



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 22092

REPORT OF CALIBRATION of Aerial Mapping Camera

February 28, 1997

Camera type:	Wild RC10	Camera serial no.:	3563
Lens type:	Wild Universal Aviogon /4	Lens serial no.:	13078
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Us Imaging, Inc.
Bartow, Florida

Reference: Letter dated February 17, 1997, from Mr. Michael O'Leary.

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: 153.014 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	0	-1	0	1	1	0
Decentering (um)	0	0	0	1	1	2

Symmetric radial distortion parameters

$K_0 = 0.2537 \times 10^{-4}$
 $K_1 = -0.6283 \times 10^{-8}$
 $K_2 = 0.2904 \times 10^{-12}$
 $K_3 = 0.0000$
 $K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.6797 \times 10^{-7}$
 $P_2 = 0.7775 \times 10^{-7}$
 $P_3 = 0.0000$
 $P_4 = 0.0000$

Calibrated principal point

$x_p = 0.005$ mm
 $y_p = -0.001$ mm

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.

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 86

Field Angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	95	95	113	80	95	95	57
Tangential lines	95	95	95	80	95	80	67

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 5 to 268 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 420 No. 6374 and the 525 No. 6274 filter accompanying the camera are within 10 seconds of being parallel. The 525 filter was used for the calibration.

V. Shutter Calibration

<u>Indicated exposure time</u>	<u>Effective exposure time</u>	<u>Efficiency</u>
1/200	5.50 ms = 1/180 s	79%
1/400	2.88 ms = 1/345 s	79%
1/600	1.92 ms = 1/520 s	79%
1/800	1.44 ms = 1/695 s	79%
1/1000	1.15 ms = 1/870 s	79%

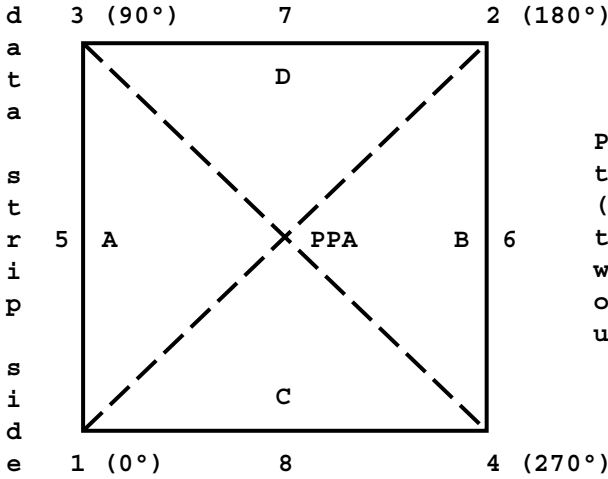
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972 (R1978).

VI. Film Platen

The film platen mounted in Wild RC10 drive unit No. 3653-387 does not depart from a true plane by more than 13 μ m (0.0005 in).

This camera is equipped with a platen identification marker that will register "387" 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.

	<u>x coordinate</u>	<u>y coordinate</u>
Indicated principal point, corner fiducials	0.004 mm	0.011 mm
Indicated principal point, midside fiducials	0.003	0.010
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.005	-0.001

Fiducial Marks

1	-106.000 mm	-105.987 mm
2	106.008	106.009
3	-105.987	106.006
4	105.998	-105.987
5	-109.995	0.013
6	110.019	0.007
7	0.003	110.003
8	0.002	-109.981

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.816 mm 3-4: 299.797 mm

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

Midside fiducials

5-6: 220.009 mm 7-8: 219.984 mm

Lines joining these markers intersect at an angle of 90° 00' 04"

Corner fiducials (perimeter)

1-3: 211.993 mm 2-3: 211.995 mm

1-4: 211.998 mm 2-4: 211.996 mm

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

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 282 mm.

LENS/FILM DISTORTION PARAMETERS

Drive unit No.: 3563-387

Base/Height ratio: 0.6

Platen ID: 387

Maximum angle of field tested: 40°

XI. Calibrated Focal Length: 153.028 mm

XIII. Lens/Film Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	2	3	4	4	2	-4
Decentering (um)	0	0	1	2	3	4

Symmetric radial distortion parameters

$$\begin{aligned}
 K_0 &= -0.7882 \times 10^{-4} \\
 K_1 &= -0.1438 \times 10^{-8} \\
 K_2 &= 0.3167 \times 10^{-12} \\
 K_3 &= 0.0000 \\
 K_4 &= 0.0000
 \end{aligned}$$

Decentering distortion parameters

$$\begin{aligned}
 P_1 &= 0.2839 \times 10^{-7} \\
 P_2 &= -0.2699 \times 10^{-6} \\
 P_3 &= 0.0000 \\
 P_4 &= 0.0000
 \end{aligned}$$

Calibrated principal point

$$\begin{aligned}
 x_p &= 0.005 \text{ mm} \\
 y_p &= -0.001 \text{ mm}
 \end{aligned}$$

The above measurements were computed from contact glass positives made from Kodak 2405 film exposed in the magazine.

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.

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/1000, dated September 11, 1984.

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