NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SIM BAY PHOTOGRAPHIC

EQUIPMENT AND MISSION SUMMARY

APOLLO 16 SUPPLEMENT

B22784

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

PREPARED BY
MAPPING SCIENCES BRANCH
NASA MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

SEPTEMBER, 1972

4.0 OPTICAL BAR PANORAMIC CAMERA (PC)

The panoramic camera had an apparent malfunction of the Automatic Exposure Control (AEC) sensor resulting in an over exposure of the film. This problem was noted through the telemetry data and was accounted for in processing of the film with the result that all exposures are usable. As an estimate of the exposure problem, 63% of the frames were from $\frac{1}{2}$ to 2 stops overexposed, 13% were normal and 24% (near terminator) were underexposed. For further details see the Apollo 16 Mission Report.

The CTE time for center of each exposure was read and is tabulated in Table 4.1. As with the MCS the CTE time can be related to UTC (USNO) using Table 6.1.

The Defense Mapping Agency, Topographic Center (DMATC) will transform (rectify) the photography using the orbital support data. They will produce one set of rectified first generation master negatives from the second generation positive provided by Manned Spacecraft Center (MSC). MSC will then produce the required sets or rectified products to provide the users. This product will be referred to as a rectified second generation negative/positive. Definitions of the products are as follows:

1. Second Generation Master Positive - The film provided by MSC made directly from the flight film.

2. Rectified First Generation Master Negative - The rectified

negative made by DMATC in the transforming printer from the second generation positive.

3. Rectified Second Generation Negative/Positive - Film produced by MSC from the rectified first generation master negative.

TR-71-3404-4

CAMERA CALIBRATION REPORT

CAMERA UNIT SN-005

AUGUST 1971

Prepared By

Autometric Operation
Equipment Division
Raytheon Company

IDA Building
400 Army-Navy Dr.
Arlington, Virginia 22202

Prepared For

Fairchild Space and Defense Systems
300 Robbins Lane
Syosset, L.I., New York 11791

CAMERA CALIBRATION RESULTS

Lunar Mapping Camera SN-005 Stellar Calibration

Terrain Lens (205) Constants of Internal Geometry

EFL = 75.908 mm. S.D. = 0.003
CFL = 75.936 mm. S.D. = 0.003

Principal Point With Respect to Indicated Principal Point
(Indicated principal point: x_{ipp} = 0.0 mm., y_{ipp} = 0.0 mm.)

x_p = -0.010 mm. S.D. = 0.001 mm.

y_p = -0.004 mm. S.D. = 0.001 mm.

Radial Distortion Parameters (Associated with EFL)

$K_1 = -0.13678194 \times 10^{-5}$ S.D. = $0.47248211 \times 10^{-7}$

$K_2 = 0.53824020 \times 10^{-9}$ S.D. = $0.18745325 \times 10^{-10}$

$K_3 = -0.52793282 \times 10^{-13}$ S.D. = $0.22270336 \times 10^{-14}$

Lens Decentration Distortion Parameters

$J_1 = 0.12275363 \times 10^{-5}$ S.D. = $0.58458719 \times 10^{-6}$

$J_2 = -0.24596243 \times 10^{-9}$ S.D. = $0.12912871 \times 10^{-9}$

ϕ_0 = 1.8859721 radians S.D. = 0.47117268 radians

Stellar Lens (103) Constants of Internal Geometry

EFL = 75.605 mm. S.D. = 0.018 mm.

*CFL = 75.605 mm.

Principal Point With Respect to Indicated Principal Point
(Indicated principal point x_{ipp} = 0.0 mm. , y_{ipp} = 0.0 mm.) ,

x_p = 0.025 mm. S.D. = 0.029 mm.

y_p = -0.016 mm. S.D. = 0.032 mm.

Radial Distortion Parameters (Associated with EFL)

