CORONA J

PERFORMANCE EVALUATION REPORT

MISSION 1110-1 and 1110-2

FTV 1656, CR-11

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 1656.

Lockheed Missiles and Space Company has the contractual responsibility for evaluating payload performance. This document is the final payload test and performance evaluation report for Mission 1110-1 and 1110-2 which was launched on 20 May 1970.

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INTRODUCTION

This report presents the final performance evaluation of Missions 1110-1 and 1110-2 of the Corona Program. The purpose of this report is to define the performance characteristics of the CR-11 payload system and to identify the source of in-flight anomalies.

The performance evaluation was jointly conducted by representatives of Lockheed Missiles and Space Company (LMSC) and ITEK at the facilities of NPIC and AFSPPF. The off-line evaluation of Corona engineering photography acquired over the United States was performed at the individual contractors plants.

The quantitative data used for this report is obtained from government organizations. The diffuse density data, and MTF/AIM resolution are produced by AFSPPF. The vehicle attitude error values and frame correlation times are made at NPIC who also supply the Processing Summary reports published by [redacted]

Computer programs developed by A/P are utilized to calculate and plot the frequency distribution of the various contributors to image smear to permit analysis and correlation of the conditions of photography to the information content and quality of the acquired pictures. Computer analysis of the exposure, processing and illumination data provides the necessary data to analyze the exposure criteria selected for the mission.

This report contains certain data summarized from [redacted] Processing Summary [redacted] and AFSPPF TERO Report, [redacted]

SECTION 1

MISSION SUMMARY

A. MISSION OBJECTIVES

The payload section of Mission 1110, placed into orbit by Flight Test Vehicle 1656 and THORAD Booster (SLV-2H) S/N 69-045, consisted of two panoramic cameras, one DISIC camera, two Mark 5A recovery capsules and a space structure to enclose the cameras and provide mounting surfaces for all equipment. Figure 1-1 presents an inboard profile of the CR-11 payload system. The Corona "J" system is designed to acquire search and reconnaissance photography of selected areas of the earth from orbital altitudes. An eight day -1 mission and a seven day -2 mission was planned.

B. MISSION DESCRIPTION

The payload was launched from Vandenberg Air Force Base (VAFB) at 2135:10Z (1435:10 PDT) on 20 May 1970. Ascent and injection were normal and the achieved orbit was within nominal tolerances. Tracking and command support was effected by the Air Force Satellite Control Facility consisting of tracking and command stations at [redacted] under central control of the Satellite Test Center at Sunnyvale, Calif. Mission 1110-1 consisted of an 11-day operation and was completed by air recovery on 31 May 1970. Mission 1110-2 was completed with an air recovery on 8 June 1970 following a 7-day photographic operation.

The comparison of the planned and actual orbit parameters is tabulated as follows:

ORBITAL PARAMETERS

Parameter	Planned	Orbit 2 Actuals
Period (Min.)	88.73	88.69
Perigee (N.M.)	88.5	91.0
Apogee (N.M.)	146.7	143.1
Inclination (Deg.)	83.00	83.01
Perigee Latitude (Deg. N)	38.56	41.65
Eccentricity	0.0084	0.0071

Four drag make-up rockets were fired during Mission 1110-1, and three during 1110-2.

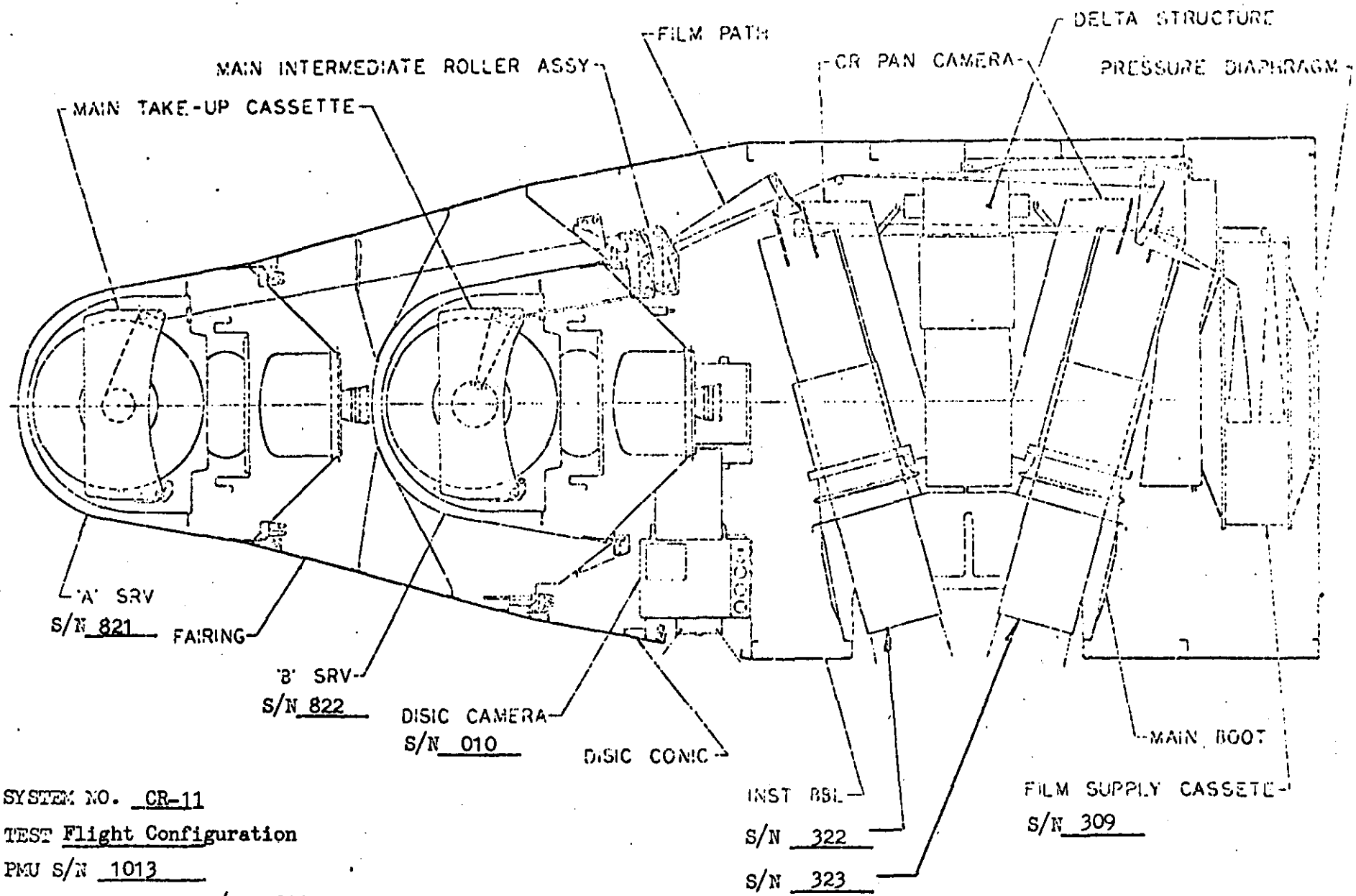
C. PANORAMIC CAMERAS

Both instruments operated satisfactorily throughout both missions. The image quality of the recovered photography was rated as good to poor by the photointerpreters. The basic assessment of the mission photography by the Performance Evaluation Team was that only mediocre performance was achieved on this mission. Both small scale imagery caused by the high altitude orbit and the poor resolution performance of the camera system during ground test were the most significant factors contributing to poor performance.

D. DISIC CAMERA

The DISIC camera operated satisfactorily throughout both missions. Although several characteristic markings are present on the record, no significant photographic degradation occurred. Approximately 12 to 20 point type stellar images are present in most stellar frames and the image quality of the index record was good where not degraded by static fog.

PAYLOAD PROFILE AND SERIAL NUMBERS



SYSTEM NO. CR-11

TEST Flight Configuration

PMU S/N 1013

SLOPE PROGRAMMER S/N 211

CLOCK S/N 624

SWITCH PROGRAMMER S/N 213

FIGURE 1-1

E. OTHER SUBSYSTEMS

With the exception of the exposure control programmer which exhibited one erroneous time out and the -1 recovery system which experienced a deceleration chute malfunction, all subsystems performed satisfactorily during the entire mission.

F. COMPONENT IDENTIFICATIONS AND SETTINGS

1. Forward Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	323
Main Camera Lens	I210
Supply Horizon Camera Lens	E23810
Take-up Horizon Camera Lens	E23768

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5
Slit Widths	
S_1	0.141"
S_2	0.167"
S_3	0.203"
S_4	0.108"
F/S	0.153"
Filter Types	
Primary	Wratten 23A
Secondary	Wratten 25

Film Types

Primary	Eastman Type 3404 (14300 ft)
Secondary	Eastman Type SO-349 (2000 ft)

Supply (Port) Horizon Camera:

Lens	55mm f/6.3
Aperture Setting	f/6.3
Exposure Time	1/100 second
Filter Type	Wratten 25

Take-up (Starboard) Horizon Camera:

Lens	55mm f/6.3
Aperture Setting	f/8.0
Exposure Time	1/100 second
Filter Type	Wratten 25

2. Aft Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	322
Main Camera Lens	I193
Supply Horizon Camera Lens	E40783
Take-up Horizon Camera Lens	E40772

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5
Slit Widths	
S_1	0.104"
S_2	0.132"
S_3	0.160"
S_4	0.080"
F/S	0.118"

Filter Types

Primary	Wratten 21
Secondary	Wratten 23

Film Types

Primary	Eastman Type 3404 (14,300 Ft.)
Secondary	Eastman Type SO-349 (2,000 Ft.)

