



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

September 11, 2003

Camera type: Wild RC20*	Camera serial no.: 5062
Lens type: Wild Universal Aviogon A4-F	Lens serial no.: 13110
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. 305053, dated September 11, 2003.

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: 153.081 mm

II. Lens Distortion

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

Symmetric radial distortion parameters

$$\begin{aligned} K_0 &= -0.9468 \times 10^{-5} \\ K_1 &= -0.1347 \times 10^{-8} \\ K_2 &= 0.1398 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering distortion parameters

$$\begin{aligned} P_1 &= -0.2332 \times 10^{-6} \\ P_2 &= -0.9436 \times 10^{-7} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated principal point

$$\begin{aligned} x_p &= 0.011 \text{ mm} \\ y_p &= 0.010 \text{ mm} \end{aligned}$$

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: 92

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	113	67	113	95	67
Tangential lines	134	113	95	80	95	95	80

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 525 No. 5347 filter accompanying this camera are within 10 seconds of being parallel. This filter was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	1719	1719	8.21	1/140	87
1/250	908	907	4.24	1/270	87
1/500	459	457	2.14	1/540	87
1/1000	230	230	1.08	1/1060	87

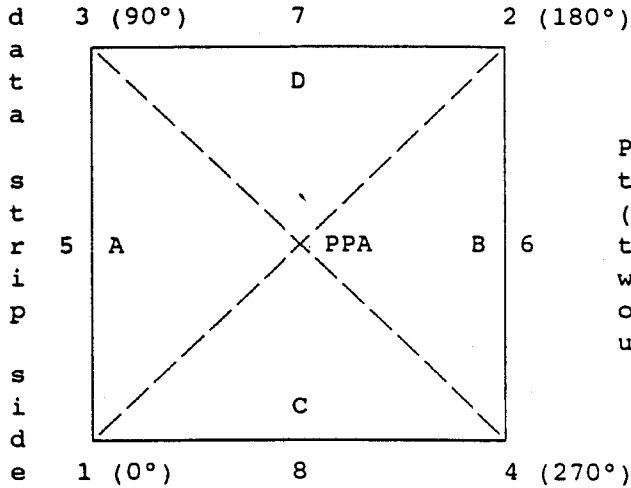
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC20 drive unit No. 5062-481 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 "481" 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	0.005 mm	0.004 mm
Indicated principal point, midside fiducials	0.007	0.002
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.011	0.010

Fiducial Marks

1	-106.003 mm	-105.997 mm
2	106.002	105.996
3	-105.983	105.999
4	106.000	-105.997
5	-109.996	0.004
6	110.013	0.000
7	0.011	109.997
8	0.003	-110.002

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.812 mm 3-4: 299.799 mm

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

Midside fiducials

5-6: 220.009 mm 7-8: 219.999 mm

Lines joining these markers intersect at an angle of 89° 59' 55"

Corner fiducials (perimeter)

1-3: 211.996 mm 2-3: 211.986 mm
1-4: 212.003 mm 2-4: 211.993 mm

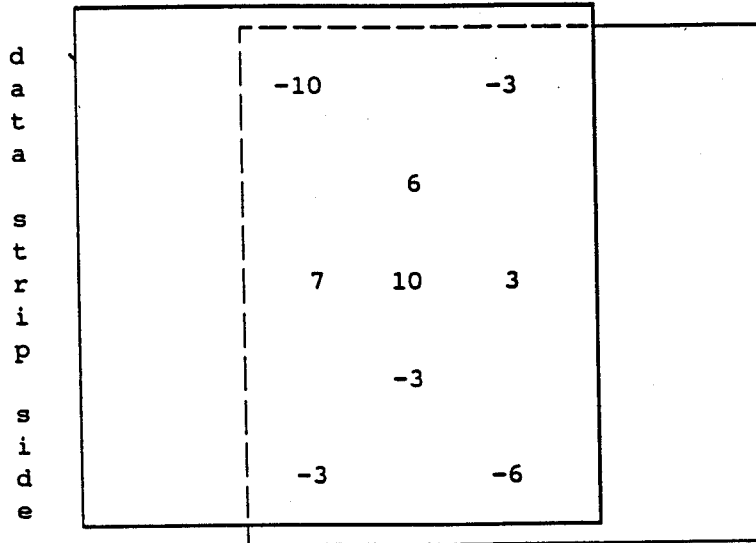
The method of measuring these distances is considered accurate within 0.003 mm

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

IX. Stereomodel Flatness

FMC Drive Unit No.: 5062-481
 Platen ID: 481

Base/Height ratio: 0.6
 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 stereo models. The values are based on comparator measurements on Kodak 4425 copy film made from Kodak 2405 film exposures. These measurements can vary by as much as $\pm 5 \mu\text{m}$ from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution:	44							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	57	48	40	40	40	40	

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2672, dated August 3, 2000.

Gregory I. Snyder
 Commercial Remote Sensing Project Manager
 National Mapping Division