TOP SECRET - CORONA/LANYARD

SYSTEM

PERFORMANCE EVALUATION REPORT

MISSION 8003

P E T

TOP SECRET - CORONA/LANYARD

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

FOREWORD

THIS REPORT PREPARED FOR AND BY DIRECTION OF

[redacted]

OFFICE OF

THE SECRETARY OF THE AIR FORCE

Preparing Unit:

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AF Unit Post Office
Los Angeles 45, California

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

PUBLICATION REVIEW

This report has been reviewed and is approved.

ALBERT W. JOHNSON
Captain, USAF
Team Manager

PERFORMANCE EVALUATION TEAM
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ABSTRACT

An evaluation was made of the Lanyard Mission 8003 based on examination and analysis of the flight mission product. The evaluation was performed by the Director of Special Projects Performance Evaluation Team, assisted by personnel of the National Photographic Interpretation Center, Aeronautical Chart and Information Center, and the 6594th Test Squadron (AFSPPL)(AFSC).

It was concluded that the objective to achieve an average ground resolution of five feet was not met. The system did demonstrate in a few instances that is has the potential of achieving the stated goal of five feet from 110 nautical miles. It is believed that the major cause for the nonachievement of system performance goals is that the desired temperature of the lens and the platen support tube was not attained on orbit. This produced an adverse environment for the optics and may have caused a lens element to shift in its mountings during Orbit 9, which could account for the sudden downward shift in RES values occurring at that point.

The cause for the payload failure after normal operation for 22 orbits has been established as a failure in the intervalometer system controlling the main panoramic camera and the stellar-index camera. Corrective measures will be taken before the next flight.

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

The physical condition of the film was generally excellent throughout. A few minor deficiencies were noted and investigative action initiated to correct these before the next launch.

Geopositioning was within acceptable limits, and the objective to obtain mono and stereo photos of specific targets was achieved. The Agena D and the roll joint, which points the camera, functioned satisfactorily. The clock accuracy was within ± 7 milliseconds.

The index camera failed after three frames. The stellar camera exhibited erratic metering but operated for the duration of its mission.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

LIST OF ILLUSTRATIONS

Number		Page
1	0° Roll, Mono Operation	26
2	0°, Stereo Operation	27
3	15° Roll, Mono Operation	28
4	15° Roll, Stereo Operation	29
5	Mission Coverage Plot	30
6	Mission Coverage Plot	31
7	Actual vs Allowable Exposure	34
8	Frequency Distribution - Brightness Ratio	35
9	Average RES and Brightness Ratio per Frame	36
10	Average RES Variation - Areas 1, 3, and 5	37
11	Temperature Profile - Orbit 8	38
12	Micro-Analyzer Trace - Pass D02, Frame 030	39
13	Micro-Analyzer Trace - Pass D14, Frame 123	40
14	Micro-Analyzer Trace - Pass A18, Frame 012	41
15	Micro-Analyzer Trace - Pass D20, Frame 024	42
16	Micro-Analyzer Trace - Pass D20, Frame 032	43
17	Micro-Analyzer Trace - Pass D21, Frame 045	44
18	V/h Ramp Match	45
19	Typical Vehicle Attitudes	46
20	Measurement Comparison Test	66
21	Attitude Errors and Rate - Pass D06, Frames 001 - 016	67

LIST OF ILLUSTRATIONS (Cont)

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

LIST OF TABLES

PERFORMANCE EVALUATION TEAM

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PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

SECTION I

MISSION 8003 HISTORY

Mission 8003 was launched from Vandenberg Air Force Base 0000:17Z on 31 July 1963.

The satellite vehicle consisted of the "L" panoramic camera with the supporting Stellar Index (S/I) camera, the recovery system, and the Agena. The payload was mated to the Agena by an electro-mechanical roll joint to obtain increased target coverage.

This satellite was boosted into orbit by an improved Thor, Agena D combination. The orbit achieved had the following parameters:

	Actual	Nominal
Inclination	74.94°	75.0
Period	90.59 min.	90.72 ± .15 min.
Perigee	91.87 nm at 52.98° N. Lat.	93.0 + 3.5-5 nm at 50° N. Lat.

Mission 8003 was programmed for a five day operational mission. The primary objective was to demonstrate the system potential for obtaining high quality, large scale photography of selected targets. This involved mono and stereo operations in roll angles of -30°, -15°, 0°, +15°, +30°. The design goal is five foot ground resolution.

Upon injection into orbit, the instrument operated for one burst as programmed to verify lens lock release and otherwise demonstrate proper electric mechanical operation.

