~~TOP SECRET~~

C/[redacted]

Copy No.[redacted]

14 0000017150

[redacted]

C/[redacted]

CORONA J

PERFORMANCE EVALUATION REPORT

MISSION 1049

15 APRIL 1969

Approved: [redacted] Ma[redacted]r
Advanced Projects[redacted]

Approved: [redacted] M[redacted]ger
Program[redacted]

FOREWORD

This report details the performance of the payload system during the operational phase of the Program [redacted] Flight Test Vehicle 1648.

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 1049 which was launched on 12 December 1968.

TABLE OF CONTENTS

INTRODUCTION

This report presents the final performance evaluation of Corona Mission 1049. The purpose of this report is to define the performance characteristics of the J-50 payload system and to evaluate the technical characteristics of the mission, including analysis of any 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, preparation of the flight program, in-flight operations support, data analysis, and mission reports to the community. The initial evaluation of the recovered film was made by NPIC personnel at the processing facility. The full Performance Evaluation Team (PET) included representatives of LMSC, ITEK Corporation, Eastman Kodak Company, and cognizant government organizations. The PET meeting took place at the National Photographic Interpretation Center (NPIC). Off-line evaluation, using engineering photography acquired over the United States, was performed at facilities of individual contractors.

The quantitative data summarized in this report is originated by government and contractor organizations. Diffuse Density measurements are produced by the Air Force Special Projects Production Facility. Vehicle attitude readings and frame correlation times are provided by NPIC. The Processing Summary report is published 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 and limiting ground resolution, and also of illumination/exposure/processing components in order to investigate exposure criteria.

SECTION 1

MISSION SUMMARY

A. MISSION DESCRIPTION

Corona Satellite Mission 1049 was planned to acquire search, cartographic, and reconnaissance photography of selected terrain areas. Two mission segments were planned to total fifteen days of orbital operation. Both segments nominally would return over 6,000 operational panoramic frames, each covering approximately 1,725 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 standard J-1 configuration, consisting of a space structure containing two panoramic cameras and associated control/support equipment, with separate Stellar-Index cameras and recovery subsystems for each mission segment. The payload had been assembled and tested at A/P, successfully completing all required test procedures.

The flight was launched from Vandenberg AFB during the afternoon of 12 December 1968. All ascent and injection events were normal; the orbit achieved had parameters close to nominal. Photographic operations proceeded without incident until failure of the FMC programmer drive in mid-mission. This necessitated utilizing alternate FMC control methods for the remainder of the flight; the imagery was not discernably affected. Loss of two vehicle batteries caused a reduction in orbital operation to eleven days. Higher temperatures than usual were experienced throughout the flight. The first mission segment was successfully completed, after 5 1/2 days of flight, by the cut-and-wrap operation followed by air-catch of the recovery capsule a half day later. The second segment was successfully terminated by air-catch of the capsule on the eleventh day.

All cameras operated throughout the mission. Imagery was generally degraded because of a focal anomaly, although several passes exhibited very good quality, rating a MIP of 85 for the first segment. Other flight problems were either minor, or of a characteristic nature.

B. FLIGHT CONFIGURATION

VEHICLES:	THORAD Booster (SLV-2G)			527
	AGENA Satellite (SS-01B)			1648
	RECOVERY (SRV-MK5):	1049-1	USE -	751
		1049-2	USE -	752

PANORAMIC CAMERAS:	Assembly No.	224 (Master)	225 (Slave)
MAIN:	Look Direction	Forward	Aft
	Slit (Inches)	0.165	0.135
	Filter (Wratten Type)	23A	21
	Aperture (T/Number)	3.8	3.8
	Focal Length (Inches)	24.001	24.000

HORIZON:	Location	Input	Output	Input	Output
	Look Direction	Port	Starboard	Starboard	Port
	Exposure Time (Seconds)	1/100	1/100	1/100	1/100
	Filter (Wratten Type)	25	25	25	25
	Aperture (F/Number)	6.3	8.0	8.0	6.3
	Focal Length (Inches)	2.152	2.160	2.152	2.163
FILM:	Kodak Type		SO-230	SO-230	
	Length (Feet)		16300	16300	
	Emulsion No., Date		103;11/68	103;11/68	
	No. Splices		4	4	
STELLAR/INDEX CAMERAS			1049-1	1049-2	
ASSEMBLY NO.			D 123	D124	
STELLAR:	Reseau No.		162	165	
	Exposure Time (Seconds)		1.0	1.0	
	Aperture (F/Number)		1.8	1.8	
	Focal Length (Inches, Nom.)		3.346	3.346	
	Film (Kodak Type)		3401	3401	
	Emulsion No., Date		231;09/67	231;09/67	
INDEX:	Reseau No.		157	158	
	Exposure Time (Sec. Actual)		1/420	1/220	
	Filter (Wratten Type)		21	21	
	Aperture (F/Number)		4.5	4.5	
	Focal Length (Inches)		1.512	1.514	
	Film (Kodak Type)		3400	3400	
	Emulsion No.; Date		148;09/67	148;09/67	

B. ENVIRONMENTAL TESTING

The first thermal/altitude environmental test of the J-50 system was conducted in the LMSC HIVOS chamber from 21 to 28 May 1968, using 3404 film. Test results were unacceptable because of heavy corona marking by both panoramic and both stellar cameras. The system was returned to A/P for modification and the scheduled Resolution testing. The second HIVOS test, without the Stellar/Index cameras, was conducted from 13 to 19 August using SO-230 film. The results were considered acceptable.

1. Pan Corona Marking

Material from the panoramic cameras was affected by corona during both tests. For the first test, heavy start-up corona occurred at internal pressures from 0 to 42 micrometers. The periodic "two pi" marking occurred at pressures below 7 micrometers. The camera metering rollers were the source of both corona forms; all four were changed for the second test.

Minor start-up corona caused by the Slave instrument input metering roller was encountered during the second test only at pressures below 5 micrometers; the Master unit was unaffected. No periodic marking was found. On one occasion after an extended inoperative period, light corona occurred at the Slave supply, as the film peeled off the spool. The second test demonstrated acceptability of the new rollers; no corona was noted in flight.

SECTION 2

PRE-FLIGHT SYSTEMS TEST

A. SUMMARY

The J payload systems are subjected to extensive pre-flight testing and preparation by A/P, in order to demonstrate resolution of any system problems, and to provide confidence in system capability to reliably perform the flight mission. Standard tests include photographic resolution, thermal/altitude environment, vibration environment, light leak, and a test series for flight preparation. Additional tests are performed as required.

The J-50 system successfully passed all aspects of the testing operations, providing acceptable performance and adequate operational confidence. Two altitude environmental tests were required, as the film from the first test was unacceptably marked by corona. The panoramic cameras were modified and the second test verified a significant reduction in corona marking.

Continuing problems were encountered during testing with cycle period deviations from nominal, and with irregular photographic scan rates ("banding"). These problems were adequately resolved in test; no cycle period problems were noted during flight, and only mild banding was detectable, with no apparent image degradation. The system was characterized throughout testing by heavy film scratching.

2. Pan Data Recording.

The data recording appeared good for the first test, although the time word indices were somewhat heavy and the time trace tended to appear late on the first frame of some operations. This time trace condition recurred during the second test, and also in flight. The lamp voltages were not reset for the faster film used for the second test, and no quality evaluation was attempted. It was noted, however, that the start-of-pass lamp was not functioning; this was replaced after the test.

3. Pan Marking

No significant marking of the panoramic material was noted for the first test. The second test record indicated that the film clamps required adjustment on both cameras, because of the unusually heavy pressure marks at the horizon format areas. These clamps were subsequently adjusted. An extended pressure mark was noted along one edge of the Master film for approximately 58 to 67 inches during two successive operations. This marking gave the appearance of the film riding up on a roller flange, although the cause could not be identified. This condition was never seen again although film path tracking was monitored closely in an effort to find the cause.

Heavy multiple rail scratching, which had also been noted during previous testing, occurred on material from both cameras, for both tests. The scratches were frequently noted penetrating through the emulsion. This characteristic continued throughout testing, causing heavy emulsion deposits on the film support rails. Magnitude of the scratches appeared somewhat greater for tests at ambient.

General overall fog was apparent on the SO-230 film used for the second test, on the material remaining in the film path between the supply and take-up between operations. Severity of the fogging appeared to be 1) directly related to the duration of the inoperative period, and 2) inversely related to the time from the test start; the heavier fog was more prevalent more towards the beginning. This type of minor fogging appeared to be an environmental characteristic of the SO-230 material, and was also noted during flight.

4. Stellar/Index Cameras

Both Stellar cameras produced unacceptable corona marking during the first test, although appearance of the Index material was relatively good. The corona density ranged to 0.68 net, and affected up to 12% of the formats from unit 124. The cameras were removed and sent to ITEK for roller replacement and adjustment, and were not available for re-testing with the J-50 system. They were both tested later with another J-1 system. This second test of the cameras indicated that about 75% of the unit 123 Stellar formats were affected by light corona, but the marking occurred outside the format area. Because of this, acceptance was recommended despite exceeding the specified corona frequency limit. The unit 124 Stellar formats contained minor acceptable corona marking. Neither of the Index unit records evidenced corona effects. All data recording on both units was acceptable.

A faulty metering solenoid in unit 123 caused 22 double-exposed Stellar and Index frames. The solenoid was repaired and no subsequent problems were noted.

5. Operational Performance

Scan rate variation near the start of scan was noted for both panoramic cameras during testing. This banding, which had been seen during previous component and acceptance testing, appeared to be more severe during the first environmental test, especially for the Slave instrument. The camera drives and timing were readjusted and the interlocks reworked, and some improvement was noted during subsequent tests. However, some banding remained as a system characteristic throughout the flight.

Cycle rates of the Master were up to 5% slower than the calibrations, for the first test. Previous test history also indicated difficulty with the Master cycle rates; up to 10% deviation had been experienced, usually fast. Special rate checks were made, and a coastdown problem discovered in the Master. After adjustment, the recalibration was acceptable, and no difficulty was encountered during the second environmental test.