$K_1 = -0.29521587 \times 10^{-5}$ S.D. = $0.66902029 \times 10^{-5}$

$K_2 = 0.62955833 \times 10^{-8}$ S.D. = $0.55472982 \times 10^{-7}$

$K_3 = 0.35059172 \times 10^{-10}$ S.D. = $0.13785884 \times 10^{-9}$

Lens Decentration Distortion Parameters

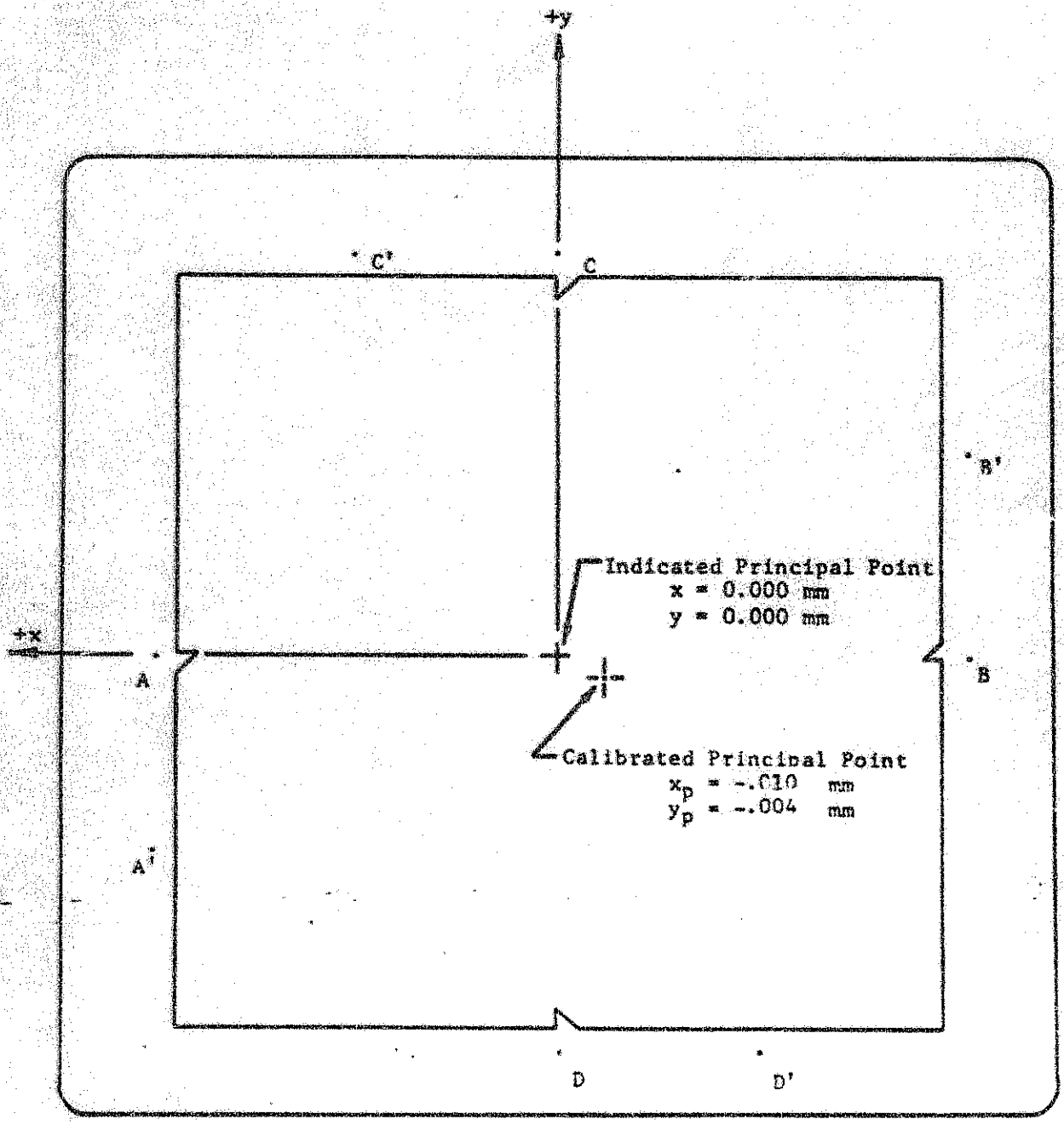
$J_1 = 0.33334002 \times 10^{-4}$ S.D. = $0.16154460 \times 10^{-4}$

$J_2 = -0.13166663 \times 10^{-6}$ S.D. = $0.71341518 \times 10^{-7}$

ϕ_0 = 2.3499853 radians S.D. = 0.49675031

*NOTE: CFL can be assumed to be the same as EFL. Distortion on format from 0 - 15 mm. < 2μ and from 15 - 18 mm. < 10μ.
Note added by Mapping Sciences Branch.

PRINCIPAL POINT LOCATION FOR TERRAIN CAMERA, LENS NO. 205



(Emulsion Up)

negative

Direction of Flight

Figure 1.

Results of Lock-Angle Calibration

Relative Orientation Matrix Defining a Transformation from the Terrain Camera to the Stellar Camera

0.999997475	-0.002218617	0.000356483
0.000123793	-0.104011499	-0.994576087
0.002243663	0.994573620	-0.104010962

Relative Orientation Angles (Degrees, Minutes, Seconds)

OMEGA = -95 58 12.727
PHI = 0 7 42.789
KAPPA = -0 0 25.534

Covariance Matrix

0.19674×10^{-10}	-0.62779×10^{-12}	0.65630×10^{-12}
-0.62779×10^{-12}	0.36913×10^{-10}	-0.15550×10^{-11}
0.65630×10^{-12}	-0.15550×10^{-11}	0.89801×10^{-9}

Standard Deviation of Orientation Angles (Arc-seconds)

S.D. OMEGA = 0.92
S.D. PHI = 1.25
S.D. KAPPA = 6.18

Statistical Data From Simultaneous Solution

Weighted Sum of Squares = 0.047418

Degrees of Freedom = 1830

Standard Deviation of Unit Weight = 0.005 mm.

