the green record were poor compared to the color. Therefore, it is recommended that the green record DP printing criteria be closely evaluated for Mission 1208 and compared to the color DP for both highlight and shadow density detail to determine why the green record highlight tone reproduction is poorer than the color DP.

5.3.2.3 Interpretability of the Infrared Color Duplicate Positive

The PIs had two basic reactions from reading the color infrared acquisition material (FE-3916). These were that it was either Very Good or Poor. His choice of a quality rating was directly influenced by the type of target he was interpreting, i. e. , military intelligence-related targets were Poor,

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while economic intelligence-related targets were Very Good.

For military-related intelligence, the PIs generally felt that the infrared was Poor because it had lower resolution than the black and white DP and because of the acquisition conditions, i.e., remote area coverage with excessive snow covering most targets of interest. Only a limited amount of chromatic information was present in these kinds of acquisitions. Since 50% of the IR was acquired with varying degrees of snow cover, little or no color information was extracted that aided in the interpretation of military intelligence targets.

For PIs involved in the interpretation for economic intelligence, the IR coverage was considered Good to Excellent. The PIs engaged in the wheat yield study stated that snow covering of many areas lowered the interpretability, but in most cases did not negate it. Only when wheat fields were completely covered did interpretation suffer greatly and even then, other related information could be extracted. Color aided the PI in detecting and recognizing a group of windbreakers in the snow. On the black and white photography, the PI stated that he could have mistaken the windbreakers for storage areas. Color information combined with PI experience with this type of intelligence made the difference.

The wheat field areas acquired in Op 700 were considered to be an example of Good IR acquisition. There was clear weather, no snow, and excellent color balance. All these factors enabled the PI to extract more information than could otherwise be obtained from the black and white coverage, or the IR coverage with excessive snow cover. Much information due to color contrast created by the recording of IR radiation could be extracted from the FE-3916 DP. PIs expressed the hope that future IR coverage could be as good as that acquired in Op 700.

5.4 GEODETIC POSITIONING

5.4.1 Summary

An analysis was done comparing photogrammetrically intersected ground positions using first data base attitude and then nominal attitude to reflect the orientation of the vehicle. The 1207 MPR contained data base attitude. Nominal attitude represents zeros for pitch, roll, and yaw. The results indicate that the data base attitude was a better estimator of vehicle orientation than nominal attitude.

5.4.2 Procedure

Table 5-8 on pages 5-17 thru 5-19 gives the absolute errors found using the two types of attitude data for 41 known geodetic positions acquired on Mission 1207.

A statistical comparison was made. In order to make this comparison, the following two values are calculated for each intersected position:

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TABLE 5-8
GEODETIC POSITIONING ERRORS

Op	Frame	Camera	Scan Angle (degrees)	Data Base Attitude			Nominal			Data Base		
				Yaw (degrees)	Roll (degrees)	Pitch (degrees)	Lat (feet)	Long (feet)	RMS	Lat (feet)	Long (feet)	RMS
11	024	Fwd	60	.1097	-.1300	.0951	3,382	-4,099	5,314	4,679	1,662	4,965
22	003	Fwd	30	.1179	.0386	.0948	-932	-394	1,012	587	-291	655
27	008	Fwd	5	.1179	-.1066	.0988	-152	4,583	4,585	628	3,287	3,346
27	014	Fwd	-15	.1138	-.1300	.0947	-1,661	1,529	2,272	-1,256	-51	1,257
49	003	Aft	-10	.1179	-.1287	.1035	749	-1,608	1,774	1,296	455	1,374
60	007	Fwd	35	.0605	-.1260	.0752	820	-1,533	1,739	1,276	454	1,354
50	013	Fwd	5	.1219	-.0466	.1091	1,752	247	1,769	2,755	-476	2,796
66	003	Aft	-15	.1009	-.1131	.0472	1,195	-1,777	2,141	1,165	-686	1,352
74	005	Fwd	-30	.1139	-.1097	.0628	527	-2,366	2,424	223	-595	635
87	014	Aft	-35	.1179	-.1096	.1112	284	1,448	1,476	324	290	435
95	015	Aft	-35	.1138	-.1300	.0918	547	2,350	2,413	294	776	830
128	013	Fwd	10	.1219	-.3160	.0600	465	-417	625	1,141	278	1,174
144	006	Fwd	-10	.1219	-.0406	.0832	1,101	47	1,102	1,586	886	1,817
149	019	Aft	30	.1097	-.1300	.0307	2,525	-2,273	3,397	3,333	-249	3,342
176	005	Aft	10	.1179	-.0535	.0788	-1,959	558	2,037	-1,000	69	1,002
181	025	Fwd	-5	.1138	-.1260	.0994	1,050	-1,549	1,913	1,645	20	1,646
186	004	Fwd	5	.1219	-.8640	.1030	-1,131	641	1,300	-222	-453	504
204	014	Aft	20	.1179	-.1219	.1073	-828	-2,317	2,461	636	-793	1,016

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TABLE 5-8 (CONT'D)

Op	Frame	Camera	Scan Angle (degrees)	Data Base Attitude			Nominal			Data Base		
				Yaw (degrees)	Roll (degrees)	Pitch (degrees)	Lat (feet)	Long (feet)	RMS	Lat (feet)	Long (feet)	RMS
215	006	Fwd	20	.1219	-.0772	.1037	40	-1,538	1,538	1,162	-322	1,206
232	016	Aft	-15	.1138	-.1300	.0586	1,545	-1,737	2,325	1,586	-650	1,714
245	002	Aft	-15	.1135	-.1300	.0911	646	-1,348	1,495	1,121	-245	1,147
249	005	Fwd	15	.1219	-.0366	.0868	-5,474	2,147	5,880	-4,515	1,485	4,753
279	007	Aft	-35	.1219	-.0889	.0989	1,033	-454	1,128	1,124	454	1,212
289	015	Fwd	35	.1097	-.1251	.0833	587	-458	744	-405	-2,565	2,597
319	023	Aft	-30	.1097	-.1300	.0275	2,582	-772	2,695	2,906	-1,898	3,471
349	021	Fwd	-15	.1016	-.1260	.0877	1,954	515	2,021	1,691	-1,180	2,062
361	049	Aft	5	.0990	-.1300	.0913	901	168	916	40	-1,147	1,148
378	042	Fwd	5	.1097	-.1300	.0953	304	-438	533	-425	-2,022	2,066
391	008	Aft	10	.1057	-.1300	.0949	881	317	936	-20	-1,020	1,020
407	028	Fwd	-15	.0894	-.1300	.0919	2,370	-117	2,373	1,995	1,955	2,793
412	010	Fwd	-10	.1179	-.0963	.0308	2,400	346	2,425	2,582	-952	2,752
423	004	Aft	-5	.1219	-.0611	.0592	2,278	-571	2,348	1,823	-1,070	2,114
454	049	Aft	-20	.1097	-.1300	.0913	2,380	-2,005	3,112	2,663	-741	2,764
495	004	Fwd	-25	.0538	-.0772	-.0184	891	584	1,065	334	-784	852
511	014	Aft	35	.1179	-.0609	.1193	-2,066	1,046	2,316	-243	-113	268
528	004	Fwd	-10	.0606	-.0875	.0949	-162	-1,850	1,857	486	-761	903
551	017	Fwd	35	.1179	-.0528	.1120	-1,529	-2,967	3,338	152	-1,701	1,708

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TABLE 5-8 (CONT'D)

Op	Frame	Camera	Scan Angle (degrees)	Data Base Attitude			Nominal			Data Base		
				Yaw (degrees)	Roll (degrees)	Pitch (degrees)	Lat (feet)	Long (feet)	RMS	Lat (feet)	Long (feet)	RMS
552	009	Fwd	-5	.1179	-.0408	.1074	-790	812	1,133	30	71	77
562	005	Aft	-35	.1219	-.0809	.1073	1,620	-34	1,620	1,630	-774	1,804
648	005	Aft	-10	.1154	-.0691	.0586	587	-752	954	871	-213	897
694	023	Fwd	15	.1097	-.1300	.0662	466	-1,915	1,971	1,063	-390	1,132

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$$Q_i = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix}_i^T \begin{bmatrix} \text{cov} \end{bmatrix}_i^{-1} \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix}_i$$

and

$$R_i = \begin{bmatrix} \Delta x' \\ \Delta y' \\ \Delta z' \end{bmatrix}_i^T \begin{bmatrix} \text{cov} \end{bmatrix}_i^{-1} \begin{bmatrix} \Delta x' \\ \Delta y' \\ \Delta z' \end{bmatrix}_i$$

where:

Q_i is the length squared of the normalized error vector using nominal attitude.

R_i is the length squared of the normalized error vector using data base attitude.

$\Delta x, \Delta y, \Delta z$ are the components of the error vector between the known geocentric position and the computed position using nominal attitude.

$\Delta x', \Delta y', \Delta z'$ are the components of the error vector between the known geocentric position and the computed position using data base attitude.

$\begin{bmatrix} \text{cov} \end{bmatrix}$ is the variance/co-variance matrix of the intersected geocentric position.

The normalizations are necessary because the targets are imaged at various scan angles which result in different expected errors of the intersected positions. The Q_i and R_i values were summed to form Q and R respectively.

$$Q = \sum_{i=1}^n Q_i \quad R = \sum_{i=1}^n R_i$$

where:

n is the number of targets.

This simple summation is acceptable because each target is on a different camera operation. The expected errors on different operations are assumed to be independent. Q and R are chi-squared distributed random variables with 3n degrees of freedom, i.e., n points each with an x, y, z component.

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A summary of these computed values is given in Table 5-9.

TABLE 5-9

STATISTICAL DATA ON GEODETIC POSITIONING

<u>RV</u>	<u>Q</u>	<u>R</u>	<u>N</u>	<u>F</u>	<u>Rejection Level (%)</u>
1	4.0575	2.8511	33	1.423	75
2	5.3903	3.6686	33	1.469	75
3	3.3191	2.2208	30	1.495	75
4	<u>2.5704</u>	<u>1.1206</u>	<u>27</u>	2.294	99
Total	15.3373	9.8611	123	1.555	99

An F-test to determine if there is a significant difference between Q and R for the data from the entire mission was performed where:

n = degrees of freedom

$F = Q/R$

Null Hypothesis (H_0): $Q = R$

Alternate Hypothesis (H_1): $Q > R$

It is possible to reject the null hypothesis (H_0) at the 99% level. Therefore, there is no reason to doubt that the errors in the intersected positions are greater with nominal attitude.

As a result of this analysis, NPIC has recommended to NRO/SPC that data base attitude be reported in the 1208 MPR. Future PFA reports will no longer include geodetic positioning analyses unless areas of concern develop for a specific mission.

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SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 CAMERA OPERATIONS AND PERFORMANCE

A. Both cameras functioned satisfactorily and demonstrated a functional orbit life of 103 days, which was substantially longer than originally planned. In addition to the 1414 Film, the Aft Camera successfully utilized approximately 5,000' of SO-255 Color Film and 50' of FE-3916 IR Film.

