



United States Department of the Interior

USGS Report No. OSL/2941

U.S. GEOLOGICAL SURVEY

Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

May 6, 2003

Camera type:	Zeiss RMK TOP 15*	Camera serial no.:	149984
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	150634
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Midwest Aerial Photography
Galloway, Ohio

Reference: Midwest Aerial Photography letter of authorization
dated April 29, 2003, signed by Ms. Jeannie Radford.

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: 152.688 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	1	1	2	2

Symmetric radial
distortion parameters

Decentering
distortion parameters

Calibrated
principal point

$$\begin{aligned}
 K_0 &= -0.1926 \times 10^{-4} \\
 K_1 &= 0.4291 \times 10^{-8} \\
 K_2 &= -0.1777 \times 10^{-12} \\
 K_3 &= 0.0000 \\
 K_4 &= 0.0000
 \end{aligned}$$

$$\begin{aligned}
 P_1 &= -0.1220 \times 10^{-6} \\
 P_2 &= 0.8697 \times 10^{-7} \\
 P_3 &= 0.0000 \\
 P_4 &= 0.0000
 \end{aligned}$$

$$\begin{aligned}
 x_p &= -0.003 \text{ mm} \\
 y_p &= 0.006 \text{ mm}
 \end{aligned}$$

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: 108

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

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 Zeiss KL-F (36%) filter No. 151124 and the USGS TOP 15 KL-F (60%) test filter No. 142399 are within 10 seconds of being parallel. The USGS test filter, in conjunction with the internal "B" 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 (%)
1/100	3948	3979	10.88	1/120	79
1/200	1795	1764	5.29	1/240	79
1/300	1204	1229	3.54	1/360	79
1/400	818	867	2.59	1/490	79
1/500	665	679	2.07	1/610	79

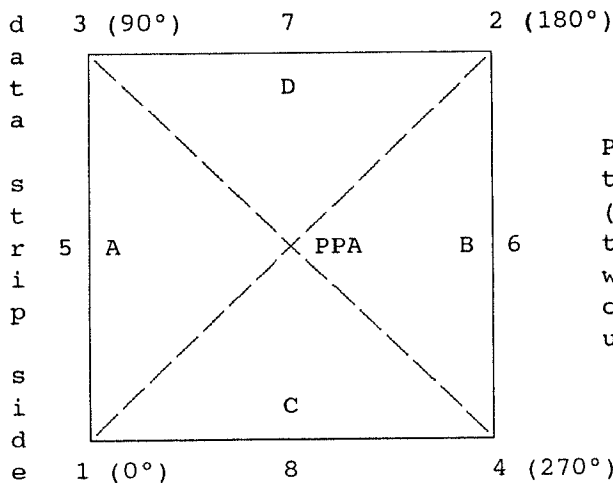
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platen mounted in T-MC film magazine No. 150616 does not depart from a true plane by more than 13 μ m (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "151222" 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	0.010 mm	0.017 mm
Indicated principal point, midside fiducials	0.006	0.015
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	-0.003	0.006

Fiducial Marks

1	-112.989 mm	-112.981 mm
2	113.009	113.016
3	-112.993	113.015
4	113.014	-112.981
5	-112.997	0.017
6	113.018	0.013
7	0.009	113.014
8	0.003	-112.999

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 319.609 mm 3-4: 319.615 mm

Lines joining these markers intersect at an angle of 90° 00' 05"

Midside fiducials

5-6: 226.015 mm 7-8: 226.013 mm

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

Corner fiducials (perimeter)

1-3: 225.997 mm 2-3: 226.002 mm

1-4: 226.003 mm 2-4: 225.997 mm

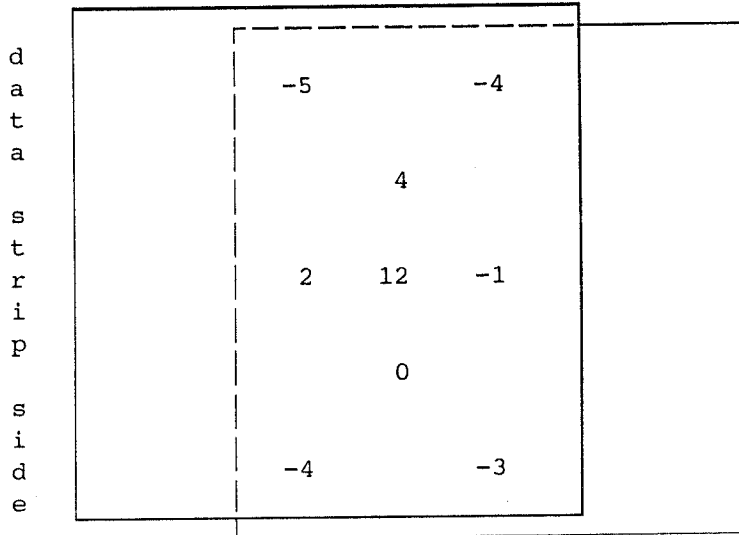
The method of measuring these distances is considered accurate within 0.003 mm

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 254 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

IX. Stereomodel Flatness

FMC Magazine No.: 150616
 Platen ID: 151222

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: 53

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	67	67	57	57	57	48	48
Tangential lines	67	57	57	57	48	48	48

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2731, dated March 9, 2001.

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 National Mapping Division