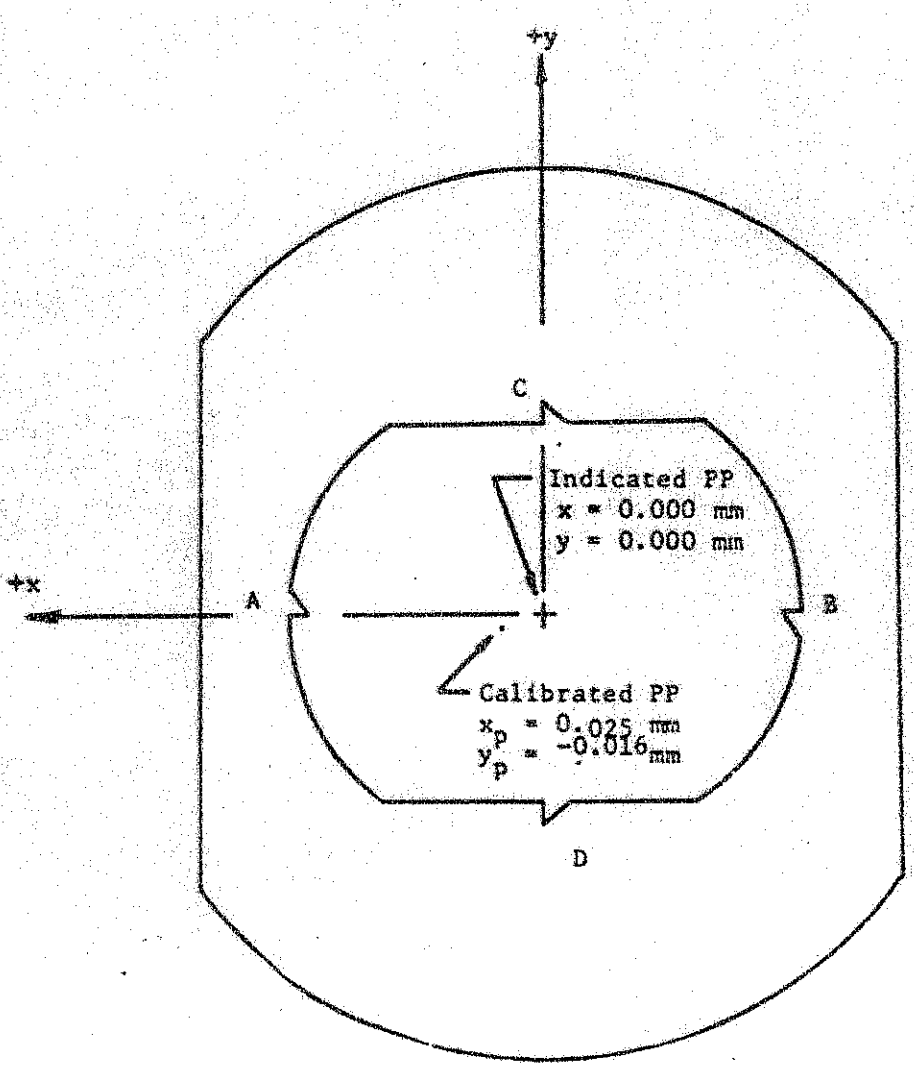
Master Fiducial Coordinate List for Terrain Camera

(Data provided by Fairchild Company)

Note: All coordinates are in millimeters. Refer to Figure 1 for fiducial positions

$A_x = 60.222$	$A'_x = 60.006$
$A_y = 0.000$	$A'_y = -30.769$
$B_x = -60.210$	$B'_x = -60.040$
$B_y = 0.000$	$B'_y = 30.786$
$C_x = 0.002$	$C'_x = 30.891$
$C_y = 60.022$	$C'_y = 60.172$
$D_x = - 0.003$	$D'_x = -30.747$
$D_y = -60.021$	$D'_y = -59.896$

PRINCIPAL POINT LOCATION FOR STELLAR CAMERA, LENS NO. 103



(Emulsion up)

negative

Direction of Flight

Figure 2.

EXPLANATORY NOTES - Calibration of Unit SN-005

1. General

All mensuration by Autometric utilized the original negative film stellar exposures whichwere obtained the night of 22 June 1971 at the White Sands facility.

A copy of the Incoming Acceptance Test by Fairchild Camera and dated April 5, 1971 gave the lens serial number and other basic data for the mapping camera. However, nothing has been received by Autometric for the 35 mm stellar camera. Arbitrarily, a lens serial number of 103 has been assigned to the orientation camera since no other identification is available.

2. Distortion Function

Radial distortion, Δr, is represented by an odd-power polynomial in r, the radial distance from the principal point.

$$\Delta r = K_1 r^3 + K_2 r^5 + K_3 r^7$$

The x and y components of r are

$$\Delta x_r = (x') \, \Delta r/r = (x') \, (K_1 r^2 + K_2 r^4 + K_3 r^6)$$

$$\Delta y_r = (y') \, \Delta r/r = (y') \, (K_1 r^2 + K_2 r^4 + K_3 r^6),$$

where x' and y' are the measured image coordinates relative to the principal point origin.

Tangential distortion, Δt, is represented by an even-power polynomial in r.

$$\Delta t = J_1 r^2 + J_2 r^4$$

The x and y components of Δt are

$$\Delta x_t = -\Delta t \sin \phi_o = -(J_1 r^2 + J_2 r^4) \sin \phi_o$$

$$\Delta y_t = \Delta t \cos \phi_o = (J_1 r^2 + J_2 r^4) \cos \phi_o$$

where ϕ_o is the angle the axis of maximum tangential distortion makes with the x-axis.

The x' and y' image coordinates can be corrected for radial and tangential lens distortion by the functions

$$x = (1 + K_1 r^2 + K_2 r^4 + K_3 r^6)\, x' - (J_1 r^2 + J_2 r^4) \sin \phi_o$$

$$y = (1 + K_1 r^2 + K_2 r^4 + K_3 r^6)\, y' + (J_1 r^2 + J_2 r^4) \cos \phi_o$$

where x and y are corrected image coordinates and K_1, K_2, K_3, J_1, J_2, ϕ_o are the distortion parameters given by the calibration.