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

The orbit attained was very close to the desired orbit and the pass 2 ephemeris was demonstrated to be adequate for mission planning.

Rev 9 telemetry indicated the main camera to be operating normally but the S/I camera to be metering excessively. It was also noted that the desired thermal environment for the payload had not been attained.

The roll joint was left caged until Rev 16 to have a comparison of photography before and after uncage, On Rev 16 it was uncaged as programmed and operation was normal.

Roll maneuvers to obtain photography were successfully executed 13 times. The instrument was rolled back to zero at the end of each pass.

Functional T/M indicated essentially normal operation of the main camera through orbit 22, with the temperatures still high and the S/I camera metering excessively.

On orbit 25, no operation was indicated in response to tracking station real time commands. Also, an increased power drain on the Agena batteries was noted by T/M.

No further operation of the main instrument was indicated in response to real time commands given on subsequent orbits and the increased power drain persisted.

The decision was made to recover on the next appropriate orbit. Recovery was accomplished on orbit 33 at 0250Z, 2 August 1963.

The photographic product recovered consisted of 908 frames (approx. 1900 ft) from the main camera, 500 ft from the index camera, and 250 ft from the stellar camera. About 60% of the main camera coverage was in stereo.

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

SECTION II

PERFORMANCE EVALUATION TEAM OBJECTIVES

The Performance Evaluation Team was assembled after the recovery to compile a consolidated evaluation of Mission 8003. The report was made under the management of the Program [redacted] Team members from Space Systems Division monitored the mission and participated in the evaluation.

The team compiled data from analysis of the photographs for inclusion in a final report for the [redacted]. This analysis covers the fields of command, geoposition, and photography. In all cases the record was studied to determine how well the results compared with the planned mission. For example: the command summary shows that the camera was operated at a specified time to obtain a photograph of a target, the best-fit ephemeris locates the actual position of the satellite at that system time and observation from the photographs indicates the actual geographic position. Further analysis compared actual and commanded camera speeds and burst times. Finally, an analysis of the film itself indicated how well the camera system operated in producing high resolution and acceptable film densities. Where available, telemetry was used to confirm system operation. The preliminary evaluation was submitted to the associate contractors in the form of tabulated data and some pertinent commentary.

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

The Aeronautical Chart and Information Center (ACIC) performed geoplot of the mission coverage and related predicted versus actual coverage and qualified differences with their knowledge of map accuracies.

The National Photographic Interpretation Center provided a subjective image evaluation with respect to its suitability for intelligence purposes.

The 6594th Test Squadron (AFSPPL) provided photometric data, administrative and reproduction support, and was host to the team during the evaluation.

The associate contractors and system engineering organizations furnished team members and performed the system and payload analysis.

SECTION III

COMMAND AND GEOPOSITIONING

A. Command Structure

The Lanyard Command system is comprised of the Type 8 Orbital Timer, a V/H Programmer, and a command decoder. The basic type 8 programmer is loaded before flight with the commands as a function of elapsed time to turn the camera system on and off, and to control certain system function. The timer may be periodically reset by real time commands from the ground to ensure that desired operations are obtained. Real time commands are also used to select programs, V/H ramps, and similar functions. A complete description of payload real time and orbital timer commands follows:

R E A L T I M E C O M M A N D S

No	A/P	Command
4		Command Operate Applies power to decoder, pulls lens cell retaining pin, executes a stereo pulse operation
8	A	V/H ramp selector An 11 position switch is stepped to select any 1 of 11 ramps
9	B	Program 1, 2, or 3 selector A 3 position switch is stepped to select either program 1, 2, or 3.
10	C	Ramp start-time selector An 11 position switch is stepped to select any 1 of 11 stored start times for the V/H programmer

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

11 D Operation Enable/Disable. Intermix deck selector. Stereo override. A 4 position switch provides the following command possibilities:

Position 1 - Enables stored program commands for panoramic instr operation. Selects intermix sequence from Deck 1

Position 2 - Disables all stored program commands for panoramic instr and roll joint operation unless in intermix mode. Selects intermix sequence from Deck 2.

