



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

October 30, 1998

Camera type:	Wild RC20*	Camera serial no.:	5084
Lens type:	Wild Universal Aviogon A4-F	Lens serial no.:	13108
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Air Photographics, Inc.
Martinsburg, West Virginia

Reference: Air Photographics, Inc., purchase order
No. 5046, dated October 22, 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: 153.235 mm

II. Lens Distortion

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

Symmetric radial
distortion parameters

$$\begin{aligned} K_0 &= 0.3050 \times 10^{-4} \\ K_1 &= -0.8042 \times 10^{-8} \\ K_2 &= 0.3941 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering
distortion parameters

$$\begin{aligned} P_1 &= -0.1084 \times 10^{-6} \\ P_2 &= 0.1670 \times 10^{-6} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated
principal point

$$\begin{aligned} x_p &= 0.002 \text{ mm} \\ y_p &= -0.008 \text{ mm} \end{aligned}$$

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.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 84

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	95	57	95	95	67
Tangential lines	113	113	95	67	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. 6629 and the 525 No. 7389 filters accompanying this 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>
1/125	7.50 ms = 1/135 s	80%
1/250	4.00 ms = 1/250 s	80%
1/500	2.00 ms = 1/500 s	80%
1/1000	1.05 ms = 1/950 s	80%

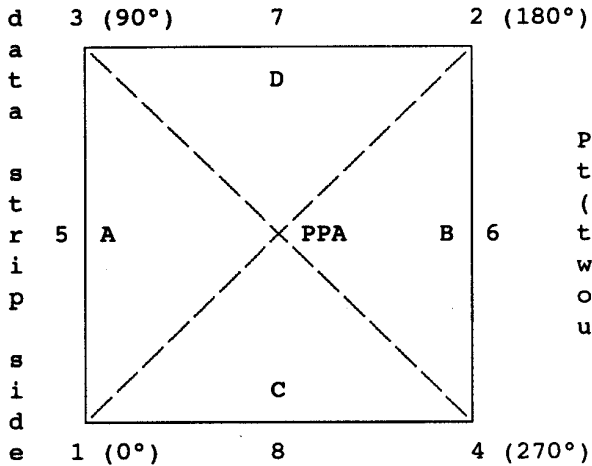
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC20 drive unit No. 5084-4 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 "4" 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	-0.011 mm	0.004 mm
Indicated principal point, midside fiducials	-0.014	0.006
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.002	-0.008

Fiducial Marks

1	-106.012 mm	-105.995 mm
2	105.992	106.005
3	-106.008	106.004
4	105.987	-105.995
5	-110.011	0.005
6	109.989	0.008
7	-0.009	110.012
8	-0.019	-110.007

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.816 mm 3-4: 299.809 mm

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

Midside fiducials

5-6: 220.000 mm 7-8: 220.019 mm

Lines joining these markers intersect at an angle of 89° 59' 47"

Corner fiducials (perimeter)

1-3: 211.999 mm 2-3: 212.000 mm

1-4: 211.999 mm 2-4: 212.000 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.

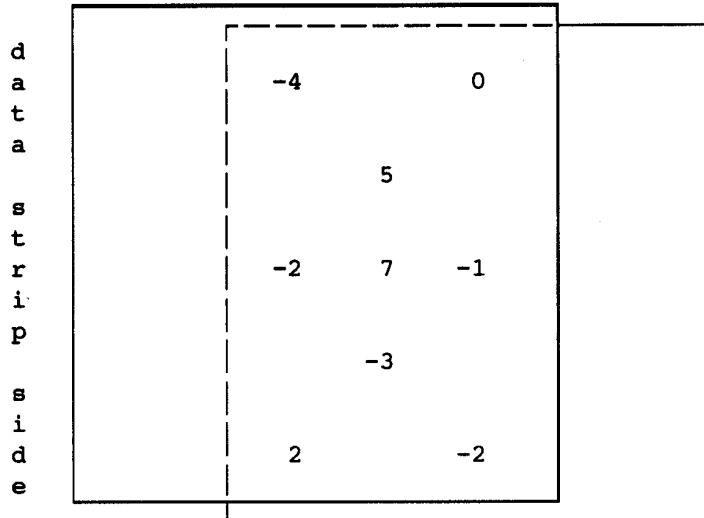
IX. Stereomodel Flatness

FMC Drive unit No.: 5084-4

Base/Height ratio: 0.6

Platen ID: 4

Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 43

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	48	40	48	48	40
Tangential lines	57	48	48	40	40	40	40

LENS/FILM DISTORTION PARAMETERS

FMC Drive unit No.: 5084-4
Platen ID: 4

Base/Height ratio: 0.6
Maximum angle of field tested: 40°

XI. Calibrated Focal Length: 153.237 mm

XII. Lens/Film Distortion

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

Symmetric radial distortion parameters

$K_0 = -0.9932 \times 10^{-4}$
 $K_1 = 0.1058 \times 10^{-7}$
 $K_2 = -0.1741 \times 10^{-12}$
 $K_3 = 0.0000$
 $K_4 = 0.0000$

Decentering distortion parameters

$P_1 = 0.2656 \times 10^{-6}$
 $P_2 = -0.4376 \times 10^{-7}$
 $P_3 = 0.0000$
 $P_4 = 0.0000$

Calibrated principal point

$x_p = 0.002$ mm
 $y_p = -0.008$ mm

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/2166, dated January 30, 1996.

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