



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

November 17, 2016

Camera type: Zeiss RMK Top 15\*  
Lens type: Zeiss Pleogon A3/4  
Nominal focal Length: 153 mm

Camera serial no.: 151965  
Lens serial no.: 151889  
Maximum aperture: f/4  
Test aperture: f/4

Submitted by: Wisconsin Department of Transportation  
Madison, WI

### Reference:

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: 152.802 mm

### II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial ( $\mu\text{m}$ )	0	1	1	2	1	-1
Decentering tangential ( $\mu\text{m}$ )	0	0	0	0	1	1

Symmetric radial distortion	Decentering distortion	Calibrated principal point
$K_0 = -0.9054\text{E-}05$	$P_1 = -0.2624\text{E-}07$	$x_p = -0.002 \text{ mm}$
$K_1 = -0.3538\text{E-}08$	$P_2 = 0.4756\text{E-}07$	$y_p = 0.011 \text{ mm}$
$K_2 = 0.2902\text{E-}12$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 106

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	159	159	159	113	113	95	95
Tangential Lines	159	159	134	113	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 USGS TOP 15 test filter KL-F (60%) No. 142399 and KL-F(36%) filter No. 151821 are within 10 seconds of being parallel. The USGS TOP 15 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 ( $\mu$ )	$\frac{1}{2}$ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	3370	3399	11.35	1/110	81
1/200	1858	1680	5.43	1/230	80
1/300	1244	1234	3.64	1/330	79
1/400	899	878	2.59	1/490	79
1/500	702	741	2.10	1/610	78

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).

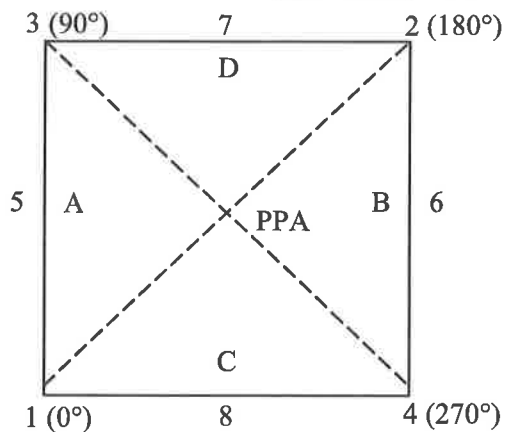
### VI. Magazine Platen

The platen mounted in Zeiss film magazine No. 151638 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 "151773" in the data strip area for each exposure.

**VII. Principal Point and Fiducial Mark Coordinates**

data strip side



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.

Indicated principal point, corner fiducials  
 Indicated principal point, midside fiducials  
 Principal point of autocollimation (PPA)  
 Calibrated principal point (point of symmetry)

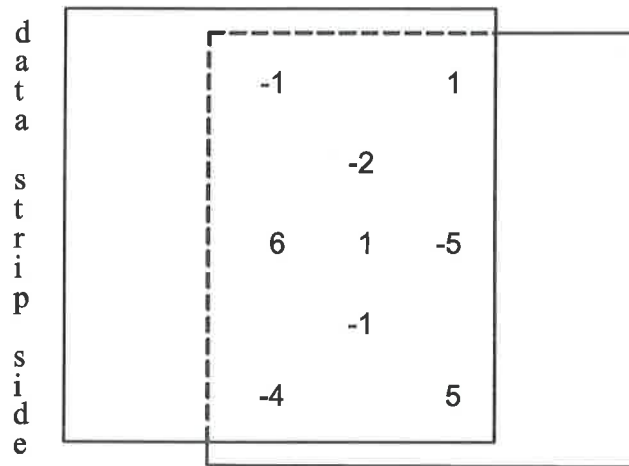
<u>X coordinate (mm)</u>	<u>Y coordinate (mm)</u>
0.011	-0.001
0.006	0.002
0.000	0.000
-0.002	0.011
<u>Fiducial Marks</u>	
1	-112.984
2	113.014
3	-112.987
4	113.014
5	-112.985
6	113.006
7	0.007
8	0.005

**VIII. Distances Between Fiducial marks**

Corner fiducials (diagonals)	1-2: 319.614 mm	3-4: 319.608 mm
Lines joining these markers intersect at an angle of 90° 00' 00"		
Midside fiducials	5-6: 225.991 mm	7-8: 226.004 mm
Lines joining these markers intersect at an angle of 89° 59' 49"		
Corner fiducials (perimeter)	1-3: 225.993 mm	2-3: 226.000 mm
	1-4: 225.998 mm	2-4: 226.004 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 254mm 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:** 151638**Base/Height ratio:** 0.6**Platen ID:** 151773**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 Agfa Avitone P3p copy film made from Agfa Aviphot Pan 200 film exposures. These measurements are considered accurate to within 5  $\mu\text{m}$ .

**X. System Resolving Power on film in cycles/mm****Area-weighted average resolution:** 51**Film:** Pan 200

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	67	67	57	57	48	48
Tangential Lines	57	67	67	48	48	40	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3640, dated June 13, 2013.

Ryan Longhenry  
Long Term Archive Project Manager  
Climate and Land Use Change