Several component problems were determined during the first test. The FMC programmer did not start for one simulated rev, and problems occurred with the ramp delay stepper. Several anomalies were noted in the instrumentation system. These problems were resolved by the time of the second test, when only two anomalous monitors were reported. One additional problem during the second test was an abnormally large clock error. A subsequent Clock Accuracy test indicated proper clock operation, and no further errors were noted; the clock performed very well in flight.

6. Thermal Performance

Mainplate thermal limits for the first test were established by standard procedure at 45° to 100° for orbital simulation, 70° to 80° for the inoperative "soak" periods, and 110° to 120° for the terminal chamber recompression. During the first day of operation, faulty thermocouples caused the chamber operation to increase temperature above the desired range, although the error was found prior to the instruments reaching the 100° limit. The temperatures were above 90° for approximately 16 hours, to a maximum of 96°. The test was discontinued until temperatures returned to normal and the thermocouples were repaired. Temperatures were below 90° for the remainder of the orbital simulations and soaks. During recompression, the instruments reached a maximum of 120° for three hours, and were over 100° for 15 hours.

The procedure for the second test was modified to the current 90° limit for the instruments for all operations and recompression. Actual temperatures during soak and operations were 90° or lower, although there was a short excursion to 98° during recompression.

C. RESOLUTION TESTING

Evaluation of the material from the initial Resolution test of 10 June 1968 indicated that location of the Slave camera peak value did not meet current acceptance criteria. The low-contrast peak, at 128 lines/millimeter, was located at -0.0005 focal position, but should have been at -0.002 ± 0.001.

The Master unit produced an acceptable 110 l/mm low-contrast peak at the -0.0025 focal position.

The Slave unit scan head was shimmed and the retest completed on 26 June, also using 3404 type film. Evaluation of this material indicated that both units were acceptable:

High-contrast peak:	Master 181 l/mm at -0.003 Slave 190 l/mm at -0.004
Low-contrast peak:	Master 125 l/mm at -0.002 Slave 134 l/mm at -0.003

After this second test was accepted, the system was prepared for the second enviromental test. The preparation sequence included replacement of metering rollers, rail lift checks, a special cycle rate check, power tests, and command box modification.

D. LIGHT LEAK TESTING

Evaluation of the type 3401 material from the Light Leak test, run in early May 1968, indicated minor drum leaks from both panoramic instruments. Film was marked at three locations. These were considered acceptable in that flight effects of drum leaks are usually light and the leaks are seldom repairable.

An additional leak was found to lightly mark the Master film in the vicinity of the first recovery capsule/forebody interface. The interior of the forebody was repainted to prevent light seepage through the forebody ablative material.

E. FLIGHT PREPARATIONS

1. Stellar/Index Camera Readiness

Film from the Post-storage Baseline test of 19 November 1968 demonstrated acceptable performance. General appearance of the Stellar material was good; fiducials were somewhat heavy although the grid intersections were clear. Faint metering roller sitmarks were noted in formats from both Stellar units. A small, periodic minus-density spot along the #123 film center was apparently caused by a guide roller flaw. These minor factors were not considered to degrade interpretation or measurement of the Stellar data.

Material from the Index units was also considered satisfactory. There were some broken grid lines on the #124 reseau, but all intersections were clear. The #124 format also showed several minor minus-density spots. The difference in exposure time between the two units was obvious in the dissimilar format fog levels. This difference, 1/417 vs 1/222 second, was not anticipated to affect data interpretability and was a condition that had existed since manufacture.

The supply cassettes were loaded and the cameras installed in the J-50 structure. Sensitometric samples of the flight film indicated normal quality.

2. Panoramic Camera Readiness

Two tests were necessary to demonstrate readiness of the panoramic cameras. While film from the Master unit for the first test appeared acceptable, material from the Slave unit indicated a need for further rail cleaning and investigation of periodic plus-density marking along one edge. The rails were recleaned and rouged, and a small metallic particle removed from the frame metering roller which apparently caused the marking, which was not subsequently observed.

Material from the second test, on 2 December 1968, was recommended as acceptable. There was heavy, multiple rail scratching and some emulsion build-up on the rails of both instruments, especially at the shrinkage notches. This was very similar to that observed on previous systems without polished rails. The rails had been cleaned as well as possible in the field.

Scan rate variation was found on both cameras, estimated at 10% near scan start. This banding tendency had been noted throughout testing, and had been improved by adjustments to timing and balance of the units. All data recording appeared adequate.

Because of the in-flight failure of the J-49 camera drive system, the J-50 drive had been inspected and modified. No abnormal conditions were discovered. The gear pins were epoxied in place to assure retention under any stress situation.

Loading of the primary film into the panoramic supply cassette was accomplished on 3 December without incident and according to procedure. The cassette was mounted in the conic structure and the routine splicing operation completed the following day.

3. System Confidence Operations

The system Confidence operations at A/P were performed on 4 December and demonstrated normal system performance, with no problems noted. Visual verification was made of all functions observable from outside the system with all doors removed, i.e.: horizon and Stellar shutter operation, proper film threading, film scratching, system cleanliness, etc. All instrumentation indicated proper operation. Transport and tracking appeared very smooth. Rail scratches were heavy. Some minor backing scratches near film edges were noted from both supply spools. All shutter functions were proper. Some emulsion build-up was visible on the rails of both units.

After final system assembly, the routine Light Search failed to reveal any light leaks, despite increasing instrumentation sensitivity four times over that specified in the procedure.

At the pre-flight Audit meeting, held 4 December, system data were reviewed by customer representatives and found acceptable for flight.

The system was shipped by truck to the "L" building at Vandenberg AFB, where a short Receiving Inspection operation indicated proper functions.

Mating with the AGENA vehicle was scheduled for 9 December, and launch for 11 December. However problems with a command box and the THORAD guidance forced postponement of the launch date to

12 December to allow repair time. Mating was completed late on 10 December. Additional short operations after mating and after erection of the flight system were performed as routine items in the countdown procedure.

SECTION 3

FLIGHT OPERATIONS

A. SUMMARY

Launch, ascent, and injection operations were good. The payload functioned throughout the mission, although photographic results were of lower quality than anticipated. Temperatures were higher than predicted. Vehicle functions were normal, excepting battery failures which shortened mission duration. Function of the recovery systems was near-nominal, resulting in air-catches of both capsules.

B. FLIGHT CONFIGURATION

The booster was a standard Douglas THORAD with three solid strap-on rockets for thrust augmentation. The LMSC AGENA satellite vehicle carried nine drag make-up rockets (DMU), each of 2000 pounds thrust, for orbit adjustment, a slower speed (1:0.75 ratio) orbital timer for extended active operational life, and more flexible command and control capability. Payloads included a [redacted] and the J-50 photographic system.

C. LAUNCH

The flight was launched at 2222Z from Satellite Launch Complex pad 3-West at Vandenberg AFB. The ascent phase was normal; both the booster and AGENA systems performed as programmed, with injection at the velocity meter ("hard") shutdown of the engine.

Launch was within the window, specified as 2130Z to 2230Z. This window, in conjunction with the camera settings and Stellar limits, had been chosen to maximize useful panoramic coverage of northern latitudes throughout the flight.

D. ORBIT

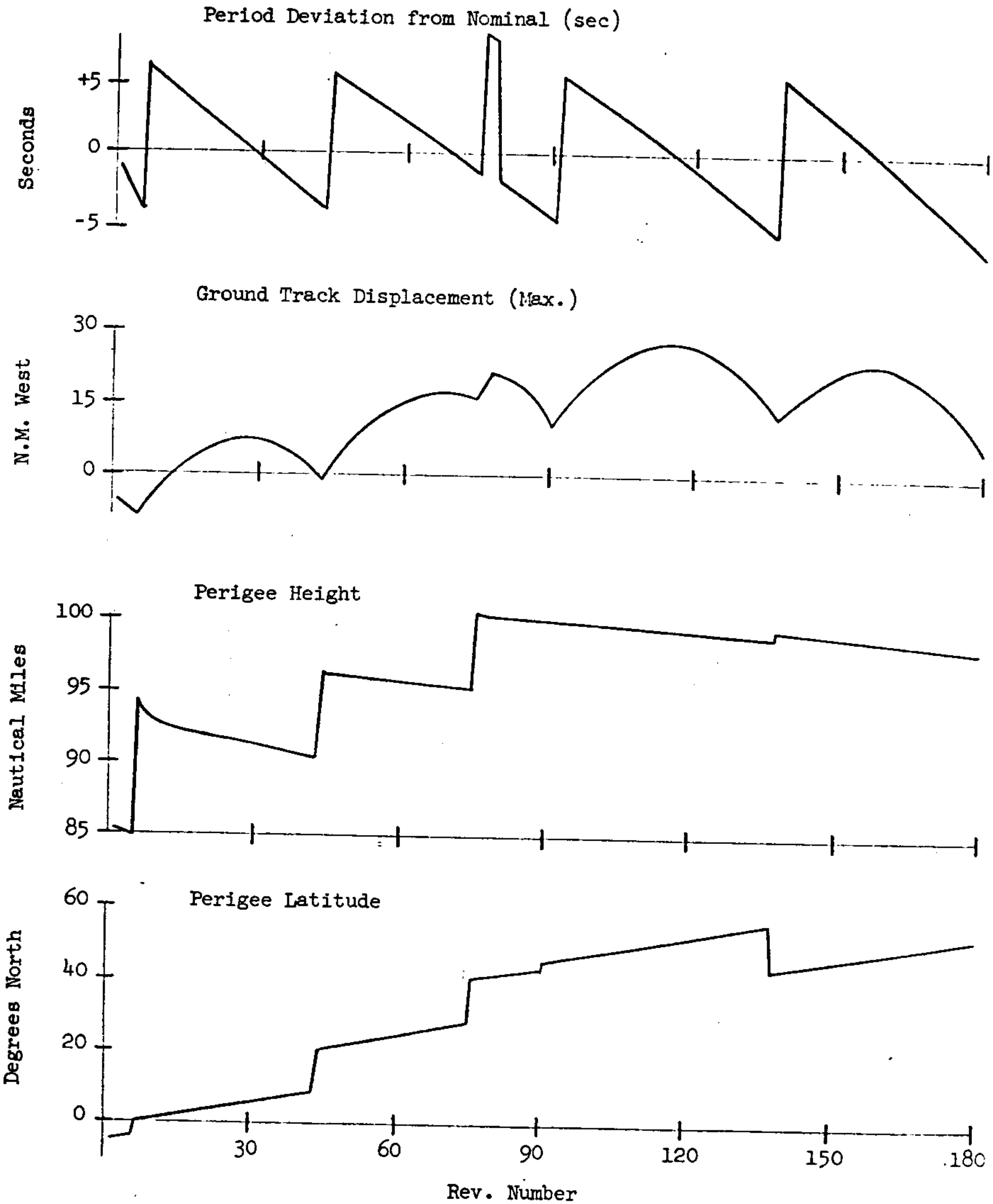
Orbit parameters achieved were well within the predicted three-sigma values for dispersions from nominal for the planned near circular orbit. Perigee was just over three miles low (three-sigma tolerance fifteen miles) and argument of perigee was rotated eleven degrees south (three-sigma tolerance seventy-five degrees). The first DMU rocket was fired on Rev. 5 at a location which would raise perigee altitude. A boost/deboost DMU sequence was commanded on Rev. 75 and 78 to provide an even more circular orbit to assist FMC control after failure of the FMC programmer.