Supply (Starboard) Horizon Camera:

Lens	55mm f/6.3
Aperture Setting	f/8.0
Exposure Time	1/100 second
Filter Type	Wratten 25

Take-up (Port) Horizon Camera:

Lens	55mm f/6.3
Aperture Setting	f/6.3
Exposure Time	1/100 second
Filter Type	Wratten 25

3. DISIC Camera

a. Component Assignment

Component	Serial Number
Camera	010
Index Reseau	114
Stellar Reseaus	
Port	9P
Starboard	12

b. Camera Data and Flight Settings

Stellar Cameras:

Lens	3 in. f/2.8
Exposure Time	1.5 seconds
Filter Type	None
Film Type	Eastman Type 3401 (2000 Ft.)
Aperture Setting	f/2.8

Index Camera:

Lens	3 in. f/4.5
Exposure Time	1/500 second
Filter Type	Wratten 12
Film Type	Eastman Type 3400 (2200 Ft.)
Aperture Setting	f/6.3

SECTION 2

PRE-FLIGHT SYSTEMS TEST

The CR payload systems are subjected to a sequential series of tests required to demonstrate a satisfactory confidence level in the flightworthiness of the systems. These tests include static verification, dynamic performance, operation in simulated thermal-altitude environment, light leak evaluation and dynamic photographic performance measurements. Significant baseline levels and anomalies experienced on CR-11 during pre-flight testing are as follows:

A. ENVIRONMENTAL TESTING

Payload system CR-11 was tested in the environmental HIVOS chamber; in Aschenbrenner Grid Test (AGT) configuration from November 17 through November 24 1969.

1. HIVOS Test

Pan Instruments

The test was performed using SO-380, UTB material. Instrument system operation was generally satisfactory with the exception of a number of anomalies as follows: the forward looking instrument's supply horizon shutter failed open several times during the test. The forward looking instrument failed to shut down twice after a long run and failsafe occurred once at the end of the power off time delay period. The aft looking instrument exhibited weak or absent inboard rail holes.

Evaluation of the material revealed no corona or density marking was generated by the pan instruments.

Analysis of the AGT test records indicates that UTB lift increases with decreasing temperature. As a result, modified thermal conditioning was provided to obtain optimized temperature range during flight in order to minimize temperature effects on payload lift.

DISIC Camera

The material from the DISIC instrument NO. 10 exhibited a number of anomalies as follows: During the "A" mission the stellar material contained the usual skew bead marking. Stellar material obtained from the "B" mission had a corona stripe through the format area with a maximum density of 0.60 above base fog on approximately 20% of the frames. Approximately 18% of the terrain material from the "B" mission exhibited corona stripes along the edges of the frames within the format area. The terrain SLP was misadjusted resulting in out of focus dots which bloomed beyond the specified maximum diameter.

The terrain take-up rotational TM and the terrain shutter pulse TM was erratic throughout the test.

Command Subsystem

Exposure control (Uncle 101) could not be commanded manually or from the orbital programmer after rev. 2 and remained in position 11 throughout the remainder of the HIVOS test.

Pressure Make-Up Subsystem

The pressure make-up surge valve and pulser valve functioned erratically through rev 8 of the "A" mission. Both the surge valve and pulser valve malfunctioned during one operate interval in the "B" mission.

Subsystem Performance

All other subsystems including clock, exposure control subsystem, FMC programmer, tape recorders, and instrumentation subsystem functioned normally.

B. RESOLUTION TEST

Initial resolution tests were performed using SO-380 UTB material. The conversion of CR-11 from UTB to 3404 film invalidated the initial resolution tests. The preliminary resolution test using 3404 film was performed on 4 March 1970. The results indicated that the peak through focus position (for each camera) was marginal and that .0005 inch shim would have to be removed from the scan heads of each pan camera. The final resolution test conducted on 6 March 1970 using 3404 film verified that the marginal peak position had been corrected and demonstrated acceptable performance by both cameras.

Results of the through-focus resolution test on pan cameras 322 and 323 show the following characteristics:

Aft-looking Camera No. 322

Maximum low contrast resolution 125 lines/mm at -0.0010 inches peak focal position.

Fwd-looking Camera No. 323

Maximum low contrast resolution 178 lines/mm at -0.0007 inches peak focal position.

The final test data for both cameras is shown in Figures 2-1 and 2-2. Both cameras met the system requirements specification.

C. LIGHT LEAK TEST

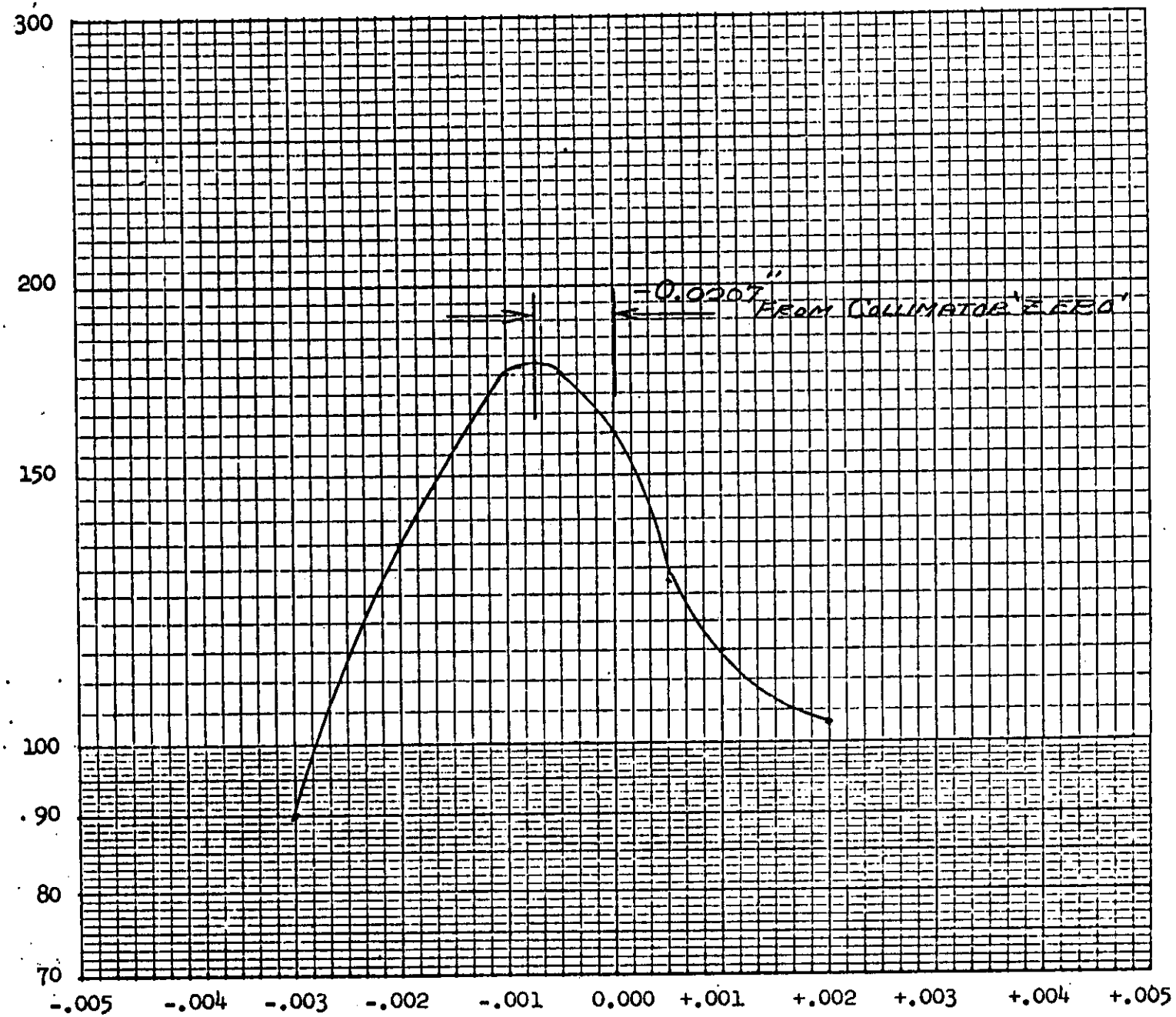
The photomultiplier light search test conducted after flight loading indicated that the system was free of light leaks with the exception of a very small leak in the forward camera drum. No corrective action was deemed necessary or practical.

D. FLIGHT LOADING AND CERTIFICATION

DISIC No. 10 was loaded and installed in the CR-11 payload system on the 7th and 8th of May 1970. Film samples taken from both DISIC and pan systems were processed and evaluated. The photographic qualities were found to be satisfactory. The film from the forward looking camera No. 323 was inspected and a pressure induced plus density stripe was observed extending through the H.O. format varying in length from five to seven inches. It was decided that no significant loss of photographic utilization would be caused as a result of the plus density stripe.

A waiver of performance specification was granted for the corona marking generated by DISIC No. 10 during HIVOS testing. The extent of the marking was not considered to have a significantly degrading effect on overall mission interpretability.

