CORONA J

PERFORMANCE EVALUATION REPORT

MISSION 1107-1 and 1107-2

FTV 1652, CR-7

Approved [redacted] Manager
Advanced Projects

Approved [redacted] Manager
Program [redacted]

FOREWORD

This report details the performance of the payload system during the operational phase of the Program [redacted] Flight Test Vehicle 1652.

Lockheed Missiles and Space Company has the responsibility for evaluating payload performance under the Level of Effort and "J" System contracts.

This document constitutes the final payload test and performance evaluation report for Mission 1107 which was launched on 24 July 1969.

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INTRODUCTION

This report presents the final performance evaluation of Corona Mission 1107. The purpose of the report is to define the performance characteristics of the CR-7 payload system and to evaluate the technical aspects of the Mission, including analysis of in-flight anomalies.

The payload system was assembled, tested, and certified for flight at the Advanced Projects (A/P) facility of Lockheed Missiles and Space Company (LMSC). A/P also provided services including pre-flight mission parameter planning, and mission reporting to the community. The initial evaluation of the recovered film was made by NPIC personnel at the processing facility. The Performance Evaluation Team (PET) meeting at NPIC included representatives of LMSC, ITEK Corporation, Eastman Kodak Company, and cognizant government organizations. Off-line evaluation was performed at facilities of individual contractors, using engineering photography acquired over the United States.

The quantitative data summarized in this report is originated by governmental and contractor organizations. Diffuse terrain density and target density measurements are produced by the Air Force Special Projects Production Facility. The Processing Summary report is provided by [redacted]

These quantitative data are used by A/P computer programs to provide processed information allowing correlation of operational photographic conditions with image quality. Analyses are made of image smear components, limiting ground resolution, and exposure/processing data.

SECTION 1

MISSION SUMMARY

A. MISSION DESCRIPTION

Corona Satellite Mission 1107 was planned to acquire cartographic and reconnaissance photography of selected terrain areas. Two mission segments were planned to total eighteen days of orbital operation. Each mission segment would return approximately 6000 panoramic frames and each frame would nominally cover 1725 square miles.

The flight configuration included a THORAD booster and AGENA satellite vehicle. The on-orbit support provided by the AGENA includes real time command and telemetry links, electrical power, stored payload program timer, and attitude stabilization and control.

The payload was a J-3 configuration, consisting of a space structure containing two panoramic cameras and associated control/support equipment and recovery subsystems for each mission segment.

The flight system was launched into the planned orbit from Vandenberg AFB at 0131 GMT on 24 July 1969 (1831 PDT, 23 July 1969).

Mission 1107-1 was successfully completed by a water recovery after nine days of flight. The second mission segment was completed with an air-catch after an additional ten days of orbital flight.

The aft-looking panoramic camera number 314 operated satisfactorily throughout Missions 1107-1 and 1107-2. At film depletion, the film end was passed into the recovery system with no wrap-up.

The forward-looking panoramic camera number 315 had a film transport failure on the 13th cycle of the first on-orbit operation. It did not operate thereafter.

The DISIC stellar-terrain camera performed normally during the -1 mission and most of the -2 mission. The system failed during an independent operation on the seventeenth day of the flight.

Photographic performance of the aft-looking panoramic camera was judged as fair. The lack of stereo coverage was considered a significant user problem. DISIC photography was considered generally satisfactory.

B. FLIGHT CONFIGURATION

Mission No.	1107
Vehicle No.	1652
System No.	CR-7
Forward Looking Camera Serial No.	315
Aft Looking Camera Serial No.	314
DISIC Camera Serial No.	11

Lens Data

Forward Looking Camera (Main Lens)

Lens Serial No.	I 208
Measured Slit Width (Inches)	
Position 1	0.168
Position 2	0.215
Position 3	0.268
Position 4	0.335
Failsafe	0.298
Optics Filter Type	
Primary	W-23A
Alternate	W-21
E.O. Focal Length (Inches)(Vacuum)	24.002

Resolution	
Static (Lines/Millimeter)	
Filter	W-21
High Contrast	299
Low Contrast	201
Dynamic (Lines/Millimeter)	
ITEK Post-Vibration	
Filter	W-25
High Contrast	283
Low Contrast	198
A/P Test	
Filter	W-25
High Contrast	303
Low Contrast	207
Distortion/Pincushion (MM)	
Angle Off Axis (Deg.)	
3	0.003
2	0.002
1	0.000
0	0.000
359	0.000
358	0.001
357	0.002
Aft Looking Camera (Main Lens)	
Lens Serial No.	I-191
Optics Slit Width (Inches)	
Position 1	0.122
Position 2	0.160
Position 3	0.204
Position 4	0.255
Failsafe	0.219

Optics Filter Type	
Primary	W-21
Alternate	SF-05
E.O. Focal Length (Inches)(Vacuum)	24.003
Resolution (Lines/MM)	
Static	
Filter	W-21
High Contrast	278
Low Contrast	151
Dynamic (Lines/MM)	
ITEK Post-Vibration	
Filter	W-21
High Contrast	266
Low Contrast	136
A/P Test	
Filter	W-21
High Contrast	269
Low Contrast	141
Distortion/Pinchushion (MM)	
Angle Off Axis (Deg.)	
3	0.002
2	0.001
1	0.000
0	0.000
359	0.000
358	0.000
357	0.002

Horizon Optics

Forward Looking Camera

Take-up (Starboard)

Lens Serial No.	315G3
Exposure Time (Sec.)	1/100
Aperture	F/8.0
Filter Type	W-25
Oper. Focal Length (MM)	54.83
Radial Distortion (MM)	
10 Deg. Off Axis	0.005
20 Deg. Off Axis	0.04
Tangential Distortion	0.02

Resolution (Lines/MM)

Angle Off Axis (Deg.)	0	5	10	15	20	25	30
(Radial)	106	165	163	143	130	134	32
(Tangential)	187	164	161	148	103	86	55

Supply (Port)

Lens Serial No.	315G4
Exposure Time (Sec.)	1/100
Aperture	F6.3
Filter Type	W-25
Oper. Focal Length (MM)	55.00
Radial Distortion (MM)	
10 Deg. Off Axis	0.01
20 Deg. Off Axis	0.04
Tangential Distortion	0.02

Resolution (Lines/MM)

Angle Off Axis (Deg.)	0	5	10	15	20	25	30
(Radial)	187	186	163	127	88	150	51
(Tangential)	166	164	161	138	116	96	62

Aft Looking Camera

Take-up (Port)

Lens Serial No.	314G1
Exposure Time (Sec.)	1/100
Aperture	F/6.3
Filter Type	W-25
Oper. Focal Length (MM)	55.00
Radial Distortion (MM)	
10 Deg. Off Axis	0.015
20 Deg. Off Axis	0.05
Tangential Distortion	0.03
Resolution (Lines/MM)	

Angle Off Axis (Deg.)	0	5	10	15	20	25	30
(Radial)	187	186	184	127	124	150	64
(Tangential)	187	185	161	138	116	96	62

Supply (Starboard)

Lens Serial No.	314G2
Exposure Time (Sec.)	1/100
Aperture	F/8.0
Filter Type	W-25
Oper. Focal Length (MM)	55.00
Radial Distortion (MM)	
10 Deg. Off Axis	0.005
20 Deg. Off Axis	0.05
Tangential Distortion	0.03
Resolution (Lines/MM)	

Angle Off Axis (Deg.)	0	5	10	15	20	25	30
(Radial)	187	186	206	181	156	134	45
(Tangential)	187	185	181	155	130	109	62

DISIC Camera

Port Stellar Camera

Lens Serial No.	7P
Reseau Serial No.	7P
Aperture	F2.8
Exposure Time (Sec)	1.5
Nominal Focal Lengh (In)	3.0
Filter	None

Starboard Stellar Camera

Lens Serial No.	14
Reseau Serial No.	14
Aperture	F2.8
Exposure Time (Sec)	1.5
Nominal Focal Length (In)	3.0
Filter	None

Terrain Camera

Lens Serial No.	113		
Reseau Serial No.	113		
Filter Type	W-12		
Aperture	F6.3		
Exposure Time (Sec)	1/250 or 1/500		
Nominal Focal Length (In)	3.0		
Resolution (Hi Contrast (L/MM)			
Angle Off Axis (Deg.)	0	7.5	15
(Radial)	144	121	140
(Tangential)	114	114	89
Film Type	3400		
Filter	W-12		

Film Types

Forward Looking Camera

Split Load	Yes
Film Type	3404/3401
Length (Ft.)	16,200 & 100
Splices	7 MYLAR
Length Between Splices (Ft.)	2750-3400-3325-3390-2660 675-MCD-1000
Emulsion Data	3404-441-5-7-9/3401-309-2
Payload Weight (Lbs.)	81.5
Spool No.	112A
Box Serial No.	69

Aft Looking Camera

Split Load	No
Film Type	3404
Length (Ft.)	16,300
Splices	6 Permacel
Length Between Splices (Ft.)	2155-3495-3530-3550-3545-MCD-25C
Emulsion Data	3404-442-10-7-9
Payload Weight (Lbs)	80.7
Spool No.	216B
Box Serial No.	69

DISIC Camera

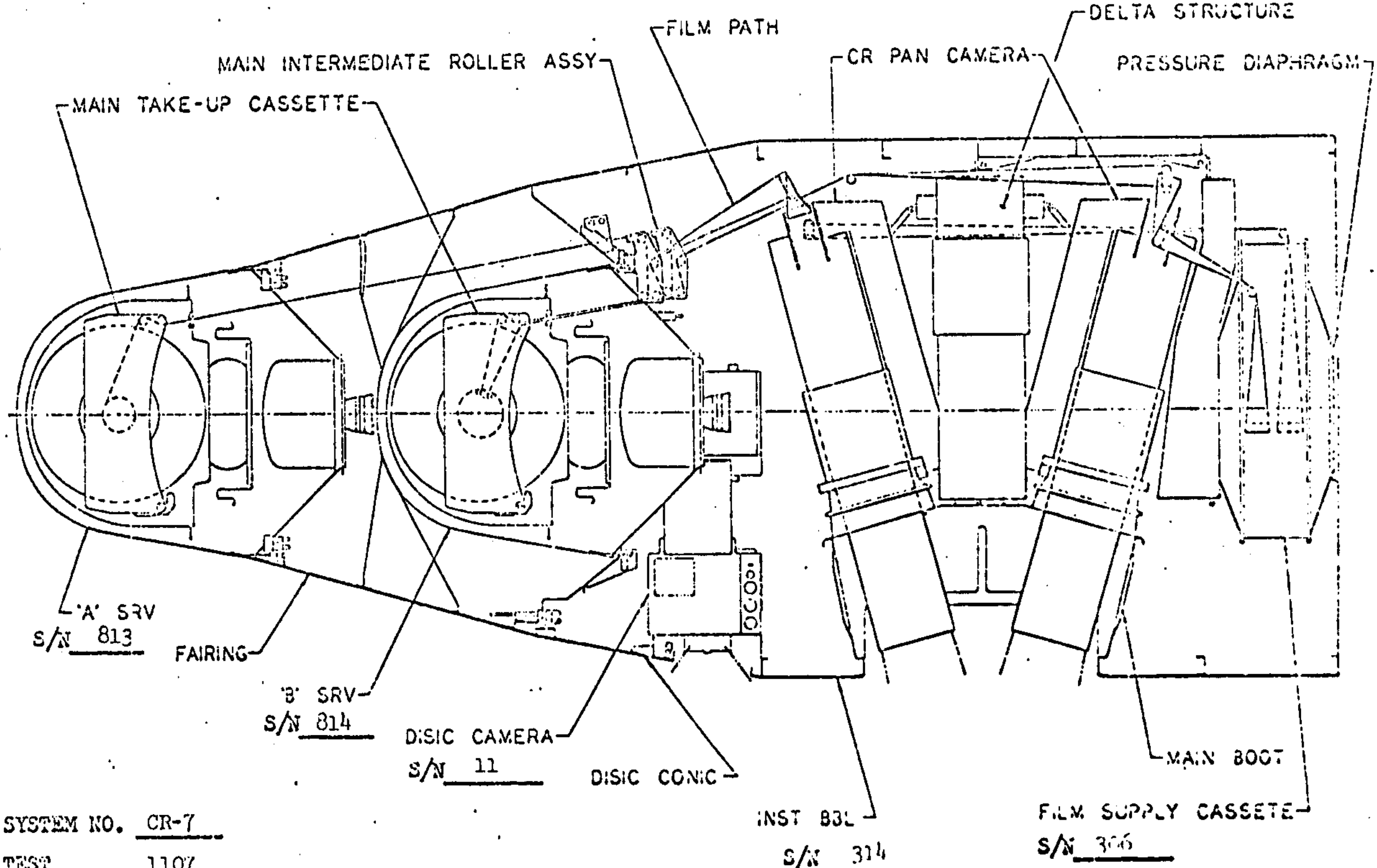
Stellar Camera

Split Load	No
Film Type	3401
Length (Ft.)	2000
Splices	Ncne
Emulsion Data	14 JC-1212-4-9
Paylcad Weight (Lbs.)	7.2-1.7

Terrain Camera

Split Load	No
Film Type	3400
Length (Ft.)	2200
Splices	None
Emulsion Data	3400-202-4-4-9
Total Film Weight (Lbs.)	22.3-19.9

PAYLOAD PROFILE AND SERIAL NUMBERS



SYSTEM NO. CR-7

TEST 1107

PMU S/N 1009

SLOPE PROGRAMMER S/N 207

CLOCK S/N 630

SWITCH PROGRAMMER S/N 207

FIGURE 1-1

SECTION 2

PRE-FLIGHT SYSTEMS TEST

A. SUMMARY

As a standard procedure, the J payload systems are subjected to a series of tests with flight type film which demonstrate that the system will perform as required during flight. The principal tests include the following:

1. Exposure of the J payload to a <u>thermal/altitude</u> environment that approximates flight conditions.
2. A <u>system light leak test</u> that ascertains the light tight integrity of the J system.
3. A <u>dynamic resolution test</u> that determines the high and low contrast resolution characteristics of each panoramic camera.
4. A <u>flight readiness test</u> that assures that the payload is acceptable prior to loading with flight film.
5. A <u>flight certification</u> that establishes the flight worthiness of the complete payload including the flight film.

The CR-7 system successfully passed all phases of the testing operations providing acceptable performance and a high degree of operation confidence.

B. ENVIRONMENTAL TEST

The CR-7 system was subjected to three environmental tests between February and June 1969.

First Environmental Test. This test was performed at the Sunnyvale HIVOS facility from 26 February 1969 thru 4 March 1969, with the system configured for AGT. Approximately 14,700 feet of SC-230 material was used in each main instrument. Material in the Terrain and Stellar units was 3400 and 3401 respectively. The AGT configuration required disabling the 200 Hz timing lamp circuit.

From evaluation of processed film, it was concluded that corona marking of camera #314 was within acceptable levels, but the corona marking of camera #315 was not acceptable. Corona marking of the DISIC #11, Stellar 3401 film was severe and not acceptable. The marking of the DISIC Terrain 3400 film was within acceptable levels.

Main camera #315 film indicated that no time word, H/O shutter, or fiducial markers were present after an early part of the test. Inspection of the DDSC indicated a Schmidt trigger failure.

The DSR unit functioned satisfactorily except for one anomaly during the register load in Rev. 12B. DSR memory did not clear when the UHF (Load Enable) was sent. Hence, a new load was transmitted and loaded on top of the existing memory load. This anomaly was also experienced in other tests. A new DSR was substituted for subsequent tests.