E. FIRST MISSION

1. Photographic Operations

Operations commenced with a short stereo confidence run during the Rev. 1 acquisition by the [redacted] tracking station. Telemetry indicated normal performance and system status. Reconnaissance operations began on Rev. 5. Through the end of the first mission segment, 2988 active frames were taken by the forward-looking camera and 2976 by the aft covering a total of 8,860,500 square nautical miles. In

MISSION 1049 ORBIT HISTORY



addition to the pre-flight material, there were 63 stereo operations, with 7 domestic operations on Revs 16, 31, 47, 48, 63, and 64. Also included are 4 passes for engineering purposes on Revs 1, 9, 73, and 81.

Operation of the cameras was normal, with the exception of the FMC control problem mentioned below. The panoramic units ran within 2% of each other throughout. Tracking and ground control facilities experienced normal operations.

2. Thermal Environment

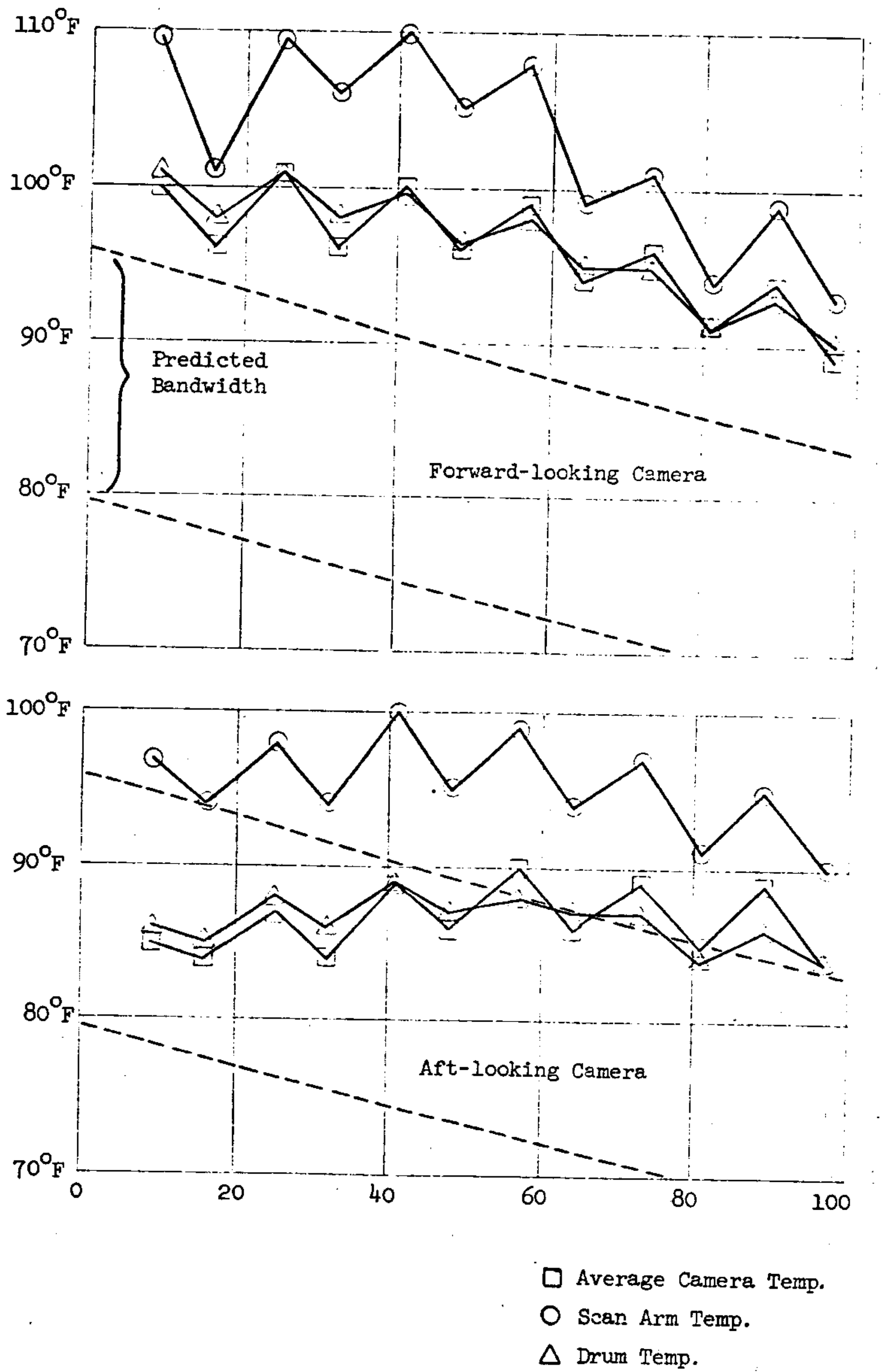
The thermal environment achieved was higher than predicted. System temperature at the beginning of the mission exceeded telemetry capability, but data analysis produced an estimated average temperature of 104°. The general limit is 90°, but because of the relatively late launch the upper boundary of the predicted thermal range was 96°.

The chart on the following page illustrates thermal disparities during the first mission segment. The "zig-zag" appearance of the data reflects typical temperature variation between alternating day and night telemetry acquisitions.

Data from the vehicle tape recorder indicated normal cyclic variations during a single rev, with 2° to 6° variation at positions on the camera mainplates, 3° on the drums, and 4° to 7° on the scan arms.

Pre-flight emissivity testing of the thermal control surfaces indicated a warm tendency. Reflective striping had been added to the basic paint pattern in order to reduce calculated temperature to within

1049-1 TEMPERATURES



the upper limits of the nominal range. Such factors as the high winter solar flux, the higher ascent thermal environment, and thermal control surface degradation may have contributed to the temperature disparity.

3. Forward Motion Compensation (FMC)

Satisfactory FMC control was maintained until prior to operations on Rev 68, when the FMC programmer became disabled. Probable cause of the failure was improper contact of a microswitch, causing power loss to the drive motor, a non-recoverable situation. Similar failures occurred during Missions 1034 and 1035. As the programmer remained inoperative for the remainder of the flight, the only method of FMC control was real-time command of the reference level voltage. This yielded a choice of eleven constant operating rates; the better compromise was selected at each acquisition to match the subsequent operations commanded. Operations through Rev 88 had indicated FMC errors up to 17% in a few frames, due to difficulty in determining the potentiometer position at which the programmer failed. Once this was determined, the correct rate could be selected. Satisfactory FMC control was maintained after Rev 88, with deviations less than the required 5%.

4. First Recovery

Panoramic film take-up was transferred to the second recovery vehicle by ground command on Rev 91, northbound. The first recovery was commanded for Rev 99, southbound. Operation of the system was normal, with all re-entry events occurring within tolerance, resulting in a successful air-catch of the capsule 21 miles south/southeast of the predicted impact point.

The radiation film pack carried in the recovery capsule indicated a light radiation enviroment for this mission (less than 0.1 Roentgen). Fogging due to radiation was well below the level necessary to degrade the imagery.

F. SECOND MISSION

1. Photographic Operations

Operations continued without additional problems during the second mission segment. An indicated 3083 frames were taken by the forward-looking camera, and 3092 by the aft prior to film depletion on Rev 170 covering a total of 8,986,300 square nautical miles. There were 59 stereo operations, with 6 domestic operations on Revs 95, 113, 127, 129, 145, and 161. Also included are the cut/wrap (Rev 91) and lens stow (Rev 99) functions necessary to the first recovery, and one engineering operation.

Operation of the cameras was normal. The panoramic units continued to run within 2% of each other. Tracking and ground control facilities experienced normal operations.

2. Thermal Environment

Temperatures continued warm, although considerably closer to the prediction for the second mission segment. Sensors generally read well below the 90 degree limit after the first recovery; a 5 to 10 degree cooling had been forecast. The chart on the following page illustrates thermal conditions during the second mission.

3. Forward Motion Compensation

Satisfactory FMC control was maintained despite failure of the programmer, as noted for the first mission. FMC errors were generally indicated below the 5 per cent level.

4. Second Recovery

The second recovery was commanded for Rev 179, southbound. Operation of the system was normal, with all re-entry events occurring with tolerance, resulting in a successful air-catch of the capsule 12 1/2 miles northwest of the predicted impact point.