Position 3 - Override all stored program stereo commands to mono operation. Intermix on Deck 1

Position 4 - Override all stored program stereo commands to mono operation. Intermix on Deck 2

12 E Orbit ON/OFF intermix start point selector
An 11 position switch is stepped to the desired starting point to set up an automatic sequence of operation enable/disable commands for succeeding orbits. Switch is stepped through sequence after setup by one punch per orbit in orbital timer track 14. There are 2 decks on the switch. Selected by RTC 11, wired as follows:

	SWITCH POSITION											
	1	2	3	4	5	6	7	8	9	10	11	
Deck 1	0	1	0	0	1	1	1	0	1	0	1	1=On for Orbit
Deck 2	1	0	1	1	0	0	0	1	0	1	0	0=Off for Orbit

15 F Program 4, 5 selector. Fixed roll angle selector. Stepping off home position 11 disables operation in Progs 1,2,3. An 11 position switch is stepped to provide the following control:

SWITCH POSITION										
1	2	3	4	5	6	7	8	9	10	11
+30	+15	0	-15	-30	+30	+15	0	-15	-30	Home
PROGRAM 4					PROGRAM 5					

ORBITAL TIMER COMMANDS

Track	Function
14	Orbit counter for intermix, V/H prog start and yaw program reset
**	Roll to zero all programs
17	Clock interrogate, telemetry enable - continuous channels
27	V/H Programmer start
28	Instrument on-program 4-(roll selected in flight)
29	Stellar/Index cameras on.
30	Stellar/Index cameras off

PERFORMANCE EVALUATION TEAM
REPORT NO.[redacted]

31	Roll execute-programs 4 and 5
32	Instrument off - program 4
33	Instrument on - program 5 -(roll selected in flight)
34	Instrument off - program 5

ENABLE			EXECUTE		
35	36	37	38	39	Program 1 - Stored roll program
40	41	42	43	44	Program 2 - Stored roll program
45	46	47	48	49	Program 3 - Stored roll program
			1	0	Roll to zero position
0	0	1	1	0	Roll to minus 15 degree position
0	1	0	1	0	Roll to minus 30 degree position
	1	1	1	0	
1	0	0	1	0	
1	0	1	1	0	Roll to plus 15 degree position
1	1	0	1	0	Roll to plus 10 degree position
1	1	1	1	0	(Binary matrix checkout)
				1	Temp sensor power off
0	0	1	0	1	Panoramic instrument on stereo pulse
0	1	0	0	1	Panoramic instrument off continuous mode
0	1	1	0	1	Panoramic instrument on stereo continuous
1	0	0	0	1	Temp sensor power on
1	0	1	0	1	Panoramic instrument on mono pulse
1	1	0	0	1	Reset panoramic instrument
1	1	1	0	1	Panoramic instrument on mono continuous

50	Yaw program
51	Tape recorder read in
52	Tape recorder off

** Varies, 15(FTV 1167), 26(FTV 1168), 16(FTV 1172 + Subsequent).

N O T E S

1. An S/I camera operation preceding the first panoramic instrument operation pulls the lens cell retaining pin.
2. Roll joint is uncaged by first zero roll command in progs 1, 2, or 3

S E P A R A T I O N C O M M A N D

Inflight reset — Eject instrument doors (Main and S/I)

G U I D A N C E T I M E R C O M M A N D S

+28V to SS/L	Eject instrument doors (Redundant), Apply power to decoder. Unstow lens cell
Arm	Slew S/I payload
Transfer	Actuate water seal
Separation	

B. Tracking and Control Response

1. The nominal orbital parameters achieved on FTV-1167 L-3 resulted in an ideal control situation. Program 1, based on the nominal orbital period, was used throughout the 22 orbit operation. The IMC control settings used during the mission were the nominal settings established prior to launch. A ramp change was made on orbit 23 to compensate for a slightly faster than nominal cycling rate determined on data acquired on orbit 16. Illustration 23 shows the quality of the obtained fit. The only payload commands used during the 22 orbit mission were for "intermix" control; for selection of the active orbits within the flight program.

2. The tracking network provided early convergence on the achieved orbit. This resulted in accurate prediction of coverage block locations from the initial prediction based on tracking data acquired through orbit 2. Updated tracking data (through orbit 9) was used for the prediction of block locations for orbits 13 through 22.

3. Block location predictions are based on H-timer control so that the timer is maintained in perfect synchronism with the orbit. Deviations between the predicted block locations and the actual block locations are due to imperfect H-timer control.

4. One gross timer mismatch occurred during the mission on orbit 6. This mismatch was a result of timer adjustments given based on orbit 2 tracking data which were in effect until the next tracking station acquisition at orbit 7 [redacted]. This mismatch resulted in a 57 mile latitude error in operation 6 DM 1, essentially missing one-half of the mono block.