The Switch Programmer failed to time out correctly during 9 revs. Investigation revealed that the reset/start relay wiper contact was too critical for both wipers to make/break simultaneously. A modification to both the Slope and Switch Programmer boxes was accomplished to rectify the problem.

A pulsing network was added to the FMU system in order to obtain a 60 micron pressure range when FMU is enabled. HIVOS test records indicate that the 60 micron range was not met. This apparently was due to the delta time selected of the pulsing network and only 30 microns were experienced. A change in delta times was made for subsequent tests.

A clock/IRIG time correlation was computed to verify clock accuracy. Accumulative clock error, over a 72-hour period, averaged .010 seconds/day.

The telemetry system operation was normal throughout test except for some spurious noise levels on certain T/M monitors during camera operations. This was investigated and it was found that the return lines of the T/M points were not isolated from unreg return in the recording equipment. This was corrected prior to CR-7 returning to second chamber test.

The SRV tape recorder systems functioned satisfactorily throughout both phases of the HIVOS chamber test. There was however, some difficulty with the ADAPS playback equipment (Ampex recorder) and some data had to be reprocessed to validate system performance.

Second Environmental Test. The CR-7 system was environmentally retested at the Sunnyvale HIVOS facility between 26 March and 1 April 1969. The pan camera film requirement was changed to 3404 film. Approximately 2560 cycles (6800 feet) was run on each pan camera. 3400 film and 3401 film were used in the DISIC Terrain and Stellar units respectively.

Major changes in the system configuration were: Use of test forebodies rather than flight forebodies; installation of new film metering rollers in camera #315; modification of wiring to Switch and Slope Programmers; and adjustment of PMU timer settings.

Camera #314 produced low density corona affecting 70 frames at pressures of 5 to 35 um. of Hg. Camera #315 produced very low density corona affecting 40 frames at pressures of 2.2 to 5.5 um. of Hg. Neither camera produced corona at the normal operating pressures of 50 to 57 um. of Hg.

DISIC #11 Terrain film marking was within acceptable levels. Marking on the Stellar film was much improved from the first HIVOS test. A low density streak, 0.02 to 0.08 density above base fog, affected 20 per cent of the frames. Since this anomaly would not significantly affect program objectives, a waiver was requested and granted.

The delta time settings for the pulsing PMU network did not allow the internal pressure range requirement of 50 microns to be met. A recorded pressure of 35 microns was experienced. The external PMU test box was utilized to control the pressure range. Uncle commands U103 and U104 were commanded to position 8, the alternate filter position. A pressure of 35 microns was also experienced in this configuration. If the PMU system had been working properly approximately 17 microns of pressure should have been experienced. Post chamber test indicated a failure in the internal "B" timing circuit.

The Exposure Control System and FMC System performance was normal.

The following problem occurred in the Command System: Uncle 104 stepped several times during the test, as a result of permacel splices. Uncle 103 however did not step when the permacel splice passed through Instrument 314. This was subsequently found to be due to MCD circuit sensitivity characteristics and not readily changed. The final flight requirements for the system did not include a mixed film load and the MCD circuit was disabled.

The DSR failed during this test. After two hours of operating on 3-29-69 (1500 seconds into Rev 2) the DSR lost frame and word sync, then produced a T/M readout of one's, zero's, and repeat bits that did not correspond to memory. A few minutes later the T/M readout went to a continuous T/M level. During the night the temperature decreased about 10°F, and the DSR functioned normally in the morning. However, after two hours of operation the temperature rose about 10°F, and the DSR malfunctioned in the same manner. The temperature of the components located near the DSR was 110°F at the time of failure. This DSR was subsequently replaced by one that did not have the temperature/pressure sensitivity.

The cycle rates were acceptable throughout the test. The rates were running approximately ½% fast on both instruments. The per cent deviation between the two instruments was approximately ½%, with Instrument 314 running faster.

Third Environmental Test. At the request of the Resident Office, a third HIVOS test was conducted on the CR-7 system during the period 6 to 11 June 1969. A primary purpose of this test was to obtain data on corona marking characteristics of SO-180, a reversal-type, false-color film, with extended infrared sensitivity. Both main instruments utilized supply rolls consisting of 2,000 feet of 3404 film, followed by 3,000 feet of SO-180. Material used in the DISIC terrain and stellar units was 3400 film and 3401 film. Testing was conducted at pressures ranging from 0.4 to 220 um. of Hg.

On the 3404 film, a small amount of low density corona marking (acceptable) was found from camera #314. This occurred at an internal pressure of 28 um. of Hg. No significant marking was found on the 3404 film from camera #315.

On the SO-180 material, camera #314 generated severe corona marking at all pressures. Camera #315 was relatively clear except for start-up marking and some low density marks associated with the SLP pressure pad. Since it had been decided not to fly SO-180 film in this system, these results were not significant.

The main instruments operated satisfactorily throughout the test except for one malfunction. Cycle rates were computed and the results indicated that at top-of-ramp the rates were running 10.5% slow. Post-chamber testing revealed that the Limiter in Instrument No. 1 was not allowing either panoramic instrument to run at a rate faster than 1.72 sec/cycle. This anomaly was rectified and tested.

T/M data from the DISIC unit indicated satisfactory operation throughout the test except for one anomaly. The T/M monitor did not indicate that the shutter was firing. Post-inspection of the material verified that the shutter operated properly.

The DSR unit was loaded with three simulated flight loads and two malfunctions were noted. The first malfunction was the failure of the output register to shift the executed word out and the new word in. The second malfunction was the failure of the operate monitor to indicate that an execute had been given. After completing the standard chamber requirements, a special DSR checkout was accomplished at altitude environment. Neither of the failures could be repeated. Another test was conducted after the system was returned to A/P and the DSR was exercised approximately 500 cycles. No anomalies occurred and the DSR is considered flightworthy. The preceding anomalies were the only failures in the command system during chamber testing.

All Timer events from the Switch and Slope programmers occurred as programmed.

A clock accuracy check was computed and results indicated an error of approximately 10 milliseconds/day. This is well within reading error and specification limit.

The pulsing PMU system was tested in the chamber prior to orbital cycling and again during orbital cycling. No anomalies occurred. Gas consumption rate could not be determined due to the abbreviated chamber test.

Film Flatness Tests. Although the first environmental test was configured for AGT, the data were not read at A/P, but were forwarded to Boston. This test, performed on SO-230 (STB) film, was reported to have indicated satisfactory flatness. However, with the change to 3404 film, also STB, but coated differently from SO-230, the test results were not considered directly applicable.

After the second environmental test, there was concern that soft-appearing rail lamp images from camera #315 might be indicative of film movement or a non-flat condition. An AGT on camera #315, using 3404 film, was run on 28 May 1969. The results were evaluated separately by Boston and A/P personnel. The results of these evaluations were similar with the A/P data indicating more marginal performance along the time word edge of the format than did the Boston data. It was concluded that the extent of flatness variability did not warrant corrective action.

C. LIGHT LEAK TEST

A standard system light leak test was performed on the CR-7 system on 18 November 1968. The panoramic cameras were loaded with 3401 film. The system was placed in flight configuration and was exposed to external illumination calculated to produce a fog density equivalent to that encountered on four orbits of flight using 3404 film. After this exposure, the film was retrieved and processed at the "full" level.

Film from each camera contained one high density fog spot. The source of this fog on each film was traced to one source at the forebody/fairing interface. This was the pin puller teardrop fitting on the -Z axis. This source of light leakage was eliminated by adjustment of a rubber light shield at the teardrop fitting. Subsequent light searches using photometers verified that the leak had been eliminated.

D. RESOLUTION TEST

A thru-focus dynamic resolution test of the CR-7 system was performed on 30 April 1969. This was after the second environmental test but before the third one. The maximum low contrast resolution of camera #314, using a Wratten 21 filter, was 145 lines per millimeter at the -0.001 inch focal position. The maximum low contrast resolution of camera #315, using a Wratten 25 filter, was 220 lines per millimeter at the zero focal position. It is noted that the camera

[redacted]

#314 lens was a second generation type, while the camera #315 lens was a third generation type.

Following the third HIVOS test, on 21 June 1969, a final resolution test was performed to verify the location of peak focus. The following results were obtained.

Pan Camera #314

Maximum high contrast resolution: 269 lines/mm at -0.001" focal position.

Maximum low contrast resolution: 141 lines/mm at -0.001" focal position.

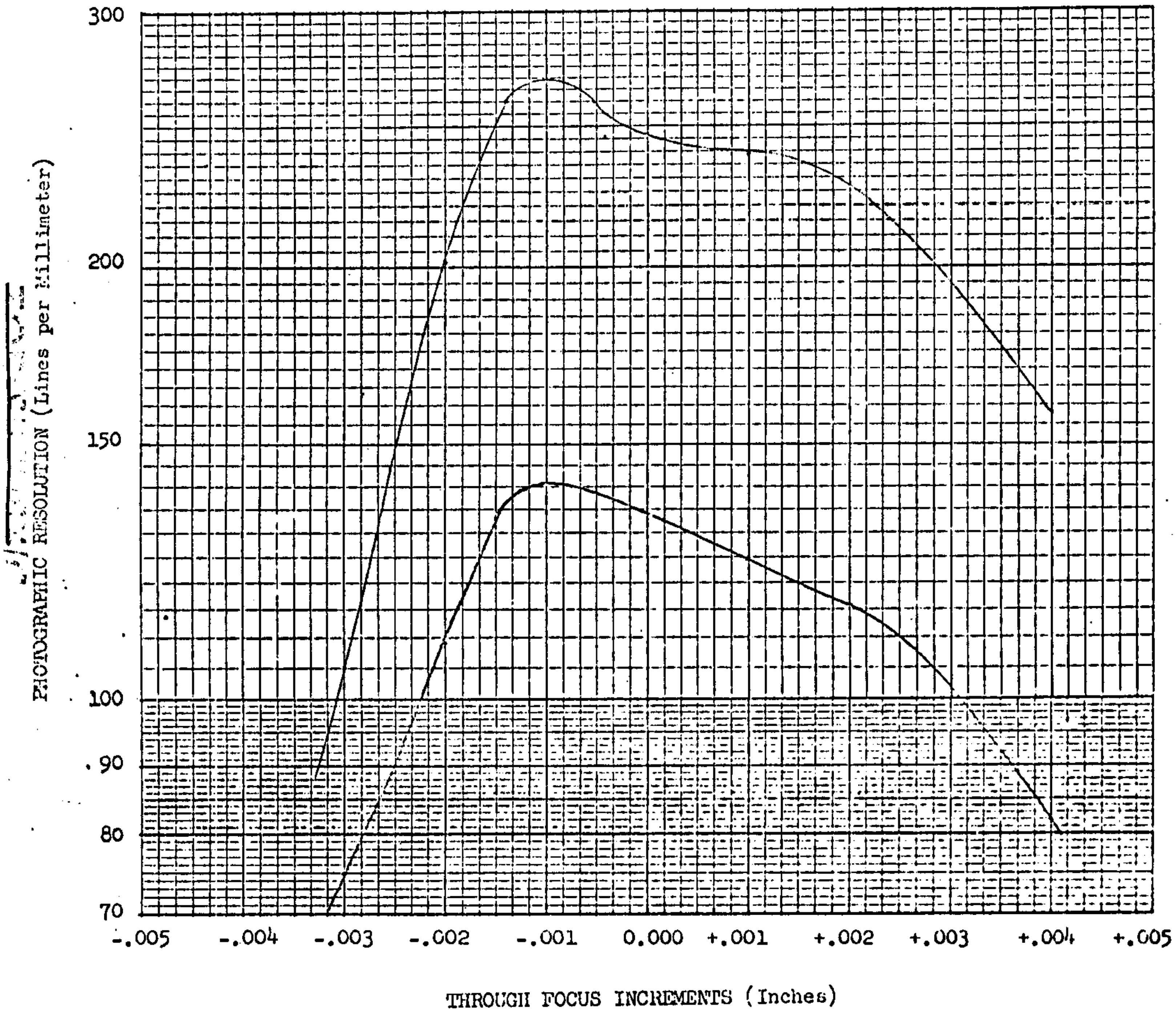
Pan Camera #315

Maximum high contrast resolution: 303 lines/mm at the zero focal position.

Minimum low contrast resolution: 207 lines/mm at the zero focal position.

The results of this final thru-focus resolution test are plotted in Figures 2-1 and 2-2 for panoramic cameras #314 and #315 respectively.

PRE-FLIGHT RESOLUTION, PAN CAMERA #314



Camera No. 314

Payload No. CR-7

Resolution (1/mm)

High Contrast: 269

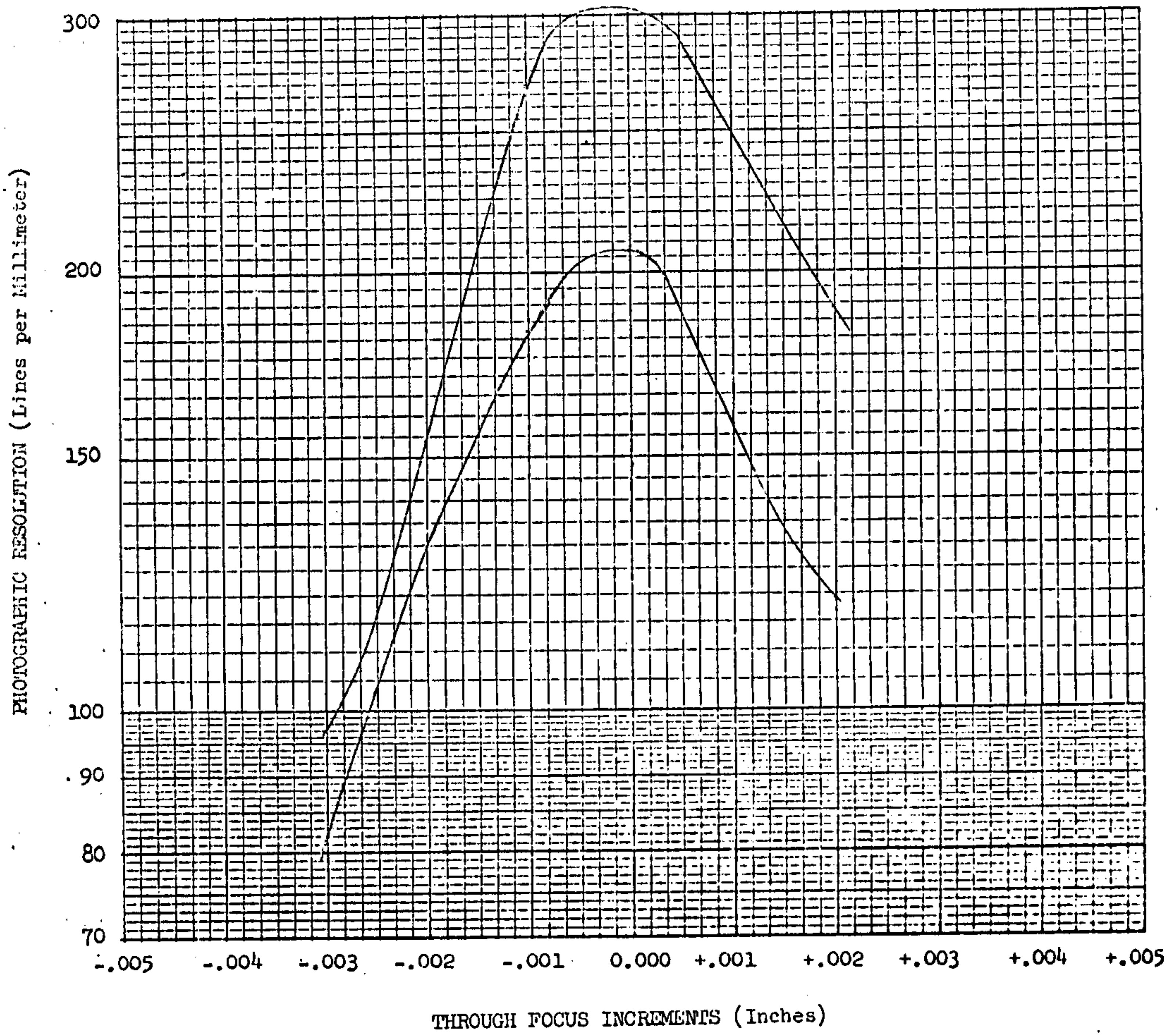
Low Contrast: 141

Film Type: 3404
W-21 filter

Test Date: 6-21-69

FIGURE 2-1

PRE-FLIGHT RESOLUTION, PAN CAMERA #315



Camera No. 315

Payload No. CR-7

Resolution (1/mm)

High Contrast: 303

Low Contrast: 207

Film Type: 3404
W-25 filter

Test Date: 6-21-69

FIGURE 2-2

E. FLIGHT READINESS TEST

DISIC flight readiness was performed on 9 July 1969. All data were present and acceptable. The usual skew bead mark was present along one edge of the Stellar film but did not enter the active format at any point.