Radial distortion curves for terrain camera lens 205 are presented in Figure 3. The figure gives the EFL radian distortion curve from the stellar calibration and compares the corresponding CFL curve with the Fairchild CFL curve as determined by laboratory methods. Both CFL curves represent radial distortion characteristics under vacuum conditions, balanced for equal positive and negative distortion values.

Studies made by Fairchild indicate that a negligible change in distortion occurs when the camera is operated under vacuum conditions rather than the atmospheric conditions under which the stellar calibration was performed. As a result of the supporting Fairchild data given below, no adjustment is made for the change in operating medium from 5000 feet altitude (610 mm. Hg.) to vacuum (0.0001 mm. Hg.).

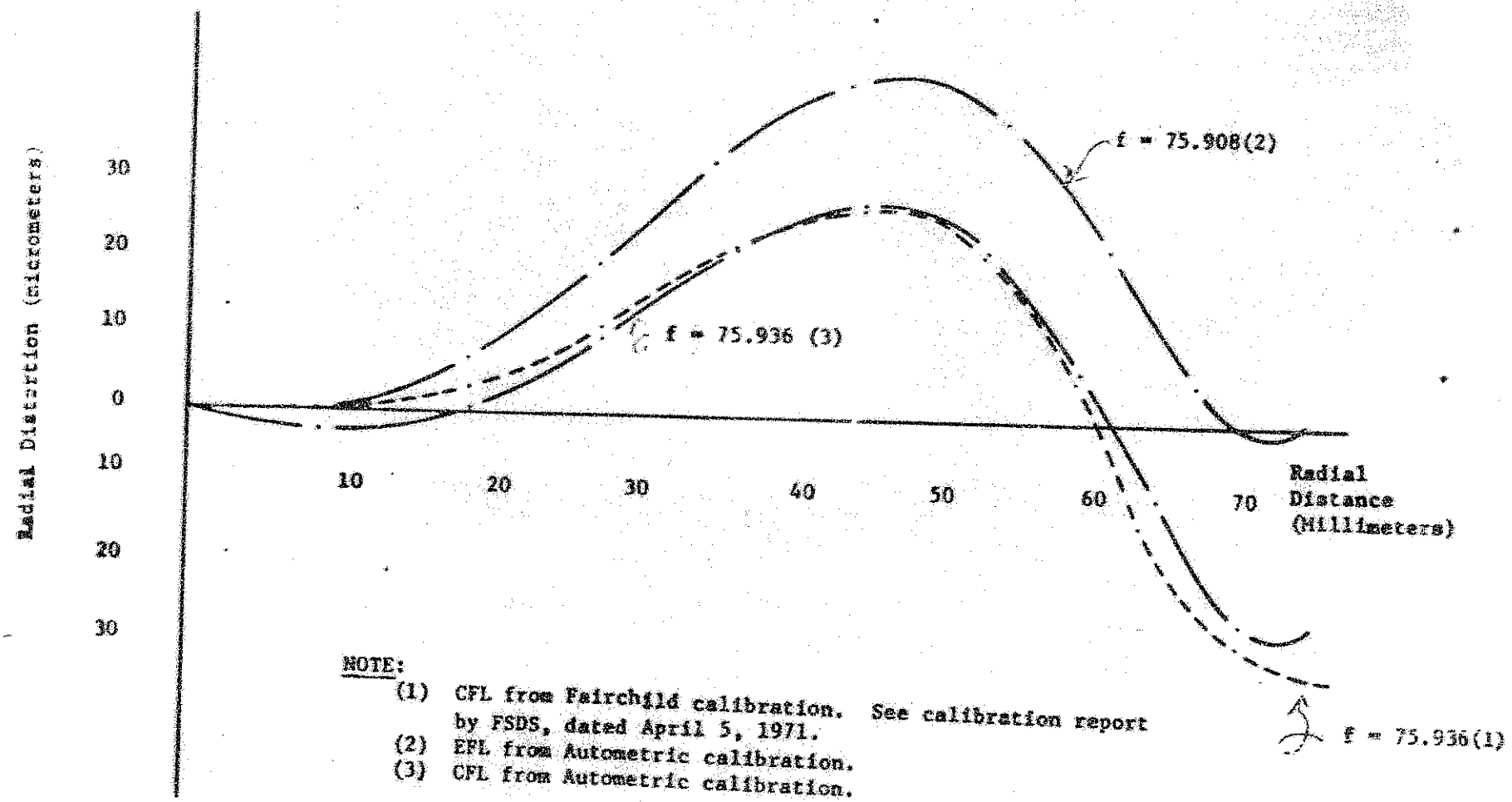
Field Angle (Degrees)	Distortion Change (Micrometers)
11.25	-0.05
22.50	-0.14
33.75	-0.25
45.00	-1.10

COMPARISON OF RADIAL DISTORTION CURVES

for

LUNAR MAPPING CAMERA SN-005

TERRAIN LENS SN-005



NOTE:

(1) CFL from Fairchild calibration. See calibration report by FSDS, dated April 5, 1971.
(2) EFL from Autometric calibration.
(3) CFL from Autometric calibration.