PRE-FLIGHT DYNAMIC RESOLUTION



Camera No. 323

Payload No. CR-11

Resolution (l/mm)

High Contrast: N/A

Low Contrast: 178

Film Type: 3404

Test Date: 3/6/70

Prepared By: _____

Date: _____

FIGURE 2-1

TOP SECRET/C

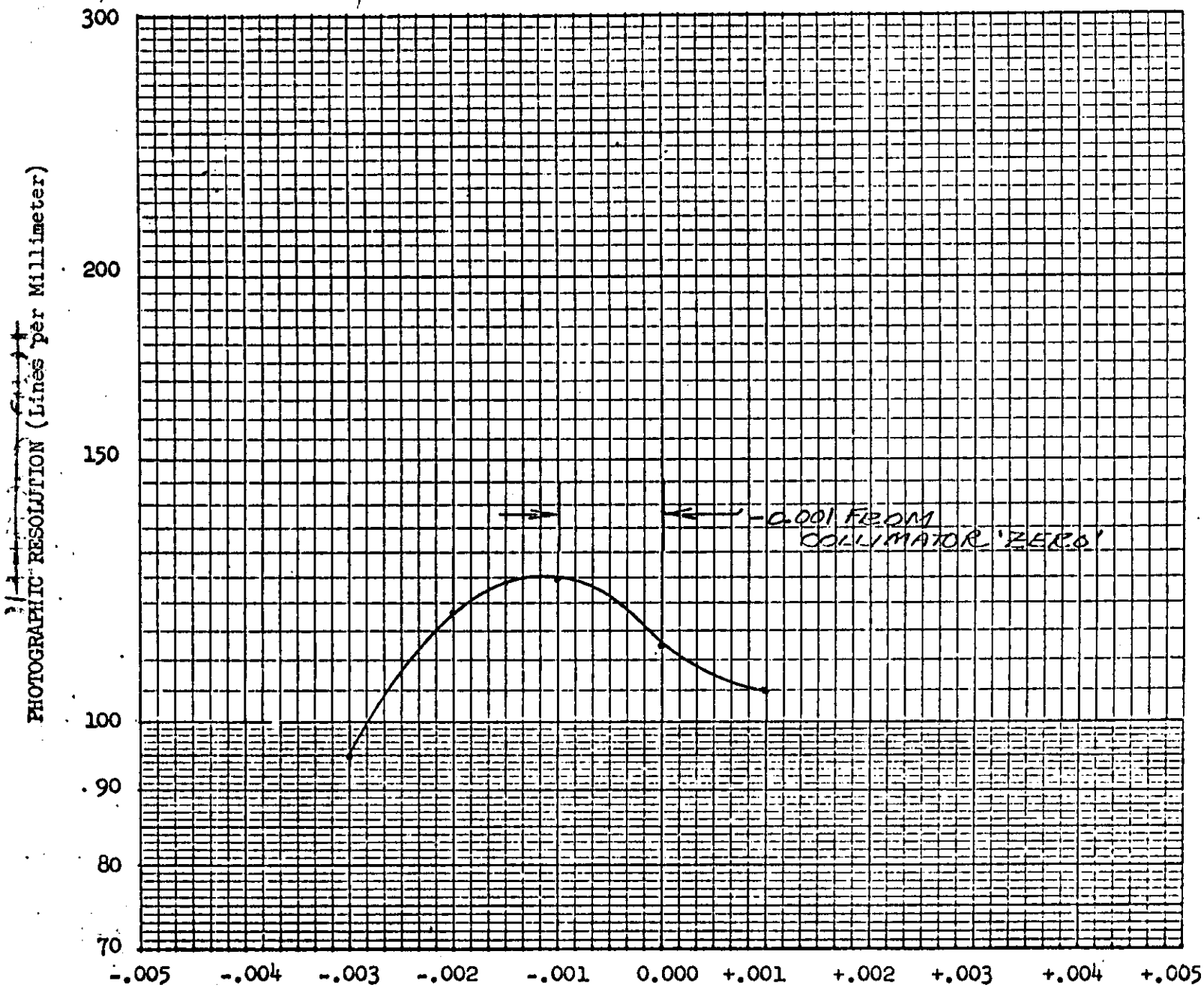


FIGURE 2-2

Camera No. 322

Payload No. CR-11

Resolution (1/mm)

High Contrast: N/A

Low Contrast: 125

Film Type: 3404

Test Date: 3/6/70

Prepared By: ———

Date: _____

SECTION 3

FLIGHT OPERATIONS

A. SUMMARY

Lift off occurred at 21:35:10 GMT (System Time 77710.7) on 20 May 1970 from SLC-3 west pad. All launch, ascent and injection events occurred as programmed. The orbit achieved was within the 3 sigma predicted dispersions.

Both panoramic cameras operated normally throughout the flight. The transfer sequence occurred normally when commanded.

The DISIC system operated satisfactory during the flight. The cut and splice sequence was completed normally.

The Digital Storage Register Command System operated satisfactorily throughout the flight.

The clock system operated normally and satisfactory clock system time correlation was obtained.

The exposure control programmer appeared to operate satisfactorily except for one observed incorrect time out during the flight.

The Forward Motion Compensation (FMC) generator operated normally and a satisfactory match was maintained to the required FMC throughout the mission.

The pressure make-up system operated normally during the mission.

The instrumentation system functioned normally throughout the flight.

The thermal environment was generally lower than predicted but within acceptable limits.

Both SRV tape recorders performed satisfactorily during the mission.

Both recovery systems were successfully recovered by air catch and except for an anomaly of the -1 chute deployment, all events were normal.

B. DMU OPERATION

Seven DMU rockets were fired during the mission to maintain ground track and period control. The Ground Track Error at the ascending node ranged from 25.8 nautical miles west to 23.3 nautical miles east. The DMU firings programmed, were satisfactory for attaining mission objectives. The following is a summary of DMU firings:

Rocket No.	Pass Fired	System Time (Sec.)	Period Change (Sec.)	Velocity Change (Ft/Sec.)	Period at Firing (Min.)
1	40	32291	15.04	24.2	88.49
2	82	81640	10.20	16.3	88.53
3	127	63373	14.92	24.0	88.43
4	156	43412	10.09	16.1	88.53
5	196	82784	17.36	27.7	88.46
6	239	53535	17.49	28.1	88.44
7	288	54847	17.70	28.3	88.47

Figures 3-1 and 3-2 are plots of orbit history and operation distribution data.

C. ORBITAL PARAMETERS

The following tabulation describes the orbital parameters both predicted and Pass 2 actual.