Reseau fogging at the center of the Stellar format averaged +.30D gross on the starboard format and +.32D gross on the port. The base was +.12D, leaving a net fog of +.18D for the starboard and +.20D for the port.

Flight readiness was performed on pan cameras #314 and #315 on 11 July 1969. All data were present and acceptable for flight.

Slit image measurements were as follows:

	Aft, #314	Forward, #315
S4	0.255"	0.335"
S3	0.204"	0.268"
S2	0.160"	0.215"
S1	0.122"	0.168"
Failsafe	0.219"	0.298"

F. FLIGHT CERTIFICATION

Flight loading of the DISIC was performed on 12 July 1969. The pan cameras were loaded on 14 July 1969. Both were without incident. Sensitometric measurements made on samples of this flight film for both pan cameras and DISIC verified satisfactory photographic characteristics. Film types evaluated were 3400, 3401 and 3404.

Film tracking was acceptable during dynamic operation. Rail scratching was slight on #315, and moderate on #314.

Final photometer check for light leaks showed a slight leak alongside the drum on Camera #315. The only other leak was at the silver dollar where the strap that grounds the payload frame to the vehicle frame passes through the dollar. This hole is potted at the base at the time of mating to the vehicle.

The photographic performance of the CR-7 was certified for flight.

SECTION 3

FLIGHT OPERATIONS

A. SUMMARY

Mission 1107 was launched normally into the planned orbit without incident. All ascent and injection events occurred as programmed. The orbit achieved was within the 3 sigma predicted dispersions. The total mission lasted for 19 days with an 9-day first segment and a 10-day second segment.

The aft-looking panoramic camera #314 operated satisfactorily throughout the flight. Forward-looking panoramic camera #315 had a film transport failure on the 13th cycle of the first on-orbit operation. Photographic performance, judged only from the aft-looking camera, was fair. Utility of photography was reduced by the lack of stereo coverage. The aft-looking camera performance was about what was expected considering the operational conditions (altitude, illumination) of the mission.

The DISIC camera operated normally throughout the 1107-1 mission and most of the 1107-2 mission. The instrument stalled on rev. 282. Terrain image quality was good -- the best that had been obtained from a DISIC system. The starboard stellar camera was capped for most of the mission because of the high level of solar illumination resulting from the orbit flown. Both stellar and terrain films of 1107-2 were degraded by electrostatic marking which was symptomatic of the instrument failure.

B. LAUNCH

The flight was launched at 1831 hours PDT on 23 July 1969 (0131 hours GMT on 24 July 1969) from Satellite Launch Complex 3 West at Vandenberg Air Force Base. All launch, ascent, and injection events occurred as programmed.

C. ORBIT

Mission 1107 was launched into the planned orbit. All orbit parameters attained were well within the specified tolerances.

Orbit conditions computed from Rev 2 data are shown in Table 3-1.

TABLE 3-1

Mission 1107 Orbit Parameters (Rev. 2)

Orbit Parameter	Predicted	Tolerances	Actual
Period (min)	88.52	(+.32, -.36)	88.49
Perigee Altitude (nm)	99.4	(+11, -12)	102.0
Apogee Altitude (nm)	132.5	(+23, -24)	127.6
Eccentricity	0.0049	(+.0035, -.0034)	0.0034
Inclination (deg)	75.01	(+0.19, -0.17)	74.95
Argument of Perigee (deg)	114	(+105, -101)	136.7
Regression Rate (deg/rev)	22.33		22.32

Seven DMU rockets were used for period control during the 308 revs of the flight to maintain the ground tracks. No firing was required for dispersions as the initial orbit was near nominal.

Ground track errors were approximately 5 nautical miles east to 17 nautical miles west of nominal at the equator. After the final firing on Rev. 279, the ground track error increased to 38 nautical miles west of

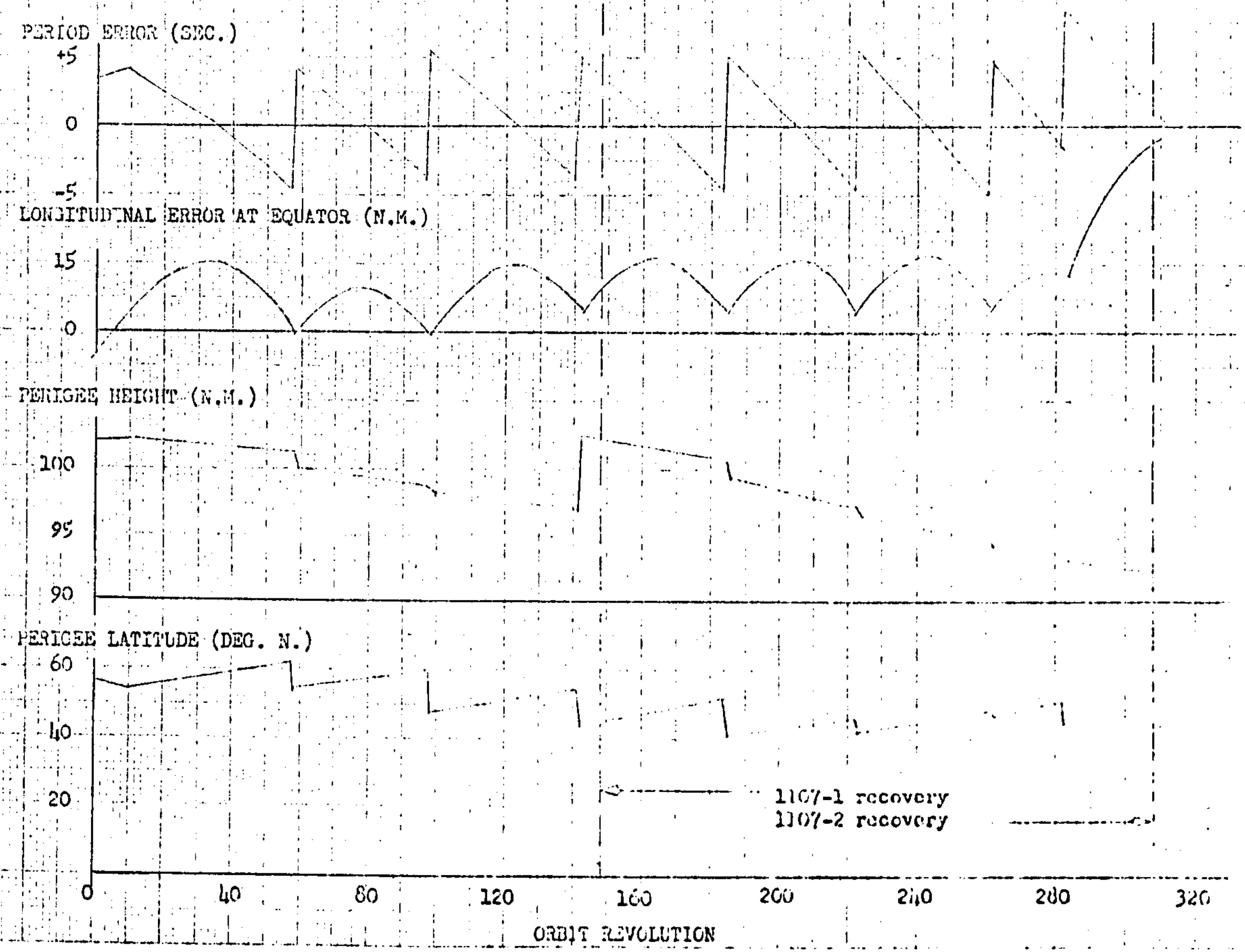


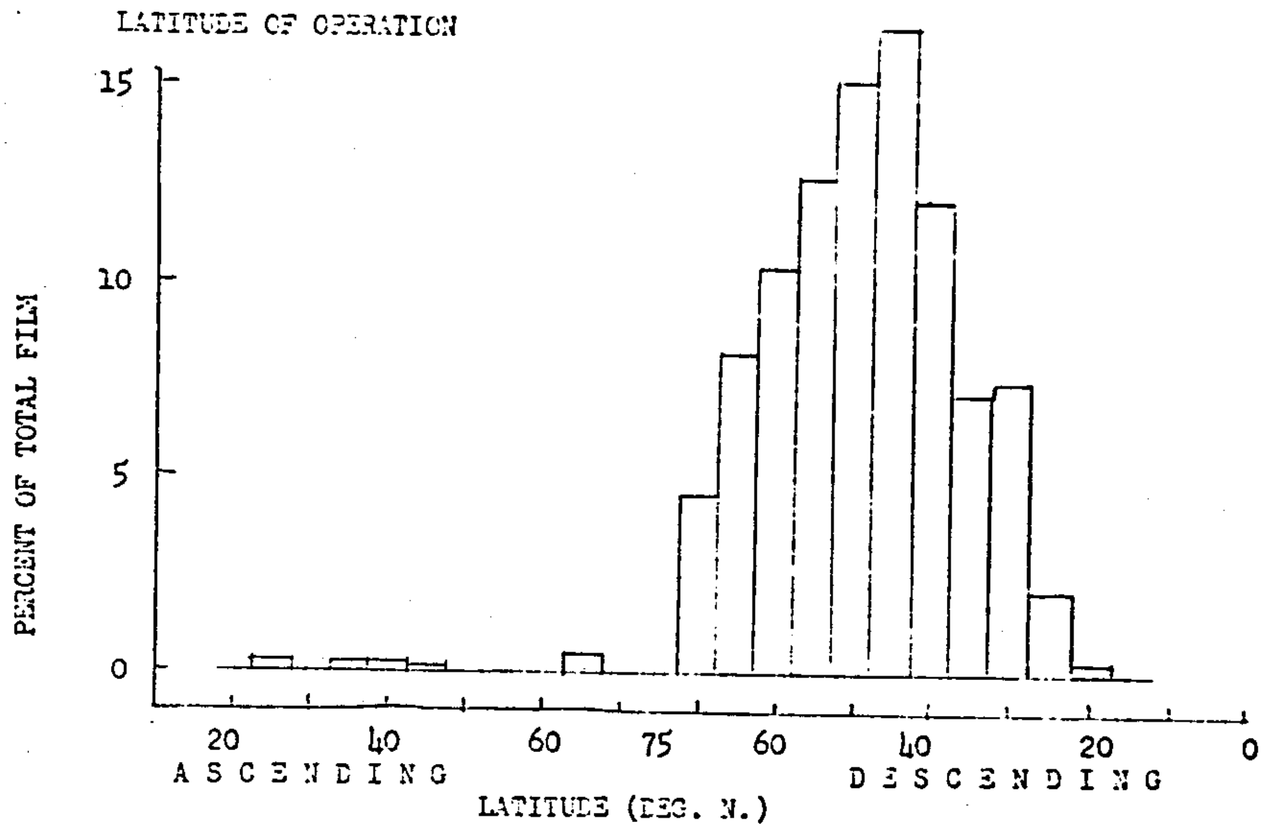
Figure 3-1 CR-7/1107 Orbit History

nominal at Rev. 299 where the last operation was taken. Figure 3-1 shows the orbit history maintained throughout the mission. A summary of the DMU firings is shown in Table 3-2. Figure 3-2 shows the frequency distribution of operations and mean frame altitude of Mission 1107.

TABLE 3-2

Rocket Firings and Orbital Effects

Rocket No.	Pass Fired	System Time	Period Change (Sec)	Velocity Change (Ft/Sec)	Period at Firing (Min.)
1	58	54425	9.27	14.85	88.36
2	97	02615	9.23	14.8	88.37
3	140	59345	9.00	14.5	88.37
4	182	21476	10.03	16.06	88.37
5	220	50110	10.06	16.11	88.37
6	258	78811	10.21	16.32	88.37
7	279	17854	10.16	16.24	88.37



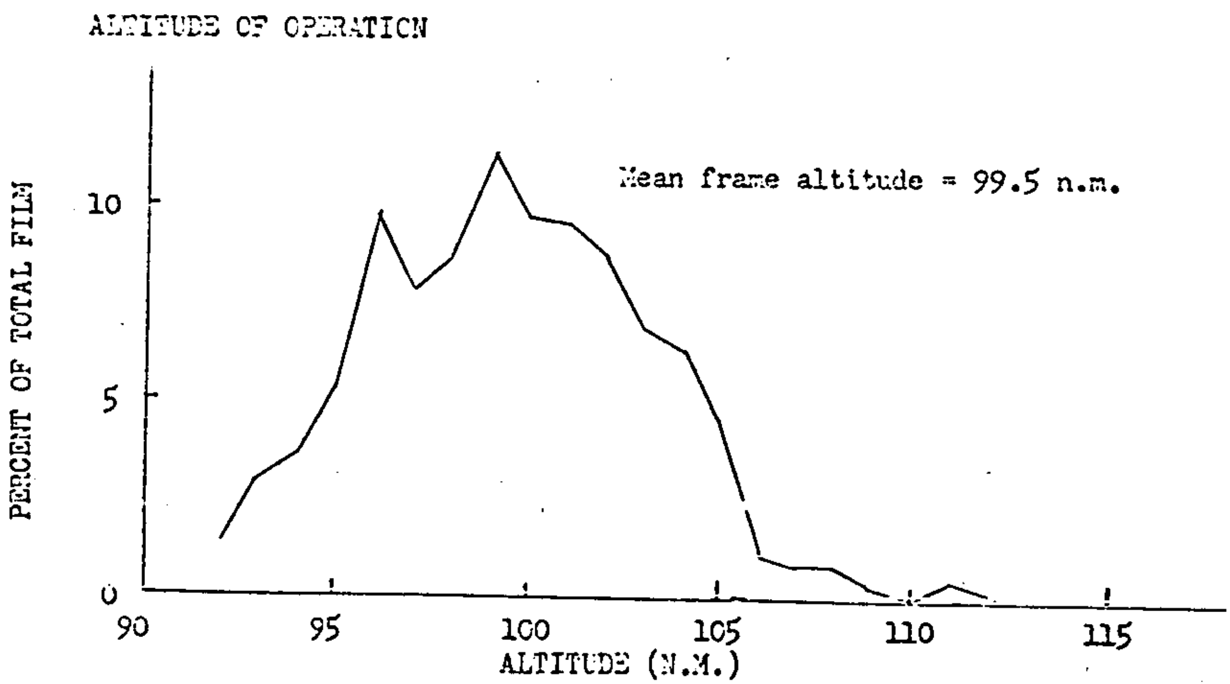


FIGURE 3-2 Location of Pan Camera Operations

D. PANORAMIC CAMERAS

Panoramic camera #314 operated normally throughout the flight. The camera passed the tag end into the recovery system with no wrap-up.