B. Preflight focus settings were correct for both cameras. Focus was adjusted 30 microns to accommodate for the color film. Subjective analysis indicated that color focus was set properly and that the very good imagery was the best quality color photography acquired on the 1200 Series to date.

C. Preflight synchronization settings on the OOAA for 1414 Film were examined by smear slit image displacement analysis and found to be correct in both the cross-track and in-track directions on the Forward Camera. However, the Aft Camera required a commanded three-step change, slowing the film in-track. A similar correction was required on Mission 1206. It is recommended that the ground tests used to set the Aft Camera in-track film speed be reviewed for possible sources of error.

D. Color film smear slit image displacement analysis indicated that the cross-track speed was too slow by approximately .05 inch/second. The color film on Mission 1206 was also found to be too slow (approximately .04 inch/second). It is recommended that the 1208 color film cross-track OOAA setting be -14 relative to the 1414 Film rather than -16 as in Missions 1206 and 1207.

E. Analysis of the Aft Camera film tear on Op 304 indicates that the most probable cause was a connector cap which became ingested into the Take-up. 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.

F. A ground resolved distance tradeoff analysis indicated that a perigee altitude change was preferable to the metering capstan resonance in the Forward Camera Vx/h range from .0470 to .0478 radians/second. A design change has been incorporated in SV-8 which eliminates the resonance. This has been verified in ground tests.

G. It was noted on several previous missions that the VEM major axis profiles were unusual in that peak performance was at the center of scan and dropped off at the beginning and end of scan. This phenomenon is referred to as "McDonald's Arches." Special analyses are being performed on the 1207 record to gain further understanding of this phenomenon. The results are to be published in the Mission 1208 PFA Report.

H. The line-lens MTF study was not completed on Mission 1207 because of unusable acquisitions. The engineering tests will be rerun on Mission 1208. The question of the orbital off-axis MTFs should be resolved and recorded in the Mission 1208 PFA Report.

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I. Microscopic plus-density marks appear periodically on the mission photography. They appear more often on the Forward side than on the Aft. A better understanding of the nature and occurrence of this phenomenon must be gained via investigation of upcoming flight and test films.

J. There is a significant discrepancy in the degrees of field curvature on both cameras measured in Chamber A-2 and on-orbit. The source of this discrepancy should be identified.

K. An exposure analysis of the 1414 Film indicated a slight overexposure (.05 log E) relative to the present aim criterion of 1.0 mean scene density. Because the peak of subjective quality generally coincides with a 1.1 mean scene density, it is recommended the aim be raised to 1.1 density.

L. The 1414 Film Type exposure differences between the Forward and Aft Cameras were corrected with a two count exposure bias (-.06 log E). This bias adjustment should be applied to the Aft unit on future missions.

M. Exposure analysis of both SO-255 and FE-3916 was rated good. No change in exposure criteria is recommended.

N. A new three-step snow bias provided an improvement over the old single-step bias. An exposure (log E) deviation closer to optimum was achieved using this new bias routine. It is recommended that the new snow bias routine be continued.

O. As recommended by the 1206 PFA Team, Radiation Monitoring Packets (RMPs) for 3401, 3414, and SO-255 Films were included in all segments of Mission 1207. Comparison of the four packet controls to the zero controls shows no change in radiation effects from previous missions. It is recommended that the RMP Program be continued, but the film evaluation be conducted only as required.

6.2 PROCESSING, REPRODUCTION, AND DUPLICATE IMAGE QUALITY

A. The quality of the black and white DPs has remained consistent with those of previous 1200 Series missions. The second generation DPs made at BRIDGEHEAD on 1207-4 using the experimentally modified Redondo Printers had improved highlight tonal quality over the current duplicate system.

B. A new film, SO-287, was used to make the color DPs from both the conventional color and infrared color films. The resolution quality of the SO-287 DPs is substantially better than that of the SO-356 DPs made on previous missions. Tone reproduction and color balance problems existed on 1207-1. A special pre-flashing technique was implemented for adjusting system sensitometry to provide improved tone reproduction of the color duplicate positives.

6.3 EXPLOITATION SUITABILITY

A. Overall, the interpretation suitability for 1207 was average for 1200 Series missions. The majority of the targets read out by NPIC fell in the 3 and 4 NIIRS ratings, with a range from 1 to 6. Both the color and black and white imagery were degraded by cloud cover, snow, haze, obliquity, and low solar elevation; these factors are reflected in the NIIRS data.

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B. The introduction of SO-287 Film for color duplicate positive reproduction resulted in a significant improvement in the exploitation capability of the color duplicate positive. However, SO-356 was substituted for the SO-287 for the DP used by the PIs engaged in the wheat yield study because of tone reproduction problems.

C. An evaluation by geodetic positioning of MPR attitude data indicated that the data base attitude was a better estimator of vehicle orientation than nominal attitude. It is recommended that this technique be incorporated on a regular basis.

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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 1206, as well as those from previous missions for which action had not been completed at the time of publication of the 1206 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. This, in addition to 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: Mission 1206 was 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 operations should be a primary factor in planning any mission but even more significant during summer operations. Mission 1207 was also affected. Study 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: Investigation is continuing.

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. 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 1206 with biases in microdensitometry being removed between chamber and mission data. For the Aft Camera, on-orbit MTFs agree consistently with the test MTFs for seven positions across the field. For the Forward Camera, the same discrepancy

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exists as with the 1205 data, i.e., the orbital off-axis MTFs are suppressed. Further evaluation is being carried out using VEM analysis data from mission photography which suggests that the effective field curvature on-orbit is not quite as severe as that measured during Readiness testing. Improper acquisition parameters and a higher priority engineering requirement precluded successful completion of this study in Mission 1207. The work should be carried to completion in Mission 1208.

7.2.2 Mission 1206

A. RECOMMENDATION: Because a focus adjust of +6 microns was required for the color portion of this mission, it is recommended that focus be adjusted by +36 microns in the future when transitioning between 1414 and SO-255 Films.

ACTION: For Mission 1207, focus adjustment between 1414 and the relatively short amount of SO-255 footage in RV-1 was the nominal +30 microns. This was assessed to be correct. Because of the relative focus insensitivity with color film, the nominal +30 microns compensation should continue.

B. RECOMMENDATION: The OAAA was successfully exercised to correct Aft Camera film synchronization errors of .035 inch/second in both the in-track and cross-track directions. The magnitude and sign of the error was measured using the smear slits. The combined use of the OAAA capability and the smear slit measurements is a very effective engineering tool for determining film velocity errors. This engineering testing should continue to establish the accuracy of the ground settings of the IMC parameters on a per mission basis.

ACTION: This engineering testing was successfully carried out on Mission 1207, resulting in an Aft Camera in-track on-orbit correction. Testing is continuing to determine whether there is a repeated error in launch set IMC parameters.

7.3 PROCESSING AND REPRODUCTION RECOMMENDATIONS

7.3.1 Mission 1205

A. RECOMMENDATION: The PFA Team recommends that BRIDGEHEAD continue to pursue improvements to the SO-255 color product and process.

ACTION: A study of improvements in color film performance through process alterations is underway.

7.3.2 Mission 1206

A. RECOMMENDATION: Darker color DPs made for 1206-2 and 1206-3 yielded some improvements in highlight detail, but at the expense of poorer color fidelity. A study is recommended to determine the trade-off between better highlight detail with darker print densities versus better color fidelity with lighter print densities to result in a procedure for customized printing.

ACTION: Since the new color duplicating film was introduced on Mission 1207, this action is suspended.

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7.4 EXPLOITATION SUITABILITY RECOMMENDATIONS

7.4.1 Mission 1206

A. RECOMMENDATION: The image quality of the photography acquired during this mission was significantly affected by atmospheric haze and solar acquisition parameters. The front-lighting, specular reflections, and high solar altitudes are a function of the sun and camera positions at time of acquisition. The location of the specular reflections and front-lighting on the photography is a function of the launch time. Haze is also a function of launch time. It is recommended that launch times for future missions be planned to minimize the effects of haze and solar acquisition parameters on the photography.

ACTION: Mission 1207 photography was similarly degraded, but to a lesser extent due to the time of year. A software program is being developed to identify locations of this source of degradation by operation and frame. Since the PFA Team is responsible for evaluating these effects and is totally aware of the phenomenon involved, direct participation by members of the PFA Team in mission planning is recommended.

B. RECOMMENDATION: Analysis of "data base" and "nominal" reporting of vehicle attitude in the MPR concluded that the data base was the better estimator of vehicle orientation. NPIC recommends that "data base" attitude reporting be used for Mission 1207.

ACTION: Data base attitude was reported in the 1207 MPR. Subsequent analysis confirms that this method is superior to attitude reporting. This action is complete.

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APPENDIX A

GLOSSARY OF TERMS

ACC Mode	Software Option that Finds Areas of Intelligence Value for a Rev Span.
ACS	Attitude Control System.
AFSPPF	Air Force Special Projects Production Facility.
Aft	Aft-looking Camera, Camera B.
AIM	Aerial Image Modulation.
AOB	Air Order of Battle.
AOES/System II	General Purpose Satellite Flight Support Software at STC.
AUGIE	Acronym for Data Compression Technique Used for RTS to STC Data Transmission.
AVE	Aerospace Vehicle Equipment.
BBRT	Bird Buffer Retrieval Tape. Records at STC from Transmissions from RTS.
BRIDGEHEAD	Primary Film Processing and Immediate Post Flight Evaluation Facility.
BUFT	Backup Film Transport.
C-	Camera Power-off Command.
C+	Camera Power-on Command.
CEI	Contract End Item.
CEWG	Color Evaluation Working Group.
Chamber A	Photographic Vacuum Test Chamber Located at East Coast SSC Facility.
Chamber A-2	Photographic Vacuum Test Chamber Located at SVIC Facility.
CIE	Commission Internationale de l'Eclairage (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.
CRYSPEP	On-orbit Performance Prediction Program Combining Target Acquisition, Atmospheric, Illumination, and Camera Performance Models.
CRYSTAL BALL	Photometric Atmospheric Model Computer Program. Used to Calculate Exposure for Orbital Acquisitions.
CV	Constant Velocity.
CW	Continuous Wave.
DEA	Decision Element Array.
DGMAP	Computer Program for Magnetic Force Field Predictions.
DIM	Dynamic Image Motion.

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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.
EXTRFPLS	Focal Plane Position Transducer and LSFS Reading Extractor Program.
FAFNIR	Program that Locates CORN Deployed Targets and Edge Catalog Targets.
FAK	Forward Assembly Kit.
FBS	Film-to-Bar Synchronization.
FFL	Flange Focal Length.
FIDAP	Flash Image Displacement Analysis Program.
FOCMO	Thru Focus Motion Plot and Line Indicated Focus Program.
Fwd	Forward-looking Camera, Camera A.
FPP	Focal Plane Position.
fps	Feet Per Second.
FT	Film Transport.
FT +	Film Transport-on Command.
FT -	Film Transport-off Command.
FTFD	Field Test Force Director.
GAWA	Grand Area Weighted Average.
GMT	Greenwich Mean Time.
GOB	Ground Order of Battle.
GRD	Ground Resolved Distance.