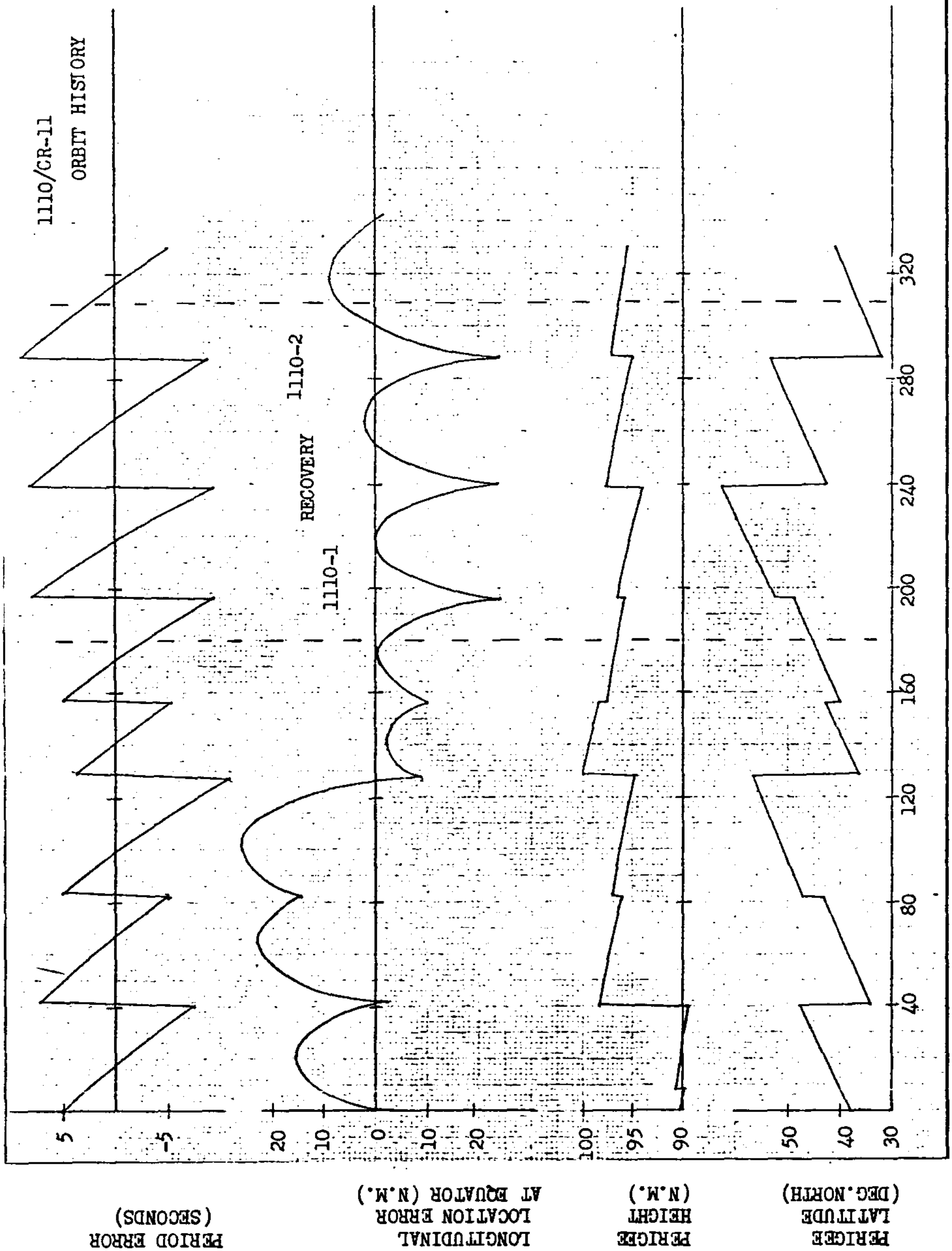
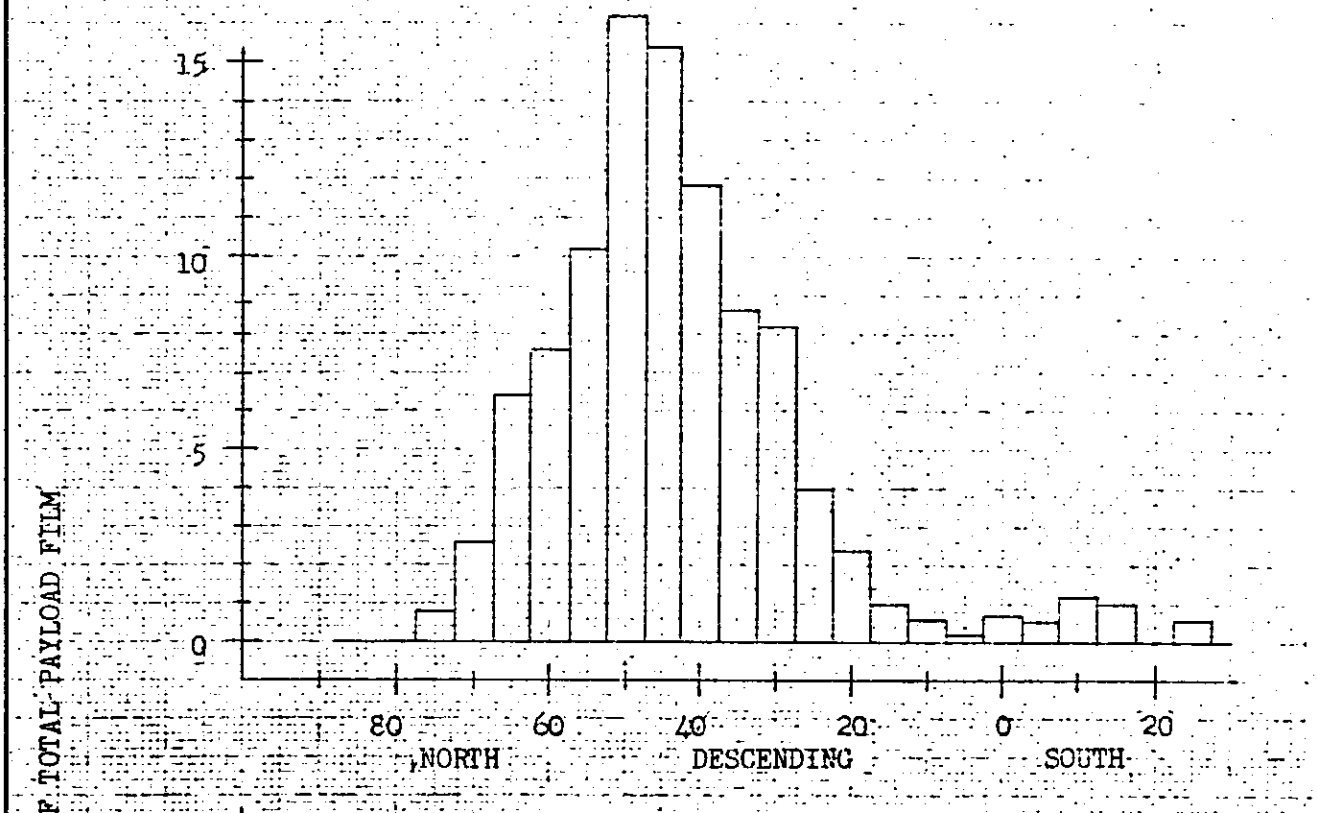

1110/CR-11
ORBIT HISTORY
PERIOD ERROR (SECONDS)
5
-5
LONGITUDINAL LOCATION ERROR AT EQUATOR (N.M.)
20
10
0
10
20
PERIGEE HEIGHT (N.M.)
100
95
90
PERIGEE LATITUDE (DEG.NORTH)
50
40
30
1110-1
RECOVERY
1110-2
40
80
120
160
200
240
280
320
ORBIT REVOLUTION

FIGURE 3-1

1110/CR-11 OPERATION



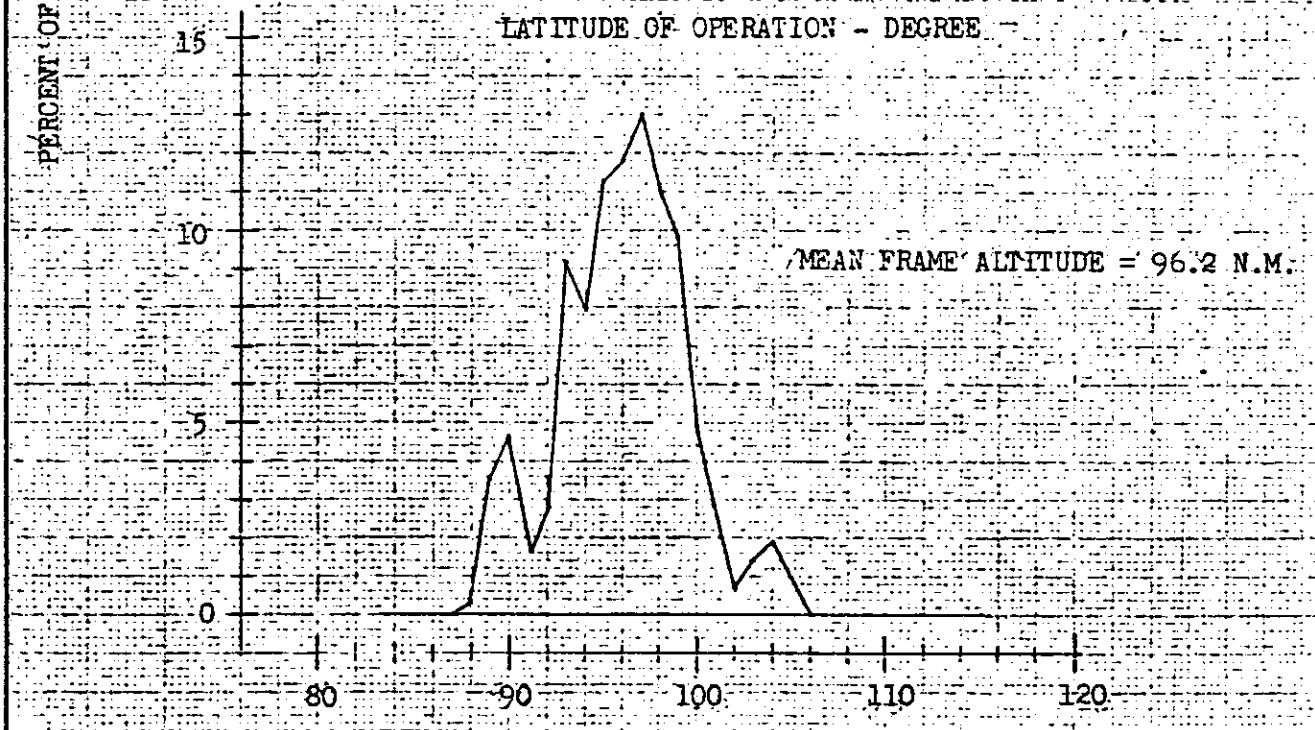


FIGURE 3-2

Orbit Parameter	Predicted	Pass 2 Actual
Period (Min.)	88.73 (+0.33,-0.38)	88.69
Perigee (N.M.)	88.5 (+7,-7)	91.0
Apogee (N.M.)	146.7 (+12,-14)	143.1
Eccentricity	0.0084(+0.0020,-0.0024)	0.0071
Inclination (Deg.)	83.00 (+0.20,-0.15)	83.01
Arg. of Perigee (Deg.)	141 (+66,-63)	138
Regression Rate (Deg/Rev)	22.31	22.29
Geodetic Latitude of Perigee (Deg.)	38.56	41.65

D. PANORAMIC CAMERA PERFORMANCE

Both panoramic cameras exhibited normal film transport characteristics and operated satisfactorily throughout the flight.

Both cameras were loaded with 3404 and SO-349 (3414) film types. The aft looking camera was loaded with 12,150 ft of 3404 spliced to 2000 ft. of SO-349 spliced to 2150 ft. of 3404. The forward looking camera was loaded with 13150 ft. of 3404 spliced to 2000 ft. of SO-349 spliced to 1150 ft. of 3404. Aft looking camera film depletion occurred on frame 42 during Pass 300. Film depletion of the forward looking camera occurred on frame 30 during Pass 300.