Panoramic camera #315 failed on the first on-orbit operation on Rev. 1 at [redacted] tracking station. The film transport system failed on the 13th frame of a 15-frame operation, however, the lens system continued intermittent rotation through Rev. 4. All of the pre-launch operations were normal and the recovered film provided no indications about the problem.

Just prior to camera shut down, the film transport failed although the camera completed the shut down sequence satisfactorily. The following is a summary of forward-looking camera failure indicators which were abstracted from the telemetry flight data.

1. Erratic rotation of output metering roller.
2. 0.1 Second pause on input idler roller (5 pauses).
3. Take up voltage ramp down starting at idler first pause.
4. Increase in forward drive voltage and decrease in reverse drive voltage.
5. Unregulated current ramp increase from 16 to 30 amps.
6. Tach-feedback indicated slow down starting at 13th center of format (cf).
7. Output metering roller, input idler, output idler, intermediate idler stopped simultaneously at 13th cf.
8. Input metering roller started slow down at approximately the 13th cf and was stopped by 0.7 second later.
9. No film motion followed the 13th exposure.

10. Deramp of lens rotation following 13th exposure appeared normal.

11. Cycle period of 13th frame was 30 milliseconds slow.

12. After failure, there was a slight speed-up of unit when the frame metering roller disengaged.

13. Input/output idler ratios indicated shuttle against 101 percent stop.

Utilizing all the telemetry data, the failure was analyzed in depth by Lockheed and Itek personnel. It was possible, with some degree of confidence, to reconstruct the sequence of failure. However, it was not possible to pinpoint the actual cause or causes. Two possible causes of failure were hypothesized by means of logical analysis:

1. Film restriction or film velocity reduction at the shuttle input.

2. Film restriction at the supply cassette.

Since no cause could be identified, the Performance Evaluation Team (PET) recommended no action and closed the matter as an action item.

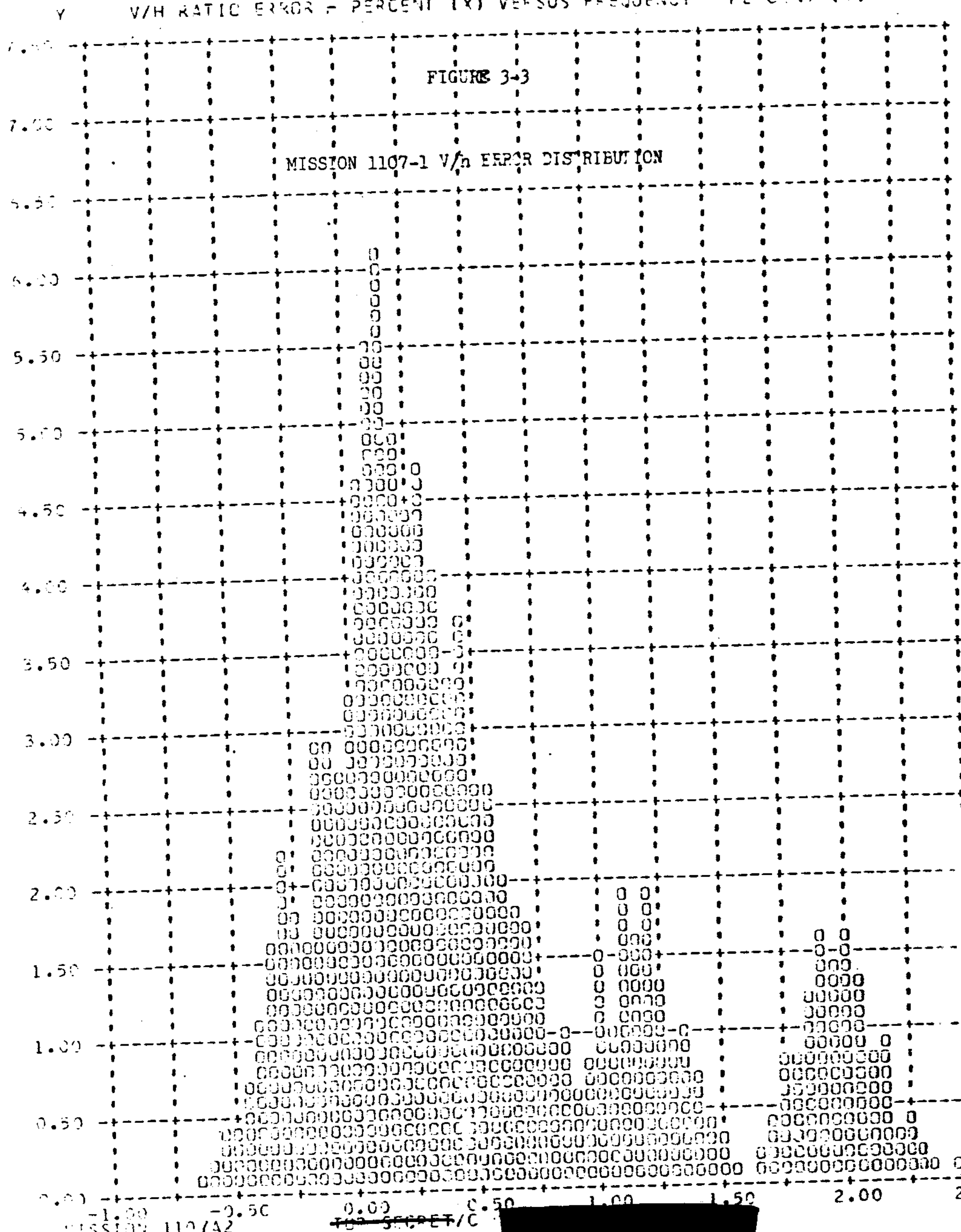
A satisfactory ramp-to-orbit match was maintained during both missions of the flight. Except for Revs. 1-8 and 23-25, the V/h mismatch was kept within plus or minus one percent for 95 percent of the frames taken. The ramp-to-orbit match is maintained by selecting the best combinations of start, half-cycle, and delay positions. The exceptions to accurate orbit matching mentioned above were due to use of incorrect orbit data. The V/h match performance is shown in Figures 3-3 and 3-4.

The forward-looking camera metered six and one-half frames into the recovery vehicles before stall. The aft-looking camera produced 2953 frames of photography during Mission 1107-1, and 3095 frames of photography during Mission 1107-2.

[redacted]

FRAMES 1-6 OF EACH OP OMITTED   OC PERCENT = 1.77

V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)



MISSION 1107A2

TOP SECRET/C [redacted]

[redacted]

FRAMES 1-6 OF EACH OP [redacted] OMITTED 90 PERCENT = 0.79

Y V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)

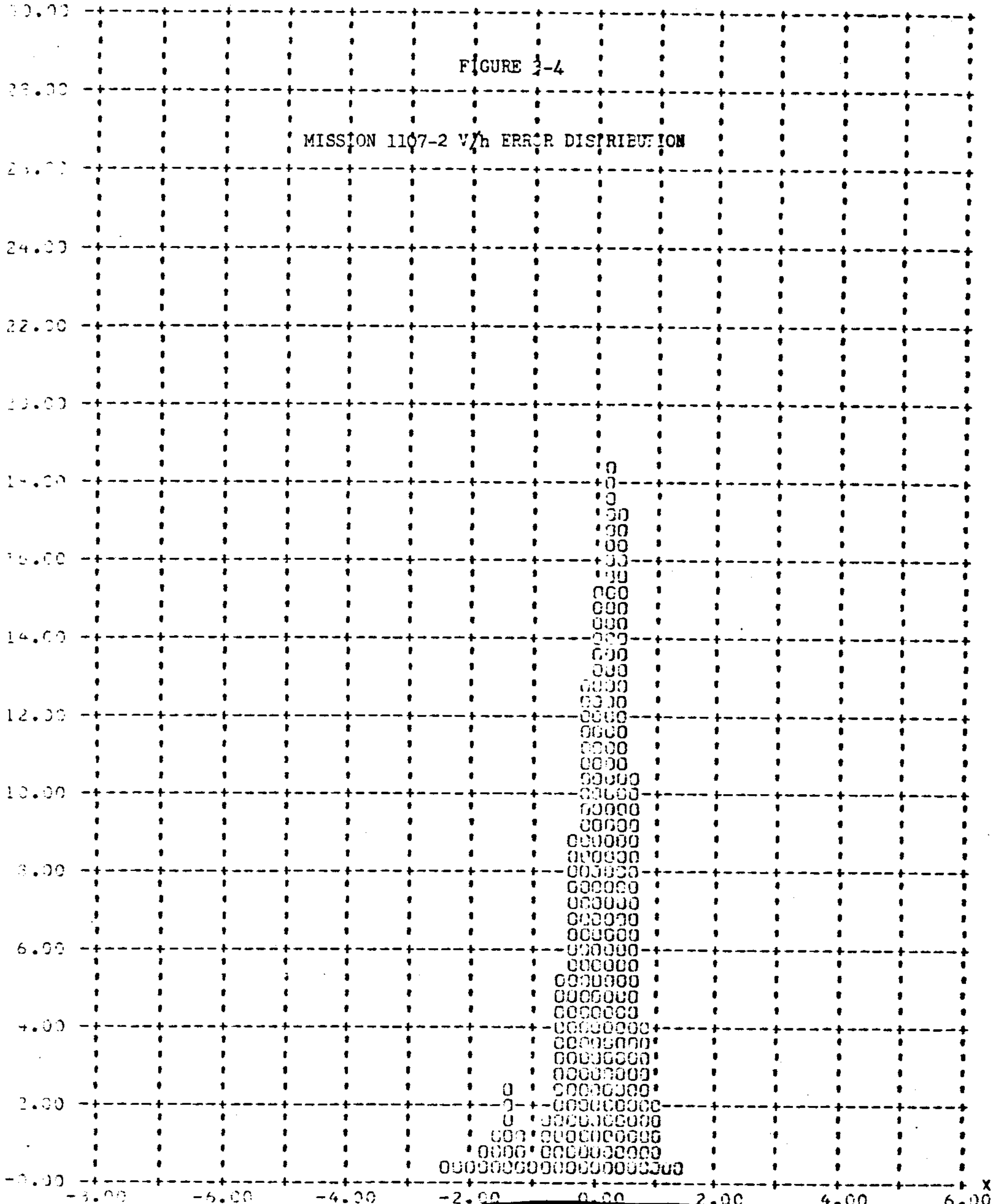


FIGURE 3-4

MISSION 1107-2 V/h ERROR DISTRIBUTION

MISSION 110781 ~~TOP SECRET~~/C [redacted]

E. DISIC

The DISIC functioned properly during the -1 mission. On Rev. 282 during the -2 mission, the system failed during a 70 cycle programmed independent operation with 50 cycles completed.

It appeared that for an unknown reason there was a loss of tension in the terrain film take-up which allowed the metering rollers to pick up a loop of film and wrap it around the roller causing a stall. This condition then reflected through the drive train to produce a complete stall. It appeared that several feet of terrain film had been drawn back into the system from the take-up. A wrap-up stall has been the failure mode observed in test when film slack develops downstream from the metering rollers.

An extensive investigation after the flight failed to establish the cause of failure. Test of the recovered take-up assembly indicated normal operation. Examination of DISIC film paths on other systems in test did not suggest a specific cause.

F. INSTRUMENTATION AND COMMAND

The instrumentation system performed normally throughout the flight. The command system performed normally with the exception of the DSR. Two anomalies occurred with the DSR during the mission. The first resulted in a double shift in the output register. This occurred when the Load Disable Command (U-119) was given while a Brush 30 was in the hole of the H-Timer tape on Rev. 82. The first shift in the output register occurred as a normal function of the Load Disable Command. The second shift in the output register occurred as a result of the Logic being enabled while the Brush 30 was in the hole. This is a design deficiency. It will be corrected by soft ware removing Brush 30 punching during tracking station acquisition times.

The second anomaly occurred 6 times and resulted in the failure to shift the first word into the output register. These were caused by the Load Disable Command being given while three other logic timing sequences were in sync. This failure mode is being corrected by modifying the control logic hardware.

G. EXPOSURE CONTROL SYSTEM

The exposure control system functioned properly throughout the flight. However, fixed slit widths selected by real time commands were found to fit the target requirements better than the automatic control, and was used throughout the flight.

H. CLOCK SYSTEM PERFORMANCE

The clock system operation was normal and resulted in satisfactory clock/system time correlation.

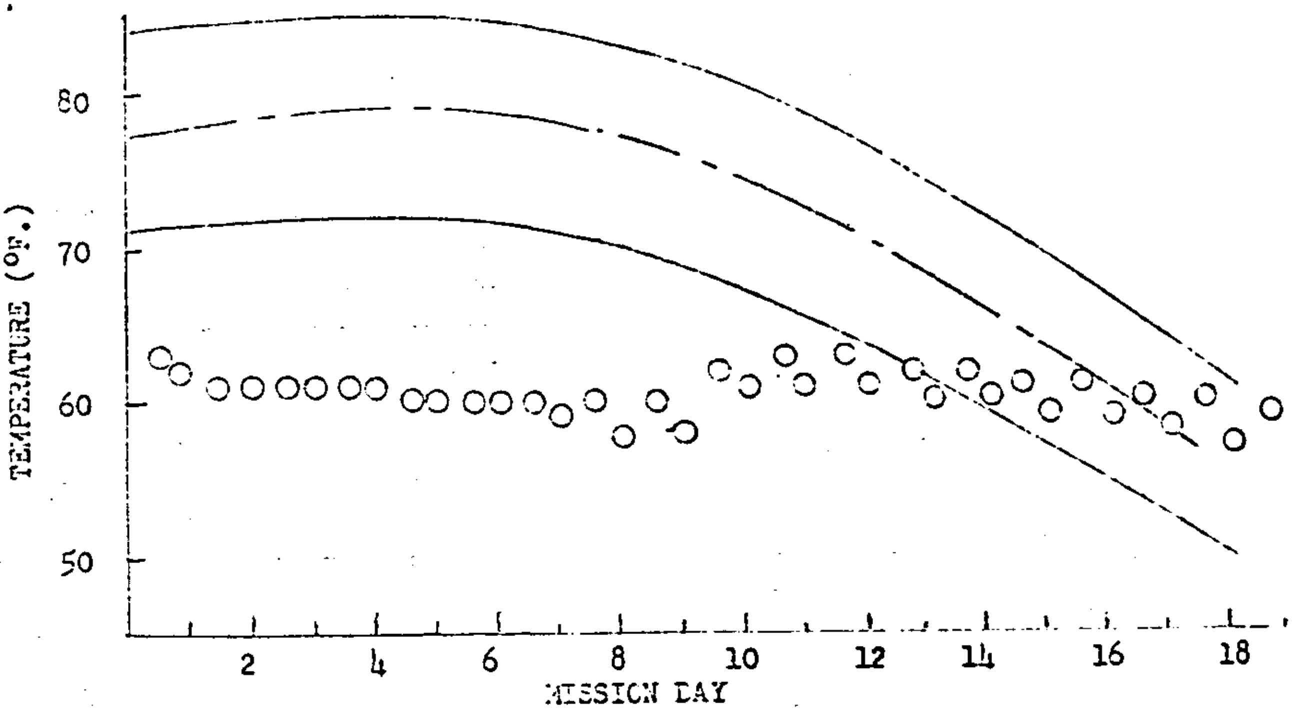
I. PMU SYSTEM OPERATION

The PMU functioned properly throughout the flight, using 9.5 lbs/min. with 1400 psi remaining at the end of the -2 mission.

