USGS Report No. OSL/2486

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

September 18, 1997

Camera type: Wild RC10
Lens type: Wild Aviotar II
Nominal focal length: 305 mm

Camera serial no.: 1758
Lens serial no.: At II 4114
Maximum aperture: f/4
Test aperture: f/6.6*

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

Reference: ATAC purchase order No. 7493,
dated August 28, 1998.

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: 304.677 mm

This measurement is considered accurate within 0.005 mm

II. Radial Distortion

Field angle	$\bar{D}_c$	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	-3	-3	-2	-2	-4
15	0	0	1	-1	1
22.7	1	0	2	0	1

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, a full least-squares solution is used to determine the calibrated focal length. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length referred to the calibrated principal point (point of symmetry) are listed for azimuths 0°, 90°, 180° and 270°. The radial distortion is given in micrometers and indicates the radial displacement away from the center of the field. These measurements are considered accurate within 5 um.

* Limitation imposed by collimator aperture

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 39

Field angle:	0°	7.5°	15°	22.7°
Radial Lines	81	68	20	16
Tangential lines	81	81	48	40

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	4.25 ms = 1/235 s	73%
1/400	2.25 ms = 1/445 s	73%
1/600	1.50 ms = 1/665 s	73%
1/800	1.13 ms = 1/890 s	73%
1/1000	0.90 ms = 1/1110 s	73%

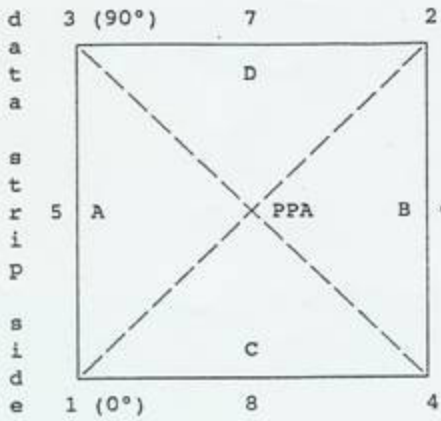
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC10 drive unit No. 1758-139 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 "139" 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	-0.017 mm	0.005 mm
Indicated principal point, midside fiducials	-0.019	0.003
Principal point of autocollimation	0.0	0.0
Calibrated principal point (point of symmetry)	-0.001	-0.008

Fiducial Marks			
1	1 (-) (-)	A	-106.021 mm	-105.998 mm
3	2 (+) (+)	2	105.978	105.999
2	3 (-) (+)	3	-106.012	105.998
4	4 (+) (-)	4	105.987	-105.998
	5 (-) (+)	5	-110.022	0.002
	6 (+) (+)	6	109.989	0.004
	7 (-) (+)	7	-0.016	109.997
	8 (-) (-)	8	-0.023	-109.993

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.810 mm 3-4: 299.810 mm

Lines joining these markers intersect at an angle of 90° 00' 02"

Midside fiducials

5-6: 220.011 mm 7-8: 219.990 mm

Lines joining these markers intersect at an angle of 89° 59' 51"

Corner fiducials (perimeter)

1-3: 211.996 mm 2-3: 211.990 mm

1-4: 212.008 mm 2-4: 211.997 mm

The method of measuring these distances is considered accurate within 0.005 mm

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/1566, dated September 19, 1990.

Frank C Maccue

Frank C. Maccue
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National Mapping Division

CAMERA CALIBRATION CERTIFICATE

CAMERA TYPE :	RC10
LENS TYPE :	30 AT II
LENS NO. :	4114
Lens focal length:	304.66mm
ARC Sensor No.:	034

Calibration date: 18.01.2000 SwissOptic AG, Heerbrugg

RC10 30 AT II No. 4114 18.01.2000

Aperture: 4.0
Filter on goniometer: 450NM
Filter on camera: --
C.F.L. : 304.659 mm

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

Radius	Half - Sides				Mean
mm	1	3	2	4	
10	-0.1	-0.5	1.3	-2.9	-0.5
20	-1.0	-2.3	-2.2	-6.4	-2.9
30	-1.7	-2.0	-0.4	-4.1	-2.0
40	-1.7	-1.7	-0.6	-5.3	-2.3
50	0.3	-0.9	-0.4	-4.8	-1.4
60	0.8	-2.3	0.8	-3.9	-1.1
70	4.3	1.8	2.4	-3.5	1.2
80	3.8	0.7	2.9	-0.1	1.7
90	5.0	2.1	4.4	0.2	2.9
100	4.5	2.0	2.8	-0.1	2.3
110	3.7	2.3	4.6	1.5	3.0
120	0.2	-0.2	-1.0	0.4	-0.1
130	-3.6	-0.1	-3.7	-1.6	-2.2
140	-1.4	-0.4	-3.2	-1.5	-1.6