Film consumption is listed in the following tabulation:

FRAMES

	Pan 322 (Aft Looking)	Pan 323 (Fwd Looking)
Sample	15	15
Pre-Launch	130	130
-1 Mission	2995	2994
-2 Mission	3027	3014
Total	6167	6153

E. DISIC PERFORMANCE

The DISIC camera performed satisfactorily throughout the flight. Cut, splice and transfer to the second recovery stystem occurred satisfactorily when commanded by KZ-39. Film depletion on the terrain camera occurred on frame 55 during Pass 301. The stellar payload was not exhausted at -2 mission recovery. The stellar camera was loaded with 2000 ft. of 3401 film and the terrain camera was loaded with 2000 ft. of 3400 film.

Film consumption is listed in the following tabulation:

	FRAMES	
	Stellar	Terrain
Sample	44	26
Pre-Launch	125	109
-1 Mission	2510	2422
-2 Mission	2910	2749
Total	5589	5306

F. INSTRUMENTATION AND COMMAND SYSTEM PERFORMANCE

The instrumentation system operated normally throughout the flight. The command system, both Real Time Commands (RTC's) utilizing Uncle and SILO command systems, and Orbital Programmer Stored Programmer Commands (SPC's) operated satisfactorily throughout the flight.

G. FORWARD MOTION COMPENSATION PERFORMANCE

The FMC programmer operated satisfactorily during the entire mission. A satisfactory match to the required FMC was maintained throughout the -1 and -2 missions. Mismatch error was less than plus or minus one percent for 82.5 percent

of the -1 mission operations and 89.3 percent of the -2 mission operations. The mean error was 0.22 percent for the -1 mission and 0.01 percent for the -2 mission. The V/H match performance is shown in Figures 3-3 through 3.6.

H. EXPOSURE CONTROL SYSTEM PERFORMANCE

The exposure control programmer was observed to time out incorrectly once during the flight. The early timeout occurred on Pass 38 at [redacted] After SPC 51, the timer should have stepped to slit width 3 in 240 seconds, however the timer stepped in 20 seconds.

I. CLOCK SYSTEM PERFORMANCE

The clock system operation was normal throughout the flight and good correlation between clock and system time was obtained. Correlation equations and constants are as follows:

First Order Fit

System Time = $A_0 + A_1$ (clock time) where:

A_0 = 0.78004999460D 04

A_1 = 0.999999707955D 00

Sigma = 0.00996

Number of points = 37

Second Order Fit

System Time = $A_0 + A_1$ (clock time) + A_2 (clock time)^2

A_0 = 0.78004706980D 04

A_1 = 0.999999798020D 00

A_2 = 0.50776241450760D -13

Sigma = 0.00325

Number of points = 37

FRAMES 1-3 OF EACH 10 OMITTED 30 PERCENT = 0.74

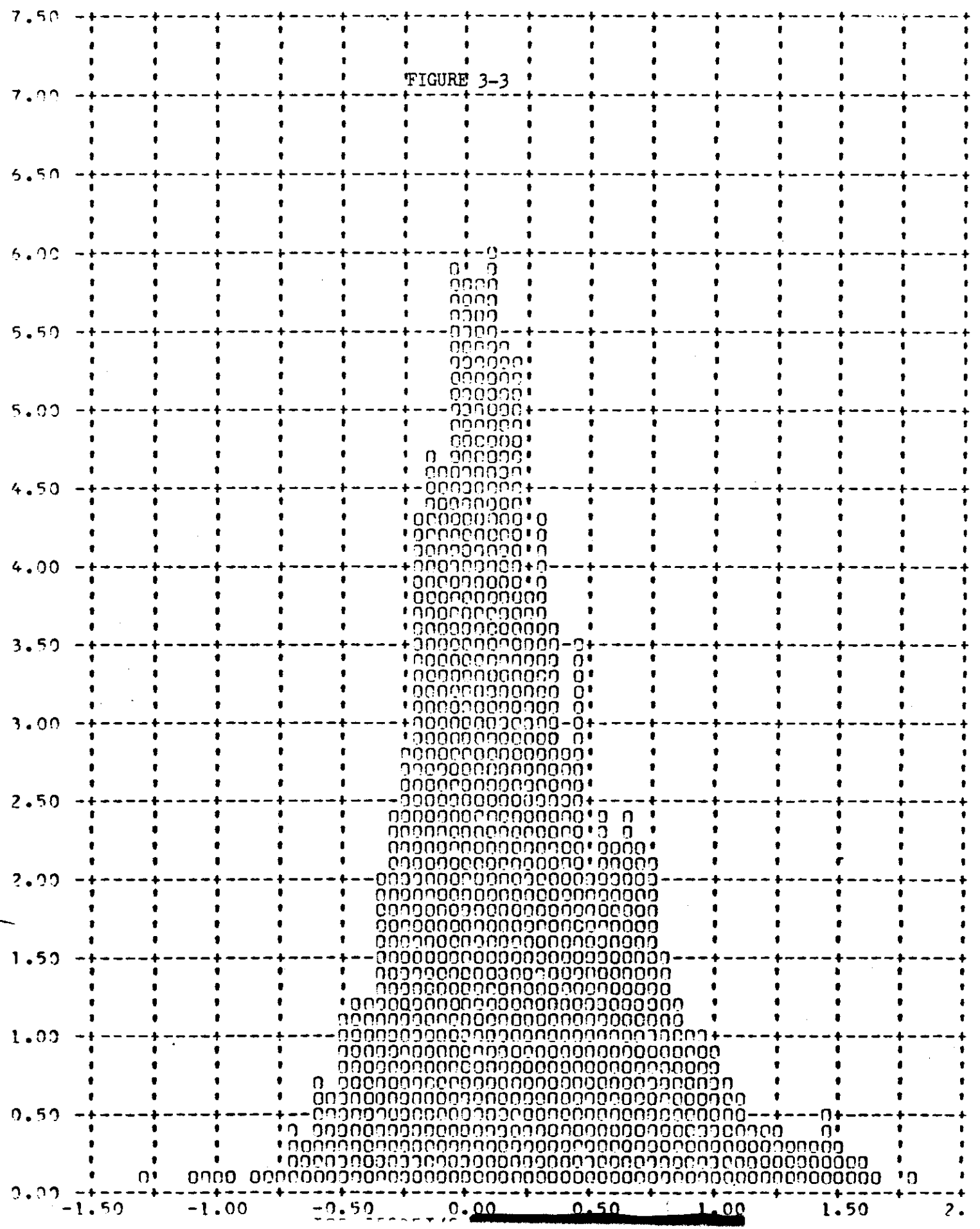


FIGURE 3-3

FRAMES 1-3 OF EACH 30 OMITTED 30 PERCENT = 0.70

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

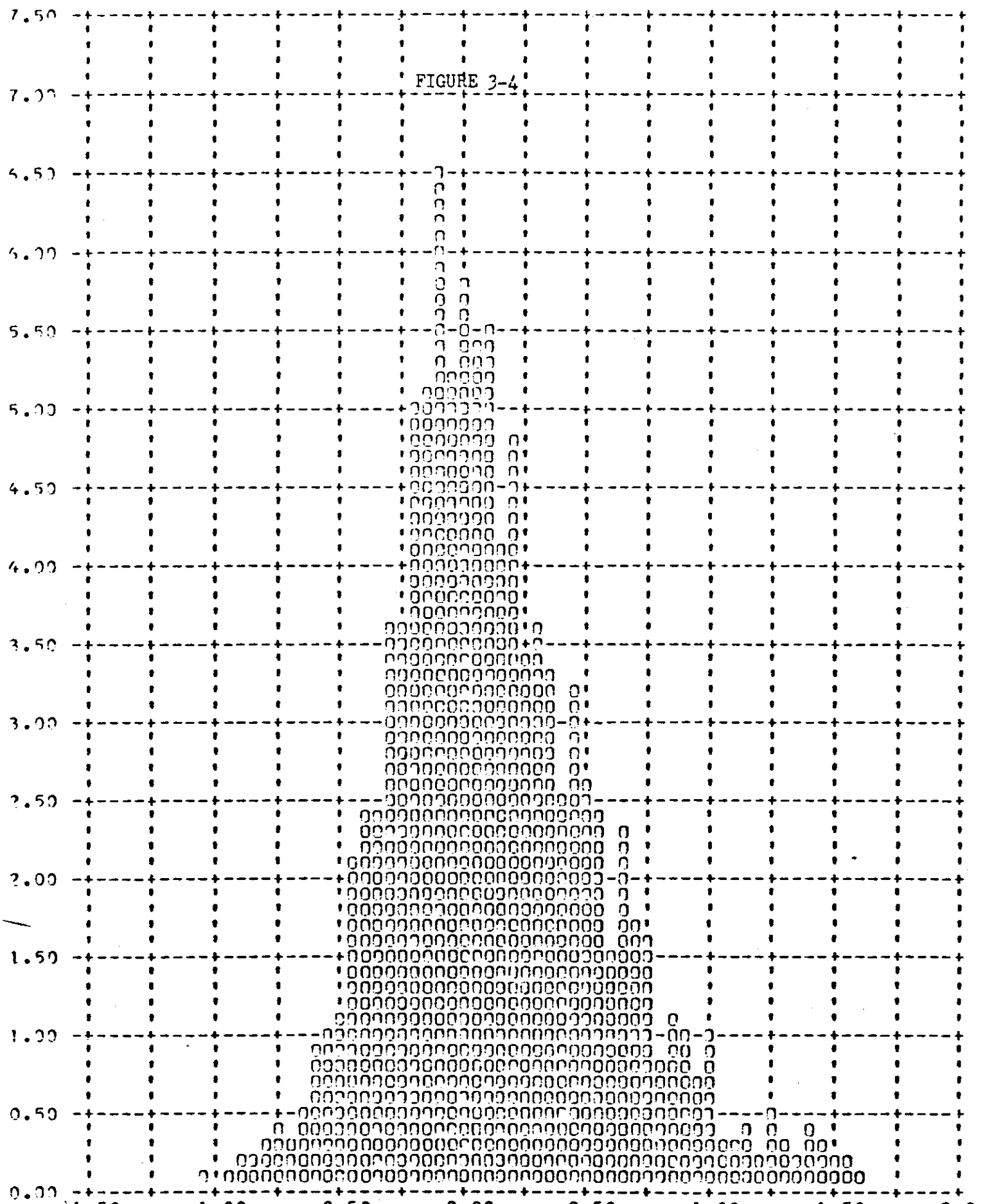


FIGURE 3-4

FRAMES 1-3 OF EACH OP OMITTED 20 PERCENT = 0.75

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

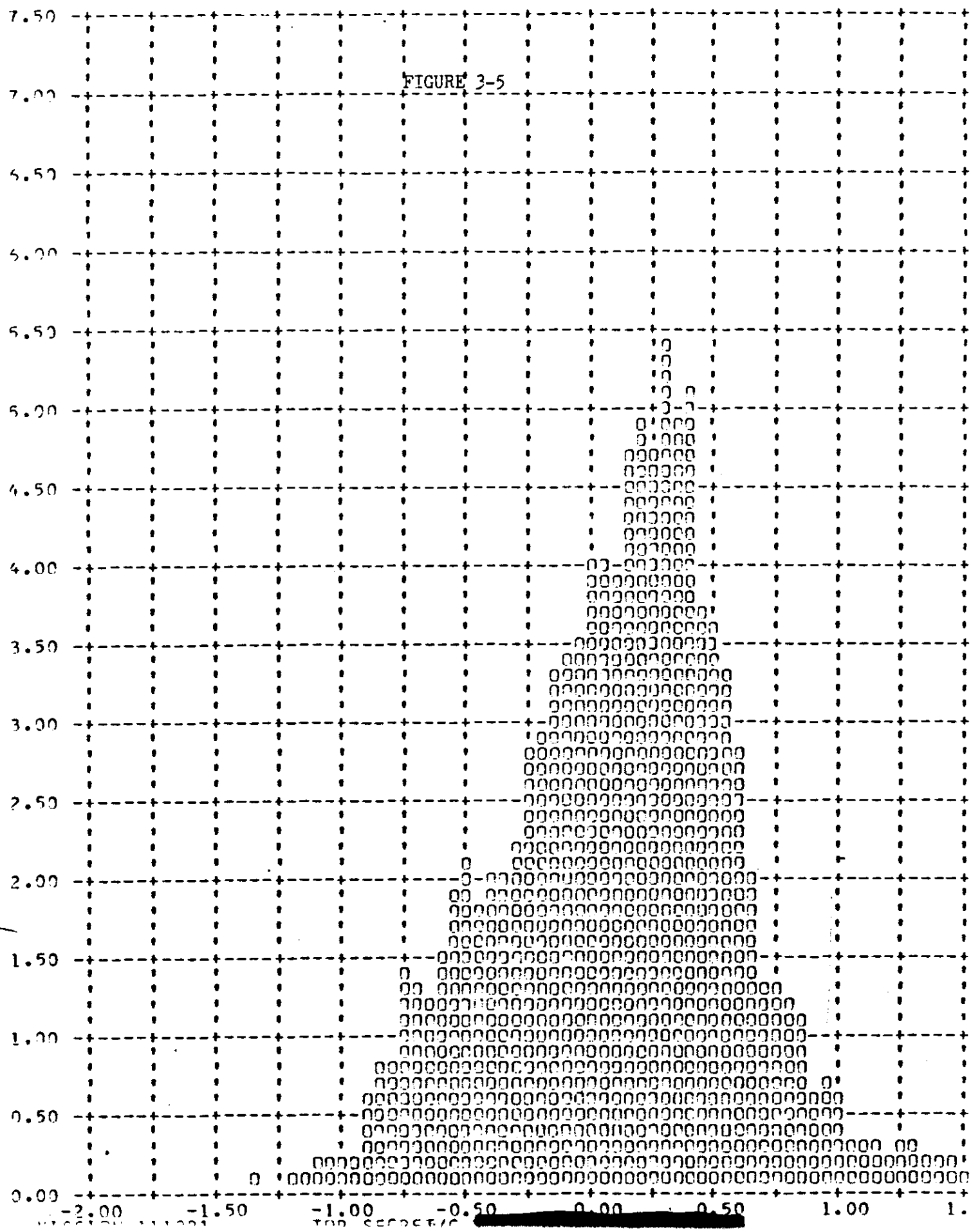


FIGURE 3-5

FRAMES 1-3 OF EACH OR OMITTED 90 PERCENT = 0.74

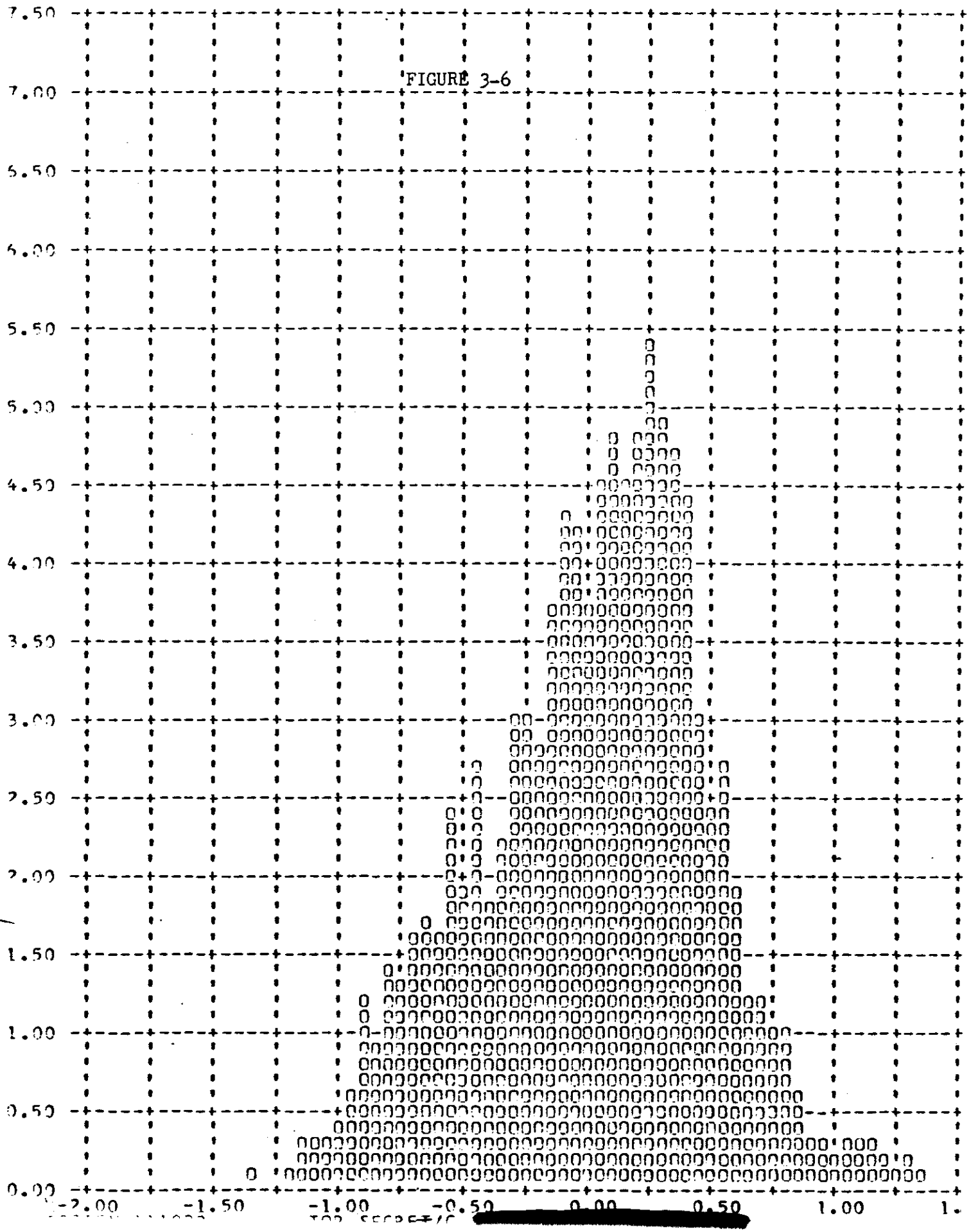


FIGURE 3-6

J. PMU SYSTEM OPERATION

The PMU operation was normal with a gas consumption of 6.64 psi/min with 1800 psi remaining at the end of the -2 mission.