J. THERMAL ENVIRONMENT

Although average pan camera temperatures were stable throughout the missions, they did not conform to predictions. The forward-looking camera was colder than anticipated since it was not operating throughout the mission. Predicted average temperature ranges and observed average temperatures for both panoramic cameras are shown in Figure 3-5.

NO. 1 PAN CAMERA (AFT LOOKING)



NO. 2 PAN CAMERA (FORWARD LOOKING)

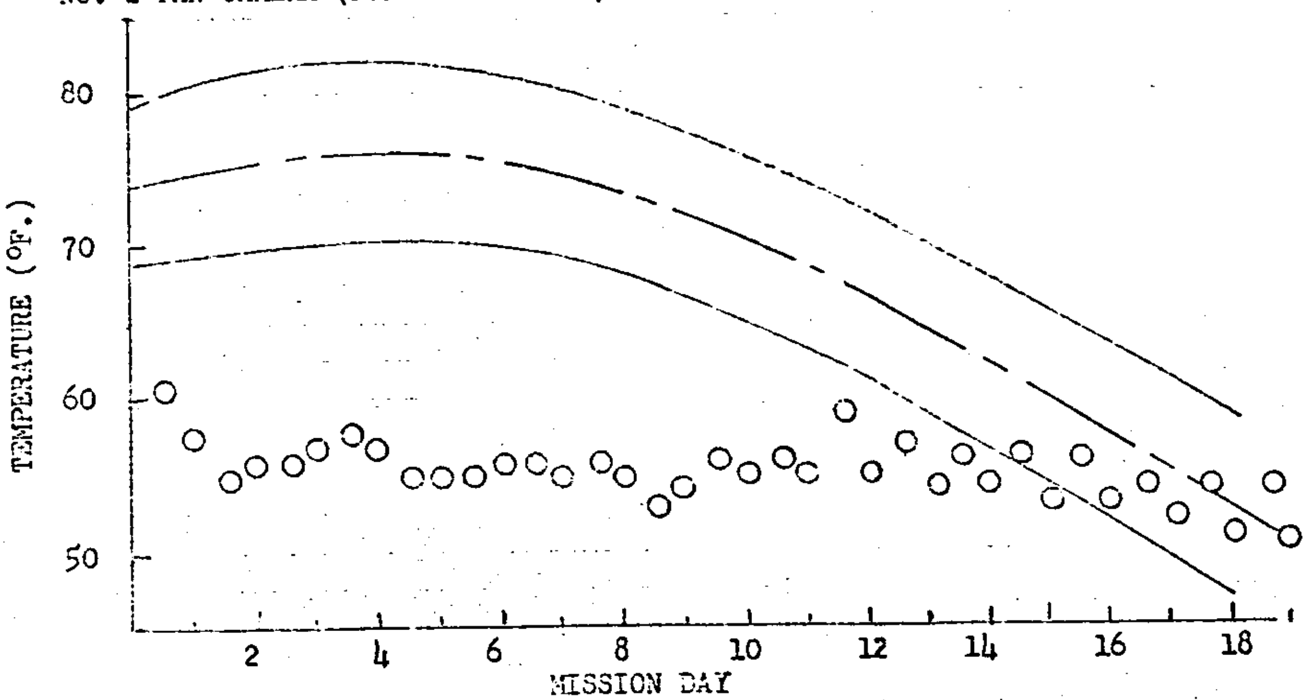


FIGURE 3-5 Panoramic camera temperatures.
The dashed and solid lines indicate predicted temperatures and tolerances respectively. The circles are averages of recorded instrument temperatures.

K. RECOVERY SYSTEM PERFORMANCE

The -1 recovery capsule was successfully recovered by a water recovery on Rev. 147. All re-entry events were within tolerance. The impact was 147 n.m. north of the predicted location. This was caused by a software problem at the Satellite Test Center.

The -2 recovery capsule was successfully recovered by an air catch on Rev. 308. All events were within tolerance. The impact was 28 n.m. north of the prediction.

L. SRV TAPE RECORDER

The tape recorders in both the -1 and -2 missions performed satisfactorily. A total of 236 minutes of data was recorded and processed from the two recorders.

M. POST MISSION TESTING

The post mission testing was conducted to determine the cause of failure on the DISIC and Panoramic Camera #135. Several attempts were made to run the DISIC in Independent and Slave modes with no results. Likewise no results were collected in attempts to run the Panoramic Camera #315.

N. RADIATION DOSAGE

Each recovery system flown on a Corona mission contains a sealed packet of Eastman Type 3401 and Royal X Pan emulsions to determine the total radiation received at the take-up cassette. Both film types have been irradiated by LMSC at various levels and the base plug fog densities recorded after controlled processing.

Following recovery the film dosimeter packets are removed at A/P and processed with a pre-flight sample of the same film type and sensitometric control film. The resulting base plus fog density measurement of the dosimeter strips is used to ascertain the total radiation level. The table below presents the base plus fog readings for the dosimeter strips and the radiation level equivalents.

	Mission 1107-1		Mission 1107-2	
Emulsion	B + F Density	Radiation	B + F Density	Radiation
Type 3401	0.11	0.1R	0.13	0.2R
Royal X Pan	0.25	0.4R	0.26	0.4R

These levels are below that which will degrade the photography.

SECTION 4

PHOTOGRAPHIC PERFORMANCE

A. SUMMARY

The overall photographic quality of Mission 1107 is somewhat less than typical previous J-3 missions. The failure of the forward-looking camera (with a higher resolution, third generation lens) and the resulting lack of stereo photography reduced the effectiveness of the mission.

The DISIC terrain photography was acquired with a reduced aperture lens for the first time. The resulting image quality was better than any previous mission. The DISIC stellar photography was also of acceptable quality. Failure of the DISIC subsystem on rev 282 near the end of the mission was of minor operational significance. However, there were frequent electrostatic discharge effects on both DISIC films through the -2 portion of the mission which did cause significant degradations.

The following footages and exposed frames were recovered from Mission 1107.

Mission	Camera	Film	Footage	Frames
1107-1	Forward	3404	325	5
	Aft	3404	8067	2953
	Stellar	3401	578	1913 Stbd.
				1907 Port
	Terrain	3400	850	1907
1107-2	Forward	3404	4	2
	Aft	3404	8143	3095
	Stellar	3401	528	1863 Stbd.
				1864 Port
	Terrain	3400	812	1823

B. PANORAMIC CAMERAS

1. Image Quality

The $6\frac{1}{2}$ frames of photography recovered from the forward looking camera contained cloud cover with no usable imagery and no basis for evaluating photographic performance.

The overall image quality of the Aft camera was considered to be fair throughout the mission. Some systematic variation in image quality was noted in the formats. During 1107-1, imagery at the take-up end and along the data block edge was slightly better than the remaining areas. During the 1107-2 mission, imagery along the data block edge was slightly better but no difference was detected between supply and take-up ends. In general, the imagery had an out-of-focus appearance at magnifications of 50 X and above.

The MIP (Mission Information Potential) rating assigned to each mission segment was 95. The MIP frame in 1107-1 was number 30 in rev D122; in 1107-2 it was number 20 of rev D170. These MIP ratings are the first established under a revised rating system using standard reference criteria. As a result of this new system, the MIP ratings of all previous 1100 series missions have been changed with the exception of mission 1104.

MIP Ratings of 1100 Series Missions

Mission	Revised MIP	Previous MIP
1101	85	95
1102	90	100
1103	90	95
1104	No Change	115
1105	95	100
1106	110	105
1107	95	—

Two aspects of the mission deserve particular attention from the standpoint of photographic quality. This was the first 1100 series mission to be flown at a perigee height of about 100 nautical miles. The eighteen percent increase in nominal perigee height represents a corresponding reduction in ground resolution for any system. Secondly, this was the first 1100 series mission flown at an inclination and launch time to provide ascending, as well as descending, orbital coverage. The additional capability for ascending coverage entails penalties in photographic quality. One penalty is increased smear that results from the exposure time increase with the low solar elevations that are characteristic of ascending - descending orbits. Another characteristic of such orbits is large solar azimuths. That is, the sun direction is to the side of the system rather than in front When the large azimuths are combined with low solar elevations, there is an illumination variation across the formats. Such scenes can be acceptably exposed on the original negative but result in a condition known as "intra frame density variation" which is difficult to properly print at a single level. While the ascending - descending coverage orbits provide significant increases in target acquisitions over limited latitudes, such orbits generally do not optimize photographic quality. The flight records show that less than 3 percent of the pan camera photography was acquired on ascending passes None of the ascending coverage was of denied areas.

Duplicate positive film from domestic engineering operations was evaluated by A/P at Lockheed Missiles and Space Company. The low solar elevations of 1107-1 are particularly evident. As the mission progressed, rotation of the orbital plane provided higher solar elevations with a general improvement of the photography. Much of the engineering photography was cloud covered, as was the entire mission There is no one simple reason for the large extent of cloud dover. In part, it is due to the locations photographed and the season of the year. To a probably significant extent, it is also due to the local time of photography, being relatively early or late in the day, i.e., the ascending - descending coverage type of mission.

Controlled Range Network (CORN) targets acquired on five engineering operations through the flight were evaluated. All of the targets acquired were of the mobile type and included the 51-51 T-bar array. A new target designated the "Vernier T-bar", was deployed at four of the five sites for this mission. This target supplements the 51-51 T-bar by providing resolution elements over the range of 7 to 10 feet in six inch increments. The average observations of several readers using original negatives are summarized in Table 4-1. These results closely approach the best that could be expected from camera No. 314.

2. <u>Data Recording</u>

The forward and aft looking cameras produced complete and normal auxiliary data with all of the recovered photography. Imagery of the PG rail holes, scan lines, 200 cycle time marks, slur pulses, camera serial numbers, time words, start of pass marks, and horizon fiducial marks were present and acceptable. An horizon camera malfunction is described in paragraph C, below.

3. <u>Anomalies</u>

There are certain anomalies that recur from mission to mission and others that are characteristic of a particular system. While such anomalies have

TABLE 4-1

VISUAL EVALUATION OF BAR TARGET IMAGERY FROM ENGINEERING OPERATIONS

Camera, Rev, Frame #	Ground Resolution FMC/Scan (Feet)	Geographic Location	Universal Grid Coord. X	Universal Grid Coord. Y	Target Type Contrast	Weather Conditions
Aft, A9, 24	16/16	Quartzite, Az.	35.7	3.8	T-Bar 5:1	Scattered clouds
Aft, A74, 14	12/12+	Brothers, Or	36.0	4.2	T-Bar 5:1	Clear
Aft, A74, 14	8.7/8.5	Same	Same		Vernier 5:1	Clear
Aft, D129, 6	12/13	Goshen, Or	31.9	3.8	T-Bar 5:1	Clear
Aft, D129, 6	9.3/NR	Same	Same		Vernier 5:1	Clear
Aft, D242, 11	12/12	Coos Bay, Or	30.6	0.8	T-Bar 5:1	Clear
Aft, D242, 11	8.7/8.8	Same	Seme		Vernier 5:1	Clear
Aft, D274, 16	8/12	Folly Farm, Or	32.3	0.9	T-Bar 5:1	Clear
Aft, D274, 16	7.8/8.5	Same	Same		Vernier 5:1	Clear

NR - Not resolved

not been eliminated, their effects on flight imagery have been minimized. On the six and one-half frames of photography recovered from the forward camera, no anomalies were observed. With a larger amount of film from this camera, some anomalies would be expected.

Two light leaks affected the aft camera film. One produced a small spur-like fog pattern on the fourth frame of some passes. The other affected the full width of the film for several inches on the sixth from last frame of most 1107-1 passes. The density of the fog patterns varied with the length of inoperative periods. The fog on the fourth frame was caused by a light leak at a corner of the forward camera drum. The fog on the sixth from last frame was probably due to a leak at a latch of the "A" recovery vehicle interface. Fog density was greater than usual because of longer inactive periods experienced on this flight. No action was indicated for either of these leaks.

A subtle longitudinal plus density mark was present on the original negative of the aft looking camera. This mark was only occasionally detectable. This mark was typical of an abrasion caused when the emulsion was rubbed during transport.

The intermittance of the mark, being observed in part two only and not being present during pre-flight evaluation, prevents identification of the source. No action was recommended.

C. HORIZON CAMERAS

Both horizon cameras on the forward looking main camera functioned properly and produced well defined imagery from the three cycles that were recovered.

Both horizon cameras on the aft looking main camera were non-operational until frame 15 of pass D08 The fiducial marks associated with these horizon cameras exposures were present, while telemetry data indicated an absence of shutter commands. Telemetry indicated proper operation prior to launch. Partial failure of the relay which supplied unregulated voltage pulses to the horizon camera shutter is the most probable cause. The PET recommended no action because the relays are sealed and the failure does not adversely affect the primary mission. Operation of these horizon cameras was normal for the remainder of the mission.

D. DISIC STELLAR/TERRAIN CAMERAS

1. Stellar Cameras

The stellar cameras functioned properly until the DISIC failure on rev 282. The port camera produced approximately 15 to 25 point type stellar images throughout the flight. The orbit and launch time of this mission produced a high level of solar illumination on the starboard side of the vehicle with the result that the starboard camera capping shutter remained closed for approximately 90 percent of the 1101-1 mission and 20 percent of the 1107-2 mission. Where the starboard camera was not capped, there were approximately 10 point type stellar images. The overall density of the starboard stellar frames was higher than the port frames and stellar images were difficult to detect.

The stellar film was degraded by corona and electrostatic discharge. The condition tended to become worse during the latter part of the mission and in some degree was associated with the system failure.

A subtle light leak occurred on starboard frames which were in the exposure position when the shutter was capped. This anomaly was caused by long sit periods during which there was a high level of solar illuminance at the starboard lens. Light leakage around the shutter produced minor fogging on the record.

Dendritic static traces were present on some frames. Wavering plus density static traces are present throughout the mission. Dendritic discharge in the starboard formats was relatively severe. Dentritic traces emanating from the film edge are characteristic of unspooling or roller flange discharge. The wavering plus density pattern is characteristic of this system in some sensitive pressure windows. Some correlation between marking and PMU off periods was noted Starboard format discharge resulted from dirt accumulation on the reseau plate. As a result, pre-flight splicing and threading procedures have been modified to minimize DISIC film and camera exposure to dirt and foreign material.

2. Terrain Camera

The image quality produced by the mission 1107 terrain camera was the best produced by any DISIC system to date. This unit had the first F/6.3 lens to be used operationally. Previous units had F/4.5 lenses.

While the terrain camera provided superior image quality, there was extensive degradation from electrostatic and corona marking. Much of this marking, particularly during the second part of the mission apparently was related to the system failure on rev 282. The degree of marking was generally less when the PMU was on.

Exposure of the DISIC terrain photography appeared to be generally satisfactory. The shift between 1/250th second exposure and 1/500th second exposure was planned to occur as near 25 degrees solar elevation as pan camera control requirements would permit. The transition generally was within plus or minus ten degrees of solar elevation. When the transition occurred at a lower elevation (10 to 15 degrees) underexposure was evident but was not reported to be degrading.

High density areas were common on the terrain film and casual examination suggested serious overexposure. It was found that such areas were usually from clouds and specular reflections off water. The brightness of such objects is so high that the total scene brightness range is beyond the capability of the film-processing combination. The exposure was properly controlled for the significant information content of the scene. This condition subsequently led to a recommendation to utilize a dual-gamma process on the terrain record.