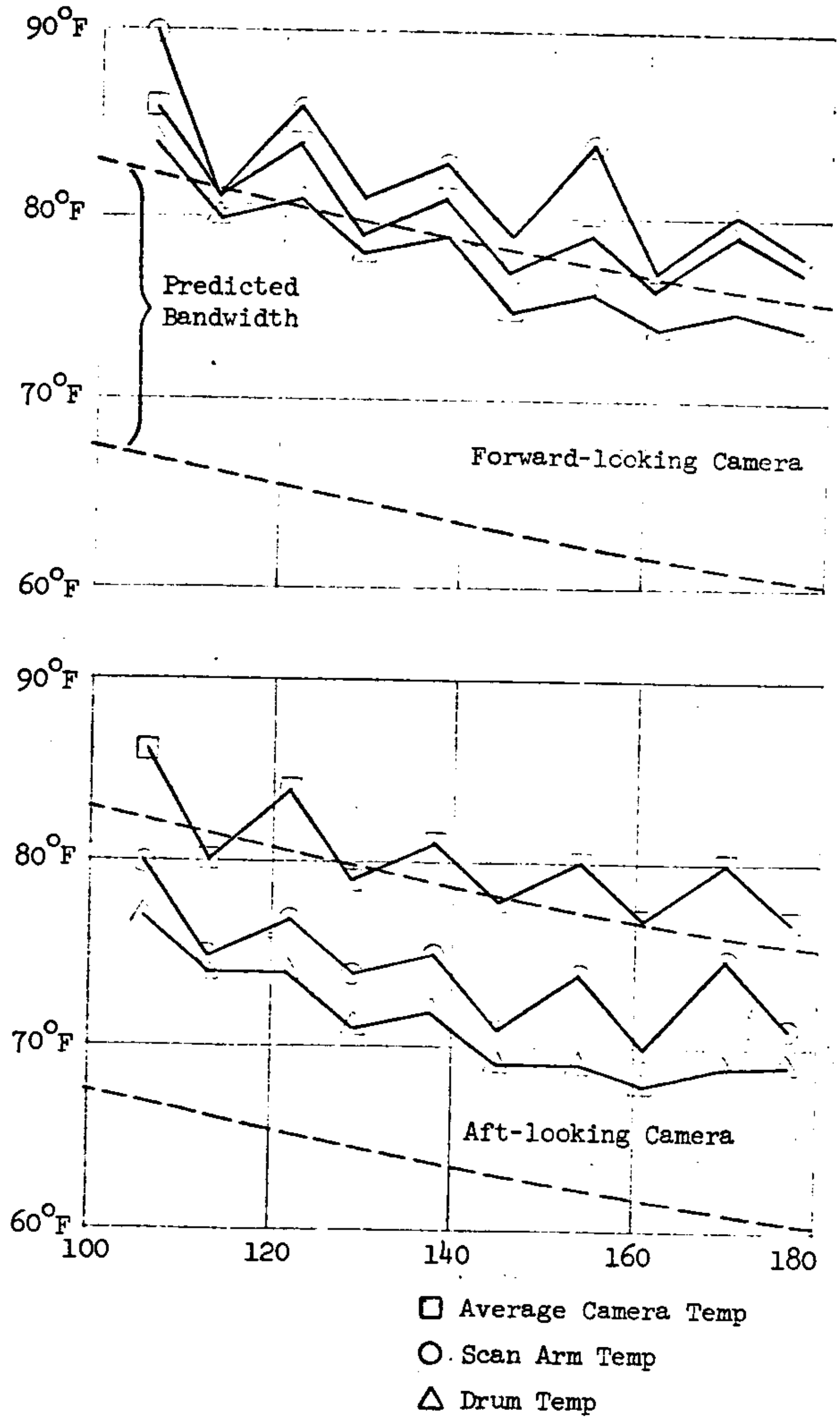
The radiation film pack carried in the recovery capsule indicated a light radiation environment for this mission. Fogging due to radiation was well below the level necessary to degrade the imagery.

G. COMPONENT OPERATION

1. Clock

Clock system operation appeared normal throughout both mission segments. Satisfactory correlation was obtained between telemetered clock data and tracking station time at [redacted] The ratio of system time to clock units was 1:1.000 000 15435. No difficulties were reported in utilization of time correlations by the users.

1049-2 TEMPERATURES



H. VEHICLE

1. Orbital Operations

The on-orbit support provided by the AGENA vehicle was normal, with the exception of the power supply problem discussed below. Attitude control and vehicle stability was adequate (see Section 6A). Active vehicle life ended 14-1/2 days after launch with the decline of electrical supply to below 22 volts, causing guidance instability. Vehicle re-entry occurred over the South Atlantic at approximately 30° South/15° West, 15.9 days after launch.

2. Power Supply

The intended mission was 8 days for Phase I and 7 days for Phase II. These times were reduced because of failure of two of the six Type IH batteries. The first battery (#4) failed on pass number 37 accompanied by large structure current indications. No further anomalous activity occurred until pass 59, [redacted] Shortly after acquisition battery No. 5 indicated higher than normal bus current. Approximately 0.7 seconds later excessive gas valve activity commenced, and within 7 seconds structure indications in excess of 100 amps were observed and continued for 115 seconds. Battery No. 5 gradually decayed and became inoperative on orbit 107.

Cause of the battery failures have not been determined with any certainty. The failed batteries exhibited higher than normal gassing. Postulated failures and test results under high gassing conditions (such as vent valve plugging) have been inconclusive relative to the observed failures. Corrective action has been taken to reduce or eliminate the assumed failure mechanisms. Although procedure changes have minimized the effects of gassing, the cause remains unknown and investigation is being continued by the battery vendor.

2. Stellar/Index Cameras

Both Stellar/Index cameras functioned normally. Telemetry data indicated the programmer, metering functions, and shutter monitor performed satisfactorily during the observed engineering passes. Each camera had not depleted the film supply by the end of its respective mission segment.

3. Instrumentation and Command

The payload command system performed satisfactorily throughout the flight. The UHF ("UNCLE") command link was utilized as the primary system, and there were no reported problems. The payload instrumentation system operation was normal throughout the flight, with no major anomalies reported. The only problem encountered was having some temperatures above the instrumentation capability, early in the mission.

4. Yaw Control

The yaw programmer appeared to function normally throughout the flight. It was set, pre-flight, to produce a nominal maximum yaw deviation of 3.368 degrees at the equator, southbound. Post-flight analysis of the Stellar data indicated minor yaw excursions from the nominal, but generally satisfactory performance, with two minor exceptions noted in Section 6A.

5. Pressure Make-up System

The pressure make-up system operated normally throughout the flight. Internal camera pressure of approximately 50 micrometers was maintained by the 6.3 pounds/minute flow rate. A surplus of 970 pounds of gas remained after termination of the second mission.

SECTION 4

PHOTOGRAPHIC PERFORMANCE

A. SUMMARY

Photography from the panoramic cameras was of inconsistent quality throughout both mission segments. General quality of the aft-looking material was better than that of the forward-looking, which is typical for recent missions. A Mission Information Potential (MIP) of 85 was assigned for the first mission segment. The second segment was not rated. Photointerpreters estimated the utility of the first part as generally fair, and the second as fair to poor.

Photography from both Stellar/Index cameras was consistently good. Stellar imagery from the second mission was partially flared, as is typical for the J-1 system, but could be utilized to provide attitude information. Terrain imagery was good, with no problems revealed.

B. PANORAMIC CAMERAS

1. Image Quality

The best photography of Mission 1049 is considered comparable to that acquired by a normal J-1 mission. Most of the material is considered as useful to the photointerpreter. However, some of the material was not of the quality typical of the J-1 system. A significant difference in quality from the two cameras was noticeable near the end of the first segment but was not as obvious during the second. During these latter operations, material from both cameras was of comparable, and lower, quality than during the first segment.

In addition to general softness, there was a focal gradient across the format of the aft-looking material, the softer side near the time trace. A similar band was observed along the block-side format edge of the forward-looking material, but to a much lesser degree. This was more noticeable during the first segment, as the effect was later absorbed by the general image softening described previously.

Photography during some passes appeared normal with none of the above effects observed. The better individual frames, including the MIP selected for both mission segments, were from the forward-looking camera, although this unit usually produced imagery of lower quality.

The failure of the FMC programmer did not detectably affect photographic quality of those passes taken at maximum indicated FMC error; forward smear was not visible. This, however, may have been obscured by the general softness. A few isolated instances of smeared imagery were noted randomly throughout the mission, but were not correlatable with the programmer failure or other known factors.

Of the several possible causes of the soft panoramic photography, the PET considered thermal aspects as more significant. Data were presented to show that the back focal length of the lenses could have shifted by approximately 0.0015 inch with the higher temperatures encountered during the first mission. Thermal gradients across the lens could further displace the focal plane. Thermal gradients in the mainplate could distort the relative position of the rails, affecting film lift by the scan head rollers. Additionally, the higher initial temperatures could have caused permanent distortion of a critical 0.003-inch nylon spacer between the fourth and fifth lens elements, affecting coma and/or spherical abberation characteristics.

It has been previously noted in Section 2B that temperatures were higher during environmental testing than for the flight, particularilу during the first test recompression. Any permanent optical distortion was not detected during subsequent resolution testing.

Two characteristics of the flight photography do not appear to be wholly explainable by thermal considerations alone. The first is the occasional "normal" pass (Revs 30, 47, etc.) noted interspersed throughout the mission. The second is the gradual deterioration of general quality, especially for the second mission segment, despite temperatures lowering to a more desirable range. Even if permanent distortions were introduced by high initial temperatures, the quality should not reduce upon a return to normal. There is, however, little doubt that the thermal condition was a contributing factor to the photographic degradation.