K. THERMAL ENVIRONMENT

Temperature data obtained during the flight indicated the temperature environment was below the pre-flight predictions. The average temperatures during the -1 mission were 61°F for both panoramic cameras. The average temperatures during the -2 mission were 60°F for both panoramic cameras. Figure 3-7 shows a graphical plot of the actual average camera temperature versus the predicted temperature as a function of the beta angle. Figures 3-8 and 3-9 show each camera's rail temperature for selected revs.

L. RECOVERY SYSTEM PERFORMANCE

a. -1 Recovery System

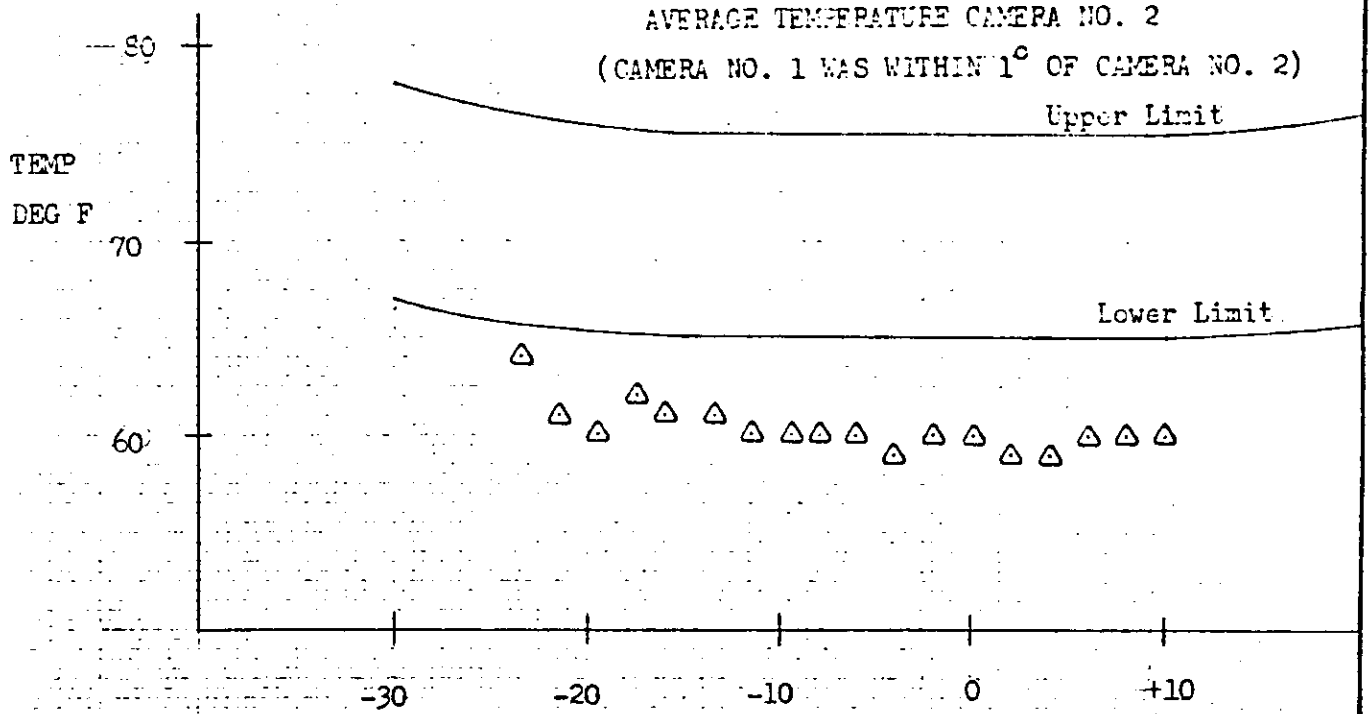
The -1 recovery capsule was successfully recovered by air catch on Rev 179. All re-entry events were within tolerance. A malfunction of the deceleration chute caused air recovery at lower than predicted altitude. Telemetry data indicated that the deceleration chute malfunctioned during deployment inhibiting its function, and causing the main chute to take the extra load. The impact was near predicted.

b. -2 Recovery System

The -2 recovery capsule was successfully recovered by air catch on Rev. 309. All re-entry events were within tolerance. The impact was near predicted.

M. SRV TAPE RECORDER SYSTEM

The SRV tape recorders for the -1 and -2 missions performed satisfactorily. There were a number of spurious center of format pulses recorded which were generated at the start-up of camera 322. A total of 211 minutes of data was recorded and retrieved from both recorders.


AVERAGE TEMPERATURE CAMERA NO. 2
(CAMERA NO. 1 WAS WITHIN 1° OF CAMERA NO. 2)
Upper Limit
Lower Limit
TEMP
DEG F
80
70
60
-30
-20
-10
0
+10
BETA ANGLE - DEGREES

