



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

April 18, 2000

Camera type:	Zeiss RMK A 15/23*	Camera serial no.:	134653
Lens type:	Zeiss Pleogon A2/4	Lens serial no.:	127816
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Kenney Aerial Mapping, Inc.  
Phoenix, Arizona

Reference: Letter dated April 6, 2000, from Mr. Gordon Smith.

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: 152.810 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-2	-4	-6	-6	-3	5
Decentering (um)	0	1	2	5	7	10

Symmetric radial  
distortion parameters

Decentering  
distortion parameters

Calibrated  
principal point

$$\begin{aligned} K_0 &= 0.9326 \times 10^{-4} \\ K_1 &= 0.5941 \times 10^{-9} \\ K_2 &= -0.5316 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

$$\begin{aligned} P_1 &= -0.4412 \times 10^{-6} \\ P_2 &= 0.4068 \times 10^{-6} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

$$\begin{aligned} x_p &= -0.002 \text{ mm} \\ y_p &= -0.007 \text{ mm} \end{aligned}$$

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 ( $\sigma$ ) of  $\pm 3$  microns.

\* Equipped with Forward Motion Compensation

### III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 82

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	95	95	67	40
Tangential lines	113	134	95	95	80	67	57

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 B No. 134711, the D No. 134750 and the KL No. 111546 filters accompanying this camera are within 10 seconds of being parallel. The B filter was used for the calibration.

### V. Shutter Calibration

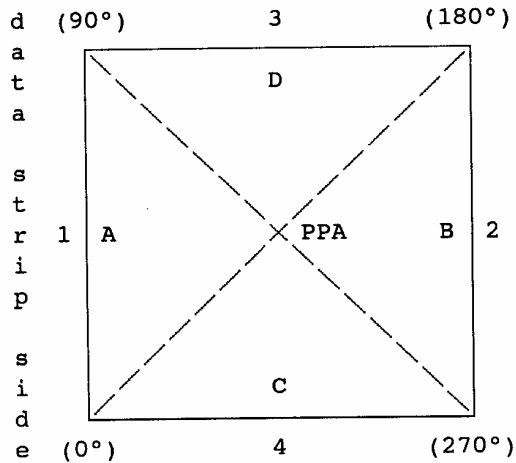
Indicated time (sec)	Rise time ( $\mu$ sec)	Fall Time ( $\mu$ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/200	1490	1518	3.88	1/160	80
1/400	726	704	1.85	1/335	80
1/600	520	504	1.25	1/500	80
1/800	376	372	0.92	1/680	80
1/1000	329	298	0.75	1/850	80

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. Magazine Platen

( Not Applicable )

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, midside fiducials	-0.002 mm	0.002 mm
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) $x_p, y_p$	-0.002	-0.007

Fiducial Marks

Fiducial Mark	X coordinate	Y coordinate
1	-113.014 mm	0.002 mm
2	112.997	0.002
3	0.005	112.974
4	-0.009	-112.997

VIII. Distances Between Fiducial Marks

Midside fiducials (diagonals)

1-2: 226.010 mm                      3-4: 225.971 mm

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

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2309, dated April 15, 1997.

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