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APPENDIX A (CONT'D)

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

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

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APPENDIX A (CONT'D)

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

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APPENDIX A (CONT'D)

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

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~~TOP SECRET- HEXAGON~~POST FLIGHT ANALYSIS REPORT
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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
Planned		88:53	88.7	154.4	96.9	142.8	
1	8	88:52	88.7	153.7	96.9	140.4	0.1
2	24	88:48	88.7	152.2	96.9	136.4	0.1
3	40	88:45	88.8	150.7	96.9	132.4	0.0
OA-1	46						
4	56	88:51	88.9	155.4	96.9	132.8	0.0
5	73	88:47	89.0	153.7	96.9	128.5	0.0
6	89	88:44	88.9	151.9	96.9	124.6	0.0
OA-2	94						
OA-3	97						
7	105	88:51	88.4	151.3	96.9	149.0	0.0
8	121	88:48	88.6	149.1	96.9	144.2	0.0
9	137	88:44	88.5	147.3	96.9	139.9	0.0
OA-4	143						
10	154	88:51	88.6	153.7	96.9	141.2	0.0
11	170	88:48	88.6	152.0	96.9	137.2	0.0
12	186	88:34	88.6	149.9	96.9	133.0	0.0
OA-5	192						
13	202	88:51	88.5	157.6	96.9	129.3	0.0
14	219	88:48	88.5	155.6	96.9	125.0	0.1
15	235	88:43	88.1	152.9	96.9	121.2	0.1
OA-6	240						
OA-7	242						
16	251	88:51	88.5	151.3	96.9	147.9	0.1
17	267	88:47	88.4	149.2	96.9	143.6	0.1
18	283	88:43	88.3	147.0	96.9	139.3	0.1
OA-8	289						
19	300	88:52	90.5	150.7	96.9	144.9	0.2
20	316	88:49	90.5	149.2	96.9	140.8	0.2

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POST FLIGHT ANALYSIS REPORT

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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
21	332	88:45	90.4	147.6	96.9	136.7	0.2
OA-9	338						
22	348	88:51	90.5	152.5	96.9	137.6	0.3
23	364	88:48	90.5	151.1	96.9	133.5	0.3
24	381	88:45	90.5	149.3	96.9	129.2	0.3
OA-10	386						
25	397	88:49	90.4	153.7	96.9	130.0	0.4
26	413	88:45	90.3	151.7	96.9	126.0	0.4
27	429	88:42	90.1	149.9	96.9	122.2	0.4
OA-11	435						
OA-12	437						
28	446	88:53	90.6	151.6	96.9	147.6	0.5
29	462	88:51	90.6	150.3	96.9	143.5	0.5
30	478	88:48	90.5	148.8	96.9	139.4	0.5
OA-13	484						
31	494	88:48	90.7	150.4	96.9	135.3	0.6
32	510	88:45	90.6	149.1	96.9	131.3	0.6
33	527	88:42	90.6	147.5	96.9	127.0	0.7
OA-14	534						
34	540	88:54	90.3	157.5	96.9	130.3	0.7
35	559	88:50	90.5	155.9	96.9	125.6	0.8
36	575	88:47	90.4	154.4	96.9	121.9	0.8
OA-15	581						
OA-16	583						
37	592	88:50	90.3	148.9	96.9	147.9	0.8
38	608	88:47	90.3	147.1	96.9	147.1	0.9
39	624	88:44	90.2	145.4	96.9	139.5	0.9
OA-17	630						
40	640	88:51	90.4	151.3	96.9	142.5	1.0
41	656	88:47	90.3	149.2	96.9	138.3	1.0
42	673	88:42	90.2	146.5	96.9	133.7	1.0

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~~TOP SECRET - HEXAGON~~POST FLIGHT ANALYSIS REPORT
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APPENDIX B (CONT'D)

<u>Day</u>	<u>Rev</u>	<u>Period</u> (min/sec)	<u>Perigee</u> (NM)	<u>Apogee</u> (NM)	<u>Inclination</u> (degrees)	<u>Argument of</u> <u>Perigee</u> (degrees)	<u>Beta</u> <u>Angle</u>
OA-18	678						
43	689	88:52	90.5	151.2	96.9	138.4	1.1
44	702	88:48	90.3	151.7	96.9	135.2	1.1
45	721	88:45	90.4	149.5	96.9	130.2	1.2
OA-19	727						
46	738	88:51	90.4	154.4	96.9	130.5	1.2
47	754	88:47	90.4	152.6	96.9	126.6	1.2
48	770	88:43	90.3	150.7	96.9	122.8	1.3
OA-20	776						
OA-21	778						
49	786	88:52	90.6	149.8	96.9	147.8	1.3
50	802	88:48	90.5	148.0	96.9	143.4	1.3
51	819	88:44	90.9	145.9	96.9	138.2	1.4
OA-22	824						
52	835	88:51	90.4	151.5	96.9	140.9	1.4
53	851	88:48	90.4	149.8	96.9	136.8	1.4
54	867	88:44	90.3	148.1	96.9	132.8	1.4
OA-23	873						
55	884	88:52	90.5	154.0	96.9	134.4	1.5
56	900	88:48	90.5	152.3	96.9	130.5	1.5
57	916	88:44	90.4	150.5	96.9	126.6	1.5
OA-24	922						
58	932	88:50	90.4	155.7	96.9	127.0	1.5
59	948	88:47	90.4	154.0	96.9	123.1	1.5
60	965	88:43	90.2	151.9	96.9	118.9	1.5
OA-25	970						
OA-26	972						
61	981	88:51	90.4	149.5	96.9	147.9	1.5
62	997	88:48	90.4	147.7	96.9	143.7	1.6
63	1013	88:44	90.3	145.9	96.9	139.4	1.6
OA-27	1019						

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POST FLIGHT ANALYSIS REPORT

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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
64	1029	89:12	90.5	167.3	96.9	150.2	1.6
65	1046	89:08	90.7	165.3	96.9	145.6	1.6
OA-28	1052						
66	1062	88:48	90.5	147.8	96.9	141.8	1.6
67	1078	88:43	90.3	145.4	96.9	137.7	1.5
68	1094	88:38	90.0	142.7	96.9	133.4	1.5
OA-29	1100						
69	1110	88:55	90.5	154.1	96.9	142.7	1.5
70	1127	88:50	90.4	151.5	96.9	138.2	1.5
71	1143	88:46	90.2	149.2	96.9	134.0	1.5
OA-30	1149						
72	1159	88:51	90.3	152.9	96.9	135.3	1.4
73	1175	88:46	90.2	150.5	96.9	131.2	1.4
74	1192	88:41	90.1	148.0	96.9	126.7	1.4
OA-31	1197						
75	1208	88:52	90.5	156.4	96.9	131.5	1.3
76	1221	88:49	90.5	154.5	96.9	127.7	1.3
77	1240	88:44	90.2	151.1	96.9	123.6	1.2
OA-32	1246						
OA-33	1248						
78	1256	88:51	90.2	149.8	96.9	148.0	1.2
79	1273	88:47	90.2	147.2	96.9	143.3	1.1
80	1289	88:43	90.0	144.9	96.9	139.0	1.1
OA-34	1295						
81	1305	88:52	90.6	151.2	96.9	144.7	1.0
82	1321	88:49	90.5	149.2	96.9	140.5	0.9
83	1338	88:44	90.5	146.8	96.9	135.7	0.9
OA-35	1343						
84	1354	88:51	90.7	152.2	96.9	138.4	0.8
85	1370	88:48	90.6	150.2	96.9	134.3	0.7
86	1386	88:43	90.5	148.0	96.9	130.2	0.6

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APPENDIX B (CONT'D)

<u>Day</u>	<u>Rev</u>	<u>Period</u> (min/sec)	<u>Perigee</u> (NM)	<u>Apogee</u> (NM)	<u>Inclination</u> (degrees)	<u>Argument of</u> <u>Perigee</u> (degrees)	<u>Beta</u> <u>Angle</u>
OA-36	1392						
87	1402	88:52	90.5	155.0	96.9	132.6	0.5
88	1419	88:48	90.5	152.5	96.9	126.0	0.5
89	1435	88:43	90.3	150.2	96.9	124.1	0.4
OA-37	1440						
OA-38	1443						
90	1451	88:54	91.5	151.8	96.85	145.5	0.3
OA-39	1459						
91	1467	88:45	90.4	145.1	96.85	144.0	0.2
92	1483	88:41	90.2	142.9	96.8	139.6	0.1
OA-40	1489						
93	1500	88:51	90.4	150.4	96.8	144.7	0.0
94	1516	88:47	90.2	147.8	96.8	140.4	-0.1
95	1532	88:42	90.0	144.8	96.8	136.1	-0.3
OA-41	1538						
96	1548	88:53	90.3	152.9	96.8	142.6	-0.4
97	1565	88:49	90.2	150.3	96.8	137.9	-0.5
98	1581	88:44	90.2	147.9	96.8	133.7	-0.6
OA-42	1587						
99	1597	88:52	90.5	153.4	96.8	136.8	-0.7
100	1610	88:48	90.2	151.3	96.8	133.5	-0.9
101	1629	88:42	90.0	148.1	96.8	128.1	-1.0
OA-43	1635						
102	1646	88:52	90.3	155.4	96.8	132.8	-1.1