5. This type of timer mismatch was anticipated during the early portions of the flight due to lack of precise determination of the orbital parameters

6 The reset command given at orbit 16 [redacted] was in effect until orbit 22 [redacted]. Time mismatch during this period was essentially constant and amounted to approximately a 3 5 to 4 seconds bias in all operations during this period This is considered an excessive bias to be present in the timer system after the orbit has been determined, and the cause for the bias requires further investigation. The average latitude bias of all operations that were available for evaluation was 14 15 nautical miles or an equivalent timer mismatch of 3 53 seconds

7 The performance estimate, computed and issued 15 hours after recovery, provided an accurate summary of the actual block locations The average latitude difference between the performance estimate excluding the known timer error and the actual center of block locations as determined from maps (considering all error sources) was 5.0 nautical

miles. Longitudinal errors were generally 2 nautical miles or less.

8. In summary, the orbital determination, block center predictions, and post flight Performance Estimate were satisfactory. The need for better H-timer control or alignment is indicated, based on the somewhat limited data obtained on this mission.

9. Image motion compensation control was adequate. Improvement in instrumentation or techniques is in-order to improve on the response time to non-nominal cycling characteristics.

10. Orbital Tracking Performance

The actual orbital parameters were determined very early in the mission, as seen by the tracking data "residuals". These residuals represent the apparent error of any set of tracking points when combined into the previously processed tracking data. As seen in Table I, Summary of Tracking Residuals, the actual parameters were converged upon by orbit 7. This is due in part to the fact that the actual orbital parameters were essentially nominal.

11. No degradation in tracking performance is in evidence due to the lower heights over the tracking stations on the descending side of the orbit.

TABLE I

SUMMARY OF TRACKING DATA RESIDUALS

Station	Rev	RMS Feet
[redacted]	1.3	12151.6[illegible]
	7.1	778[illegible].36
	8.2	6969.28
	9.2	622[illegible].27
	9.1	568[illegible].96
	10.2	540[illegible].86
	11.1	[illegible]912.0[illegible]
	13.3	[illegible]529.85
	16.3	[illegible].58
	17.3	7338.15
	23.1	[illegible]061.78

In summary, vehicle tracking was [illegible] on this mission.

12. Accuracy of Target Coverage

Accurate targeting is a function of several factors of which the dominant factors are:

a. Precise mission programming

b. Precise orbital determination

c. Precise control of the H-timer

d. Nominal instrument cycling performance

H-timer control (and therefore targeting) is concerned with latitude control only. There is no provision or technique for longitude control of the system.

13. It was anticipated that precise orbital control of the H-timer would not be achieved in the early portion of the

flight, basically due to the lack of precise determination of the actual orbit. This prediction was essentially confirmed by the timer mismatch that accumulated between orbit 2 [redacted] and orbit 7 [redacted] and is evident by a large latitude targeting error on orbit 6. The error was removed by timer reset at orbit 7 [redacted] The H-timer control after orbit 16 was not as good as had been expected, particularly considering the early convergence of the actual orbit. The average H-timer mismatch to the actual orbit between orbits 16 and 22 was 4.3 seconds. A review of the timer performance data obtained during the flight (reported by TWX) does not indicate any timing errors greater than 1 second. A post flight analysis of timer performance is in process and should provide more precise determination of the actual timer performance.

14. Based on 33 plotted block centers, the average latitude error as compared to the original designated points was 12.6 N. miles. The maximum error was 57 miles on orbit 6, due to timer settings based on early orbital data.

15. Pitch and roll angle data has been reviewed for the possible targeting errors due to vehicle attitude. The vehicle was generally stable, with roll angles averaging approximately 20' of arc, and pitch excursions approximately twice as much. The maximum pitch angle at block center was -1°53' resulting in a -3 mile in-track aiming error. A roll angle of 0.5 degree at 30° roll position at 120 N. mile altitude would result in a 1.4 mile cross track aiming error.

16. A tabulation of the center of block differences between the planned and actual latitudes is given in the Geoposition Tabulation Table No III, pages 23 to 25.

17. Look Point Prediction Evaluation

Look Points for the center of each block were predicted at intervals throughout the mission.

Prediction Schedule

Tracking Data Through Rev.	Look Point Prediction
2	Orbits 1 to 20
9	Orbits 13 to 35
25	Orbits 27 to 81

The early convergence of the tracking data on the actual orbit resulted in good accuracy starting with the initial prediction based on data acquired through rev 2. Using data acquired through orbit 29 as a standard, a comparison is made between the predictions made at orbit 2 and orbit 9. This indicates that an average error in the latitude of the block center of 3.84 N. miles is removed by updating. Look Point Predictions are made assuming that the H-timer is precisely matched to the orbit attained. Deviations between the predicted look points and the actual block center are a result of mismatch between the orbit and the actual timer performance.