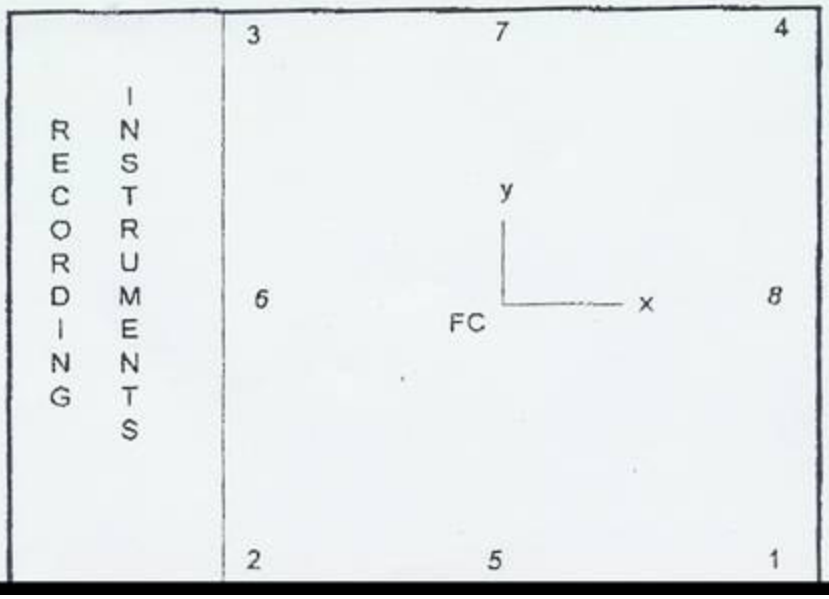
RC10 30 AT II No. 4114 18.01.2000

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

	x (mm)	y (mm)
PPA	0.007	0.013
PPS	0.020	0.000

Distances between fiducial-marks (mm)

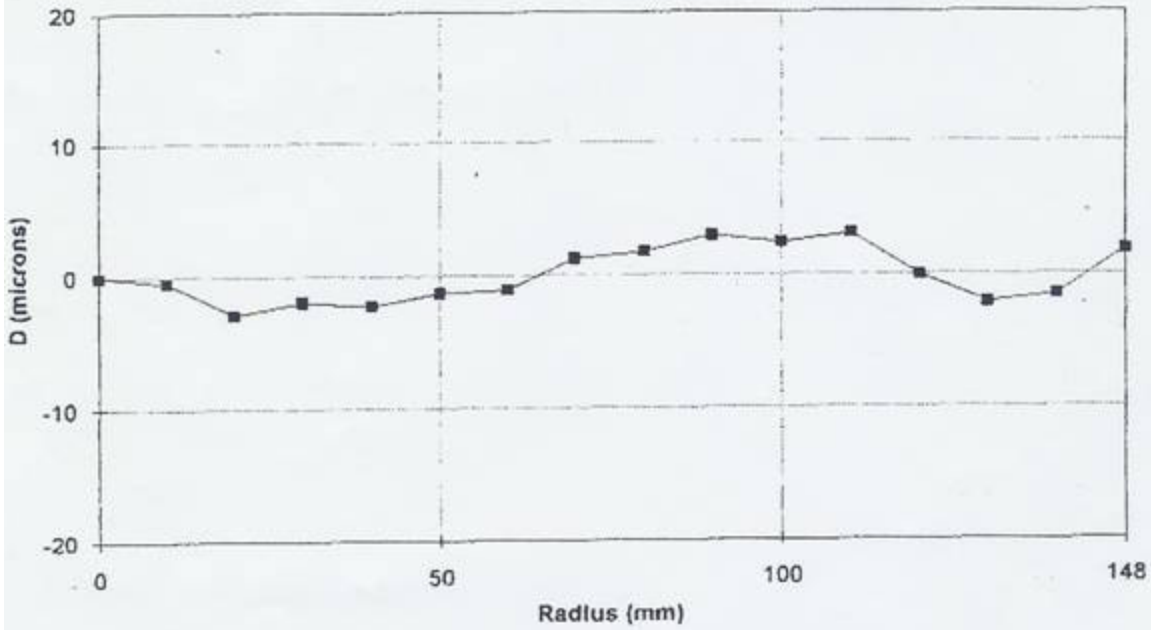
1-2=	212.011	**3-4=**	211.991	**1-3=**	299.83
2-3=	212.007	**4-1=**	212.009	**2-4=**	299.80
1-5=	106.012	**2-6=**	106.005	**3-7=**	105.99
4-8=	106.005	**5-2=**	105.999	**6-3=**	106.00
7-4=	105.992	**8-1=**	106.004		



RC10 30 AT II No. 4114 18.01.2000

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Filter on camera: --
C.F.L. : 304.659 mm

Mean radial distortion



Radial distortion for semi-diagonals referred to PPS