Two other missions, 1033 and 1046, had similar focal gradients across the format. As Mission 1033 also encountered high temperatures, the gradient was attributed to thermal shifting of the film/focal plane relationship, with the softer edge caused by the lens field curvature characteristic. Mission 1046, which was the first to be fully loaded with SO-230 film, encountered normal temperatures; the gradient was attributed to emulsion particles accumulating on the scan head rollers, shifting the film plane.

Because of the apparent emulsion build-up situation for Mission 1046, the physical qualities of SO-230 film were throughly investigated by the associate contractors. The manufacturer reported to the PET that all tests(1) revealed no differences between 3404, SO-230, and SO-205 types of film; no emulsion dusting problems had been observed. The camera manufacturer has stated that rail marking, which causes emulsion build-up, is peculiar to each rail. While the J-50 system had been characterized by heavy multiple rail scratches during pre-flight testing, the flight film did not appear to be scratched more heavily than material from several other missions. Emulsion dust did accumulate on the rail edges in flight, causing ragged format edges on material from both cameras and almost total obscuration of the middle shrinkage notches in the rails. It is possible that film lift characteristics were altered by emulsion build-up on the rails, and that this contributed to the photographic degradation.

The mechanism causing the focal quality variation in the panoramic imagery has not been completely identified. Several contributing factors may be postulated, but it appears that total analysis is not possible at this time.

(1) The tests performed were: glass gate, glass roller ("bottle"), coefficient of friction, abrasion, brittleness, and curl.

2. Quality Measurements

Microdensitometer edge trace measurements are taken by AFSPPF to establish an objective basis for quality evaluation. The values for the Modulation Transfer Function are plotted against the SO-230 Aerial Image Modulation curve at 2:1 contrast. The resultant MTF/AIM value is obtained from this intersection:

	MTF/AIM			
	1049-1	1049-2	msn average	
	cycles/mm	cycles/mm	cycles/mm	ground resol.
Forward-looking	68	61	64	16.1
Aft-looking	69	63	65	16.0

It was concluded by AFSPPF that the major contributing factor to the low values was the general out-of-focus condition prevalent throughout the mission. The prior J-1 system flight, using 3404 film, had values above 95 cycles/millimeter.

It should be noted that the "Optimal Filter MTF/AIM Program"* is now operational at AFSPPF, superseding the Interim technique in use since Mission 1023. This program is designed to measure system resolution capabilities through Fourier Transformation of an edge derivative. It has been found that results tend to be slightly lower than with the Interim method, and due care must be used in comparing the results of Mission 1049 with previous flights.

* For a complete explanation of the new technique, see SPF Technical Report [redacted] 25 March 1969, Section III.

3. Data Recording

Auxiliary data recording was generally adequate during the mission. The serial number, time word, indices, timing track, S/I slur pulse, and the blanking pulse were operational throughout. Two minor problems were noted: a partially-missing time trace on the first frame of many operations, and the size of the time word indices.

A partially-missing time trace on the first frame of an operate is a condition common to many recent missions. The neon lamps do not start quickly after extended periods of inactivity. A circuit change to increase the lamp voltage was incorporated in the cameras for Missions 1048 and 1049; both had delayed start-ups in flight and in test. As the first frame has little photographic or mensuration utility because of slow camera start-up characteristics, partial loss of the time trace is not considered harmful.

The time word index lamps had been dimmed pre-flight more than usual in order to reduce a blooming effect by the index dot beside the serial number. The resultant smaller dot caused some difficulty with the automatic reading equipment, which searches for time word bits and indices of similar size. For future J-1 systems, the lamps will be set at the lower intensity but the index aperture plate holes will be enlarged so as to provide images with dimensions similar to the time word bits.

4. Anomalies

Anomalies noted on the panoramic record were generally of a characteristic nature, exclusive of the focal problem. Electrostatic discharge marks, usually dendritic, were noted intermittently along the edges of material from both cameras. The marks were within the format area for approximately 40 frames of the aft-looking record from the second mission segment. The marking probably occurred during ground handling, where static discharging was observed both during defilming and at the supply end of the processor.

Minor banding was characteristic of material from both cameras throughout the mission. There was no apparent contribution to image degradation in the banded areas. A tendency towards scan rate variation had been noted during pre-flight testing and had been improved by adjustments.

Light leak fogging was apparent on material which remained in the film path for extended periods between operations. The fogging was heavier than usual for a J-1 system; this was attributed to the more sensitive SO-230 film. The primary source of the leaks was identified as the camera drum seals, which were noted to produce fogging during pre-flight testing. This type of leak is seldom repairable, and was considered acceptable pre-flight.

In addition to the light leaks, an enviromental fogging was noted. This was a very light general plus-density on material remaining in the film path between operates. The film is not fogged where it passes over rollers, yielding a "minus-density banding" effect. This effect was also noted during pre-flight testing; it is a characteristic of the SO-230 film.

C. HORIZON CAMERAS

The otherwise good performance of the four Horizon cameras was marred by veiling of the imagery from the port Slave camera. The veiling was heavy early in the mission, diminishing throughout the first segment, and clearing after the fifth operation of the second segment. Data reduction was not seriously affected, as attitude information was supplied by the Stellar/Index units. Roll and pitch information could have been extracted from the other three horizon cameras, if necessary.

This is the second case of veiling on the port side; The first was Mission 1105, a J-3 system launched in November 1968, just prior to Mission 1049. However, there is a long history of veiled horizon imagery on the starboard side. The cause of veiling has not been definitely established. One suspect cause of veiling relates to the angle between the orbital plane and earth-sun line (beta). Veiling occurs far more frequently at beta angles greater than 30 degrees. As the temperature is also related to the beta angle, it appears possible that significant localized thermal effects may introduce stresses which affect camera performance.

Initial beta for Mission 1049 was -43.5 degrees, diminishing to -30 degrees by the end of the first segment, and to -18.5 degrees at mission end.

D. STELLAR-INDEX CAMERAS

1. First Mission

The Stellar/Index camera was operational throughout the first mission segment, with no significant problems noted. The first frame of the Index material was not exposed. Minor intermittent edge static was apparent on the Stellar material, as were minor emulsion scratches.

Photographic quality of the Index record was normal. A higher incidence than usual of elongated Stellar images was recorded, indicating some vehicle motion during exposure.

2. Second Mission

The Stellar/Index camera was operational throughout the second mission segment. Again, no significant problems were noted. Minor intermittent edge static was also apparent on this Stellar material, as were minor emulsion scratches.

Photographic quality of the Index material was considered good. The slow shutter (1/222 vice 1/500 seconds nominal) did not appear to inhibit the quality. Approximately 20 per cent of the Stellar field was flared, and the reseau was not well defined in unflared areas. This did not affect proper reduction of the data. Some elongated star imagery was recorded, but to a lesser extent than for the first mission.

SECTION 5

PANORAMIC EXPOSURE

Exposure on the panoramic camera system is a function of the slit width used, the filter attenuation, and the scan rate. As scan rate depends upon the camera cycle rate required for FMC control to match the orbit, the primary variables for setting nominal exposure are the slit and filter.

The stated criterion for selecting the slits and filters was to maintain photographic capability up to 60° North. For a mid-winter mission with the terminator at 67° North, it becomes evident that the exposure must be increased over the usual settings in order to achieve the northern coverage. The settings and launch window were chosen using a computer analysis of the nominal orbit parameters and illumination characteristics. A 0.165 inch slit and Wratten 23A filter were selected for the forward-looking camera, with a 0.135 inch slit and Wratten 21 filter for the aft. The computer used a basic 0.58 stop basic SO-230 speed increase over the basic 3404. An additional increase of 0.17 stop was included for the Wratten 23A filter, and 0.07 stop for the Wratten 21. These factors are the same as used for previous missions with SO-230 film, and are based upon recommendations by associate contractors.

Solar elevations encountered during photographic operations are summarized below. While distribution within these ranges is non-Gaussian, most frames were taken between 7 and 40 degrees elevation during both segments. This represents a general latitude band between 20 and 60 degrees North.

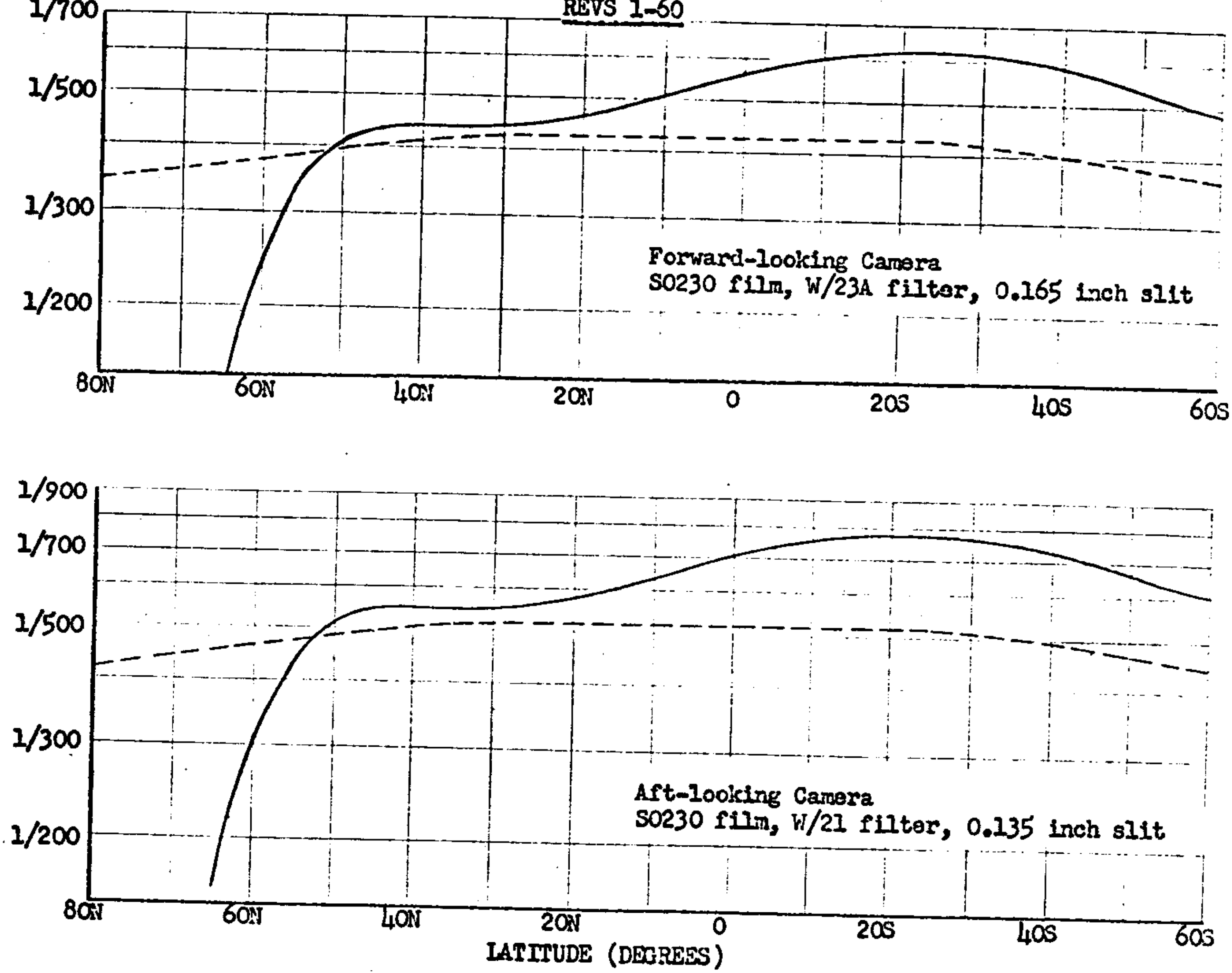
Solar direction, relative to system flight direction, was on the starboard side of the ground track. The ranges, below, represent normal dispersions for a winter mission.