3. Relative Orientation System

The relative orientation matrix

$$M = \begin{bmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{bmatrix}$$

gives the angular orientation of the stellar camera coordinate system with respect to the terrain camera coordinate system. The orientation matrix can be factored into three orthogonal matrices each representing a simple rotation of the stellar camera coordinate system about a particular stellar axis. The sequence of the three rotations must be specified, because different angular orientations result from different sequences. The orientation of x_s, y_s, z_s with respect to X_T, Y_T, Z_T can be developed as follows.

Consider a stellar camera coordinate system x, y, z initially coincident with the terrain camera coordinate system X_T, Y_T, Z_T (refer to Figure 4). The three rotations ω , ϕ, κ are applied to the stellar camera coordinate axes in the given sequence to place the system into its final position, x_s, y_s, z_s.

ω (roll) - Rotation about the x axis. Positive ω takes +y axis toward the +z axis, resulting in x', y', z' in Figure 4.

ϕ (pitch) - Rotation about the y'axis. Positive ϕ takes the +z axis toward the +x' axis, resulting in x", y", z" in Figure 4.

κ (yaw) - Rotation about the z" axis. Positive κ takes the +x" axis toward the y" axis, resulting in the final position of the stellar camera coordinate system x_s, y_s, z_s in Figure 4.

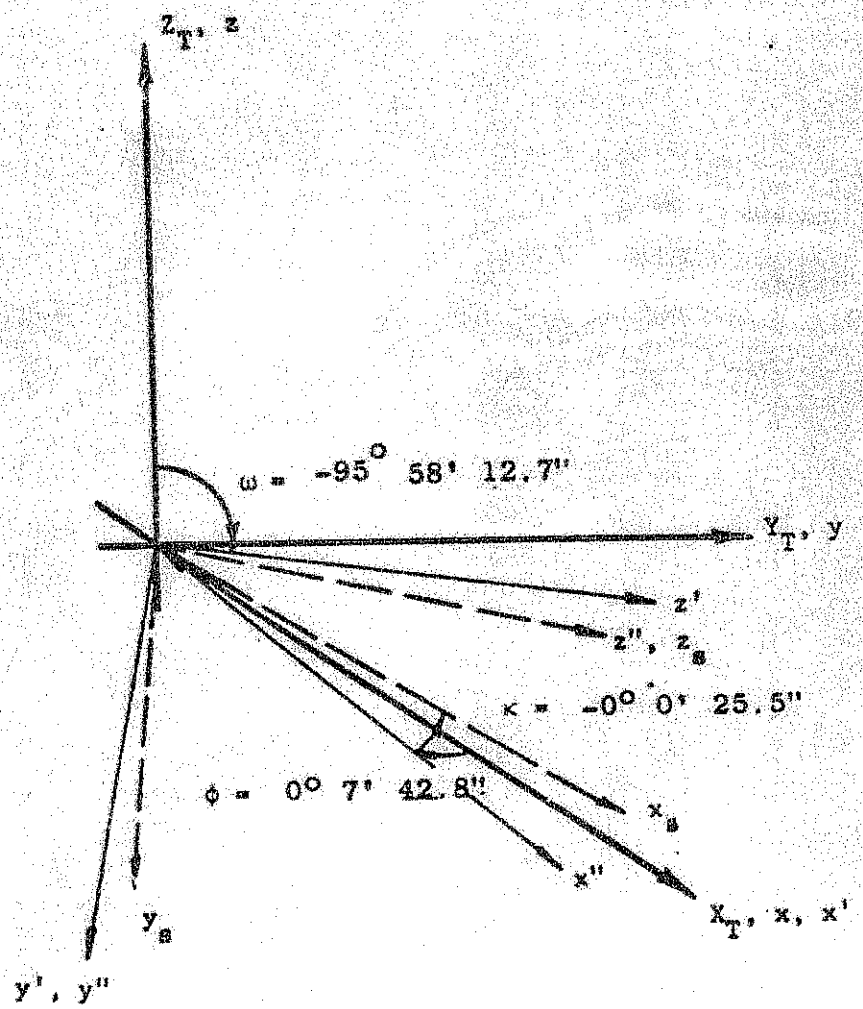


Figure 4. Orientation of Stellar Camera Coordinate System With Respect to Terrain Camera Coordinate System.

This Final Report was prepared for Fairchild Space and Defense Systems by Raytheon Company, Autometric Operation, under Contract N-0234.

Eldon D. Sewell

CALIBRATION CERTIFICATE

Submitted by

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
El Segundo, California

DATE November 11, 1970

LENS TYPE IKOTAR "B"

SERIAL NUMBER 105

NOMINAL FOCAL LENGTH 3 INCH

MAXIMUM APERTURE F/2.8

FORMAT 1.25" DIAMETER

150

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
El Segundo, California

LENS TYPE IKOTAR B
SERIAL NUMBER 105

DATE November 11, 1970

RESOLVING POWER

FILM 3400
PROCESSING MX641 1 Min @ 69°
TARGET CONTRAST 100:1

DIAG. #1 AWAR 81.1
DIAG. #2 AWAR 81.5

DIAG. #1	0°	2½°	5°	7½°	10°							
RADIAL	80	85	85	79	93							
TANGENTIAL	80	85	84	75	71							

DIAG. #2	0°	2½°	5°	7½°	10°							
RADIAL	80	85	85	89	93							
TANGENTIAL	80	85	79	75	66							

RELATIVE ILLUMINATION

10°	7½°	5°	2½°	Axis	2½°	5°	7½°	10°
86%	93%	97%	100%	100%	100%	96%	92%	86%

TRANSMISSION

91.6%

RELATIVE APERTURE

F/2.76

CALIBRATION CERTIFICATE

Submitted by

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A Division of Fairchild Camera and Instrument Corporation
El Segundo, California