SECTION 5

PANORAMIC EXPOSURE

A. INTRODUCTION

Panoramic camera exposure is determined by the scan rate, slit width, filter, and scene luminance. Scan rate is adjusted continuously in flight to compensate for forward motion. The patterns of adjustment depend on orbit geometry. Primary and alternate filters are installed before the flight. Four fixed slit widths plus a failsafe slit width are also established in each camera before the flight. The four slit widths may be operated by a preflight adjusted automatic sequence control, or fixed on command in flight. Although scene luminance is a complex variable, a criterion based on time of year is used which provides values as a function of solar elevation.

Depending on the particular operational and photographic requirements of the mission, orbits, launch date and time, and film and filters are selected. From these data slit widths and automatic sequencing relationships are established to provide the most nearly optimum exposure that can be predicted.

B. SPECIAL OBJECTIVES

1. Ascending - Descending Coverage

For the first time in the J-3 program, an orbit and launch time were selected to permit ascending (northbound) coverage as well as descending coverage. Such an orbit provided a maximum number of target acquisitions within a specified north latitude range. It is a characteristic of such orbits that photography will tend to be acquired at local times that are early or late in the day rather than near local noon.

2. Bicolor Photography

A requirement for bicolor photographic capability was established by the customer. This is a technique where the usual black and white films are exposed through a red filter on one camera and a green filter on the other camera. The result is a pair of films that may be viewed through suitable filters to observe a partial color or spectral separation effect at a higher resolution than would be possible with conventional color films.

Because of the failure of the forward looking camera on rev 1, the SF-05 (green) filter installed in the aft camera alternate position was never used. The shorter wavelength transmission of this filter would have admitted more non image forming haze light, tending to reduce resolution.

C. OPERATIONAL EXPOSURE

The very late launch time required to achieve ascending and descending coverage produced relatively low solar elevations at the beginning of the mission. This is illustrated by Figure 5-1 which shows the relatively long required exposure times as a function of ascending and descending latitude for rev 9, the first day of the mission. This exposure pattern did not change significantly through the first ten days of the mission. The reason for this relatively fixed condition was that rotation of the orbital plane caused the beta angle to increase and decrease at minimum rates as beta went through a maximum value at the end of the fourth day of the mission. During the second mission segment the required exposure curve rotated counter-clockwise at an increasing rate until on rev 298, the last day of the mission, it appeared as shown in Figure 5-2. During the first mission segment, correct exposure was achieved by fixed slits, set by real time command.

EXPOSURE POINTS

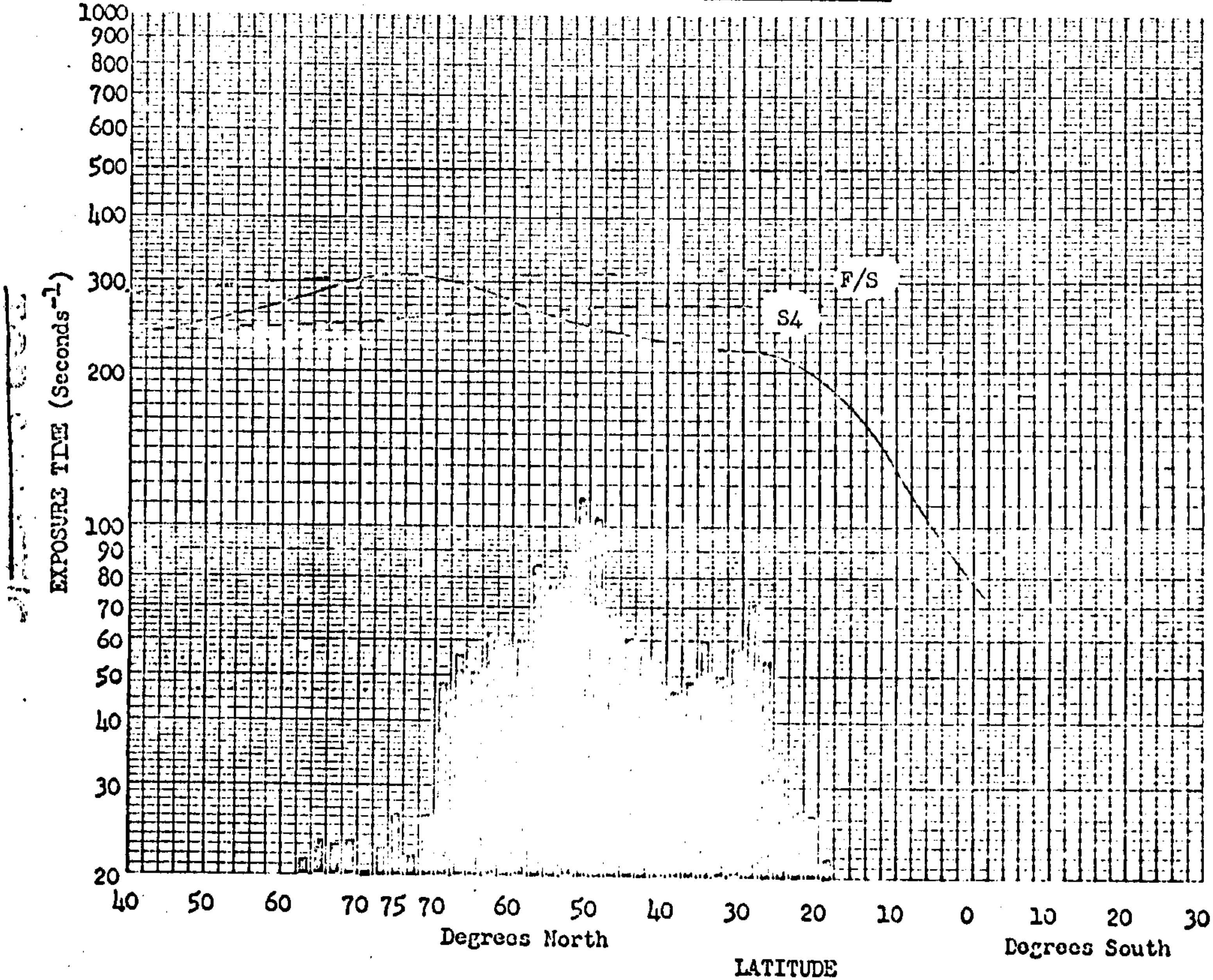


FIGURE 5-1: MISSION 1107-1 EXPOSURE REQUIREMENTS

Mission No: 1107-1

Payload No: CR-7

Camera No: 314

Pass No: 7

Launch Date: 7-24-69Z

Launch Time: 0131 GMT

Slit Width: 0.255", 0.204", 0.160", 0.122", F/S 0.219"

Filter Type: W-21

Film Type: 3404

EXPOSURE POINTS

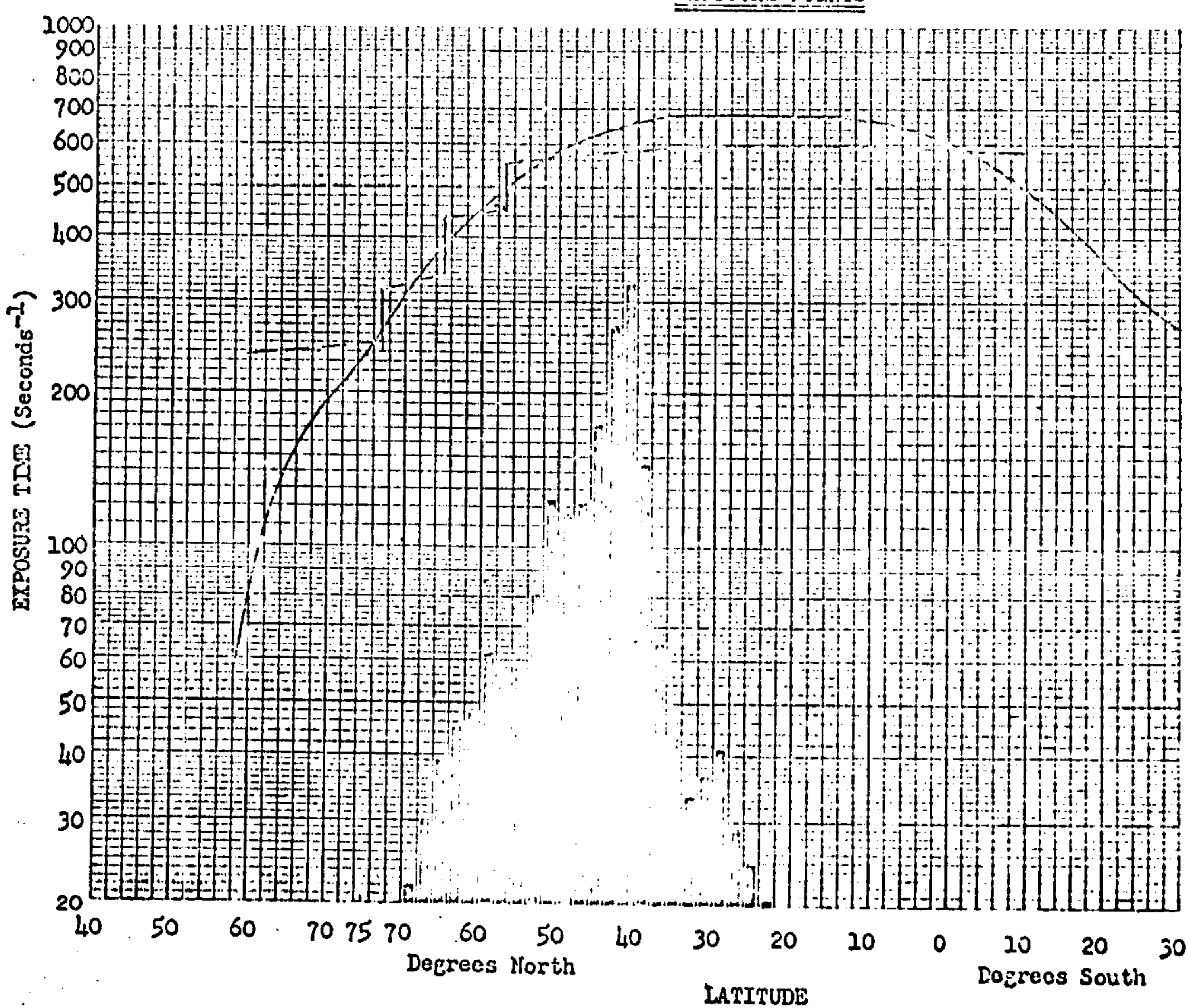


FIGURE 5-2: MISSION 1107-2 EXPOSURE REQUIREMENTS

Mission No: 1107-2

Payload No: CR-7

Camera No: 314

Pass No: 298

Launch Date: July 24, 1969

Launch Time: 0131 GMT

0.255", 0.204", 0.160",

Slit Width: 0.122", F/S 0.219

Filter Type: W-21

Film Type: 3404

During the second mission segment automatic exposure control sequences provided adequate exposure adjustments over the latitudes of primary interest. Figures 5-1 and 5-2 also summarize the relative frequency of coverage at the various latitudes.

As was mentioned earlier, the ascending - descending coverage orbit characteristically entails low solar elevations and large azimuths. The frequency of camera cycles at various solar elevations is shown in Table 5-1. The frequency of camera cycles at various solar azimuths is shown in Table 5-2.

The exposure criteria developed by Advanced Projects and used for Corona missions are based on previous flight results. Since most previous Corona missions had been designed for photographic coverage only on southbound passes, the time of photography was generally within two hours of local noon and the solar azimuths tended to be less than 40 to 60 degrees. There was also a very close relationship between solar elevations and latitudes at given times of years. These relationships are inherent, but are not seperately expressed in the exposure criteria. Therefore, it was not known how valid the criteria would be under the conditions of this mission. The Advanced Projects criteria are established on monthly time intervals. The August criterion was used for this entire mission. It provides slightly more conservative (longer exposure time) values at low solar elevations than does the July criterion.

D. PROCESS CONTROL

All of the Mission 1107 flight films were processed without incident. Dual gamma processing was used for all pan camera film. Using samples of flight film

TABLE 5-1

SOLAR EVELATION DISTRIBUTION OF PAN CAMERA OPERATIONS

Solar Elevation Interval	Mission 1107-1 Percent	Mission 1107-1 Cumulative	Mission 1107-2 Percent	Mission 1107-2 Cumulative
11 to 15 degrees	0.47	0.47		
16 to 20 degrees	1.98	2.45		
21 to 25 degrees	11.83	14.28		
26 to 30 degrees	23.40	37.68		
31 to 35	37.89	75.57		
36 to 40	19.73	95.30	10.98	10.98
41 to 45	4.70	100.00	37.86	48.84
46 to 50			24.83	73.67
51 to 55			16.09	89.76
56 to 60			9.97	99.73
61 to 65			0.27	100.00

TABLE 5-2

SOLAR AZIMUTH DISTRIBUTION OF PAN CAMERA OPERATIONS

Solar Azimuth Interval (Degrees CW from veh. head)	Mission 1107-1 Percent	Mission 1107-1 Cumulative	Mission 1107-2 Percent	Mission 1107-2 Cumulative
31 to 40			0.35	0.35
41 to 50			8.58	8.93
51 to 60	0.84	0.84	15.53	24.46
61 to 70	2.51	3.35	18.34	42.80
71 to 80	5.11	8.46	19.54	62.34
81 to 90	7.30	15.76	24.14	86.48
91 to 100	23.38	39.14	8.24	94.72
101 to 110	36.35	75.49	5.28	100.00
111 to 120	24.51	100.00		

removed before the flight, controlled exposures were added to the head and tail of each camera film and processed with it. The averaged results for both mission segments of the aft pan camera film are shown in Figures 5-3 and 5-4. These Characteristic Curves show that film processing results were very close to system standards. The only notable deviation was indicated by SPPF density data which showed the base plus fog values to range from 0.23 to 0.30, with the average of 0.25. A base plus fog value 0.20 is nominal.

E. MACRO DENSITY MEASUREMENTS

Representative diffuse density measurements are supplied by AFSPPF. Density measurements are made with a one-half millimeter spot size. At the average scale of this mission, this spot size is equivalent to a ground area of more than 500 feet diameter.

Throughout the Corona program, a criterion for proper exposure has been terrain minimum density values between 0.4 and 0.9, the former being judged underexposed and the latter overexposed. On this basis the following results were achieved.

	1107-1 Aft only	1107-2 Aft only
Within control (0.4 to 0.9 D min)	77.3%	63.4%
Underexposed (D min < 0.4)	13.6%	31.1%
Overexposed (D min < 0.9)	9.1%	5.5%

The 0.4 to 0.9 terrain minimum density criterion has not been consistent with subjective experience. The primary problem has been that many of the formats with D-min values less than 0.4 have appeared to be adequately exposed.

