



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

December 5, 2006

Camera type:	Zeiss RMK Top 15*	Camera serial no.:	141291
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	141314
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: HJW/Pacific Aerial Surveys  
Oakland, California

Reference: HJW/Pacific Aerial Surveys letter of authorization,  
dated November 11, 2006. Signed by Mr. Fred Benton.

These measurements were made on Agfa glass plates, 0.19 inch thick, with spectroscopic emulsion type APX 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: 154.048 mm

### II. Lens Distortion

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

#### Symmetric radial distortion parameters

$$\begin{aligned} K_0 &= 0.8764 \times 10^{-4} \\ K_1 &= -0.9547 \times 10^{-8} \\ K_2 &= 0.1698 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

#### Decentering distortion parameters

$$\begin{aligned} P_1 &= 0.3907 \times 10^{-8} \\ P_2 &= -0.2244 \times 10^{-6} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

#### Calibrated principal point

$$\begin{aligned} x_p &= -0.003 \text{ mm} \\ y_p &= 0.000 \text{ mm} \end{aligned}$$

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: 97

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

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. 141523 accompanying this camera, 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

Indicated time (sec)	Rise time ( $\mu$ sec)	Fall Time ( $\mu$ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/100	3930	4056	10.72	1/120	77
1/200	1904	1960	5.23	1/250	77
1/300	1208	1234	3.46	1/370	78
1/400	1040	1033	2.59	1/510	75
1/500	716	695	2.10	1/600	79

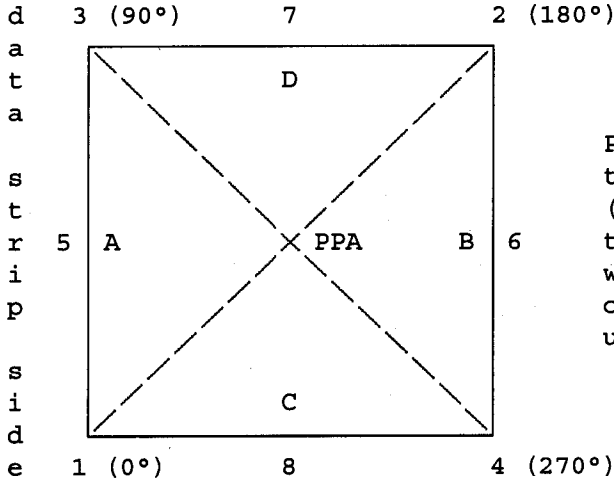
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

### VI. Magazine Platen

The platen mounted in T-MC film magazine No. 137711 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 "141626" 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	-0.001	-0.016
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) $x_p, y_p$	-0.003	0.000

Fiducial Marks

1	-112.979 mm	-113.020 mm
2	112.991	112.977
3	-113.003	112.994
4	113.017	-113.020
5	-112.993	-0.015
6	112.983	-0.018
7	-0.006	112.979
8	0.004	-113.007

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 319.588 mm      3-4: 319.635 mm

Lines joining these markers intersect at an angle of 89° 59' 50"

Midside fiducials

5-6: 225.976 mm      7-8: 225.986 mm

Lines joining these markers intersect at an angle of 90° 00' 12"

Corner fiducials (perimeter)

1-3: 226.013 mm      2-3: 225.993 mm

1-4: 225.995 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.