DATE February 15, 1971

LENS TYPE IKOGON "B"

SERIAL NUMBER 205

NOMINAL FOCAL LENGTH 3 INCH

MAXIMUM APERTURE F/4.5

FORMAT 4.5" x 4.5" DIAMETER

FAIRCHILD SPACE AND DEFENSE SYSTEMS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
El Segundo, California

LENS TYPE IKOGON B
SERIAL NUMBER 205

DATE February 15, 1971

RESOLVING POWER

FILM 3404
PROCESSING 1 Min @ 69° Mx641
TARGET CONTRAST 2:1

AWAR 105.4

	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°
RADIAL	135	146	135	126	130	129	120	117	116	65		
TANGENTIAL	135	150	131	109	89	83	83	89	89	47		

RELATIVE ILLUMINATION

Axis	5°	10°	15°	20°	25°	30°	35°	40°	45°
100%	100%	100%	100%	99%	96%	87%	81%	66%	44%

$\Sigma = 85.8$

Lens Transmittance = 44.5%

$$\text{Lent T\#} = \frac{4.5}{\sqrt{.445}} = \frac{4.5}{.667} = 6.747$$

$$\text{AWAT} = \frac{6.747}{\sqrt{.858}} = \frac{6.747}{.926} = 7.29$$

AWAT = 7.29

RELATIVE APERTURE

$$\frac{\text{EFL}}{\text{EFFECTIVE APERTURE}} = \frac{2.99302''}{.700''} = 4.28$$

8.2 LASER ALTIMETER

FAIRCHILD SPACE & DEFENSE SYSTEMS
A Division of Fairchild Camera & Instrument Corporation
300 Robbins Lane, Syosset, New York
(Data Revised 5-22-72)

1231-DM-3
DATA SHEET NO. 7 Revision B P/N 1231AA1

NASA MAPPER CAMERA NO. 71-005 LENS NO. 205

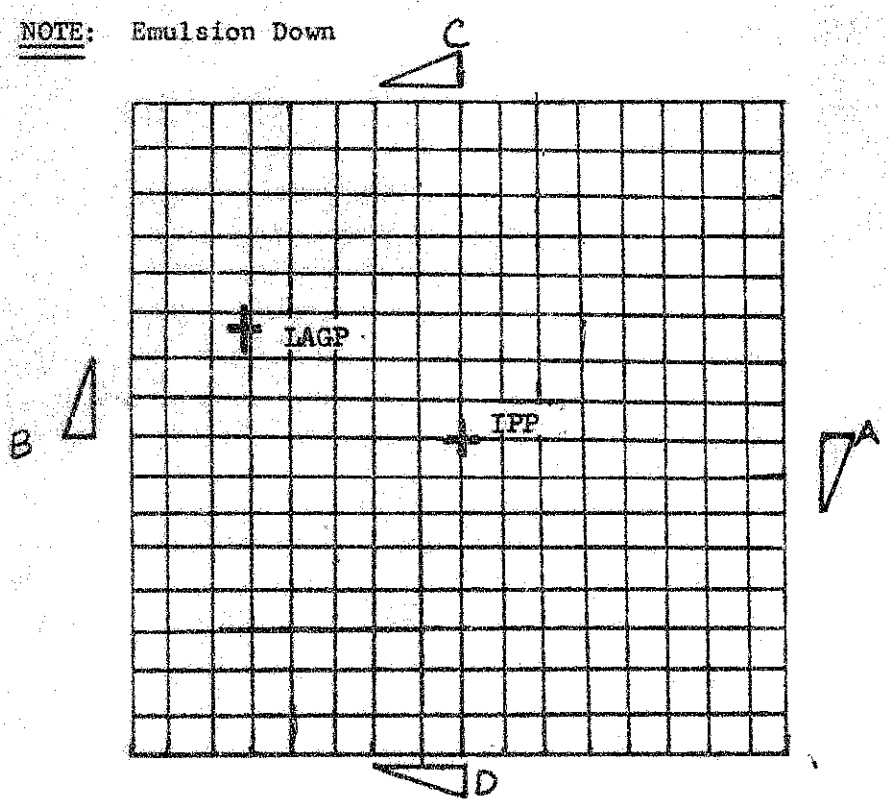
LASER ALTIMETER NO. 0005

LASER ALTIMETER GROUND MEASUREMENT POINT

The positions of all points are referenced to the Indicated Principal Point (IPP) as origin with the straight line drawn between the A and B fiducials being coincident with the X- axis. The CD line goes through the origin but is not generally coincident with the Y- axis.