RANGES OF EXPOSURE PARAMETERS

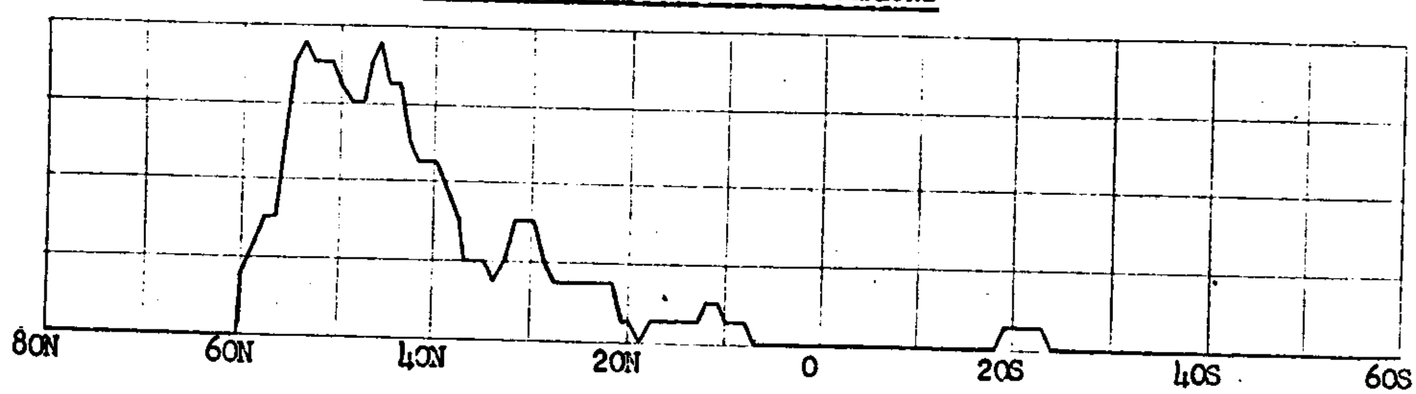
Sun Elevation:	1049-1		5° - 50°
	1049-2		7° - 68°
		Northern	Southern
Sun Direction:	1049-1	32° - 72°	87° - 91°
	1049-2	20° - 51°	86° - 101°
		Master	Slave
Exposure Time:	1049-1	1/350-1/420	1/425-1/510
	1049-2	1/365-1/415	1/440-1/500

The charts on the following pages illustrate representative exposure conditions during the mission:

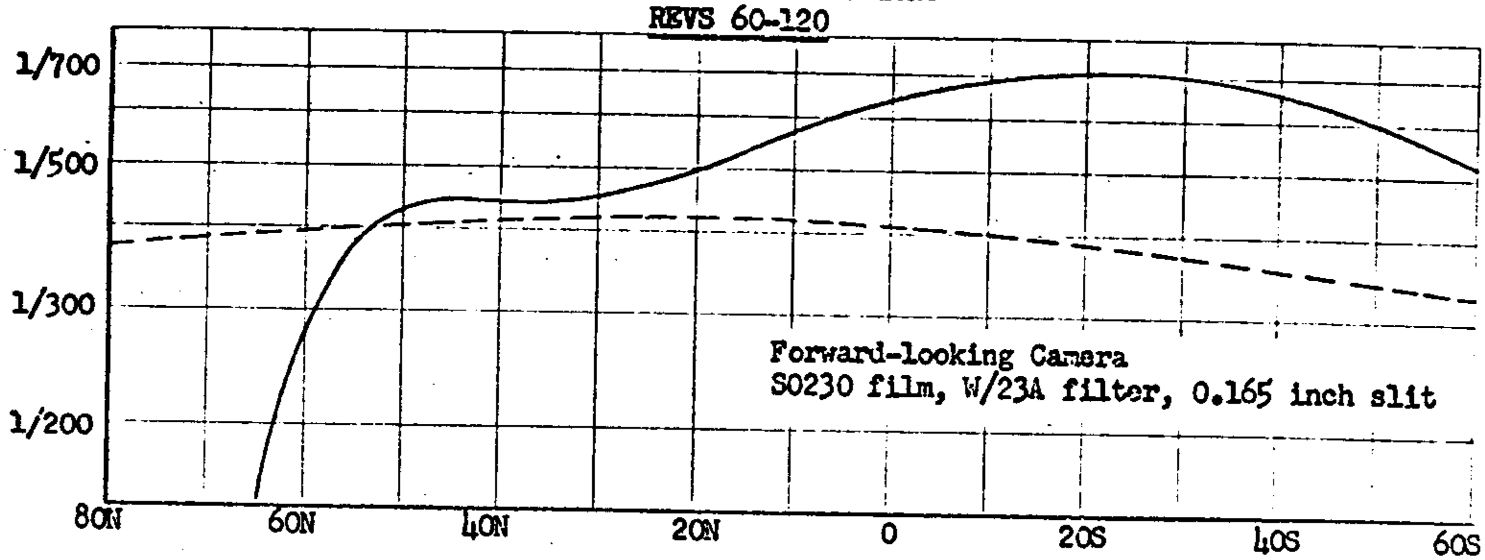
TYPICAL EXPOSURE CONDITIONS
REVS 1-60

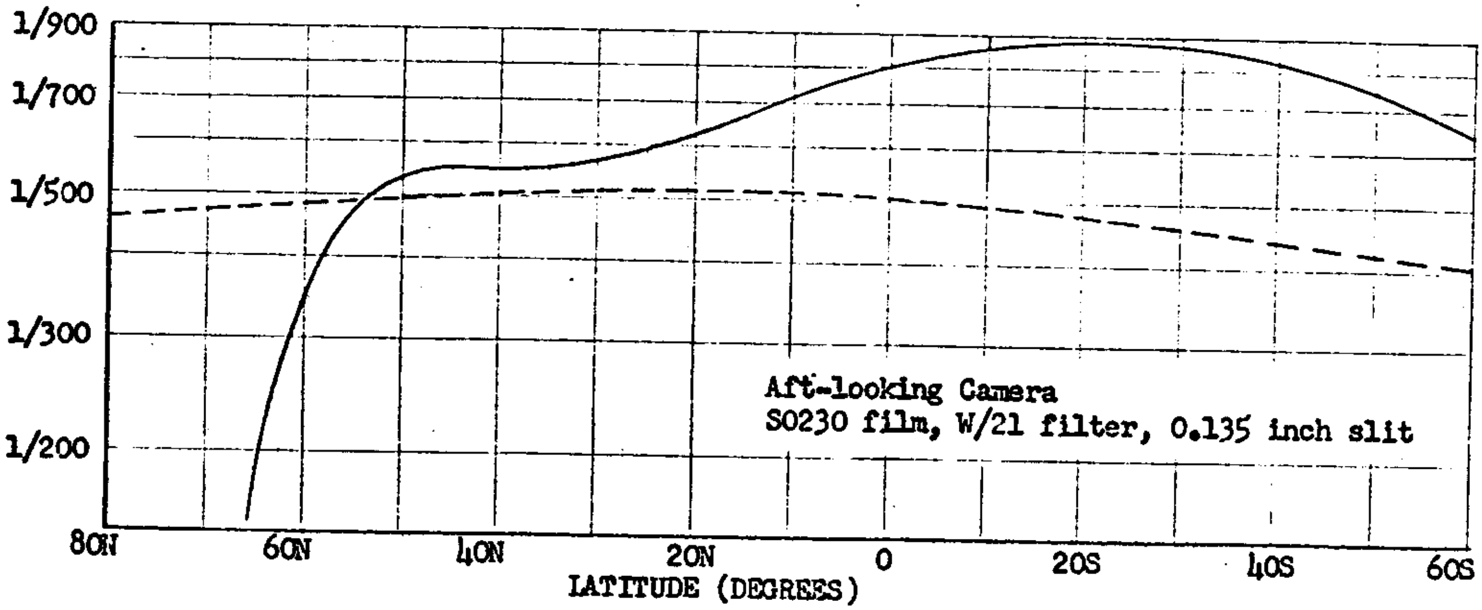


RELATIVE FREQUENCY OF OPERATIONS

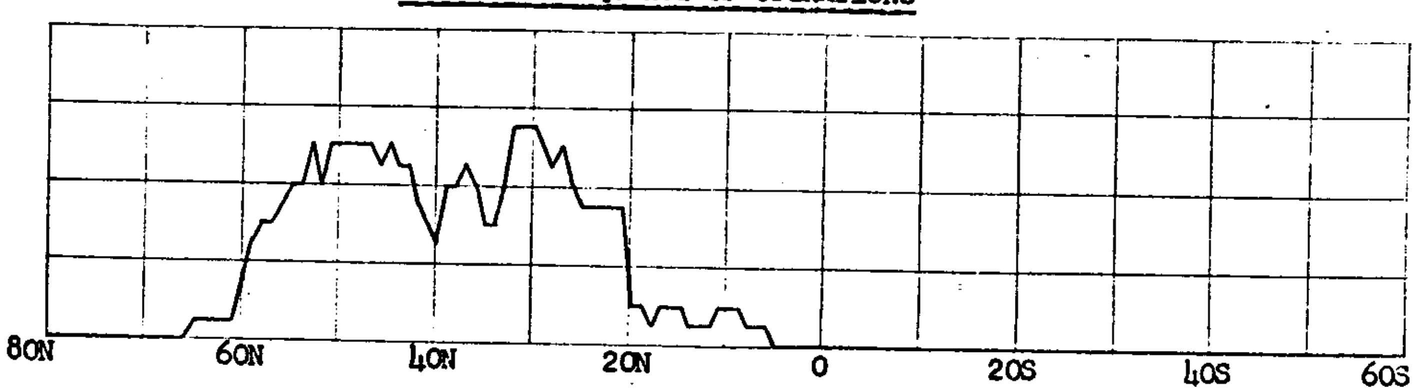


TYPICAL EXPOSURE CONDITIONS
REVS 60-120



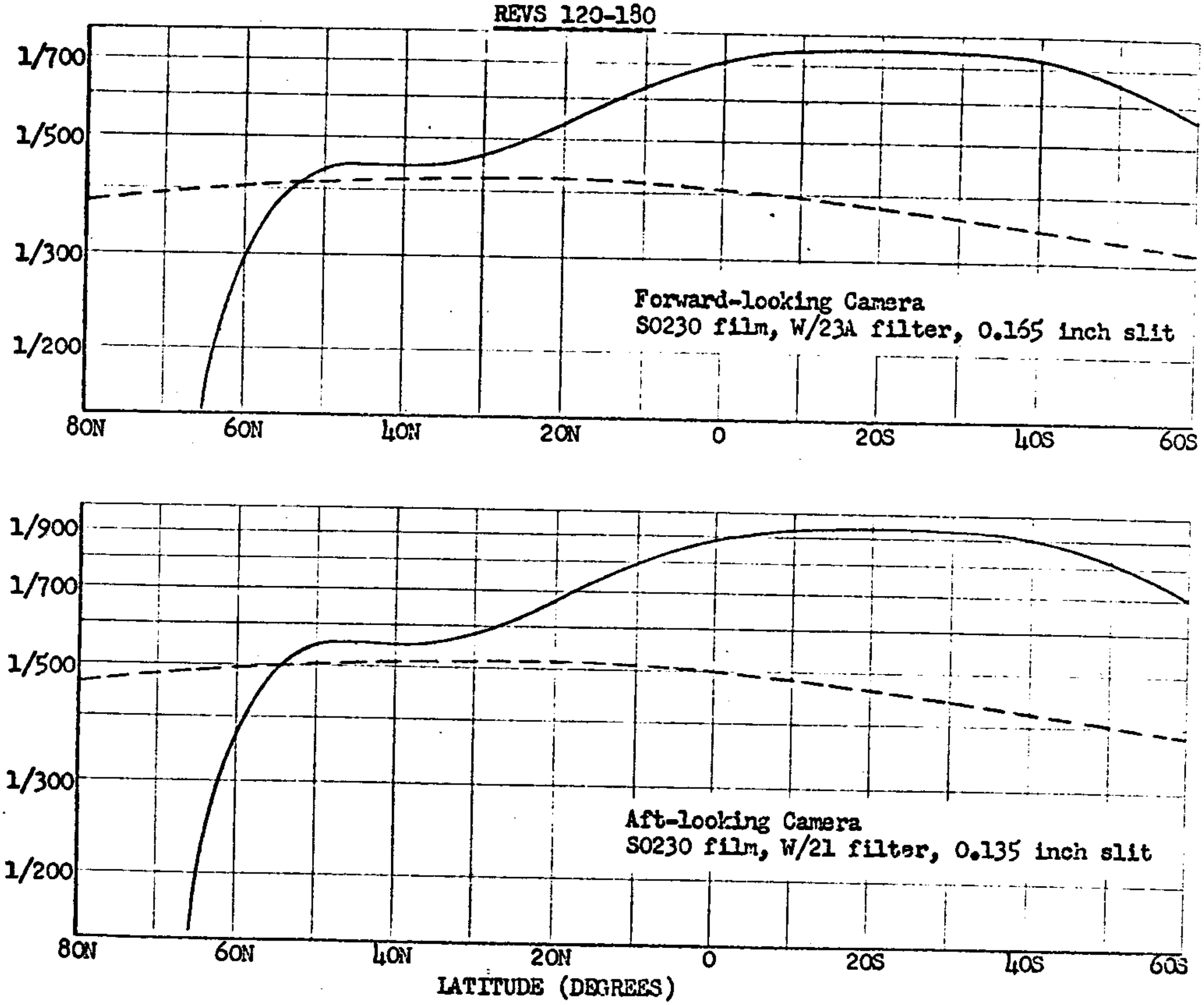


RELATIVE FREQUENCY OF OPERATIONS

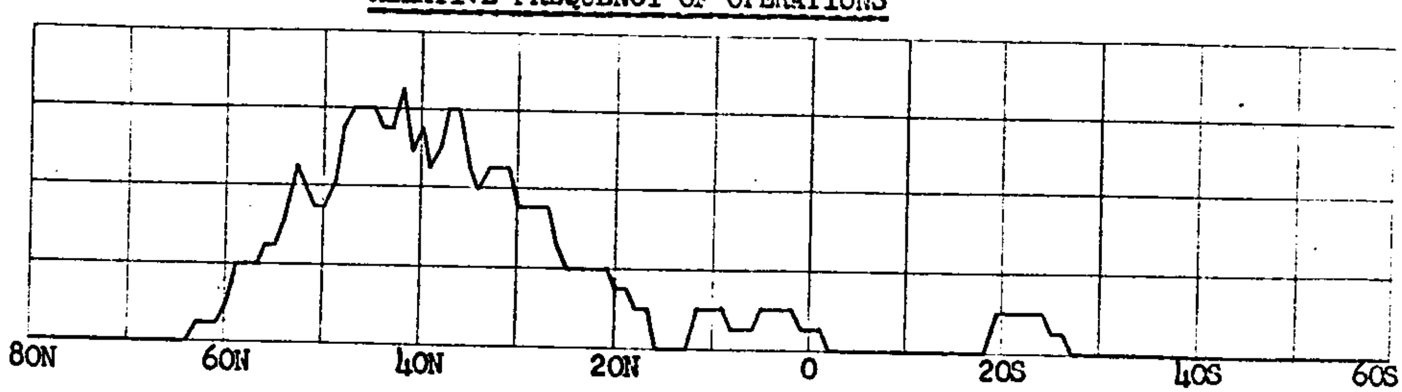


TYPICAL EXPOSURE CONDITIONS

REVS 120-180



RELATIVE FREQUENCY OF OPERATIONS



The preceding charts illustrate that the majority of frames were exposed quite closely to the nominal curve. The following table represents the mean deviation (in stops) from that curve, as encountered in the prime operating area from 60° North to 20° North latitude; this includes 91.3 per cent of all operations:

EXPOSURE DEVIATIONS FROM NOMINAL
(IN STOPS)

			Rev 30		Rev 30	
	FWD	AFT	FWD	AFT	FWD	AFT
60° North	-0.59	-0.56	-0.47	-0.44	-0.39	-0.36
40° North	+0.09	+0.12	+0.09	+0.12	+0.07	+0.10
20° North	+0.07	+0.10	+0.25	+0.28	+0.35	+0.38
Mean	-0.003	+0.025	+0.050	_0.080	+0.074	+0.104

The above data indicate that throughout the mission there was less exposure than desired at 60° North, by as much as 0.6 stop. This under-exposure rapidly decreased so that nominal, or slightly greater than nominal exposure (up to 0.4 stop) was experienced from 52° to 20° North. These differences do not indicate any significant exposure excursions from the nominal. The processing method should allow ample margin for differences of this magnitude.

Coincident with the 1049 flight, and subsequent, extensive analysis was performed on Project Sunny information. This continuing study, which is based upon specific target characteristics rather than general terrain measurements, indicates that certain modifications may be necessary to validate the exposure criteria. Using Sunny data, the nominal criteria may be raised from 0.4 to 0.7 stop at sun elevations less than 34°. A new interim nominal curve model will be used for some future missions, in order to reduce exposure by attempting to match the apparent target brightness of the Project Sunny data.