TABLE II

Look Point Prediction Accuracy (Latitude)

Operation	Rev 25 vs Rev 2	Rev 25 vs Rev 9
13 AM 1	-3 N.M.	-3
14 DS 1	5	0
14 DM 2	3	-3
15 DM 1	6	0
16 DS 1	3	-2
16 DS 2	3	-3
17 DS 1	5	1
18 AS 1	-7	-1
18 AS 2	-7	-1
18 DM 3	4	1
19 AS 1	-8	-4
19 AS 2	-8	-5
19 AS 3	-6	-4
19 DS 4	4	0
20 DM 1	4	0
20 DS 2	4	-1

18. Performance Estimate Accuracy

The Post flight Performance Estimate is a product issued after recovery giving the best estimate of each block location. The main differences between this post flight estimate and the predictions are that the estimate uses the best orbital parameter data available after recovery and actual timer performance instead of a simulated perfect timer. The timer correlation data is derived from the "post orbit command summaries" that are part of the operational reporting system. The average latitude error that existed between the estimate and 33 plotted points was 5.0 n.m. or slightly over one second in actual timer performance. The Performance Estimate was a good appraisal of actual mission targeting. Table III, Geoposition Tabulation, contains in the last column the actual latitude differences between the Performance Estimate and the plotted block locations.

C. Attitude Control

1. Vehicle attitude data given in this report is that obtained from the vehicle attitude stabilization system which furnished signals to the main panoramic data block. Additional and more accurate attitude data will become available when the stellar camera film is analyzed. It is estimated that this information should become available to Project [redacted] within thirty days. NPIC is the agency responsible for photogrammetric reduction of the stellar film.

2. For Mission 8003, the dead-bands of the vehicle guidance system were set for ± 1/2 degree in pitch, roll, and yaw. Stabilization adjustment rates were set for a 90% probability of 10 degrees per hour in pitch, 30 degrees per hour in roll, and 10 degrees per hour in yaw. Preflight calculations showed that the lens IMC drive would induce a 15 degree per hour pitch rate.

3. Vehicle attitude was examined on a frame-by-frame basis in each pass and was plotted for purposes of analysis. These show that the vehicle was generally stable throughout the mission life within the limits required by the main panoramic camera system to obtain high resolution photography.

4. In the roll axis, deviations were minor and confined largely to the dead-band limits. During recognizable periods in Pass D01 and Pass A09 when the roll attitude control gas jets were activated, the roll rate was below the permitted rate of 30 degrees per hour. During periods when the roll attitude was within the dead-band limits, roll rates vary from essentially 0 degrees per hour to a once observed maximum of 120 degrees per hour.

5. In the pitch axis, there appears to be a constant negative (nose-down) error of approximately one-half degree.

6. The most extreme errors in vehicle attitude are exhibited in passes D14 and D15. In pass D14 pitch error reaches a minus two degrees during operation 1, a series of six stereoscopic bursts programmed to occur continuously, and then recovers to nearly zero. A pitch rate of 130 degrees per hour occurs during this period. In pass D15 the error reaches minus 1 1/2 degrees near the end of operation 1. Pass D15 was a series of five monoscopic bursts programmed to occur contiguously. Highest pitch rate observed was 90 degrees per hour. It is possible that these pitch errors may be induced by the [illegible] [illegible] drive, since

PERFORMANCE EVALUATION TEAM
REPORT NO. [redacted]

observed rates occurring before pitch jet actuations are approximately those calculated before flight. Further analysis will be conducted to determine effects of long burst operations.

7. Due to the loss of the index camera, yaw attitude analysis will not be as readily attained as hoped. NPIC has agreed to undertake analysis from the main panoramic film and stellar film but progress will be slower due to the need for developing new techniques and computer programs. Preliminary crude analysis of yaw data has been made from the geoplot prepared by ACIC and these indicate that the yaw programming functioned as planned. This is further corroborated by the fact that the observers report no cross-track smear.

8. The effects of vehicle attitude on "look point" was also analyzed and was found to contribute errors ranging from 0.00 nautical miles to 1.5 nautical miles across-track and 0.2 nautical miles to 3.2 nautical miles along-track. The ACIC plotting team regarded these errors to be of minor significance.

9. An examination of the vehicle attitude before roll joint separation and after separation shows that this event had no effect on the vehicle stability or pointing accuracy.

10. The high flying aircraft with resolution targets on its wings was detected for the first time. The experiment was not completely successful due to the fact that the airplane was in a cloud at the time the photographs were taken. This and the low photo resolution make any measurements very difficult.