Calibration Fotos

Sensor ID #076

USGS Report No. OSL/2240

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 22092

REPORT OF CALIBRATION
of Aerial Mapping Camera

October 1, 1996

Camera type:	Wild RC10	Camera serial no.:	1759
Lens type:	Wild Aviotar II	Lens serial no.:	At II 4109
Nominal focal length:	305 mm	Maximum aperture:	f/4
		Test aperture:	f/6.6*

Submitted by: NASA, Ames Research Center
Moffett Field, California

Reference: ATAC purchase order No. 6569, dated September 10, 1996.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 304.886 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°
Symmetric radial (um)	-3	1	-1
Decentering (um)	0	0	1

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
$K_0 = 0.1158 \times 10^{-3}$	$P_1 = -0.4609 \times 10^{-7}$	$x_p = 0.015$ mm
$K_1 = -0.2685 \times 10^{-7}$	$P_2 = -0.7252 \times 10^{-8}$	$y_p = 0.010$ mm
$K_2 = 0.1244 \times 10^{-11}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point [point of symmetry] (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

* Limitation imposed by collimator aperture

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 27

Field angle:	0°	7.5°	15°	22.7°
Radial Lines	96	40	14	12
Tangential lines	96	68	33	20

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 2.5 to 135 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the Wild 525 No. 4039 filter accompanying this camera are within 10 seconds of being parallel. This filter was used for the calibration.

V. Shutter Calibration

Indicated exposure time	Effective exposure time	Efficiency
1/200	4.50 ms = 1/220 s	75%
1/400	2.25 ms = 1/445 s	75%
1/600	1.50 ms = 1/665 s	75%
1/800	1.12 ms = 1/890 s	75%
1/1000	0.90 ms = 1/1110 s	75%

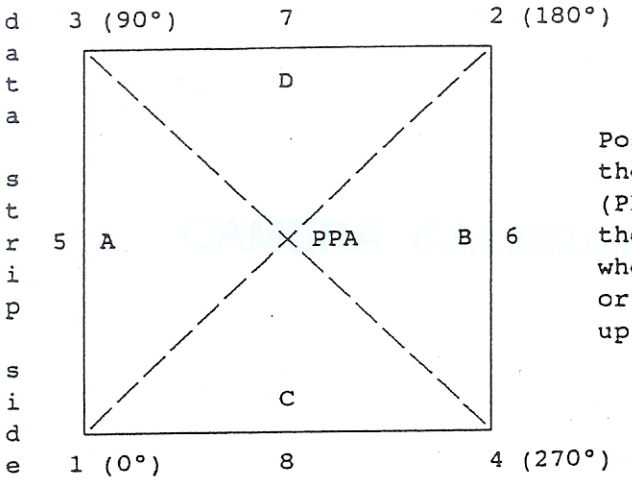
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC10 drive unit No. 1759-154 does not depart from a true plane by more than 13 um (0.0005 in).

This camera is equipped with a platen identification marker that will register "154" in the data strip area for each exposure.

VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	-0.014 mm	0.017 mm
Indicated principal point, midside fiducials	-0.012	0.013
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.015	0.010

Fiducial Marks		
1	-106.028 mm	-105.985 mm
2	105.995	106.013
3	-106.003	106.010
4	105.984	-105.985
5	-110.015	0.017
6	110.014	0.010
7	0.000	110.008
8	-0.023	-109.985

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.829 mm 3-4: 299.801 mm

Lines joining these markers intersect at an angle of 90° 00' 08"

Midside fiducials

5-6: 220.030 mm 7-8: 219.992 mm

Lines joining these markers intersect at an angle of 89° 59' 44"

Corner fiducials (perimeter)

1-3: 211.995 mm 2-3: 211.998 mm

1-4: 212.012 mm 2-4: 211.998 mm

The method of measuring these distances is considered accurate within 0.003 mm

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2060, dated December 9, 1994.

Bradish F. Johnson

Bradish F. Johnson
Chief, Optical Science Laboratory
National Mapping Division

CAMERA CALIBRATION CERTIFICATE

CAMERA TYPE : RC10

LENS TYPE : 30 AT II

LENS NO. : 4109

Lens focal length: 304.89 mm

ARC Sensor No.: 076

Calibration made by LEICA INSTRUMENTS INC.

Calibration date: 09.01.2003

LEICA AG, HEERBRUGG

RC10 30 AT II No. 4109 09.01.2003

Aperture: 4.0
Filter on goniometer: 450 NM
Filter on camera: --
Principal distance for focussing distance 850 m : 304.89 mm

Radial distortion (micrometers) referred to principal point of symmetry (PPS)
(Positive values denote image displacement away from center)

Radius mm	Half - Sides 1	3	2	4	Mean
10	1.1	-2.4	-1.8	-1.6	-1.1
20	0.1	-1.4	-1.0	-2.5	-1.2
30	-0.6	-2.4	-0.8	-3.3	-1.8
40	0.7	-2.0	-0.8	-1.5	-0.9
50	3.0	-2.4	-0.2	-0.8	-0.1
60	2.2	-1.7	1.7	0.4	0.6
70	4.9	3.3	4.3	2.9	3.8
80	5.2	3.5	3.0	4.0	3.9
90	6.3	3.3	4.7	4.0	4.5
100	5.9	3.7	5.2	3.7	4.6
110	5.5	1.3	3.1	2.3	3.0
120	-0.6	0.2	-1.2	0.2	-0.3
130	-3.0	-3.2	-3.8	-2.5	-3.1
140	-4.5	-1.5	-6.3	-4.3	-4.1
148	-6.3	-1.6	-4.4	-6.3	-4.6

