United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

December 8, 1998

Camera type: Wild RC10
Lens type: Wild Universal Aviogon /4
Nominal focal length: 153 mm

Camera serial no.: 3532
Lens serial no.: 13050
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Global Remote Sensing, Inc.
Edmonton, Alberta, Canada

Reference: USGS letter dated December 4, 1998, from Mr. Jerry Mullins.

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: 152.743 mm

II. Lens Distortion

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

Symmetric radial distortion parameters

$K_0 = 0.2136 \times 10^{-4}$
$K_1 = -0.5504 \times 10^{-8}$
$K_2 = 0.2645 \times 10^{-12}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.5129 \times 10^{-7}$
$P_2 = 0.4511 \times 10^{-7}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = 0.009$ 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: 87

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	95	113	113	80	113	95	57
Tangential lines	95	80	80	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. 6375 and the 525 No. 6430 filters accompanying this camera are within 10 seconds of being parallel. The 525 filter was used for the calibration.

V. Shutter Calibration

Indicated exposure time	Effective exposure time	Efficiency
1/200	4.50 ms = 1/220 s	79%
1/400	2.25 ms = 1/445 s	79%
1/600	1.58 ms = 1/630 s	79%
1/800	1.19 ms = 1/840 s	79%
1/1000	0.95 ms = 1/1055 s	79%

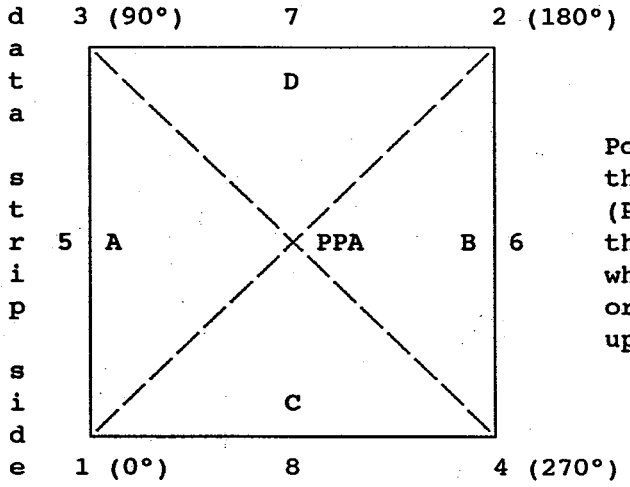
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC10 drive unit No. 3532-375 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 "375" 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	-0.006 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	0.009	-0.001

Fiducial Marks		
1	-106.020 mm	-105.995 mm
2	106.010	106.005
3	-105.993	106.002
4	105.981	-105.995
5	-110.003	-0.001
6	109.996	0.004
7	0.009	109.999
8	-0.022	-109.997

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.834 mm 3-4: 299.793 mm

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

Midside fiducials

5-6: 219.999 mm 7-8: 219.996 mm

Lines joining these markers intersect at an angle of 89° 59' 27"

Corner fiducials (perimeter)

1-3: 211.997 mm 2-3: 212.003 mm

1-4: 212.001 mm 2-4: 211.999 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.

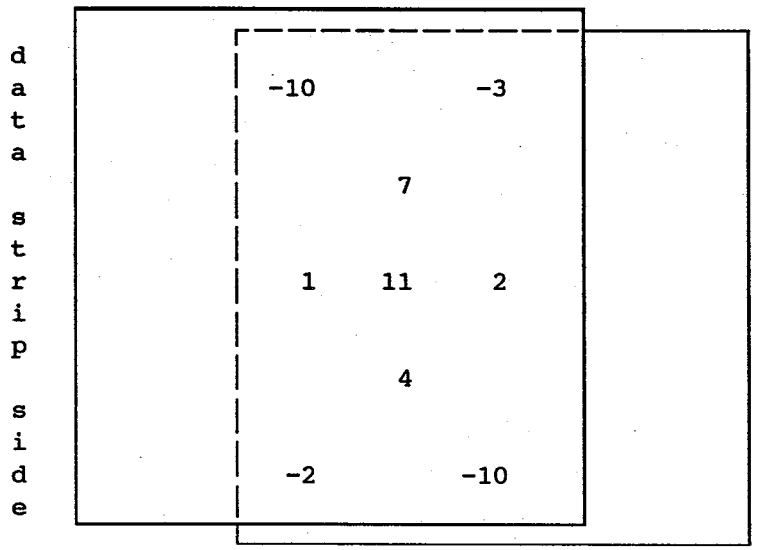
IX. Stereomodel Flatness

Drive unit No.: 3532-375

Platen ID: 375

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 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: 40

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	48	48	48	40	48	48	34
Tangential lines	48	48	40	40	40	34	28

LENS/FILM DISTORTION PARAMETERS

Drive unit No.: 3532-375 Base/Height ratio: 0.6

Platen ID: 375 Maximum angle of field tested: 40°

XI. Calibrated Focal Length: 152.744 mm

XII. Lens/Film Distortion

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

Symmetric radial distortion parameters

$K_0 = -0.8472 \times 10^{-4}$
$K_1 = 0.5259 \times 10^{-8}$
$K_2 = 0.9382 \times 10^{-13}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.1920 \times 10^{-6}$
$P_2 = -0.1307 \times 10^{-6}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = 0.009$ mm
$y_p = -0.001$ 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/2308, dated April 11, 1997.

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