Scale 1 Box = 0.005 mm

NOTE: Emulsion Down



⊕ X_{LAGP} = -0.027 mm

⊖ X_{LAGP} = -0.025 mm

AVG X_{LAGP} = -0.026 mm

⊕ Y_{LAGP} = +0.014 mm

⊖ Y_{LAGP} = +0.012 mm

AVG Y_{LAGP} = +0.013 mm

X_{LAGP} - Location on X- coordinate of Laser Altimeter Ground Measurement Point

Y_{LAGP} - Location on Y- coordinate of Laser Altimeter Ground Measurement Point

⊕ - "+g" mode

⊖ - "-g" mode

8.3 OPTICAL BAR PANORAMIC CAMERA

APOLLO 16

CAMERA CALIBRATION DATA

24-inch Panoramic Camera

Camera S/N 005
Lens S/N N-45

Test Procedure No. TP121 No. of Pages 8

TEST PROCEDURE

FOR

PROJECT 9446
VEILING GLARE MEASUREMENTS
PANORAMIC CAMERA
FOR SCIENTIFIC INSTRUMENT
MODULE

EXPERIMENT S-163

Itek

ITEK CORPORATION

Lexington 73, Massachusetts

Date 9-15-70

Lens SN N-45

	PREPARED	PROJECT APPROVAL	QUALITY ASSURANCE APPROVAL
By	R. SHERLOCK	C. BACKE	R. WESPISER
Signed	R. Sherlock	C. Backe	R. Wespiser
Date	9/17/70	9/21/70	9/18/70

CUST./GOV'T. REP. _____ Date _____
Reviewed

6.3.1.3 Itek Test Data Sheet

VEILING GLARE MEASUREMENT

Panoramic Camera Lens, P/N 105150, Serial No. N-45

	Step Wedge							Black Dot	% Veiling Glare
Step No.	1	2	3	4	5	6	7	X	
	* Calibrated Value								
	1.22	1.07	.92	.78	.65	.50	.36	X	
Field Position	* Measured Test Values								
-6°	.25	.31	.52	.89	1.28	1.51	1.82	.79	15.1
-4°	.21	.28	.42	.65	.91	1.24	1.63	.57	14.8
-2°	.24	.34	.52	.78	1.14	1.43	1.76	.64	14.0
0°	.16	.20	.26	.39	.56	.88	1.32	.31	13.8
+2°	.24	.33	.49	.80	1.06	1.38	1.68	.76	15.8
+4°	.23	.33	.49	.79	1.17	1.40	1.71	.84	17.4
+6°	.23	.33	.49	.78	1.10	1.39	1.77	.90	18.6

Legend: * Density values are logarithmic as read on the Macbeth Densitometer.

% Veiling Glare is computed from the black spot density plot (attached) for each field position.

Data Recorded By: [signature] Date: 10/19/70

QA Monitor: [signature] 10/19/70

Project Approval: [signature] 10/20/70

Test Procedure No. TP121

Test Procedure No. TP123 No. of Pages 9

TEST PROCEDURE

FOR

PROJECT 9446
SPECTRAL TRANSMITTANCE
MEASUREMENTS
PANORAMIC CAMERA
FOR SCIENTIFIC INSTRUMENT
MODULE

EXPERIMENT S-163

Itek

ITEK CORPORATION

Lexington 73, Massachusetts

Date 9-15-70

Lens S/N N-45

	PREPARED	PROJECT APPROVAL	QUALITY ASSURANCE APPROVAL
By	R. SHERLOCK	C. BACKE	R. WESPISER
Signed	R. Sherlock	C. Backe	R. J. Wespiser
Date	9/17/70	9/21/70	9/17/70

CUST./GOV'T. REP. _____ Date _____
Reviewed

6.3.1.3 Item Test Data Sheet

SPECTRAL TRANSMITTANCE MEASUREMENT

Panoramic Camera Lens, P/N 105150, Serial No. 45

Wavelength nm	Radiometer Readings A	A_1	B	B_1	% Transmittance
400	7.0	2.5	1.2	.13	30.3
420	22.4	8.2	3.6	.49	37.2
440	42.0	16.0	6.5	1.2	46.5
480	92.0	36.6	14.9	3.7	62.4
520	135.0	54.8	22.5	6.4	70.1
560	148.0	60.0	25.0	7.4	73.0
601	135.0	53.2	23.0	6.5	70.9
640	115.0	41.9	20.0	5.0	66.6
680	98.0	34.7	16.5	3.7	63.3
720	73.5	33.5	12.5	2.3	40.4

Legend:

A = Brightness of the calibrated standars Lambertian source using the radiometer telescope.

A_1 = Brightness of the collimator target as seen from the lens test position using the radiometer telescope.

B = Brightness of the calibrated standard Lambertian source using the radiometer microscope.

B_1 = Brightness of the collimator target aerial image at the image plane (lens in place) using the radiometer microscope.

% Transmittance = $\left[(B_1/B) \div (A_1/A)\right]$ X 100.

Data Recorded By: [signature] Date: 6/12-70

QA Monitor: [signature] 10/17/70

Project Approval: [signature] 10/20/70

Test Procedure No. TP123

160

6.3.1.3 Itek Test Data Sheet

T STOP CALCULATION

Panoramic Camera Lens, P/N 105150, Serial No. 45

Wavelength nm	% Transmittance	T STOP
400	30.3	6.4
420	37.2	5.7
440	48.5	5.0
480	62.4	4.4
520	70.1	4.2
560	73.0	4.1
601	70.9	4.2
640	68.6	4.2
680	63.3	4.4
720	40.4	5.5

Legend:

$$T\ STOP = \frac{f/number}{\sqrt{t}}$$ where f/number is 3.5 and t is transmittance.