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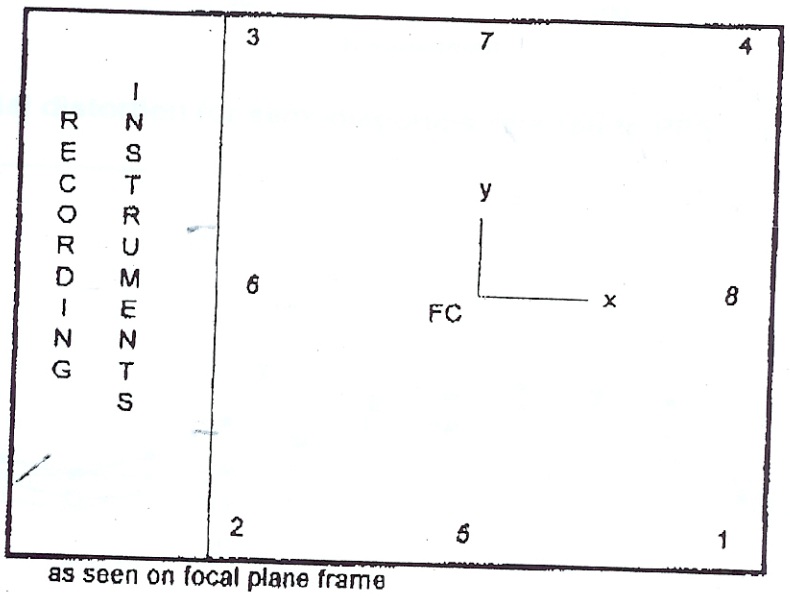
Principal point of autocollimation (PPA) and principal point of symmetry (PPS)
referred to central cross (FC), see diagram

	x (mm)	y (mm)
PPA	0.001	0.002
PPS	0.002	-0.004

Fiducial marks, referred to central cross (FC)

	x (mm)	y (mm)		x (mm)	y (mm)
1	105.999	-105.999	5		
2	-106.001	-105.999	6		
3	-106.002	106.002	7		
4	105.998	105.995	8		

Measured on: 14.05.1974

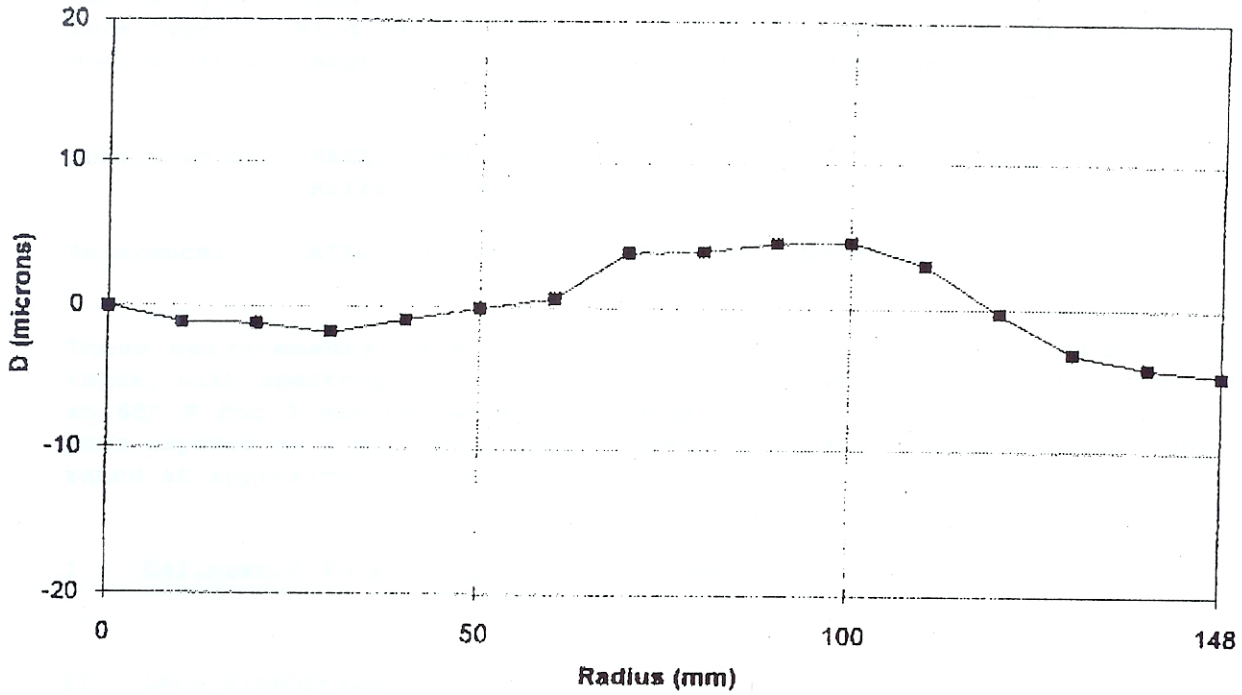


as seen on focal plane frame

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Aperture: 4.0
Filter on goniometer: 450 NM
Filter on camera: --
Principal distance for focussing distance 850 m : 304.89 mm

Mean radial distortion



Radial distortion for semi-diagonals referred to PPS

