



United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Reston, Virginia 22092

REPORT OF CALIBRATION of Aerial Mapping Camera

March 11, 1997

Camera type:	Zeiss RMK TOP 15*	Camera serial no.:	142821
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	142829
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: EastCoast Aerials, Inc.
Raleigh, North Carolina

Reference: EastCoast Aerials, Inc., purchase
Order No. 1040, dated March 9, 1997.

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: 153.789 mm

II. Lens Distortion

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

Symmetric radial
distortion parameters

$$\begin{aligned} K_0 &= 0.9919 \times 10^{-4} \\ K_1 &= -0.8367 \times 10^{-8} \\ K_2 &= 0.4038 \times 10^{-13} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering
distortion parameters

$$\begin{aligned} P_1 &= -0.2368 \times 10^{-6} \\ P_2 &= 0.2716 \times 10^{-7} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated
principal point

$$\begin{aligned} x_p &= 0.011 \text{ mm} \\ y_p &= 0.002 \text{ mm} \end{aligned}$$

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: 100

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	134	113	113	95	95
Tangential lines	113	134	113	113	95	80	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 KL-F (36%) No. 144530 filter and the USGS TOP 15 test filter KL-F (60%) 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

<u>Indicated exposure time</u>	<u>Effective exposure time</u>	<u>Efficiency</u>
1/100	11.00 ms = 1/90 s	71%
1/200	5.00 ms = 1/200 s	71%
1/300	3.34 ms = 1/300 s	71%
1/400	2.50 ms = 1/400 s	71%
1/500	2.00 ms = 1/500 s	71%

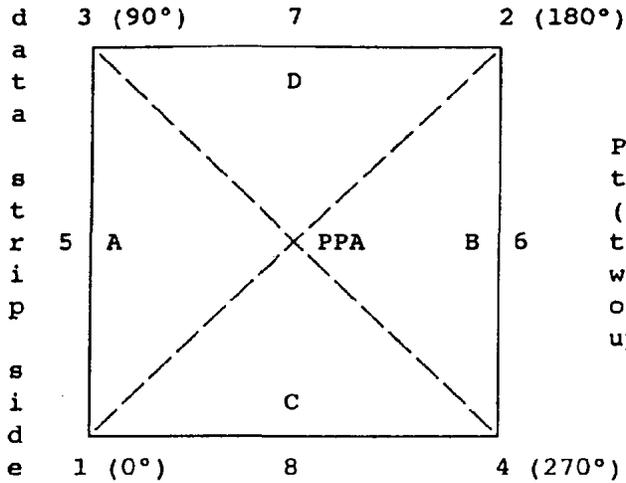
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in T-MC film magazines No. 144393 and No. 144876 do not depart from a true plane by more than 13 μ m (0.0005 in).

The platens for these film magazines are equipped with identification markers that will register "143157" for magazine No. 144393, and "144406" for magazine No. 144876 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	-0.004 mm	-0.002 mm
Indicated principal point, midside fiducials	-0.004	-0.003
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.011	0.002

Fiducial Marks

1	-113.004 mm	-113.006 mm
2	112.999	113.005
3	-113.004	112.995
4	113.003	-113.006
5	-113.004	-0.004
6	113.009	-0.003
7	0.002	112.995
8	-0.010	-113.011

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 319.622 mm 3-4: 319.618 mm

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

Midside fiducials

5-6: 226.013 mm 7-8: 226.006 mm

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

Corner fiducials (perimeter)

1-3: 226.000 mm 2-3: 226.003 mm

1-4: 226.007 mm 2-4: 226.011 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.

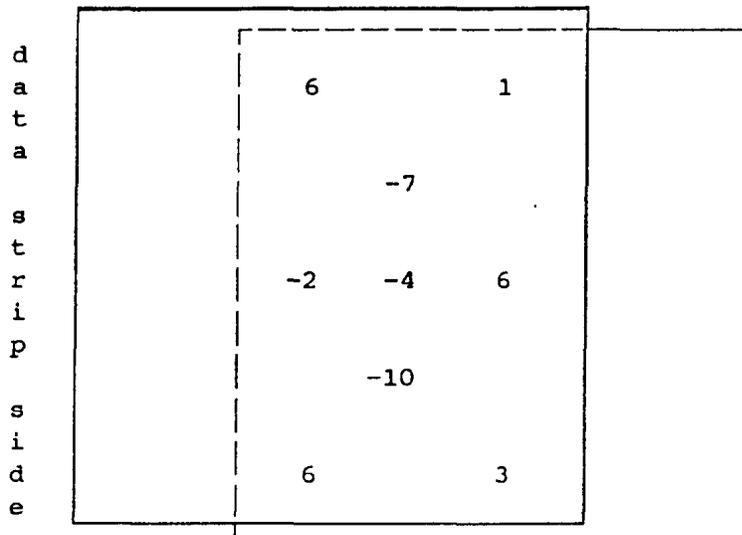
IX. Stereomodel Flatness

Magazine No.: 144393

Base/Height ratio: 0.6

Platen ID: 143157

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: 45

Film: Type 2405

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

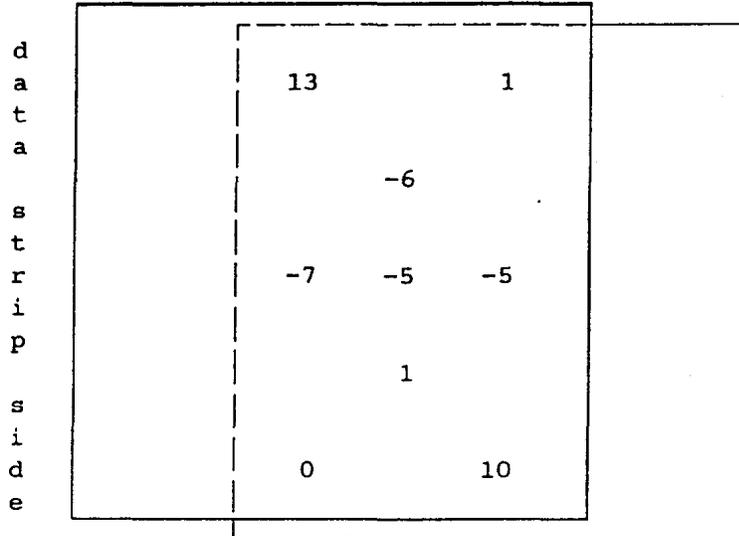
IX. Stereomodel Flatness

Magazine No.: 144876

Base/Height ratio: 0.6

Platen ID: 144406

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. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 46

Film: Type 2405

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2132, dated September 26, 1995.

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