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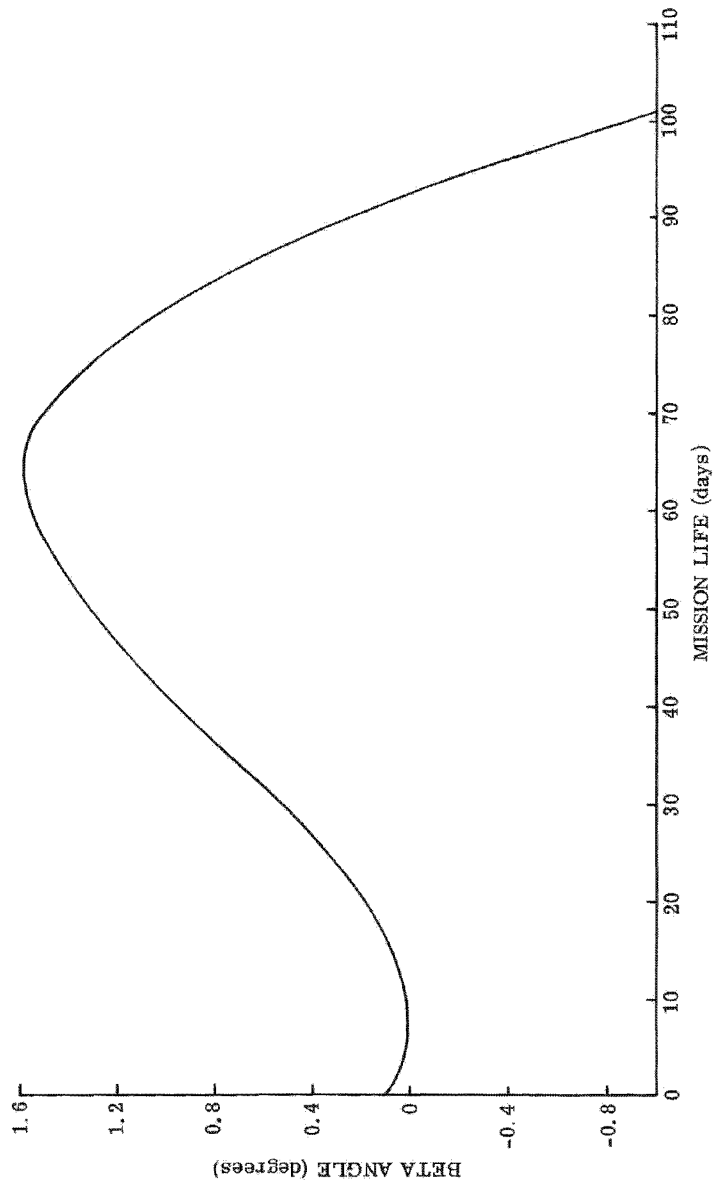
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BETA ANGLE VERSUS MISSION LIFE



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FIGURE B-1

POST FLIGHT ANALYSIS REPORT
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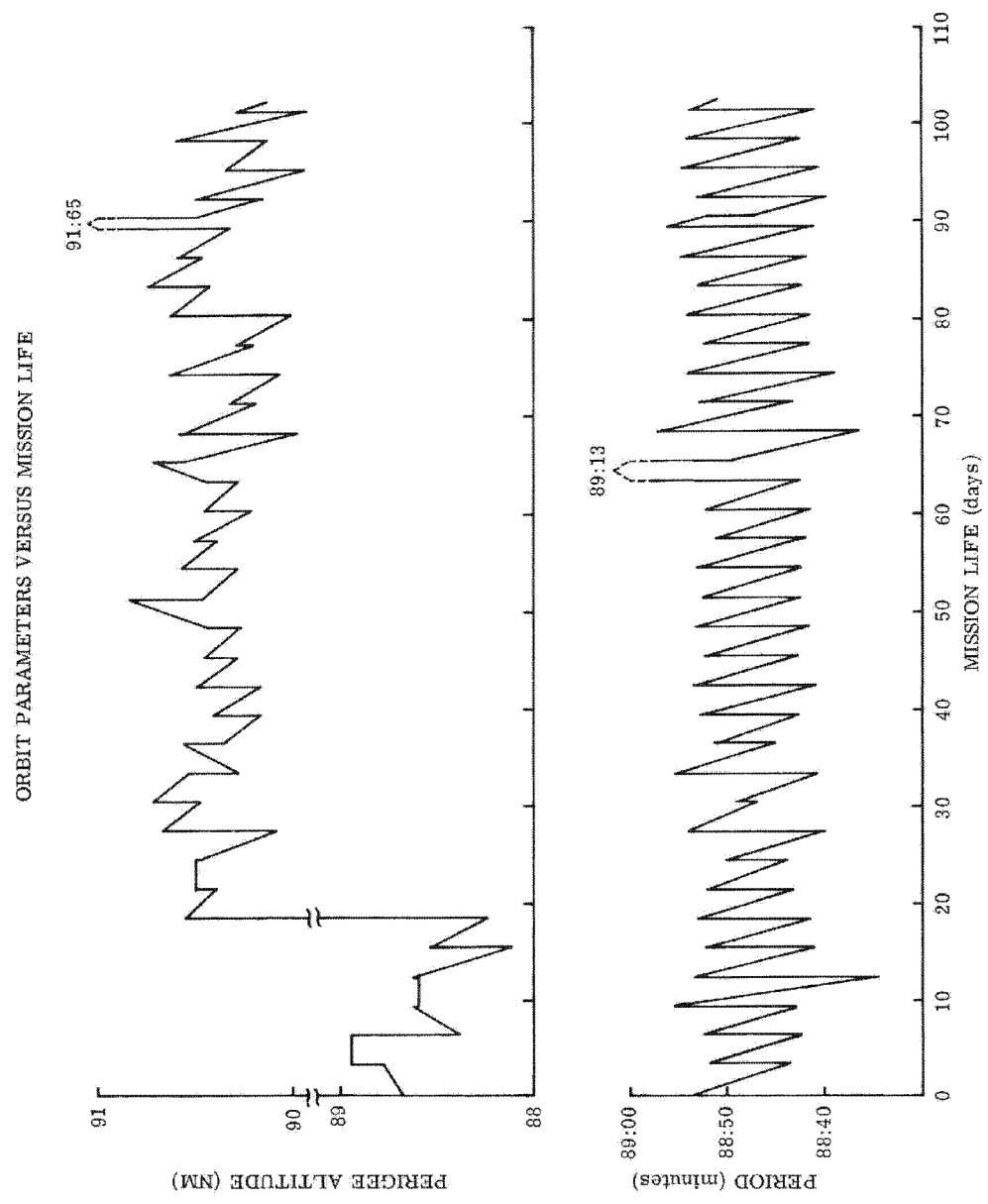


FIGURE B-2

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POST FLIGHT ANALYSIS REPORT
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APPENDIX C

CAMERA OPERATIONS SUMMARY

	R _e v	O p	S _c a n	S _c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
					Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
	PRE	L01	30	30	6	6	563	556	17	17	680	573
	PRE	L0	60	15	7	4	11	19	39	22	730	614
	PRE	L0	30	30	6	6	3	12	17	17	750	643
	PRE	L0	60	15	7	4	11	19	39	22	800	684
	PRE	L0	120	0	8	8	39	73	86	86	925	843
	PRE	L0	120	0	8	8	113	113	86	86	1124	1142
	PRE	L0	60	0	6	6	82	65	33	33	1239	1140
	PRE	L02	60	0	6	6	31	31	33	33	1303	1204
	PRE	L03	60	0	6	6	31	31	33	33	1367	1268
	PRE	L0	60	0	6	6	31	31	33	33	1431	1332
	PRE	L04	60	0	6	6	31	31	33	33	1495	1396
	PRE	L0	60	0	6	6	31	31	33	33	1559	1460
	PRE	L05	60	0	6	6	31	31	33	33	1623	1524
	PRE	L0	60	0	6	6	31	31	33	33	1687	1588
	PRE	L06	60	0	6	6	31	31	33	33	1687	1588
	PRE	L06	60	0	6	6	31	31	33	33	1751	1652
	PRE	L0	60	0	6	6	31	31	33	33	1815	1716
1207-1	3	1	60	0	6	6	127	127	33	33	1975	1876
	3	2	60	-15	6	6	24	25	33	33	2032	1934
	3	3	60	30	6	6	35	34	33	33	2100	2001
	5	4	90	0	53	53	42	50	428	428	2570	2479
	6	5	120	0	83	83	71	79	889	889	3530	3447
	7	6	90	-15	44	44	88	91	356	356	3974	3884
	8	7	60	0	6	6	52	44	33	33	4059	3961
	8	8	60	15	26	26	35	34	142	142	4236	4137
	8	9	30	15	9	9	27	19	26	26	4289	4182
	8	10	90	0	25	25	32	49	202	202	4523	4433
	9	11	60	30	28	28	54	44	153	153	4730	4630
	9	12	90	0	39	39	46	55	315	315	5091	5000
	9	13	60	-30	23	23	55	48	126	126	5272	5174
	10	14	60	-30	5	5	36	36	27	27	5335	5237
	15	15	30	-15	6	6	29	21	17	17	5391	5275
	22	16	60	30	43	43	20	26	236	236	5637	5537
	22	17	90	-15	102	102	44	54	824	824	6505	6415
	23	18	60	-15	50	50	55	47	274	274	6834	6736
	24	19	120	0	32	32	62	77	343	343	7239	7156
	25	20	60	-15	16	16	78	63	88	88	7405	7307
	26	21	60	30	29	29	35	34	158	158	7598	7499
	32	22	60	15	7	7	36	36	38	38	7672	7573
	38	23	120	0	83	83	62	78	889	889	8623	8540
	40	24	90	15	53	53	88	80	428	428	9139	9048
	41	25	90	0	35	35	66	66	283	283	9498	9397
	42	26	90	0	24	24	65	65	194	194	9747	9656
	47	27	60	0	15	15	55	47	82	82	9884	9785
	48	28	30	0	7	7	28	20	20	20	9932	9825
	48	29	60	15	13	13	20	28	71	71	10023	9924
	54	30	90	15	128	128	45	53	1034	1034	11102	11011

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
55	31	60	15	44	44	54	46	241	241	11397	11298
56	32	90	15	110	110	45	53	889	889	12331	12240
56	33	60	-15	17	17	56	49	93	93	12480	12382
56	34	60	0	10	10	36	35	55	55	12571	12472
57	35	60	-30	10	10	34	35	55	55	12660	12562
58	36	90	15	39	39	46	53	315	315	13021	12930
58	37	60	30	50	50	54	46	274	274	13349	13250
64	38	60	-30	53	53	35	36	290	290	13674	13576
65	39	30	15	8	8	29	21	23	23	13726	13620
70	40	60	30	19	0	20	0	104	0	13850	13620
71	41	90	-15	38	38	46	49	307	307	14203	13976
72	42	60	15	35	35	56	46	192	192	14451	14214
72	43	30	-30	44	44	28	21	125	125	14604	14360
72	44	90	0	36	36	30	45	291	291	14925	14696
73	45	90	0	47	47	65	65	380	380	15370	15141
73	46	90	0	22	22	60	60	178	178	15608	15379
74	47	90	0	63	63	56	57	509	509	16173	15945
74	48	30	-30	9	9	47	31	26	26	16246	16002
75	49	90	0	32	32	31	46	259	259	16536	16307
80	50	30	0	16	16	47	32	46	46	16629	16385
81	51	30	15	6	6	14	13	17	17	16660	16415
85	52	30	0	7	7	14	14	20	20	16694	16449
85	53	120	0	8	8	32	56	86	86	16812	16591
86	54	90	0	23	0	73	0	189	0	17074	16591
87	55	90	-15	53	53	66	67	428	428	17568	17086
87	56	90	0	39	39	70	69	315	315	17953	17470
89	57	60	0	35	35	54	46	192	192	18199	17708
90	58	60	15	11	11	35	35	60	60	18294	17803
91	59	60	-30	10	10	34	35	55	55	18383	17893
91	60	60	15	40	40	35	34	219	219	18637	18146
103	61	90	0	26	26	45	53	210	210	18892	18409
103	62	90	0	33	33	68	68	267	267	19227	18744
105	63	90	0	74	74	62	62	598	598	19887	19404
106	64	30	-30	5	5	46	31	14	14	19947	19449
106	65	60	30	15	15	21	28	82	82	20050	19559
107	66	60	15	14	14	33	34	77	77	20160	19670
112	67	30	30	7	7	27	19	20	20	20207	19709
112	68	30	15	6	6	13	13	17	17	20237	19739
113	69	30	0	6	6	13	13	17	17	20267	19769
117	70	60	15	7	7	18	26	38	38	20323	19833
119	71	30	-30	50	50	26	19	143	143	20492	19995
121	72	60	0	12	12	20	27	66	66	20578	20088
123	73	60	15	12	12	32	32	66	66	20676	20186
123	74	90	0	20	20	44	52	162	162	20882	20400
123	75	90	15	10	10	65	64	81	81	21028	20545
129	76	30	30	8	8	47	32	23	23	21098	20600
129	77	30	15	7	7	13	13	20	20	21131	20633
129	78	60	-15	17	17	21	30	93	93	21245	20756
130	79	30	15	9	9	29	20	27	27	21301	20803
135	80	120	0	92	0	40	0	985	0	22326	20803
135	81	90	15	38	38	84	45	307	307	22717	21155
135	82	60	-30	26	26	55	49	143	143	22915	21347
138	83	60	0	5	5	37	37	28	28	22980	21412
138	84	30	-30	7	7	30	22	20	20	23030	21454
139	85	30	-30	10	11	13	10	29	32	23072	21496