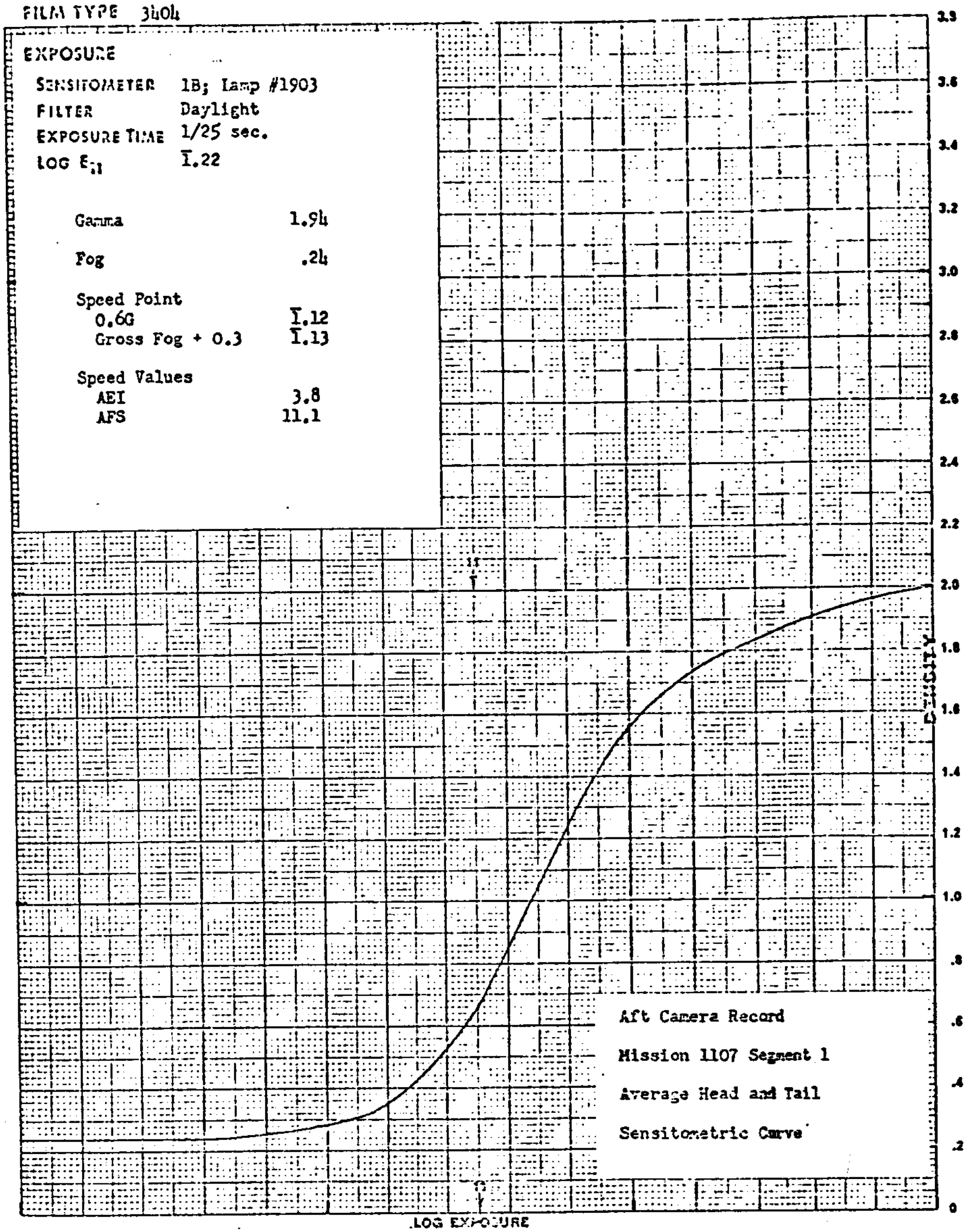


FIGURE 5-3: AFT CAMERA FILM, 1107-1, SENSITOMETRIC CURVE

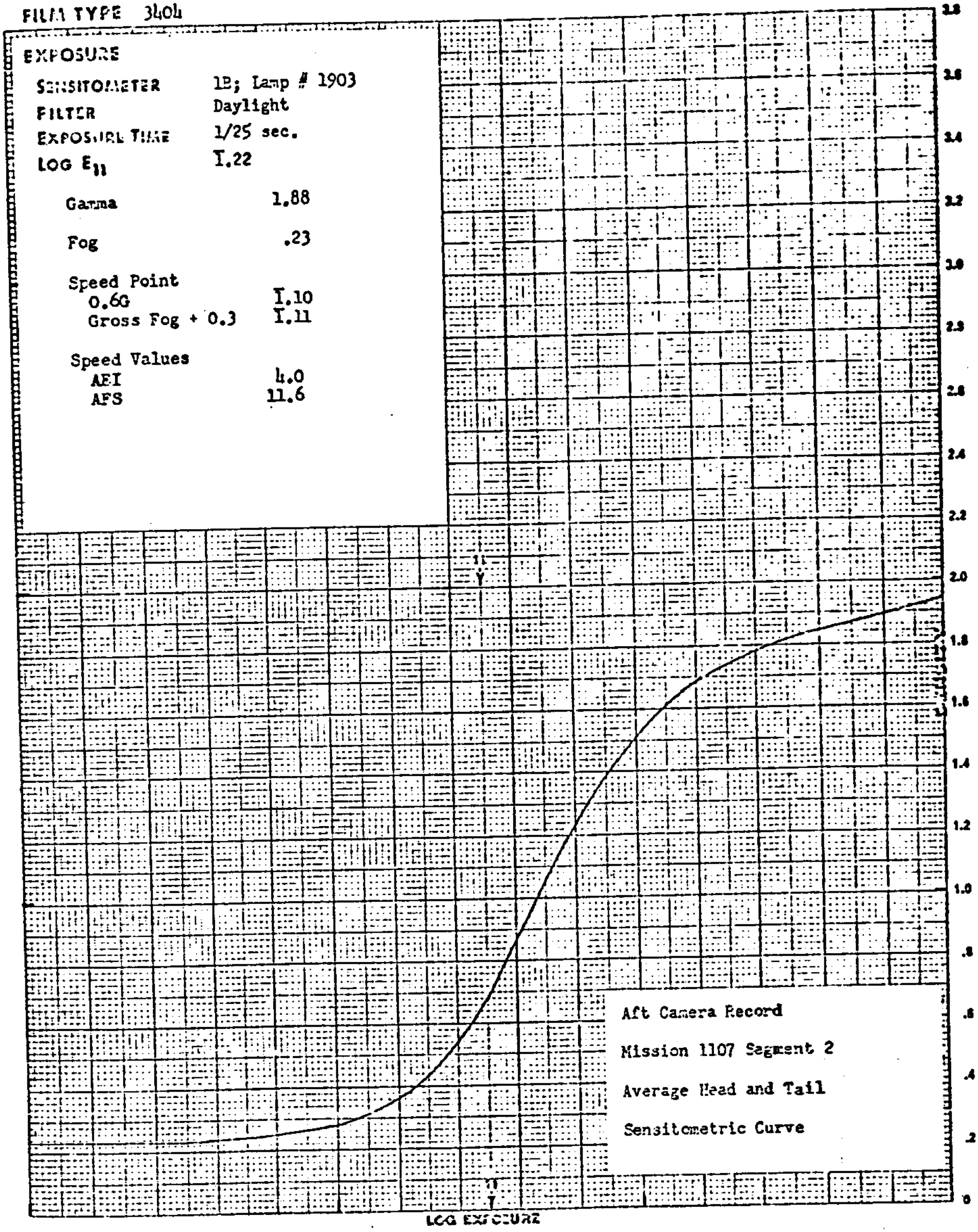


FIGURE 5-4: AFT CAMERA FILM, 1107-2, SENSITOMETRIC CURVE

Mission 1107 is the first for which AFSPPF has applied a new criterion. Using the R-2 sample D LOG E curve, the 25% maximum gamma points at each end of the curve are determined. Exposure control is then judged on the basis of the total ground scene (terrain minimum and maximum densities) falling within this range. The corresponding densities for this mission are 0.33 and 1.78. On this basis the following results were achieved.

	1107 Total Mission
Within Control	96.69%
Underexposed	0.37%
Overexposed	2.03%
Density range exceeds control	0.92%

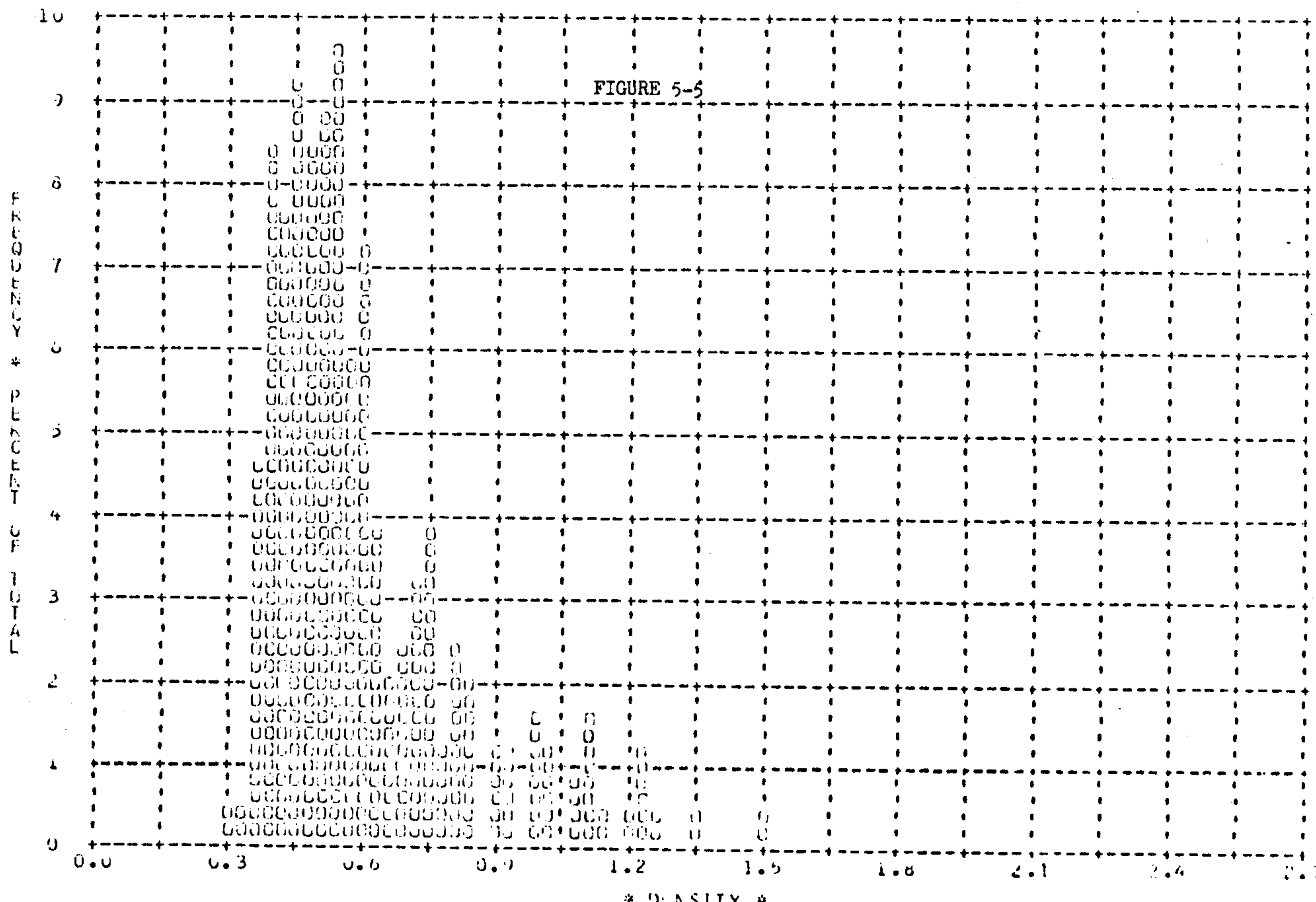
There is no physical basis for defining a precise exposure criterion. However, this new criterion appears to be consistent with subjective evaluation of the overall mission. It is also consistent with the dispersion characteristics of the data used by Advanced Projects in developing the current monthly exposure criteria.

The distributions of terrain minimum and maximum densities are shown in Figures 5-5 through 5-8. Using the SPPF tabulated density data, every sample with a D-min less than 0.4 or D-max greater than 0.9 was examined to determine the cause of density variation. This included 121 frames with D-min less than 0.4 and 39 frames with D-max over 0.9. In almost all cases, the condition could be attributed to scene luminance conditions. In a few cases, desert or semi-desert areas were listed as snow covered. This is a fairly common error in interpretation of negatives when location information is not used. No cases were found where either exposure criteria or system control were clearly in error.

MISSION * 1107-1 * INSTR * AFT * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.58 * MEDIAN * 0.52 * STD DEV * 0.21 * RANGE * 0.29 TO 1.50 WITH 264 SAMPLES

FIGURE 5-5

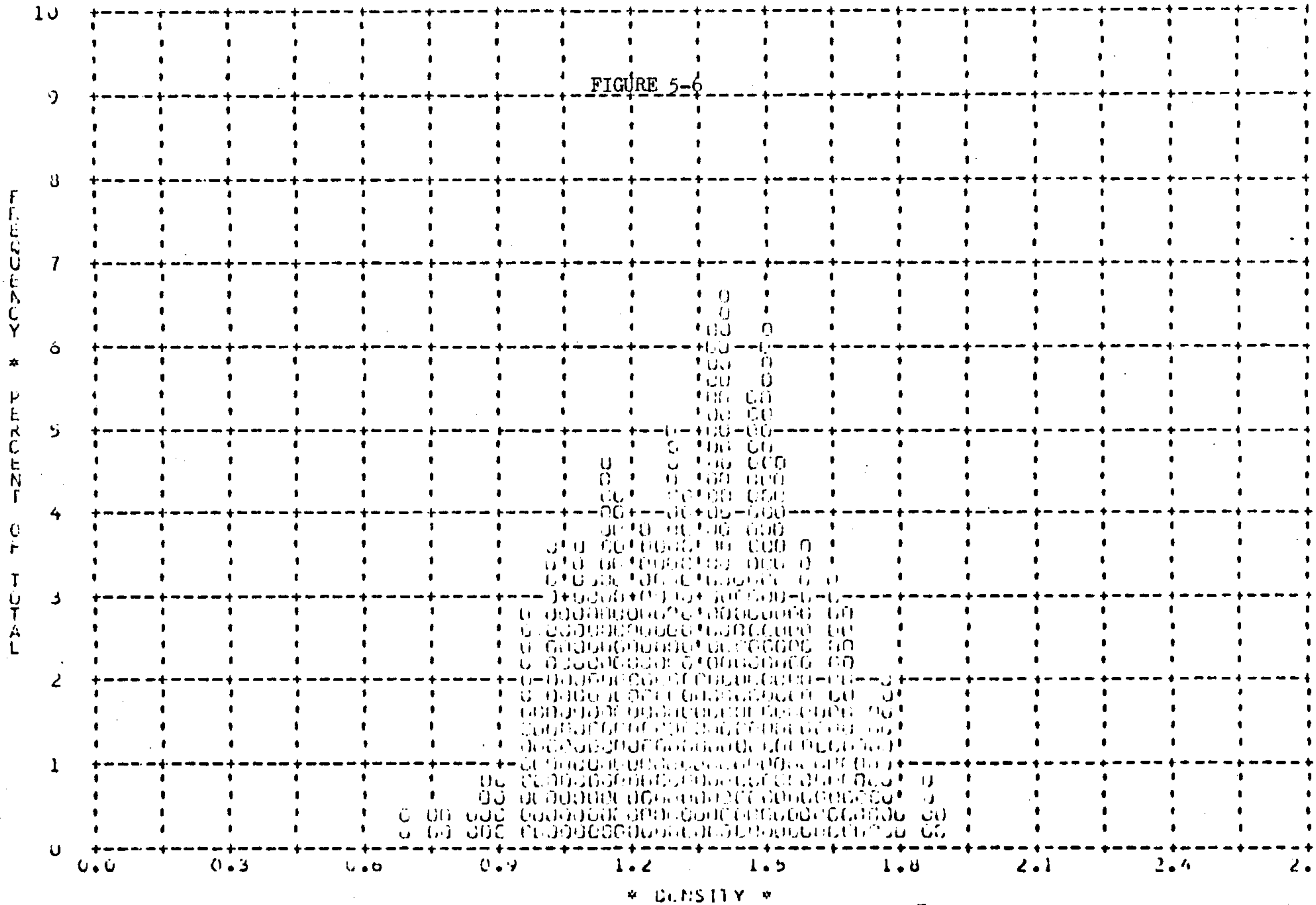


[redacted] ~~TOP SECRET~~/C--HANDLE VIA [redacted] CONTROL SYSTEM ONLY

MISSION * 1107-1 * INSTR * AFT * PLOT OF D MAX * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 1.33 * MEDIAN * 1.35 * STD DEV * 0.24 * RANGE * 0.67 TO 1.67 WITH [illegible] SAMPLES

