



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

March 30, 2017

Camera type:	Zeiss RMK Top 15*	Camera serial no.:	145846
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	145892
Nominal focal Length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Forsvarets Materielverk- Swedish Defence Admin.
Stockholm, Sweden

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: 152.990 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (μm)	0	-1	-1	0	0	1
Decentering tangential (μm)	0	1	2	4	6	8

Symmetric radial distortion	Decentering distortion	Calibrated principal point
$K_0 = 0.1643E-04$	$P_1 = 0.4756E-06$	$x_p = 0.002 \text{ mm}$
$K_1 = -0.1623E-08$	$P_2 = -0.8285E-07$	$y_p = 0.011 \text{ mm}$
$K_2 = 0.1957E-13$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 102

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	159	134	113	95	95	95
Tangential Lines	134	134	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. 149767 are within 10 seconds of being parallel. The USGS TOP 15 test filter, in conjunction with the internal "B" filter, was used for the calibration.

V. Shutter Calibration

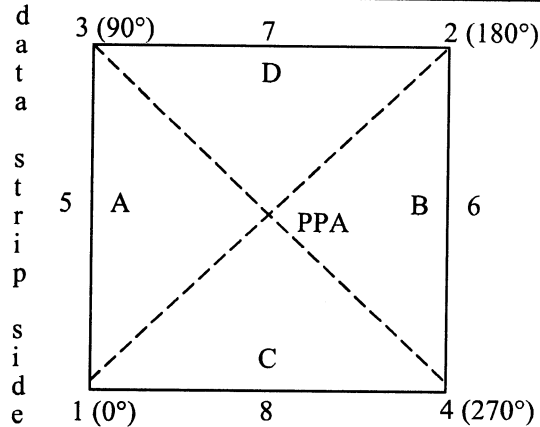
Indicated Time (sec)	Rise Time (μ sec)	Fall Time (μ)	$\frac{1}{2}$ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	2284	2096	13.01	1/90	89
1/200	1076	1046	6.36	1/180	90
1/300	699	700	4.21	1/260	90
1/400	522	515	3.12	1/360	90
1/500	429	423	2.48	1/450	89

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 TM-C film magazine No. 147466 does not depart from a true plane by more than 13 μ m (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "148018" 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.

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

X coordinate (mm) Y coordinate (mm)

0.011	-0.005
0.008	-0.008
0.000	0.000
0.002	0.011

Fiducial Marks

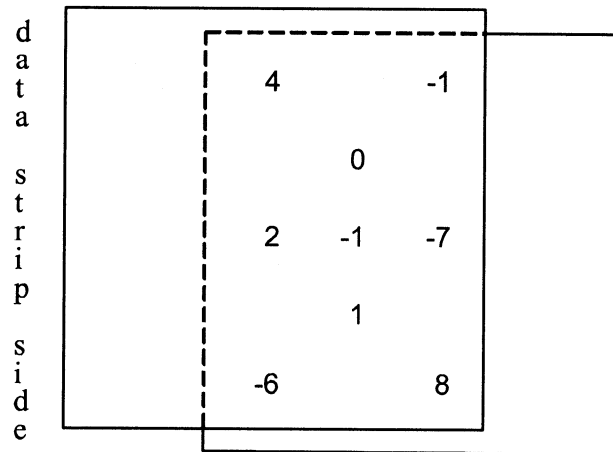
1	-112.971	-113.001
2	113.003	113.002
3	-112.991	112.988
4	113.015	-113.001
5	-112.982	-0.011
6	112.995	-0.005
7	0.003	112.993
8	0.013	-113.007

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2: 319.596 mm	3-4: 319.609 mm
Lines joining these markers intersect at an angle of 89° 59' 54"		
Midside fiducials	5-6: 225.977 mm	7-8: 226.000 mm
Lines joining these markers intersect at an angle of 90° 00' 04"		
Corner fiducials (perimeter)	1-3: 225.989 mm	2-3: 225.994 mm
	1-4: 225.986 mm	2-4: 226.003 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:** 147466**Base/Height ratio:** 0.6**Platen ID:** 148018**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 μ m.

X. System Resolving Power on film in cycles/mm**Area-weighted average resolution:** 48**Film:** Pan 200

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3604, dated August 6, 2012.

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Climate and Land Use Change