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R _e v	O p	S _c a n	S _c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)		
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft	
139	86	90	0	89	89	33	48	719	719	23824	22263	
146	87	60	-15	18	18	55	48	99	99	23978	22410	
151	88	90	0	66	66	45	53	533	533	24556	22996	
152	89	90	0	31	31	65	65	251	251	24872	23312	
152	90	60	15	17	17	55	46	93	93	25020	23451	
153	91	30	30	6	6	29	21	17	17	25066	23489	
154	92	90	0	32	32	27	43	259	259	25352	23791	
155	93	30	30	13	13	44	28	37	37	25433	23856	
155	94	60	-30	57	57	20	29	313	313	25766	24198	
160	95	60	-15	16	16	36	36	88	88	25890	24322	
162	96	60	-15	17	17	36	36	93	93	26019	24451	
166	97	30	-30	6	6	29	21	17	17	26065	24489	
167	98	60	30	7	7	21	27	38	38	26124	24554	
167	99	60	0	10	10	35	36	55	55	26214	24645	
169	100	60	-30	8	8	34	35	44	44	26292	24724	
169	101	60	-15	14	14	36	35	77	77	26405	24836	
169	102	60	-15	35	35	36	36	192	192	26633	25064	
171	103	60	30	35	35	36	34	192	192	26861	25290	
171	104	90	15	33	33	43	52	267	267	27171	25609	
173	105	30	-15	19	19	48	33	54	54	27273	25696	
186	106	60	-15	13	13	21	28	71	71	27365	25795	
202	107	30	-30	13	13	29	24	37	37	27431	25856	
204	108	30	0	9	9	14	13	26	26	27471	25895	
204	109	90	15	22	22	31	47	178	178	27680	26120	
209	110	30	0	5	5	48	33	14	14	27742	26167	
218	111	60	15	38	38	21	28	208	208	27971	26403	
219	112	60	-15	13	13	35	35	71	71	28077	26509	
220	113	90	0	64	64	47	56	517	517	28641	27082	
220	114	30	-15	8	8	48	31	23	23	28712	27136	
225	115	30	-15	7	7	14	14	20	20	28746	27170	
225	116	90	0	11	9	33	48	82	68	28861	27286	
1207-2	225	116	90	0	3	5	0	0	25	40	25	40
232	117	120	0	35	35	142	150	375	375	542	565	
234	118	60	15	16	16	79	63	88	88	709	716	
236	119	90	0	14	14	48	56	113	113	870	885	
248	120	90	-15	53	53	64	64	428	428	1362	1377	
249	121	60	30	20	20	51	42	110	110	1523	1529	
249	122	30	-30	8	8	26	20	23	23	1572	1572	
251	123	30	30	13	13	14	13	37	37	1623	1622	
252	124	120	0	19	19	46	70	204	204	1873	1896	
265	125	60	15	56	56	76	60	307	307	2256	2263	
265	126	60	-15	14	14	35	36	77	77	2368	2376	
266	127	60	-30	38	38	36	36	208	208	2612	2620	
269	128	90	0	14	14	45	52	113	113	2770	2785	
269	129	30	0	10	10	45	29	29	29	2844	2843	
281	130	60	15	13	13	20	28	71	71	2935	2942	
281	131	30	-30	11	11	28	20	31	31	2994	2993	

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R _e _v	O _p	S _c _a _n	S _C _A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
282	132	60	30	50	50	22	29	274	274	3290	3296
283	133	60	15	4	4	36	36	22	22	3348	3354
284	134	60	-15	23	23	35	36	126	126	3509	3516
284	135	60	-15	15	15	34	34	82	82	3625	3632
285	136	30	-30	11	11	29	20	31	31	3685	3683
285	137	120	0	69	69	48	72	739	739	4472	4494
286	138	60	-15	17	17	79	64	93	93	4644	4651
291	139	60	15	38	38	36	35	208	208	4888	4894
297	140	60	0	26	26	34	35	143	143	5065	5072
298	141	90	-15	10	10	46	54	81	81	5192	5207
299	142	90	15	29	29	62	61	234	234	5488	5502
301	143	60	-30	28	28	51	44	153	153	5692	5699
302	144	30	0	6	6	28	20	17	17	5737	5736
307	145	60	-15	113	113	19	27	619	619	6375	6382
313	146	60	0	32	32	35	34	175	175	6585	6591
314	147	90	15	53	53	44	52	428	428	7057	7071
315	148	60	30	4	4	53	45	22	22	7132	7138
316	149	120	0	44	44	56	72	471	471	7659	7681
330	150	90	0	107	107	84	75	865	865	8608	8621
332	151	60	0	47	47	52	44	258	258	8918	8923
333	152	90	0	50	50	44	51	404	404	9366	9378
333	153	30	30	8	8	45	29	23	23	9434	9430
334	154	30	30	5	5	13	13	14	14	9461	9457
334	155	60	-15	20	20	20	29	110	110	9591	9596
339	156	30	0	7	7	28	19	20	20	9639	9635
340	157	60	0	44	44	20	28	241	241	9900	9904
346	158	90	15	83	83	46	55	671	671	10617	10630
347	159	60	-30	74	74	53	45	406	406	11076	11081
347	160	30	30	19	19	28	19	54	54	11158	11154
348	161	120	0	47	47	42	67	503	503	11703	11724
349	162	60	-30	10	10	73	57	55	55	11831	11836
350	163	30	-30	5	5	27	19	14	14	11872	11869
350	164	60	-30	4	4	19	27	22	22	11913	11918
350	165	60	30	37	37	35	33	203	203	12151	12154
355	166	30	-15	6	6	28	22	17	17	12196	12193
362	167	60	15	13	13	21	28	71	71	12288	12292
363	168	60	-30	95	95	34	35	521	521	12843	12848
363	169	60	-30	44	44	35	35	241	241	13119	13124
364	170	60	15	53	53	35	34	290	290	13444	13448
365	171	30	30	8	8	27	19	23	23	13494	13490
366	172	90	0	45	45	31	47	364	364	13889	13901
367	173	60	15	25	25	54	46	137	137	14080	14084
367	174	60	15	7	7	35	35	38	38	14153	14157
368	175	30	30	5	5	28	20	14	14	14195	14191
371	176	60	0	15	15	20	28	82	82	14297	14301
378	177	30	-30	9	9	28	21	26	26	14351	14348
379	178	90	0	32	32	32	48	259	259	14642	14655
380	179	90	15	56	56	63	62	453	453	15158	15170
381	180	30	-30	4	4	45	29	12	12	15215	15211
382	181	90	15	50	50	30	45	404	404	15649	15660
395	182	60	-15	41	41	53	46	225	225	15927	15931
395	183	30	30	5	5	28	19	14	14	15969	15964
398	184	30	-30	6	6	13	14	17	17	15999	15995
398	185	60	15	19	19	21	28	104	104	16124	16127
405	186	90	0	7	7	46	54	57	57	16227	16238

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R _e _v	O _p	S _c _a _n	S _c _A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
411	187	60	-15	11	11	54	47	60	60	16341	16345
415	188	90	0	19	19	47	54	154	154	16542	16553
415	189	30	15	5	5	46	30	14	14	16602	16597
421	190	60	-15	4	4	20	29	22	22	16644	16648
427	191	90	0	41	41	47	57	331	331	17022	17036
431	192	90	0	10	10	65	66	81	81	17168	17183
431	193	90	0	36	36	65	66	291	291	17524	17540
443	194	60	-15	38	38	54	44	208	208	17786	17792
444	195	60	15	22	22	35	34	121	121	17942	17947
446	196	30	-30	8	8	28	21	23	23	17993	17991
447	197	90	-15	35	35	31	47	283	283	18307	18321
454	198	30	0	25	25	47	30	71	71	18425	18422
460	199	60	30	29	28	20	27	153	153	18598	18602
461	200	90	0	12	12	45	53	97	97	18740	18752
476	201	30	15	7	7	46	29	20	20	18806	18801
476	202	60	-15	12	12	19	28	66	66	18891	18895
477	203	60	-30	20	20	35	35	110	110	19036	19040
479	205	30	30	5	5	28	20	14	14	19217	19212
481	206	60	-30	29	29	19	29	159	159	19395	19400
492	207	30	-30	8	8	29	20	23	23	19447	19443
492	208	90	0	13	13	32	47	105	105	19584	19595
495	209	60	-15	18	18	51	44	99	99	19734	19738
495	210	60	15	16	16	34	33	88	88	19856	19859
496	211	60	15	11	11	33	33	60	60	19949	19952
495	212	60	15	17	17	33	33	93	93	20075	20078
496	213	30	30	38	38	27	19	108	108	20210	20205
496	214	90	0	15	15	31	47	121	121	20362	20373
497	215	30	30	29	29	46	30	83	83	20491	20486
503	216	60	-15	10	10	19	28	55	55	20565	20569
508	217	30	30	34	34	28	19	97	97	20690	20685
509	218	30	-30	6	6	13	13	17	17	20720	20715
509	219	30	-30	15	15	13	14	43	43	20776	20772
511	220	60	-15	15	15	20	28	82	82	20878	20882
512	221	30	30	6	6	28	19	17	17	20923	20918
512	222	90	0	86	86	31	47	695	695	21649	21660
517	223	60	15	9	9	53	45	49	49	21751	21754
527	224	60	-15	12	12	35	36	66	66	21852	21856
528	225	60	0	19	19	35	34	104	104	21991	21994
540	226	90	0	29	29	46	54	234	234	22271	22282
541	227	30	-30	4	4	47	32	11	11	22329	22325
541	228	30	15	4	4	14	13	11	11	22354	22349
541	229	60	-15	16	16	20	29	88	88	22462	22466
542	230	60	-15	57	57	35	35	312	312	22809	22813
544	231	30	0	7	7	28	19	20	20	22857	22852
545	232	90	0	20	20	30	46	162	162	23049	23060
556	233	30	-30	8	8	46	31	23	23	23118	23114
557	234	30	-30	23	23	14	14	66	66	23198	23194
557	235	30	15	28	28	14	13	80	80	23292	23287
558	236	60	30	26	26	20	27	143	143	23455	23457
560	237	60	-15	11	11	34	36	60	60	23549	23553
560	238	60	0	7	7	33	33	38	38	23620	23624
561	239	60	-15	14	14	33	33	77	77	23730	23734
574	240	30	0	17	17	28	19	48	48	23795	23801
574	241	90	-15	45	45	29	46	364	364	24204	24211
577	242	60	15	20	20	55	46	110	110	24369	24367