Data Recorded By: [signature] Date: 10/12-70

QA Monitor: [signature] 10/19/70

Project Approval: [signature] 10/20/70

Test Procedure No. TP123 Page 9

Test Procedure No. TP125 No. of Pages 8

TEST PROCEDURE

FOR

PROJECT 9446
RELATIVE ILLUMINATION
MEASUREMENTS
PANORAMIC CAMERA
FOR SCIENTIFIC INSTRUMENT
MODULE

EXPERIMENT S-163

Itek

ITEK CORPORATION

Lexington 73, Massachusetts

Date 9-15-70

Low S/N 45

	PREPARED	PROJECT APPROVAL	QUALITY ASSURANCE APPROVAL
By	R. SHERLOCK	C. BACKE	R. WESPISER
Signed	R Sherlock	C. Backe	R Wespiser QA 6
Date	9/17/70	9/21/70	9/18/70

CUST./GOV'T. REP. _____ Date _____
Reviewed

Q199-1 11/65

5.3.1.3 Itek Test Data Sheet

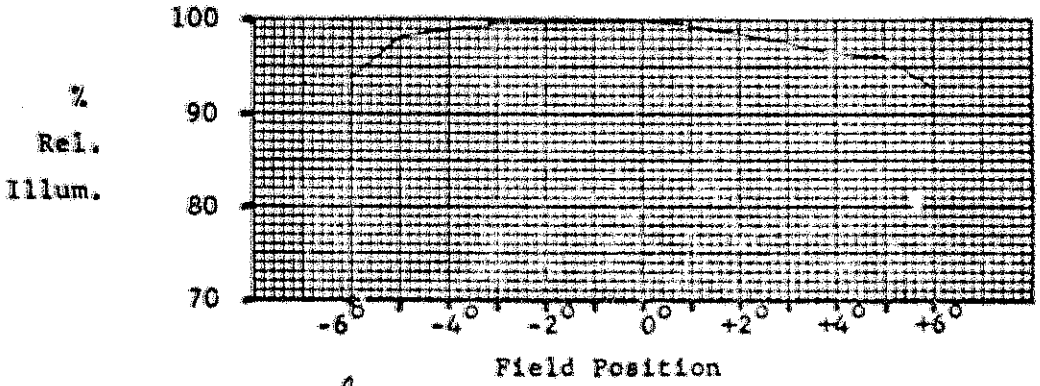
RELATIVE ILLUMINATION MEASUREMENT

Panoramic Camera Lens, P/N 105150, Serial No. N-45

	Field Position	Radiometer Readings vdc	Relative Illumination %
B	-6°	85.0	93.9
	-5°	89.0	98.3
	-4°	89.5	98.9
	-3°	90.0	99.4
	-2°	90.1	99.6
	-1°	90.2	99.7
A	0°	90.5	100.0
B	+1°	90.0	99.4
	+2°	89.0	98.3
	+3°	88.5	97.8
	+4°	87.0	96.1
	+5°	86.8	95.9
	+6°	84.0	92.8

Meter Scale for Radiometer Readings: 100

% Relative Illumination = $\frac{B}{A}$ X 100



Data Recorded By: [signature] Date: 10/12-20

QA Monitor: [signature] 10/19/70

Project Approval: [signature] 10/20/70

Test Procedure No. TP125 Page 8

Test Procedure No. TP127 No. of Pages 5

TEST PROCEDURE

FOR

PROJECT 9446

C.F.L./MEASUREMENTS
PANORAMIC CAMERA

FOR SCIENTIFIC INSTRUMENT
MODULE

EXPERIMENT S-163

Itek

ITEK CORPORATION

Lexington 73, Massachusetts

Date 9-15-70

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By	R. SHERLOCK	C. BACKE	R. WESPISER
Signed	R. Sherlock	C. Backe	R. Wespiser
Date	9/17/70	9/21/70	9/21/70

CUST./GOV'T. REP. _____ Date _____
Reviewed

Q199-1 11/65

16

104

Lens N 45

C.F.L. Calibration Summary

Filter	Field Position (degrees)	Mean C.F.L. (inches)	STD Deviation of of mean (C.F.L.)
23A	+6	23.9997	.0001
	+4	23.9985	.0002
	+2	23.9957	.0007
	0 *	23.9964	.0009
	-2	23.9957	.0002
	-4	23.9952	.0005
	-6	23.9937	.0003
12	+6	24.0002	.0002
	+4	24.0013	.0002
	+2	23.9988	.0002
	0 *	23.9967	.0015
	-2	23.9934	.0006
	-4	23.9939	.0004
	-6	23.9928	.0004
8	+6	24.0005	.0002
	+4	23.9990	.0005
	+2	23.9975	.0018
	0 *	23.9983	.0006
	-2	23.9981	.0010
	-4	23.9966	.0007
	-6	23.9979	.0006
2A	+6	23.9992	.0004
	+4	23.9986	.0005
	+2	23.9965	.0007
	0 *	23.9965	.0008
	-2	23.9961	.0002
	-4	23.9952	.0004
	-6	23.9936	.0009
no filter	+6	24.0005	.0006
	+4	23.9971	.0009
	+2	23.9919	.0009
	0 *	23.9953	.0014
	-2	23.9914	.0003
	-4	23.9965	.0003
	-6	23.9942	.0002

* Average of all field positions

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Figure I-6 - Thru-Focus Curve

RESOLUTION (l/mm)

140
130
120
110
100
90

-.0020 -.0015 -.0010 -.0005 0 +.0005 +.0010 +.0015 +.0020

FILM FRAME FOCUS POSITION