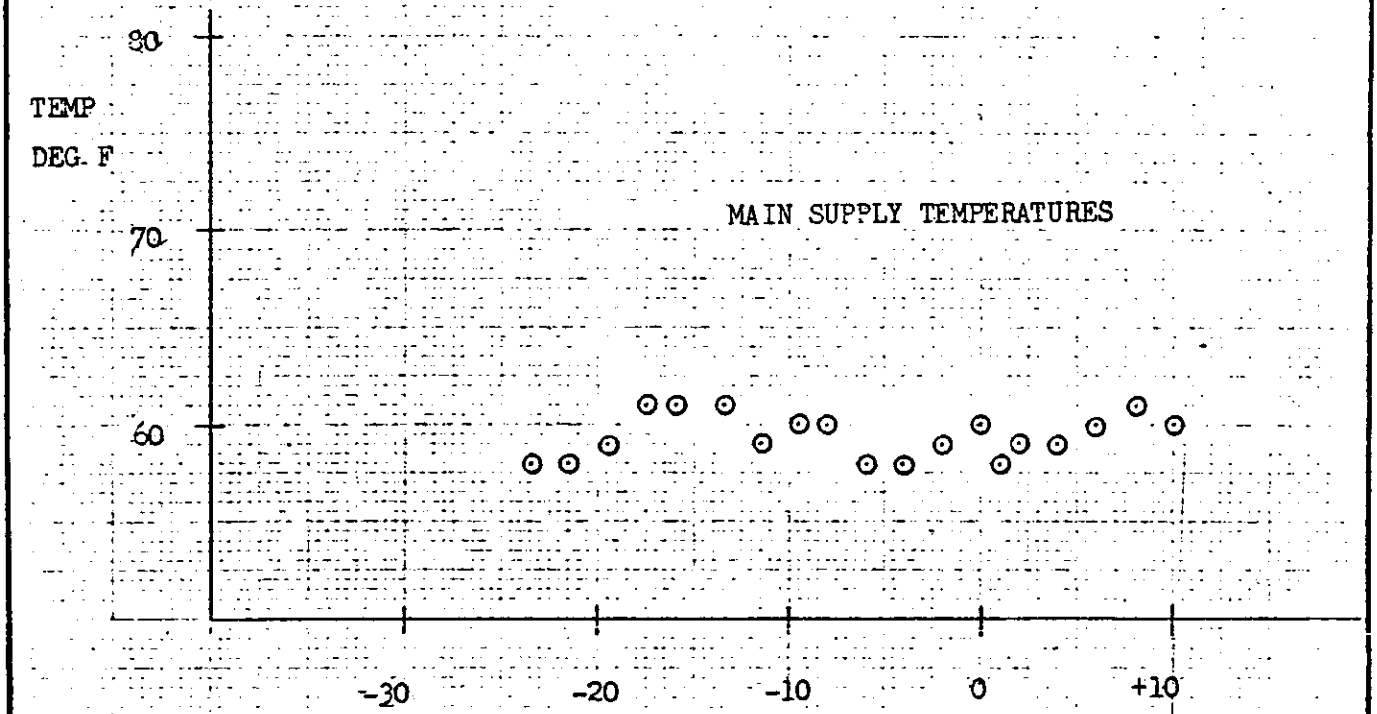

MAIN SUPPLY TEMPERATURES
TEMP
DEG. F
80
70
60
-30
-20
-10
0
+10
BETA ANGLE - DEGREES

FIGURE 3-7

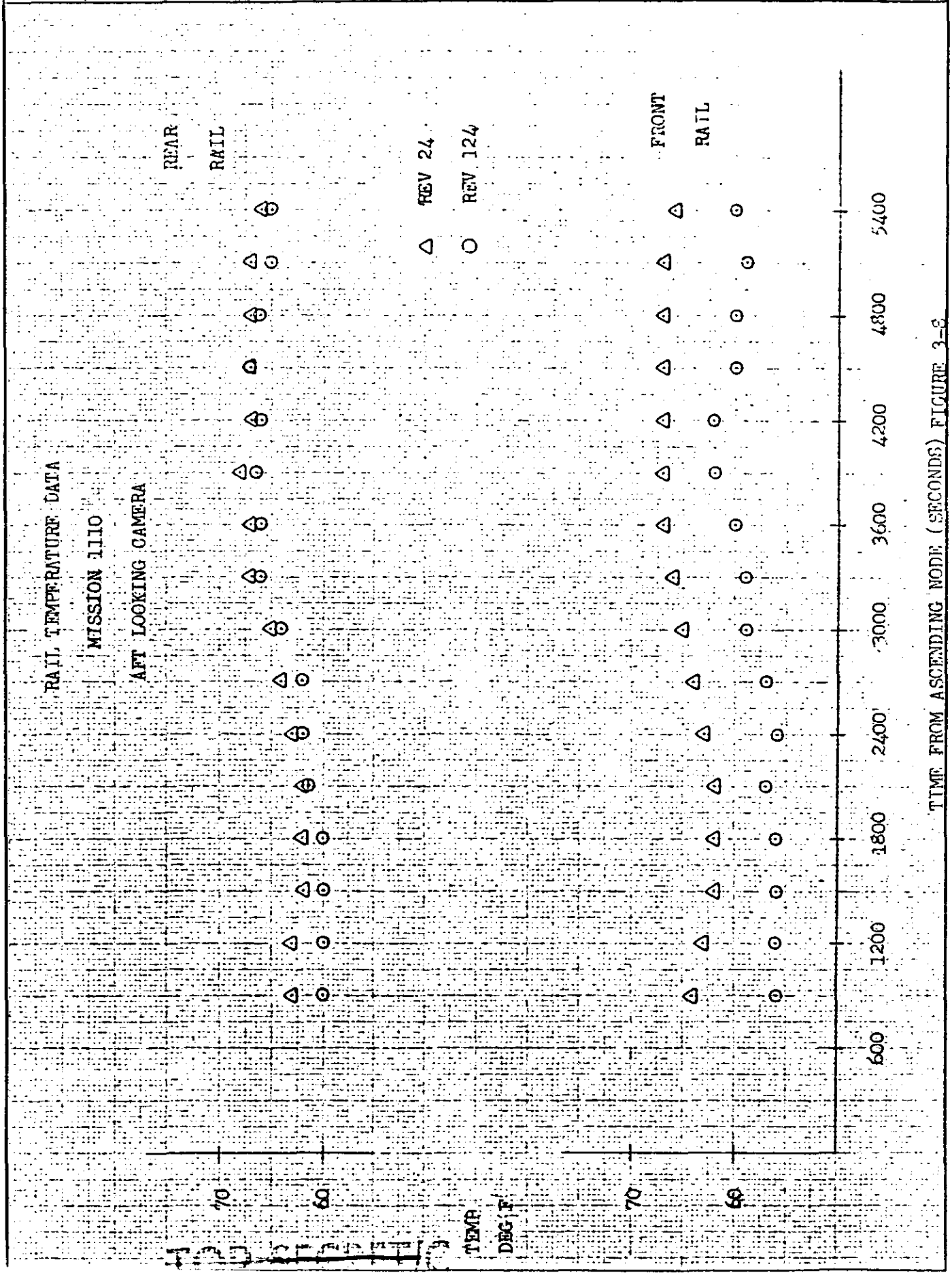

RAIL TEMPERATURE DATA
MISSION 1110
AFT LOOKING CAMERA
REAR RAIL
REV 24
REV 124
FRONT RAIL
TEMP DEG F
70
60
70
60
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (SECONDS)

FIGURE 3-8

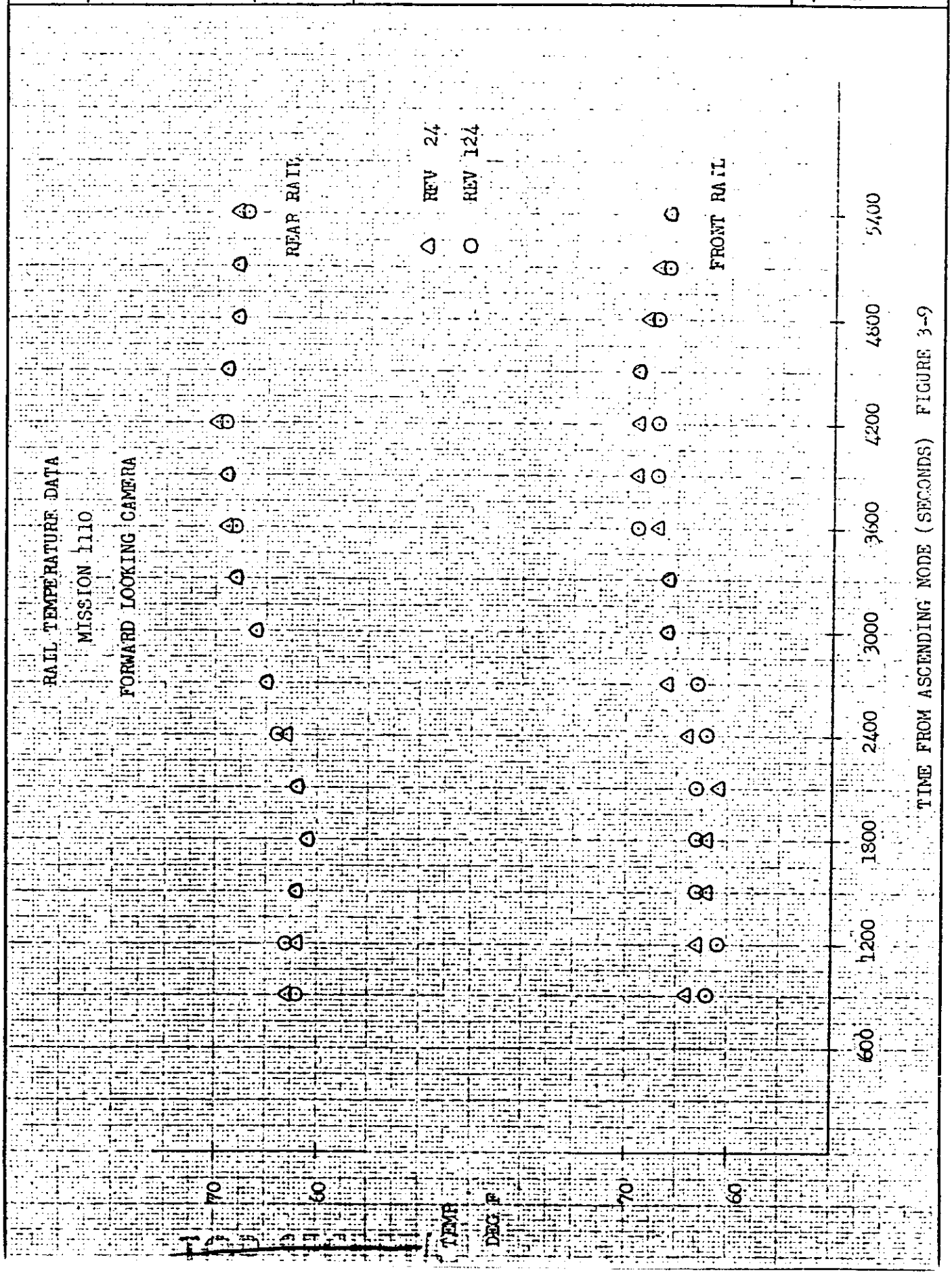

RAIL TEMPERATURE DATA
MISSION 1110
FORWARD LOOKING CAMERA
REAR RAIL
FRONT RAIL
REV 24
REV 124
TEMP DEG F
70
60
70
60
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (SECONDS)

FIGURE 3-9

N. POST EVENT 2 TESTING

The system was enabled on Rev. 309 [redacted] and operated for a number of cycles before the tag end of the film caused camera 323 to malfunction. After slipping the belt, camera 323 released the tag end and operated normally.

SECTION 4

PHOTOGRAPHIC PERFORMANCE

A. SUMMARY

Photography from the panoramic cameras was of mediocre quality compared to previous 1100 series missions. A Mission Information Potential (MIP) of 90 was assigned to Mission 1110-1 and an MIP of 95 was assigned to Mission 1110-2. Both were selected from the forward looking camera photography. The best image quality of the forward looking camera photography was slightly better than the photography from the aft looking camera. However the overall image quality of the aft looking camera photography is comparable to that provided by the forward looking camera.

Photointerpreters rated the utility of the photography from good to poor and mostly in the fair to poor category.

Photography from the DISIC terrain camera exhibited good image quality although some of it was degraded by static fog.

The photography from the stellar cameras revealed approximately 12 to 20 point type star images on most port and starboard formats.

B. PANORAMIC CAMERAS

1. Image Quality

The overall image quality of the forward looking camera photography is somewhat less than achieved by previous 1100 Corona series missions. The photography appeared sharp and clearly defined at magnifications of 25 power whereas an out-of-focus appearance resulted at magnifications of 50 power. It was observed that system characteristic out-of-focus areas were present on the third and fourth frames of some operations.

The overall image quality of the aft looking camera photography is comparable to that provided by the forward. However the best imagery from the aft looking camera is slightly less than the corresponding forward imagery. System characteristic out-of-focus areas were detectable on the fourth and fifth frames of some operations. The image quality of Mission 1110-1 is more variable than Mission 1110-1.

Several factors contributed to the mediocre photography experienced on this mission. The system was launched into a nominal 100 nautical mile orbit thereby reducing the scale of the imagery. The higher orbit favors increased coverage over image scale; directly affecting image quality.

The camera system resolution performance of Mission 1110 during ground test was the poorest of any 1100 series payload systems previously flown; which also contributed to its mediocre performance. Peak low contrast resolution for the forward camera was 166 lines/mm and 120 lines/mm for the aft camera. Each of these resolution values was approximately 20 lines/mm lower than previous 1100 series missions. The effect of the lower than normal resolution values on mission performance is partially borne out by the ground resolution values read from the three CORN targets covered on this mission. The CORN target resolution values tabulated below are generally poorer than those from previous missions. (These values are not a completely reliable indication of the effect of the camera system resolution values achieved during test, since vehicle attitude perturbations also affected these values.)