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
577	243	90	0	36	36	46	54	291	291	24706	24712
588	244	30	0	44	44	46	30	125	125	24877	24867
589	245	60	-15	10	10	20	27	55	55	24952	24949
590	246	60	-15	20	20	33	34	110	110	25095	25093
592	247	60	15	11	11	34	33	60	60	25189	25186
593	248	90	0	69	69	44	52	558	558	25791	25796
599	249	90	0	10	8	64	64	76	62	25931	25922
599	249	90	0	2	4	0	0	16	30	16	30
606	250	30	30	22	22	105	89	63	63	184	182
607	251	60	15	10	10	19	27	55	55	258	264
608	252	90	0	14	14	42	51	113	113	413	428
616	253	30	0	13	13	45	28	37	37	495	493
621	254	60	-30	14	14	19	28	77	77	591	598
622	255	60	30	11	11	34	33	60	60	685	691
626	256	60	-30	50	50	34	35	274	274	993	1000
638	257	90	0	26	26	45	52	210	210	1248	1262
639	258	60	30	23	23	51	42	126	126	1425	1430
640	259	60	15	10	10	33	34	55	55	1513	1519
640	260	60	0	9	9	33	33	50	50	1596	1602
642	261	90	0	44	44	44	52	356	356	1996	2010
643	262	90	0	32	32	61	51	259	259	2316	2330
654	263	60	-15	19	19	52	45	104	104	2472	2479
655	264	30	-30	10	10	28	20	29	29	2529	2528
655	265	60	15	12	12	20	27	66	66	2615	2621
656	266	60	-15	44	44	33	34	241	241	2889	2896
656	267	60	0	12	12	33	32	66	66	2988	2994
658	268	30	-30	5	5	27	20	14	14	3029	3028
658	269	90	0	19	19	32	47	154	154	3215	3229
670	270	60	15	23	23	54	46	126	126	3395	3401
670	271	60	-30	17	17	38	39	93	93	3526	3533
671	272	60	-30	14	14	35	35	77	77	3638	3645
671	273	60	15	18	18	34	33	97	97	3769	3775
671	274	60	-15	8	8	34	35	44	44	3847	3854
671	275	30	30	6	6	29	20	17	17	3893	3891
672	276	90	15	27	27	30	45	218	218	4141	4154
672	277	60	15	23	23	52	45	126	126	4319	4325
674	278	60	-15	20	20	35	36	110	110	4464	4471
681	279	60	-30	9	9	36	36	50	50	4550	4557
687	280	90	0	13	13	45	52	105	105	4700	4714
687	281	30	0	45	45	45	29	128	128	4873	4871
687	282	90	0	39	39	29	46	315	315	5217	5232
687	283	90	15	17	17	65	64	138	138	5420	5434
688	284	60	-15	7	7	54	46	39	39	5513	5519
689	285	30	30	9	9	28	20	26	26	5567	5565
690	286	30	15	34	34	13	13	97	97	5677	5675
690	287	60	0	15	15	18	26	83	83	5778	5784
690	288	60	0	19	19	34	34	104	104	5916	5922

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S C A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
691	289	90	0	19	19	44	52	154	154	6114	6128
702	290	90	0	26	26	59	59	210	210	6383	6397
703	291	60	15	44	44	50	42	241	241	6674	6680
703	292	30	-30	41	41	28	21	117	117	6819	6818
704	293	30	-30	32	32	14	14	91	91	6924	6923
704	294	60	0	13	13	19	27	71	71	7014	7021
706	295	60	15	13	13	35	33	71	71	7120	7125
719	296	60	-15	17	17	33	35	93	93	7246	7253
719	297	30	-15	21	21	27	19	60	60	7333	7332
719	298	60	15	21	21	19	26	115	115	7467	7473
720	299	30	15	10	10	28	20	29	29	7524	7522
720	300	60	-15	4	4	20	29	22	22	7566	7573
721	301	30	30	5	5	28	19	14	14	7608	7606
723	302	60	-15	11	11	19	28	60	60	7687	7694
723	303	90	15	19	19	46	52	153	153	7836	7899
735	304	90	0	42	42	64	65	339	339	8289	8303
735	305	30	-30	16	16	47	32	46	46	8382	8381
736	306	30	0	8	8	13	13	23	23	8418	8417
739	307	90	0	50	50	31	48	404	404	8853	8869
739	308	30	-15	7	7	46	30	20	20	8919	8919
740	309	30	-30	4	4	13	13	11	11	8943	8943
750	310	30	30	56	56	13	12	160	160	9116	9115
752	311	60	15	24	24	20	28	132	132	9268	9275
752	312	30	15	13	13	28	20	37	37	9333	9332
752	313	90	0	44	44	31	47	356	356	9720	9735
753	314	60	0	4	4	53	45	22	22	9795	9802
762	315	30	-30	8	8	22	20	23	23	9840	9845
768	316	30	15	59	59	14	13	168	168	10022	10026
768	317	60	15	11	11	23	30	60	60	10105	10116
769	318	60	0	7	7	34	35	38	38	10177	10189
783	319	60	-30	41	41	34	35	225	225	10436	10449
784	320	30	0	23	23	27	18	66	66	10529	10533
784	321	30	30	13	13	13	13	37	37	10579	10583
784	322	60	-15	12	12	21	30	66	66	10666	10679
786	323	60	-15	17	17	35	35	93	93	10794	10807
787	324	30	-15	23	23	28	19	66	66	10888	10892
787	325	90	15	11	11	34	50	89	89	11011	11031
789	326	60	-30	20	20	52	45	110	110	11173	11186
800	327	30	15	10	10	27	18	29	29	11229	11233
800	328	30	-30	16	16	13	14	46	46	11288	11293
800	329	30	-30	9	9	14	13	26	26	11328	11332
800	330	60	0	12	12	18	26	66	66	11412	11424
804	331	90	0	25	25	46	54	202	202	11660	11680
805	332	90	0	16	16	62	62	129	129	11851	11871
815	333	90	0	11	11	58	58	89	89	11998	12018
816	334	90	0	20	20	61	62	162	162	12221	12242
817	335	90	0	62	62	66	55	501	501	12788	12808
820	336	90	-15	50	50	65	66	404	404	13257	13278
822	337	90	0	19	19	63	63	154	154	13474	13495
833	338	90	0	77	77	63	62	622	622	14159	14179
834	339	60	15	4	4	53	35	22	22	14234	14236
836	340	60	-30	15	15	34	35	82	82	14350	14353
838	341	30	30	25	25	27	18	71	71	14448	14442
838	342	60	15	10	10	20	28	55	55	14523	14525
841	343	30	0	4	4	25	17	11	11	14559	14553
847	344	30	30	10	10	11	11	29	29	14599	14593
849	345	30	-30	59	59	13	14	168	168	14780	14775

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
850	346	30	-15	17	17	14	13	48	48	14842	14836
852	347	30	30	8	8	13	13	23	23	14878	14872
852	348	60	-15	11	11	19	28	60	60	14957	14960
853	349	90	0	29	29	42	49	234	234	15233	15243
853	350	30	15	6	6	44	28	17	17	15294	15288
865	351	30	-15	11	11	13	13	31	31	15338	15332
867	352	90	0	7	7	31	47	57	57	15426	15416
869	353	60	15	68	68	54	44	373	373	15853	15833
869	354	30	-30	8	8	27	20	23	23	15903	15876
869	355	60	30	35	35	21	27	192	192	16116	16095
876	356	30	-30	6	6	28	21	17	17	16161	16133
880	357	60	-30	20	20	19	27	110	110	16290	16270
882	358	60	15	38	38	34	33	208	208	16532	16511
883	359	60	-15	14	14	34	34	77	77	16643	16622
884	360	30	-30	89	89	27	18	254	254	16924	16894
885	361	90	0	77	77	29	46	622	622	17575	17562
885	362	90	0	91	91	64	64	735	735	18374	18361
891	363	30	30	7	7	46	29	20	20	18440	18410
896	364	60	15	38	38	18	26	208	208	18666	18644
897	365	30	-30	8	8	27	20	23	23	18716	18687
898	366	30	0	19	19	14	13	54	54	18784	18754
898	367	30	-30	10	10	13	14	29	29	18826	18797
898	368	90	0	60	60	31	46	485	485	19342	19328
899	369	30	15	5	5	46	30	14	14	19402	19372
901	370	90	0	53	53	30	46	428	428	19860	19846
902	371	30	-30	47	47	46	31	134	134	20040	20011
905	372	60	-30	11	11	16	24	60	60	20116	20095
913	373	30	-15	13	13	24	15	37	37	20177	20147
913	374	30	-15	5	5	13	14	14	14	20204	20175
914	375	60	0	20	20	21	28	110	110	20335	20313
914	376	30	-30	9	9	27	20	26	26	20388	20359
917	377	60	-15	47	47	21	28	258	258	20667	20645
918	378	90	15	50	50	45	53	404	404	21116	21102
931	379	30	15	10	10	46	30	29	29	21191	21161
931	380	30	30	11	11	13	13	32	32	21236	21206
932	381	60	-30	24	24	20	29	132	132	21388	21367
933	382	120	0	59	59	59	75	632	632	22079	22074
933	383	60	30	47	47	75	57	258	258	22412	22389
946	384	30	15	19	19	28	21	54	54	22494	22464
946	385	30	-15	12	12	13	13	34	34	22541	22511
946	386	30	-15	7	7	13	13	20	20	22574	22544
947	387	30	-15	7	7	13	13	20	20	22607	22577
947	388	30	0	4	4	13	13	12	12	22632	22602
947	389	60	0	14	14	20	29	77	77	22729	22708
949	390	60	15	28	28	35	34	154	154	22918	22896
949	391	60	0	45	45	33	33	247	247	23198	23176
950	392	30	-15	5	5	27	19	13	13	23238	23208
950	393	60	-15	21	21	20	28	115	115	23373	23351
950	394	90	0	39	39	47	55	315	315	23735	23721
963	395	60	-15	29	29	53	46	159	159	23947	23926
965	396	60	-15	41	41	34	34	225	225	24206	24185
965	397	60	15	13	13	36	35	71	71	24313	24291
966	398	90	0	38	38	47	55	307	307	24667	24653
967	399	60	30	25	25	53	45	137	137	24857	24835
977	400	30	0	13	13	27	20	37	37	24921	24892