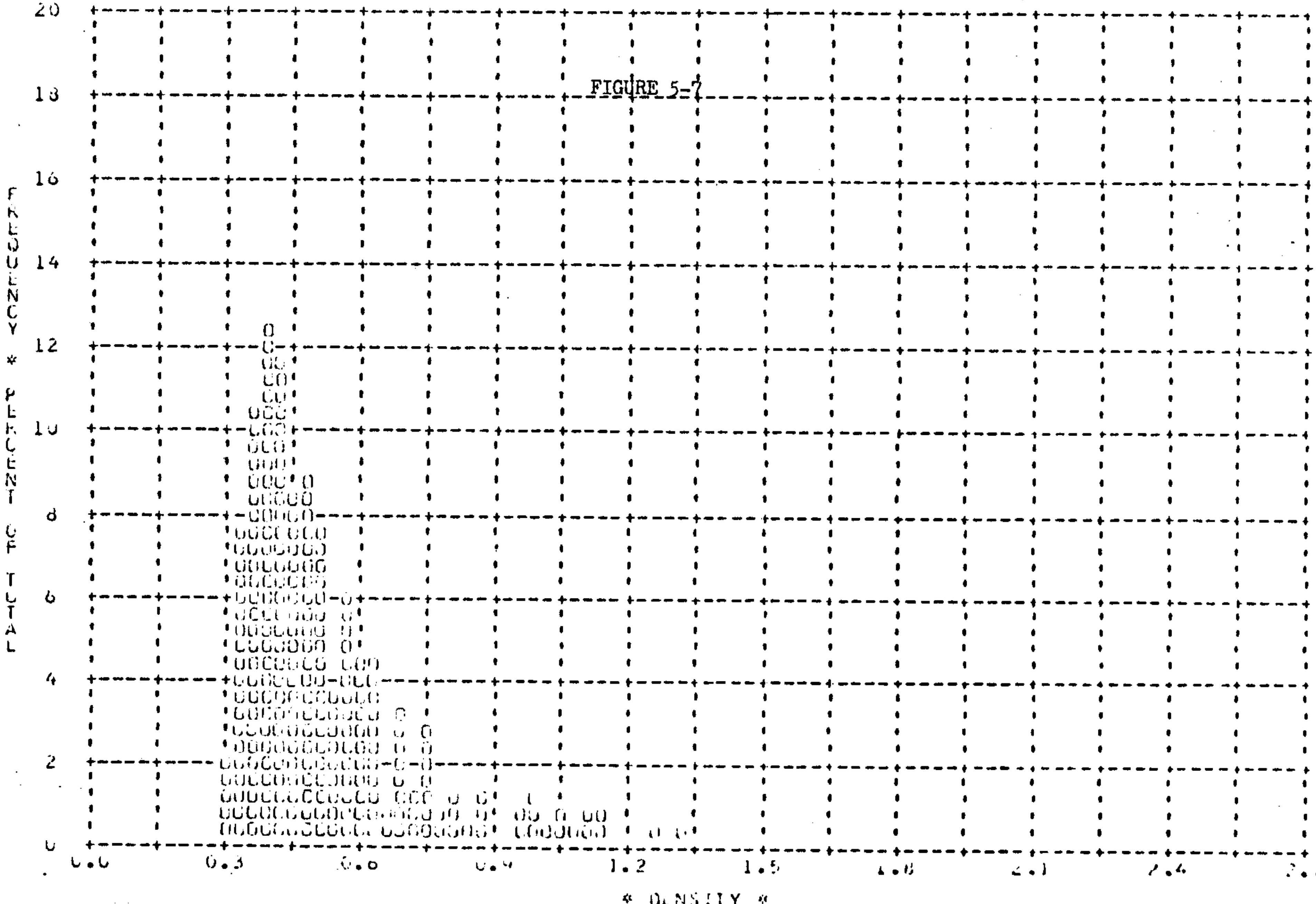
FIGURE 5-6



MISSION * 1107-2 * INSTR * AFT * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.51 * MEDIAN * 0.45 * STD DEV * 0.18 * RANGE * 0.29 TO 1.30 WITH 273 SAMPLES

FIGURE 5-7



MISSION * 1107-2 * INSTR * AFT * PLOT OF D MAX * TERRAIN * PROCESSING * DUAL GAMMA
ARITH MEAN * 1.22 * MEDIAN * 1.24 * STD DEV * 0.24 * RANGE * 0.53 TO 1.83 WITH 273 SAMPLES

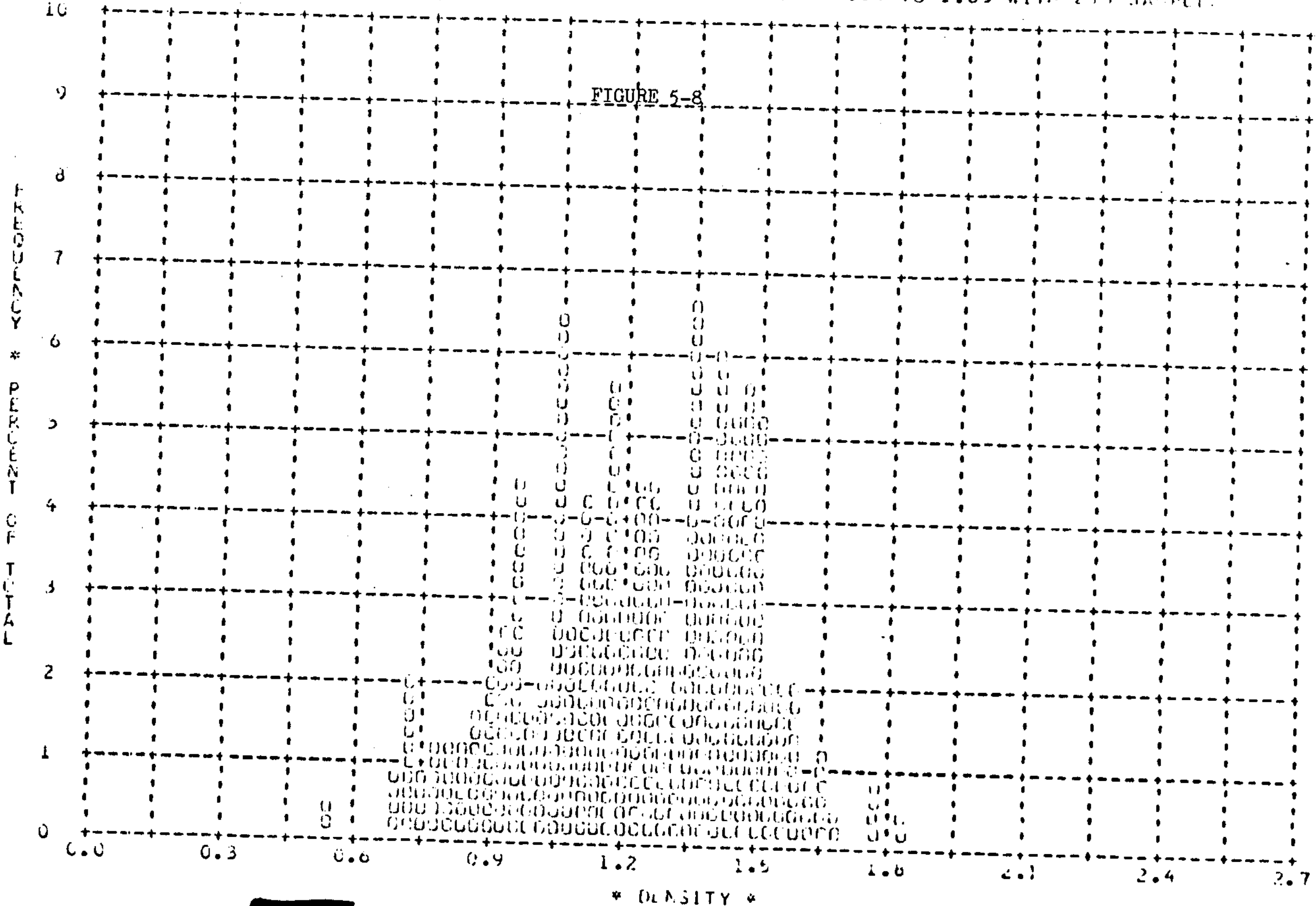


FIGURE 5-8

F. TARGET DENSITY MEASUREMENTS

A technique of evaluating photographic exposure performance through microdensitometry of specified operational targets was developed under Project Sunny. The Sunny techniques were applied to Mission 1107 by AFSPPF. As performed by SPPF, a microdensitometer spot size of 4.8 micrometers is used. This represents a circle of about 5 feet on the ground compared with a 500 foot circle for the macrodensity data discussed in the previous section. The smaller circle minimizes the integration effect of brightness variation over small areas.

A total of 42 Sunny targets were analyzed. No exposure change was recommended for 36 of these targets (86%). Small increases of one-third and two-thirds "stops" were recommended on two targets. Both of these cases were exposed according to Advanced Projects criteria but the scenes had unusually low reflectances. While both instances were probably predictable on a target basis, an adjustment was not warranted for the total format coverage.

A reduction in exposure was recommended for four targets (9.5%). These included three airfields and a launch pad superstructure. All included specular reflections (aircraft and aluminized metal structure). The three airfields would have been better exposed with the recommended two-thirds to one stop exposure reduction. It is not known whether other parts of the format would have been degraded by reduced exposure. In the case of the launch pad superstructure, the brightness range was beyond the capability of the film. A low density of 0.31 was recorded within the superstructure. In this case, it appears that no exposure change would improve total information content.

SECTION 6

IMAGE SMEAR

A. VEHICLE ATTITUDE AND RATES

A "Frame Time and Attitude Data" tape is supplied to Advanced Projects by NPIC. This tape contains the time word for each frame of panoramic photography. It also contains for each frame the pitch, roll, and yaw attitude elements that have been interpolated from the stellar photography of the DISIC. Using either this tape, or time values from the system tape recorder, a computer program at A/P calculates the exposure time of each frame and compares the camera cycle rate with the APF ephemeris to calculate the V/h mismatch (Section 3D). Then, using the NPIC attitude data for each frame, rates are calculated and combined with the crab error caused by earth rotation at the latitude of each frame.

The computer program rejects the first three frames of all operations as the large V/h error on the start-up cycles is not representative of the overall system operation. Since the forward pan camera failed at the beginning of this mission, the uncompensated impulse of the aft camera start-up caused larger attitude disturbances and a longer period of time to achieve stable operation. The attitude and rate errors are summarized in Table 6-1. It is notable that while both the range and 90% limit values are relatively large, they are comparable with the performance of some flight systems that did not have the unbalanced start-up condition.

Since the DISIC failed on Rev. 282 and only part of the DISIC record from Rev. 281 was retrieved, the attitude data for 1107-2 terminates at that point. The last 10% of the 1107-2 pan photography is not included in this error summary.

The A/P computer program also plots the frequency distribution of the rates and errors. These plots are not included as a part of this report but are maintained at A/P for reference.

TABLE 6-1

VEHICLE ATTITUDE AND RATE ERRORS

Values	Units	Mission 1107-1		Mission 1107-2	
		90%	Range	90%	Range
Pitch error	degrees	0.46	-0.82 to +0.12	0.32	-0.52 to +0.24
Roll error	"	0.30	-0.28 to +0.44	0.37	-0.42 to +0.52
Yaw error	"	0.60	-0.08 to +1.00	0.63	-0.18 to +0.90
Pitch rate error	deg/hr	27.10	-80 to +100	32.72	-45 to +95
Roll rate error	"	40.35	-95 to +100	45.24	-95 to +1.00
Yaw rate error	"	21.59	-60 to +32	17.16	-50 to +75

B. SMEAR ANALYSIS

The computed attitude and rate data discussed in the preceding paragraphs is combined with pan camera geometry to provide measures of potential camera performance at the center of each format. One measure is the percentage error of image motion compensation. The other measure, termed "resolution limit", is equal to 60% of the motion in object space (on the ground) that occurred during the exposure interval. These values, measured intrack and crosstrack, approximate the best ground resolution that could be achieved by a camera system of unlimited resoltuion capability. IMC errors and resolution limits are shown in Table 6-2.

TABLE 6-2

IMC ERROR AND RESOLUTION LIMITS

Values	Units	Camera	Mission 1107-1 90%	Mission 1107-1 Range	Mission 1107-2 90%	Mission 1107-2 Range
IMC Error	Percent	Aft	1.98	-1.0 to 2.8	0.98	-2.40 to 1.80
Intrack Resolution Limit	Feet	Aft	2.29	0 to 3.10	0.75	0 to 2.05
Crosstrack Resolution Limit	Feet	Aft	1.20	0 to 2.30	1.04	0 to 1.95

The improvement of these performance measures for the -2 mission is caused by two factors. Of primary general significance was the reduction in exposure times throughout the -2 mission because of higher solar elevations. (See Section 5C and Table 5-1.) An additional factor was the orbit errors early in the -1 mission that did not occur in later orbits. (See Section 3D.)

Although the entire 1107 mission was subject to extraordinary attitude and image smear disturbances from the single pan camera operation, the performance values in Table 6-2 are typical of other flight systems.

SECTION 7

RELIABILITY

Reliability estimates in this section begin with samples taken from the Mural Program, M-7 system. As a result, most of the Mural Program and all of the Corona Program have been included in this analysis. The DISIC subsystem (1100 series missions) is treated separately from the Stellar-Index subsystem (1000 series missions).

Reliability estimates are shown for the primary functional categories that include the panoramic cameras, main camera door ejection, payload command and control, payload clock, and overall payload functioning on orbit. The secondary reliability category includes the auxiliary camera functions such as the DISIC and horizon cameras. These estimates deal entirely with the payload. Only electrical and mechanical functions are considered. Vehicle failures are not included. Early recovery is treated as a complete mission provided that early termination was not caused by a payload malfunction.

Mission 1107 had three events that require particular reliability consideration. In the primary function category is the catastrophic failure of forward-looking pan camera No. 315. This failure was on the first operate of the mission and therefore is considered a loss for both mission segments.

In the secondary function category are horizon camera failures and the DISIC failure. The horizon camera failure for the first eight orbits is not counted as a failure. Although there were no operative horizon units during this period, the units recovered after the first half day of operation and

and functioned properly for the remaining 18-½ days of the mission. The DISIC failure near the end of the -2 mission is counted as a failure although the initial cause of failure is not known.

In computing reliability, it is necessary to define the number of cycles or hours of operation that comprise a mission segment. In some cases these values have increased over the course of the program but the newer actual values have not been included in these calculations. The effect of such adjustments would be to lower the reliability estimates slightly.

The following tabulation summarizes predicted reliability at the 50% confidence level on the basis of system experience through Mission 1107.

TABLE 7-1 ESTIMATE SYSTEM RELIABILITY

Function	Opportunities to Operate	Failures	Estimated Reliability
PRIMARY			
Panoramic Cameras	732,000 cyc.	4	98.10%
Panoramic Camera Doors	144 msns.	0	99.53%
Command & Control	15,624 hrs.	2	97,16%
Clock	15,624 hrs.	0	99.25%
Combined On-orbit Functions	-	-	94.16%
Recovery System	115	0	98.54%
SECONDARY			
Horizon Cameras	154,000 cyc.	0	98.49%
DISIC	35,895 cyc.	2	69.93%

[redacted]

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