United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

July 26, 2007

Camera type:	Zeiss RMK Top 15*	**Camera serial no.:**	141299
Lens type:	Zeiss Pleogon A3/4	**Lens serial no.:**	141334
Nominal focal Length:	153 mm	**Maximum aperture:**	f/4
		Test aperture:	f/4

Submitted by: Kenney Aerial Mapping Inc.
Phoenix, Arizona

Reference: Kenney Aerial Mapping Inc. letter of authorization dated July 19, 2007, signed by Mr. Eric Hodgins.

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: 154.084 mm

II. Lens Distortion

Field angle:	7.5º	15º	22.7º	30º	35º	40º
Symmetric radial (μm)	0	0	0	0	0	-1
Decentering tangential (μm)	0	0	1	1	2	3

Symmetric radial distortion	Decentering distortion	Calibrated principal point
K_0 = -0.1056E-04	P_1 = 0.1524E-06	x_p = -0.007 mm
K_1 = 0.2016E-08	P_2 = -0.4187E-07	y_p = -0.004 mm
K_2 = -0.6766E-13	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 (σ) of ±3 microns.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 100

Field angle:	0º	7.5º	15º	22.7º	30º	35º	40º
Radial Lines	134	134	113	113	113	95	95
Tangential Lines	134	134	113	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. 141519 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 (µ sec)	Fall Time (µ sec)	½ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	3793	3769	10.86	1/120	78
1/200	1848	1842	5.21	1/250	78
1/300	1165	1154	3.46	1/370	79
1/400	850	866	2.58	1/490	79
1/500	726	713	2.05	1/620	78

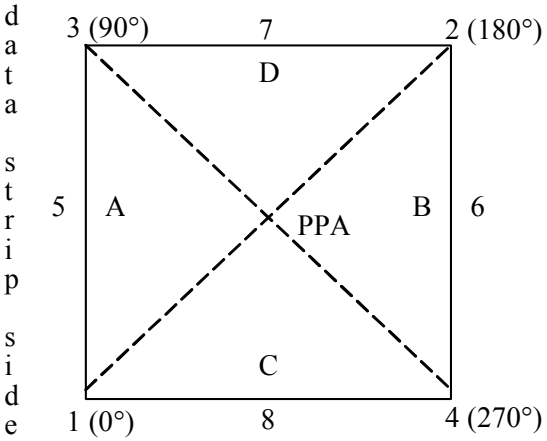
The effective exposure times were determined with the lens at aperature f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

VI. Magazine Platen

The platen mounted in Zeiss T-MC film magazine No. 137708 does not depart from a true plane by more than 13 µm (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "141630" in the data strip area for each exposure.

VII. Principal Point and Fiducial Mark 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.

	X coordinate (mm)	Y coordinate (mm)
Indicated principal point, corner fiducials	-.007	-.004
Indicated principal point, midside fiducials	.022	-.005
Principal point of autocollimation (PPA)	.000	.000
Calibrated principal point (point of symmetry)	-.007	-.004

Fiducial Marks		
1	-112.970	-113.005
2	112.989	113.029
3	-113.008	112.986
4	113.006	-113.005
5	-112.987	-.019
6	113.016	.008
7	.013	112.984
8	.031	-112.984

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2:	319.607 mm	3-4:	319.616 mm
Lines joining these markers intersect at an angle o 89° 59' 37"				
Midside fiducials	5-6:	226.003 mm	7-8:	225.968 mm
Lines joining these markers intersect at an angle o 89° 59' 52"				
Corner fiducials (perimeter)	1-3:	225.991 mm	2-3:	225.997 mm
	1-4:	225.976 mm	2-4:	226.034 mm

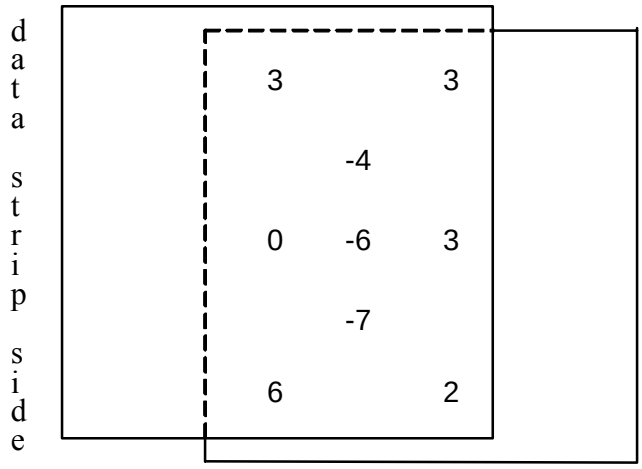
The Method of measuring these distances is considered accurate within 0.003 mm

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: 137708 **Base/Height ratio:** 0.6

Platen ID: 141630 **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 flim exposures. These measurements are considered accurate to within 5 μm.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 47 **Film:** Type 2405

Field angle:	0º	7.5º	15º	22.7º	30º	35º	40º
Radial Lines	57	57	57	48	48	48	40
Tangential Lines	57	57	57	48	48	40	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3064, dated August 5, 2004.

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