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R _e v	O _p	S _c a _n	S _C A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
977	401	30	-30	15	15	12	12	43	43	24976	24947
978	402	60	-15	9	9	19	26	49	49	25044	25022
979	403	30	30	19	19	26	18	54	54	25124	25094
979	404	90	15	15	15	28	43	121	121	25273	25258
982	405	30	-30	11	11	43	28	31	31	25347	25317
982	406	30	0	9	9	13	14	26	26	25386	25357
983	407	90	0	79	79	27	42	638	638	26051	26037
999	408	90	15	41	41	59	58	331	331	26441	26426
1005	409	90	-15	12	12	62	64	97	97	26600	26587
1013	410	30	0	5	5	47	30	14	14	26661	26631
1014	411	60	-15	23	23	19	28	126	126	26806	26785
1015	412	60	15	44	44	32	31	241	241	27079	27057
1015	413	90	15	41	41	46	53	331	331	27456	27441
1027	414	30	0	13	13	45	31	37	37	27538	27509
1027	415	30	15	7	7	13	12	20	20	27571	27541
1028	416	30	-30	17	17	13	14	49	49	27633	27604
1029	417	60	-15	12	12	18	26	66	66	27717	27696
1031	418	30	-30	20	20	26	18	57	57	27800	27771
1031	419	60	15	27	27	17	24	148	148	27965	27943
1031	420	30	-30	21	21	25	18	60	60	28050	28021
1031	421	120	0	49	49	45	68	525	525	28620	28614
1031	422	60	30	7	7	77	60	38	38	28735	28712
1032	423	60	0	10	9	33	33	53	46	28821	28791
1207-4	1032	423	60	0	4	5	0	24	30	24	30
1043	424	30	30	7	7	85	77	20	20	129	127
1043	425	30	-30	5	5	12	13	14	14	155	154
1043	426	30	-30	26	26	13	12	74	74	242	240
1044	427	30	-30	10	10	12	13	29	29	283	282
1044	428	30	0	4	4	13	12	11	11	307	305
1044	429	30	30	15	15	13	13	43	43	363	361
1045	430	30	-30	13	13	12	13	37	37	412	411
1045	431	30	-30	32	32	13	12	91	91	516	514
1045	432	60	15	16	16	20	28	88	88	624	630
1046	433	30	30	10	10	26	18	29	29	679	677
1046	434	30	-15	6	6	12	13	17	17	708	707
1046	435	30	15	10	10	13	12	29	29	750	748
1047	436	30	-15	35	35	12	13	100	100	862	861
1047	437	30	-30	12	12	12	12	34	34	908	907
1047	438	60	-15	50	50	20	28	274	274	1202	1209
1048	439	30	30	25	25	27	18	71	71	1300	1298
1048	440	30	15	4	4	13	13	12	12	1325	1223
1048	441	30	-30	4	4	13	14	12	12	1350	1349
1049	442	30	-30	29	29	14	14	83	83	1447	1446
1050	443	30	0	35	35	14	13	100	100	1561	1559
1057	444	60	0	4	4	18	26	22	22	1601	1607
1060	445	30	30	10	10	25	17	29	29	1655	1653
1060	446	60	-15	14	14	18	27	77	77	1750	1757
1061	447	60	-15	7	7	32	32	38	38	1820	1827
1061	448	30	30	5	5	26	17	14	14	1850	1858
1061	449	30	-30	4	4	13	14	12	12	1885	1884
1063	450	30	0	50	50	14	13	143	143	2042	2040
1063	451	60	30	18	18	18	25	99	99	2159	2164
1063	452	30	-30	23	23	26	20	66	66	2251	2250
1064	453	30	30	7	7	14	13	20	20	2285	2283
1064	454	60	-15	56	56	19	28	307	307	2611	2618
1070	455	30	15	7	7	28	19	20	20	2659	2657

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1076	456	60	-15	31	31	19	28	170	170	2848	2855
1077	457	30	-15	16	16	27	19	46	46	2921	2920
1077	458	30	0	7	7	13	12	20	20	2954	2952
1078	459	30	+30	4	4	13	13	12	12	2979	2977
1078	460	30	30	10	10	13	13	29	29	3021	3019
1078	461	30	0	4	4	11	11	12	12	3044	3042
1079	462	30	-15	16	16	11	12	46	46	3101	3100
1080	463	90	0	11	11	30	45	89	89	3220	3234
1080	464	30	15	9	9	44	28	26	26	3290	3288
1080	465	60	-30	12	12	18	27	66	66	3374	3381
1081	466	60	0	11	11	35	34	60	60	3469	3475
1090	467	90	0	13	13	43	51	105	105	3617	3631
1092	468	90	0	23	23	62	62	186	186	3865	3879
1094	469	60	0	10	10	53	45	55	55	3973	3979
1095	470	30	30	25	25	26	18	71	71	4070	4068
1095	471	60	0	24	24	19	27	131	131	4220	4226
1095	472	30	15	13	13	27	19	37	37	4284	4282
1097	473	30	-30	8	8	13	14	23	23	4320	4319
1106	474	60	-15	26	26	19	26	142	142	4481	4487
1108	475	30	-30	4	4	25	18	11	11	4517	4516
1108	476	60	15	23	23	9	26	126	126	4662	4668
1108	477	30	-15	13	13	27	19	37	37	4726	4724
1109	478	30	-30	7	7	13	14	20	20	4759	4758
1109	479	60	15	14	14	19	26	77	77	4855	4861
1110	480	30	-30	11	11	26	19	31	31	4912	4911
1111	481	30	15	32	32	12	11	91	91	5015	5013
1111	482	30	-30	42	42	12	13	120	120	5147	5146
1112	483	120	0	56	56	46	69	600	600	5793	5815
1125	484	30	-15	8	8	68	44	23	23	5884	5882
1127	485	30	-30	4	4	12	13	11	11	5907	5906
1127	486	60	-15	10	10	20	27	55	55	5982	5988
1128	487	30	-15	26	26	27	19	74	74	6083	6081
1139	488	30	30	19	19	12	12	54	54	6149	6147
1140	489	30	0	7	7	13	13	20	20	6182	6180
1141	490	30	-30	29	29	13	14	83	83	6278	6277
1143	491	30	0	13	14	13	9	37	40	6328	6326
1146	492	30	30	13	13	13	13	37	37	6378	6376
1146	493	30	0	4	4	13	13	11	11	6402	6400
1146	494	30	-15	10	10	13	13	29	29	6444	6442
1156	495	30	-30	7	7	14	13	20	20	6478	6475
1157	496	30	-30	7	7	13	13	20	20	6511	6508
1157	497	30	30	5	5	14	13	15	15	6540	6536
1158	498	30	-30	53	53	13	14	151	151	6704	6701
1159	499	30	15	7	7	14	14	20	20	6738	6735
1160	500	60	-30	7	7	20	28	38	38	6796	6801
1160	501	30	0	16	16	27	18	46	46	6869	6865
1161	502	90	0	20	20	28	44	162	162	7059	7071
1171	503	30	-30	11	11	43	27	31	31	7133	7129
1171	504	30	0	4	4	12	12	12	12	7157	7153
1174	505	60	15	16	16	19	27	88	88	7264	7268
1175	506	30	15	10	10	28	20	29	29	7321	7317
1176	507	30	0	16	16	13	13	46	46	7380	7376
1178	508	30	30	19	19	13	13	54	54	7447	7443
1178	509	30	30	10	10	13	13	29	29	7489	7485
1182	510	30	30	5	5	13	13	14	14	7516	7512
1184	511	60	30	17	17	20	28	93	93	7629	7633
1187	512	30	30	10	10	28	20	29	29	7686	7682

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POST FLIGHT ANALYSIS REPORT

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APPENDIX C (CONT'D)

R _e v	O P	S _c a _n	S _c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1189	513	30	-30	10	10	13	14	29	29	7728	7725
1189	514	30	-30	5	5	14	14	14	14	7756	7753
1190	515	30	30	16	16	14	13	46	46	7816	7812
1190	516	30	15	11	11	13	13	31	31	7860	7856
1190	517	30	30	13	13	13	13	37	37	7910	7906
1190	518	30	-15	6	6	13	13	17	17	7940	7936
1195	519	30	30	10	10	13	13	29	29	7982	7978
1203	520	30	-15	10	10	13	13	29	29	8024	8020
1205	521	60	-30	14	14	20	29	77	77	8121	8126
1206	522	30	-15	16	16	29	20	46	46	8196	8192
1206	523	30	15	10	10	13	13	29	29	8238	8234
1206	524	30	-30	29	29	13	14	83	83	8334	8331
1208	525	30	30	7	7	13	13	20	20	8367	8364
1220	526	30	0	4	4	12	12	11	11	8390	8387
1221	527	90	0	29	29	28	44	234	234	8652	8665
1222	528	30	-15	4	1	44	29	11	3	8707	8697
1232	529	30	-15	6	6	5	14	17	17	8729	8728
1236	530	30	-30	17	17	14	13	48	48	8791	8789
1236	531	30	-30	7	7	12	12	20	20	8823	8821
1237	532	60	15	35	35	18	26	192	192	9033	9039
1238	533	30	15	7	7	27	19	20	20	9080	9078
1238	534	30	-30	13	13	13	14	37	37	9130	9129
1239	535	30	-15	19	19	14	13	54	54	9198	9196
1240	536	30	-30	17	17	13	13	48	48	9259	9257
1240	537	60	-30	17	17	20	29	93	93	9372	9379
1242	538	60	30	6	6	35	34	33	33	9440	9446
1242	539	60	0	8	8	35	35	44	44	9519	9525
1252	540	30	-15	7	7	26	18	20	20	9565	9563
1252	541	30	15	9	9	11	11	26	26	9602	9600
1254	542	60	15	14	14	17	25	77	77	9696	9702
1254	543	30	-15	22	22	26	18	63	63	9785	9783
1255	544	30	-30	17	17	12	13	48	48	9845	9844
1256	545	30	-30	29	29	12	12	83	83	9940	9939
1256	546	30	-15	7	7	13	12	20	20	9973	9971
1256	547	30	-30	5	5	13	13	14	14	10000	9998
1257	548	90	-15	29	29	26	43	234	234	10260	10275
1258	549	60	-30	5	5	48	41	27	27	10335	10343
1258	550	90	0	39	39	46	52	315	315	10696	10710
1259	551	60	15	20	20	51	43	110	110	10857	10863
1263	552	90	0	12	12	41	50	97	97	10995	11010
1270	553	60	0	10	10	52	43	55	55	11102	11108
1271	554	60	15	38	38	34	34	208	208	11344	11350
1273	555	30	30	16	16	27	19	46	46	11417	11415
1273	556	60	0	11	11	18	26	60	60	11495	11501
1273	557	60	30	10	10	43	32	55	55	11593	11588
1274	558	60	15	16	16	32	33	88	88	11713	11709
1274	559	30	30	5	5	26	18	14	14	11753	11741
1274	560	60	-30	32	32	20	29	175	175	11948	11945
1275	561	30	15	7	7	28	18	20	20	11996	11983
1280	562	60	-30	7	7	20	29	38	38	12054	12050
1281	563	90	0	7	7	47	54	57	57	12159	12161
1286	564	30	-30	6	6	46	31	17	17	12221	12209
1287	565	90	0	13	13	29	45	105	105	12355	12359
1288	566	30	15	6	6	45	28	17	17	12417	12404
1289	567	30	0	13	13	12	13	37	37	12466	12454
1290	568	60	15	19	19	18	25	104	104	12538	12583
1290	569	60	-15	33	33	31	32	181	181	12800	12796