The recovered film was processed to a single level, using the "dual gamma" technique in the Yardleigh equipment. This was the first mission using SO-230 film to be processed in this manner. No problems were reported during the defilming, pre-splice, or processing operations except the previously-mentioned electrostatic discharges. The following table lists the sensitometric characteristics of the flight material:

SENSITOMETRIC CHARACTERISTICS

		FWD Camera			AFT Camera		
	Process Control	Preflt Sample	First Msn.	Second Msn.	Preflt Sample	First Msn.	Second Msn.
Gamma	1.80	1.69	1.70	1.82	1.74	1.75	1.82
Fog	0.23	0.25	0.24	0.25	0.24	0.24	0.26
Speed Point: 0.6 gamma	$\bar{2}.92$	$\bar{2}.90$	$\bar{2}.92$	$\bar{2}.95$	$\bar{2}.93$	$\bar{2}.93$	$\bar{2}.96$
gross +0.3	$\bar{2}.92$	$\bar{2}.90$	$\bar{2}.90$	$\bar{2}.91$	$\bar{2}.90$	$\bar{2}.90$	$\bar{2}.90$
Speed Values: AEI	6.0	6.3	6.0	5.6	5.9	5.9	5.5
AFS	18.0	18.9	18.9	18.4	18.9	18.9	18.9

Analysis of the AFSPPF macrodensity data indicates that satisfactory exposures were achieved. The usual criterion used to determine proper exposure (and/or processing level if the Interrupted method is used) is that minimum scene density should range between 0.4 and 0.9. In the sample measured for Mission 1049, 75 per cent of the frames fell within this limit. Of the remainder, 16 3/4 per cent were below 0.4 and 8 1/4 per cent above 0.9.

AFSPPF MACRODENSITY MEASUREMENTS

	1049-1		1049-2	
	FWD	AFT	FWD	AFT
Correct Exposure (0.4 to 0.9 D min):	71%	73%	73%	83%
Overexposed (>0.9 D min):	6%	8%	8%	11%
Underexposed (<0.4 D min):	23%	19%	19%	6%

The scene area measured by AFSPPF is selected subjectively, and does not necessarily represent the absolute minimum image density; the measurements are indiscriminately made of relatively gross natural and cultural areas. But as the photograph is utilized by the photointerpreter, the information content is largely based upon density variations at or near the resolution threshold of cultural targets only. Therefore, the 0.4 to 0.9 criterion is not considered a completely adequate indicator of optimum target exposure.

Maximum intelligence is generally derived from specific cultural minimum densities ranging between 0.4 and 0.9. This will usually result in minimum gross scene densities below 0.4, as the reflectance value range for natural areas tends to be lower than that for cultural areas. It becomes apparent that missions with the more desirable information will probably be reported as tending towards underexposure, using these evaluation techniques.

Characteristics of the dual-gamma processing method may be demonstrated by comparing the results of Mission 1049 with Mission 1046, which was processed using the Interrupted technique.* Exposures were estimated as equivalent throughout the primary areas despite the three month difference in launch date, because of compensating slit sizes. The same nominal criterion was applied for both; effectively, the curve is displaced approximately 25 degrees northwards for Mission 1046.

Both missions indicated an equivalent total exposure range, as based upon the processing curves. However, the curve for Mission 1046 was essentially saturated, while some additional maximum density latitude was available for Mission 1049, which provided a more desirable gradient for higher densities. The average minimum and maximum densities were approximately 0.1 lower for Mission 1049, but the difference was similar to Mission 1046; both flights encountered similar scene brightness ranges. The maximum density range was more compressed for Mission 1049.

Recent Project Sunny data evaluation indicates that Mission 1046 probably received more exposure than 1049. The new target brightness model for March (1046) is higher than for December (1049), for selected cultural areas. Re-evaluation of the exposure criteria on a monthly or seasonal basis is currently in progress.

* Ref: Mission 1046 Final Report, [redacted] pp 31-41.

SECTION 6

IMAGE SMEAR

A. VEHICLE ATTITUDE

Vehicle attitude performance data were derived from reduction of the Stellar photography by NPIC. These data are supplied to A/P, where computer analysis provides charts and tabulations of the distribution of attitude angle and rate deviations.

Performance of the attitude control system was normal, and comparable to recent missions. While any angular deviation will cause geometric variation in the photography and any rate deviation will tend to cause relative image motion, the deviations for this mission are not considered degrading to the panoramic photography. The table, below, summarizes both the total range of attitude variation and that experienced during ninety per cent of photographic operations:

	1049-1		1049-2	
	90%	Total Range	90%	Total Range
Angle Deviation (degrees):				
Pitch	0.36	-0.52 to +0.20	0.52	-0.96 to +0.16
Roll	0.18	-0.32 to +0.32	0.45	-0.84 to +0.12
Yaw	0.43	-0.25 to +1.85	0.57	+0.15 to +0.80
Rate Deviation (degrees/hour):				
Pitch	22.0	-60 to +65	34.2	-60 to +70
Roll	22.3	-48 to +70	30.7	-85 to +100
Yaw	29.7	-72 to +32	22.3	-85 to +26

(NOTE: Above data are for all but the first six frames of each foreward-looking camera operation. Data from the aft-looking camera are similar.)

The above data do not include yaw angle deviations for Revs 1 and 91, for which deviations up to +3 were recorded. Photography for these revs was accomplished prior to enabling the yaw programmer, which accounts for the large error.

Roll rates, for the aft-looking camera during the second segment, occasionally were above 100 degrees/hour after shutdown of the forward-looking unit at the end of an operation. These operations also are not included in the above tabulation. This condition is not considered abnormal, because of the reduced orbital mass of the second mission, and the increased roll moment of a single camera operating.

A minor pitch angle bias was noted throughout the first mission segment. The mean pitch deviation was approximately -0.25 degree (tail-first flight, tail down). This was not apparent during the second part; there was a broader range of deviation, with some pitch oscillations noted during longer operations.

Vehicle attitude control is concluded to have been within the normal performance envelope for both mission segments. Attitude deviations or rates did not contribute significantly to reduction of panoramic photographic quality.

B. SMEAR ANALYSIS

Data containing the time word for each panoramic photograph are supplied by NPIC to A/P. These times are correlated with the LMSC Precision Fit ephemeris to produce an analysis of FMC error, and are then combined with the vehicle attitude data to produce the net image motion compensation (IMC) errors as well as the total in-track and cross-track ground resolution limits. These resolution limits would apply to any camera system, regardless of focal length or other system capabilities.

With the exception of the operations affected by the FMC programmer failure (Revs 68 thru 88), total system limits were within the normal per formance envelope. As previously noted, smear was not detectable on the material from Revs 68 thru 88, probably because of the general reduction of image quality from other causes.

The table on the following page states the net IMC range encountered during each mission segment, and the resolution limits. The data for Revs 68 thru 88 are also tabulated separately so as to isolate effects of the programmer failure.

MISSION 1049

SMEAR ANALYSIS

		1049-1				1049-2	
		Range, Revs 5-67 89-91	Range, Revs 68-88	Total Range	90%	Total Range	90%
IMC Error, per cent:							
	FWD	-8.9 to +3.8	-17.4 to 3.6	-17.5 to 3.8	10.4	-6.5 to +10.0	3.6
	AFT	-8.6 to +3.4	-17.6 to 2.8	-17.6 to 3.4	10.8	-6.5 to 10.5	3.9
Resolution Limit, feet:							
Intrack:	FWD	6.2	17.7	17.7	9.8	8.6	3.1
	AFT	6.1	14.1	14.1	8.3	7.4	2.7
Crosstrack:	FWD	1.6	2.0	2.0	1.0	2.2	1.2
	AFT	0.7	1.1	1.1	0.6	1.2	0.6

The above data do not include crosstrack resolution limits for the operations during Revs 1 (engineering) and 91, where the yaw programmer appeared ineffective. The limits for those passes ranged as high as five feet, but are not considered exceptionally degrading because the IMC vector did not exceed 4 1/2%.

There was one southern pass during the second mission segment for which the FMC rate could not be satisfactorily adjusted. The rate was set to be adequate for the two northern operations on Rev 155, but was approximately 10% fast for the southern operation. This single operation accounts for all IMC errors above +7%, and intrack resolution limits above 5.2 feet, for 1049-2.

Maximum IMC error and resolution limits generally occur within the first ten frames of an operation. For the above tabulation, data for frames one thru six of each pass have been omitted, per standard practice. The higher-magnitude deviations typically reflect frames 7-9 of each pass.

It is concluded that less than 13% of the total mission material could have been degraded to some potentially detectable extent by FMC errors or yaw deviations. No deterioration in IMC or resolution limits was noted as the mission progressed. It does not appear that image smear was significant contribution to the lower general photographic quality of the panoramic material. The large majority of the material was taken under conditions of favorable attitude and smear control.

.SECTION 7

SYSTEM RELIABILITY

Payload reliability information for the Corona system is divided into two categories. The primary section considers significant system functions which contribute to retrieval of the more significant information, such as obtaining panoramic imagery and time data. The secondary section considers functions of the auxiliary cameras.

Primary reliability data are based upon a sample beginning with M-7. Twenty Mural program systems and all of the "J" program to date are therefore included in these calculations. This sample size is consistent with reliability reporting for the AGENA vehicle. The sample origin is changed only when system modifications or new designs are introduced to improve reliability, as for both types of auxiliary cameras.

These reliability estimates deal exclusively with the electrical and mechanical functions of the payload. Vehicle-induced failures, as not achieving orbit, are excluded. Quality of the film supply is not reflected. Recoveries prior to completion of a full mission are considered as complete missions, providing that payload operations problems did not cause the early termination. The following table summarizes payload system reliability, estimated to a fifty per cent confidence level:

PAYLOAD SYSTEM RELIABILITY

FUNCTIONS:	Opportunities To Operate	Failures	Estimated Reliability
Primary (M7 and up)			
Panoramic Cameras	230	3	98.4%
Main Doors	137	0	99.5%
Command and Control	14544 (hrs)	2	96.9%
Clock	14544 (hrs)	0	99.2%
Total Payload Functions	-	-	96.7%
Recovery (J5 and up)	107	1	98.4%
Secondary (J5 and up)			
Horizon Cameras:			
Single Camera	142000	0	99.3%
4 units, parallel redundant	-	-	99.9%
Stellar-Index Camera	32380	5	92.8%

SUMMARY

The photographic results of Mission 1049 were considered equivocally successful. The better panoramic imagery was equivalent to a typical J-1 mission, although image quality was variable throughout the mission. Auxiliary cameras performed well. The vehicle provided a stable photographic platform, however power supply problems reduced the mission duration.