



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

April 22, 2003

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.  
Las Vegas, Nevada

Reference: Kenney Aerial Mapping, Inc. letter of authorization,  
dated April 8, 2003, signed by Mr. Eric Hodgins.

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: 152.802 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	0	0	-2	-3	-2	3
Decentering (um)	0	1	3	6	9	13

<u>Symmetric radial distortion parameters</u>	<u>Decentering distortion parameters</u>	<u>Calibrated principal point</u>
$K_0 = -0.6480 \times 10^{-5}$	$P_1 = -0.5703 \times 10^{-6}$	$x_p = 0.011 \text{ mm}$
$K_1 = 0.1041 \times 10^{-7}$	$P_2 = 0.5232 \times 10^{-6}$	$y_p = -0.022 \text{ mm}$
$K_2 = -0.6861 \times 10^{-12}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 80

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	95	80	57	40
Tangential lines	113	134	95	95	95	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 Zeiss B filter No. 134711, the D filter No. 134750 and the KL filter No. 111546 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	1126	1121	3.83	1/320	81
1/400	608	611	1.95	1/640	81
1/600	395	399	1.24	1/1000	81
1/800	299	301	0.95	1/1320	81
1/1000	236	232	0.75	1/1660	81

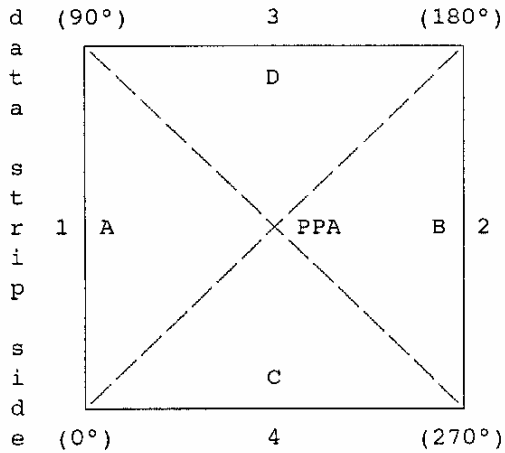
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

### VI. Magazine Platen

The platen mounted in T-MC film magazine No. 147448 does not depart from a true plane by more than 13  $\mu$ m (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "145741" 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, midside fiducials	0.000 mm	-0.004 mm
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) $x_p, y_p$	0.011	-0.022

Fiducial Marks

1	-113.011 mm	-0.004 mm
2	112.997	-0.004
3	0.007	112.968
4	-0.007	-113.004

VIII. Distances Between Fiducial Marks

Midside fiducials (diagonals)

1-2: 226.007 mm                      3-4: 225.972 mm

Lines joining these markers intersect at an angle of 89° 59' 48"

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 240 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

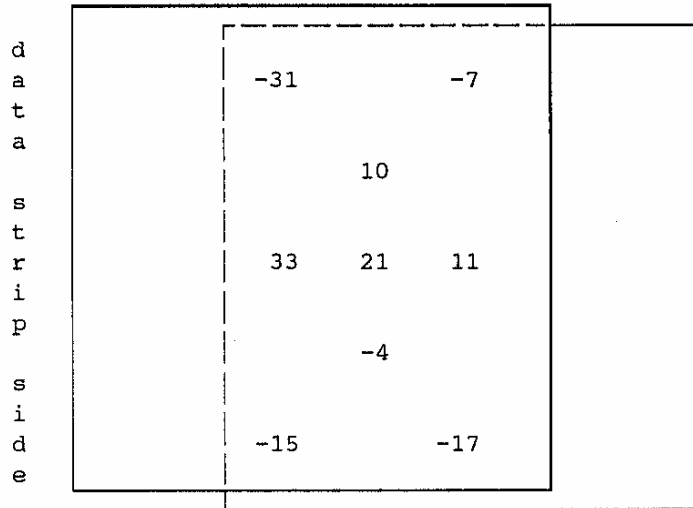
IX. Stereomodel Flatness

FMC Magazine No.: 147448

Base/Height ratio: 0.6

Platen ID: 145741

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: 39

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	48	48	40	34	24
Tangential lines	57	48	48	48	40	34	28

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2638, dated April 18, 2000.

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