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APPENDIX C (CONT'D)

R _e v	O _p	S _c a _n	S _c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1305	570	90	0	16	16	43	50	129	129	12972	12975
1305	571	60	-30	14	14	50	43	77	77	13099	13095
1306	572	60	0	13	13	33	32	71	71	13203	13198
1306	573	30	-15	24	24	24	17	69	69	13296	13284
1306	574	60	15	9	9	17	24	49	49	13362	13357
1307	575	30	15	5	5	26	18	14	14	13402	13389
1308	576	30	30	16	16	13	13	46	46	13461	13448
1308	577	30	-15	4	4	13	14	12	12	13486	13474
1312	578	30	-30	6	6	14	14	17	17	13517	13505
1317	579	60	-15	14	14	19	27	77	77	13613	13609
1319	580	30	0	16	16	26	17	46	46	13685	13672
1319	581	30	30	17	17	12	12	49	49	13746	13733
1320	582	30	30	7	7	13	13	20	20	13779	13766
1320	583	30	30	16	16	13	13	46	46	13838	13825
1320	584	30	-15	16	16	13	13	46	46	13897	13884
1322	585	30	-15	16	16	13	13	46	46	13956	13943
1322	586	30	30	15	15	12	12	43	43	14011	13998
1324	587	60	-15	8	8	19	28	44	44	14074	14070
1324	588	30	15	7	7	27	18	20	20	14121	14108
1336	589	30	-30	13	13	13	14	37	37	14171	14159
1336	590	30	0	9	9	13	12	26	26	14210	14197
1338	591	30	30	7	7	13	13	20	20	14243	14230
1338	592	30	15	7	7	13	13	20	20	14276	14263
1339	593	90	0	13	13	31	48	105	105	14412	14416
1344	594	90	0	8	8	63	62	65	65	14540	14543
1351	595	60	15	8	8	52	44	44	44	14636	14631
1353	596	30	15	10	10	27	19	29	29	14692	14679
1354	597	30	-30	10	10	13	14	29	29	14734	14722
1354	598	30	0	27	27	13	12	77	77	14824	14811
1355	599	60	15	25	25	20	28	137	137	14981	14976
1356	600	30	-30	5	5	26	18	14	14	15021	15008
1362	601	60	-30	8	8	20	29	44	44	15085	15081
1366	602	30	15	5	5	27	18	14	14	15126	15113
1370	603	30	30	16	16	12	12	46	46	15184	15171
1370	604	60	0	15	15	19	28	82	82	15285	15281
1371	605	30	-15	13	13	28	20	37	37	15350	15338
1371	606	60	-15	24	24	19	27	132	132	15501	15497
1372	607	90	0	8	8	46	53	65	65	15612	15615
1382	608	30	-15	4	4	44	29	11	11	15667	15655
1386	609	60	30	12	12	19	25	66	66	15752	15746
1386	610	60	-30	13	13	35	37	71	71	15858	15854
1387	611	30	-30	8	8	28	20	23	23	15909	15897
1387	612	30	-30	9	9	13	13	26	26	15948	15936
1387	613	30	-30	8	8	16	16	23	23	15987	15975
1387	614	30	-15	6	6	14	14	17	17	16018	16006
1387	615	60	-15	15	15	19	27	82	82	16119	16115
1394	616	30	-15	5	5	27	18	14	14	16150	16147
1400	617	30	0	14	14	13	13	40	40	16213	16200
1401	618	30	15	10	10	13	13	29	29	16255	16242
1404	619	90	0	17	17	31	47	137	137	16423	16426
1409	620	60	30	14	14	54	45	77	77	16554	16548
1410	621	90	0	10	10	45	54	81	81	16680	16683
1416	622	60	15	10	10	53	45	55	55	16798	16783
1417	623	30	30	10	10	28	20	29	29	16845	16832
1417	624	30	-30	26	26	13	14	74	74	16932	16920
1419	625	60	15	12	12	21	28	66	66	17019	17014
1426	626	30	-30	5	5	25	18	14	14	17058	17046

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~~TOP SECRET-HEXAGON~~POST FLIGHT ANALYSIS REPORT
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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1437	627	90	0	27	27	31	46	218	218	17307	17310
1449	628	60	-15	17	17	53	45	93	93	17453	17448
1451	629	30	15	10	10	27	19	29	29	17509	17496
1451	630	30	-30	16	16	13	13	46	46	17568	17555
1451	631	60	-30	15	15	20	29	82	82	17670	17666
1452	632	30	-30	10	10	28	19	29	29	17727	17714
1463	633	30	30	7	7	12	12	20	20	17759	17746
1465	634	30	-30	8	8	13	14	23	23	17795	17783
1469	635	30	-30	10	10	15	14	29	29	17839	17826
1469	636	30	30	7	7	13	13	20	20	17872	17859
1473	637	60	30	13	13	18	25	71	71	17961	17955
1480	638	30	-15	20	20	23	17	57	57	18041	18029
1482	639	30	-30	8	8	13	13	23	23	18077	18065
1483	640	30	0	13	13	13	12	37	37	18127	18114
1484	641	30	15	10	10	13	13	29	29	18169	18156
1484	642	30	0	8	8	13	13	23	23	18205	18192
1485	643	30	-15	5	5	13	13	14	14	18232	18219
1485	644	30	30	27	27	13	13	77	77	18322	18309
1486	645	60	15	8	8	20	28	44	44	18386	18381
1490	646	30	-30	7	7	28	20	20	20	18434	18421
1497	647	60	15	32	32	17	25	175	175	18626	18621
1497	648	30	-15	7	7	25	17	20	20	18671	18658
1497	649	30	-30	9	9	13	13	26	26	18710	18697
1500	650	30	-30	9	9	13	14	26	26	18749	18737
1500	651	30	-15	12	12	12	12	34	34	18795	18783
1500	652	30	15	15	15	12	11	43	43	18850	18837
1502	653	60	-15	47	47	19	27	258	258	19127	19122
1502	654	90	0	10	10	45	53	81	81	19253	19256
1514	655	60	-15	11	11	51	44	60	60	19364	19360
1514	656	30	-15	7	7	27	18	20	20	19411	19398
1514	657	90	0	15	15	30	47	121	121	19562	19566
1514	658	60	15	21	21	52	43	115	115	19729	19724
1514	659	30	-30	11	11	29	22	31	31	19789	19777
1514	660	30	-30	8	8	15	15	23	23	19827	19815
1515	661	30	-15	7	7	13	13	20	20	19860	19848
1516	662	30	-15	17	17	12	12	48	48	19920	19908
1516	663	30	-15	14	14	13	13	40	40	19973	19961
1518	664	60	15	18	18	19	27	99	99	20091	20087
1518	665	30	-30	9	9	26	19	26	26	20143	20132
1530	666	60	0	12	12	20	27	66	66	20229	20225
1533	667	30	30	28	28	28	18	80	80	20337	20323
1533	668	60	-30	8	8	18	29	44	44	20399	20396
1533	669	30	0	7	7	28	20	20	20	20447	20436
1534	670	60	-15	14	14	19	26	77	77	20543	20539
1534	671	30	15	5	5	27	19	14	14	20584	20572
1535	672	30	30	13	13	13	13	34	34	20631	20619
1544	673	30	-30	23	23	12	13	66	66	20709	20698
1544	674	30	-30	6	6	12	12	17	17	20738	20727
1544	675	30	-30	8	8	12	12	23	23	20773	20762
1546	676	30	30	10	10	13	12	29	29	20815	20803
1547	677	30	0	16	16	13	13	46	46	20874	20862
1548	678	30	15	5	5	12	13	14	14	20900	20889
1550	679	60	-15	10	10	18	26	55	55	20973	20970
1550	680	60	15	10	10	34	33	55	55	21062	21058
1550	681	90	0	16	16	44	52	129	129	21235	21239
1555	682	30	15	5	5	45	29	14	14	21294	21282
1563	683	30	30	13	13	13	13	37	37	21344	21332

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APPENDIX C (CONT'D)

R e v	O p	S c a n	S c A	Frames		Interop (ft)		Photo (ft)		Cum-Tu (ft)	
				Fwd	Aft	Fwd	Aft	Fwd	Aft	Fwd	Aft
1566	684	60	-15	43	43	20	29	236	236	21600	21597
1580	685	30	-15	5	5	28	19	14	14	21642	21630
1582	686	90	0	33	33	30	46	267	267	21939	21943
1598	687	30	0	8	8	45	29	23	23	22007	21995
1611	688	30	-30	5	5	13	14	14	14	22034	22023
1621	689	30	0	7	7	12	11	20	20	22066	22054
1631	690	30	-15	6	6	10	11	17	17	22093	22082
1631	691	90	0	27	27	32	47	218	218	22343	22347
1637	692	60	-15	20	20	52	45	110	110	22505	22502
1642	693	30	0	11	11	27	18	31	31	22563	22551
1644	694	60	0	30	30	19	27	164	164	22746	22742
1646	695	30	0	12	12	27	19	34	34	22807	22795
1646	696	60	-15	10	10	21	30	55	55	22883	22880
1647	697	30	-15	5	5	28	19	14	14	22925	22913
1648	698	60	0	9	9	19	27	49	49	23993	22989
1650	699	120	0	9	0	71	0	96	0	23160	22989
1653	700	30	0	0	5	0	15	0	14	23160	23018
WRAP						39	65	0	0	23199	23083

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APPENDIX D

PI INTERPRETABILITY RATINGS USING NIIRS TECHNIQUE

Summary of OAK and Supplement Targets

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	315	1,088	992	173	5	1	0	4	290	1,027	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	1,633	1,132	242	7	0	0	24	434	1,554	988	188	2	0
1207-4	0	14	169	656	414	76	4	0	0	13	161	596	333	28	0	0
1207 Total	0	48	1,136	4,230	3,408	707	30	1	0	47	1,096	3,993	3,015	510	11	0

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