United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

November 18, 2015

Camera type:	Zeiss RMK Top 15*	**Camera serial no.:**	144124
Lens type:	Zeiss Pleogon A3/4	**Lens serial no.:**	145913
Nominal focal Length:	153 mm	**Maximum aperture:**	f/4
		Test aperture:	f/4

Submitted by: Institut National de Cartographie et de Teledectio
Alger, Algeric

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: 152.785 mm

II. Lens Distortion

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

Symmetric radial distortion		Decentering distortion		Calibrated principal point	
K_0 =	0.2854E-04	P_1 =	0.4640E-07	x_p =	0.011 mm
K_1 =	0.3647E-08	P_2 =	0.8591E-07	y_p =	0.013 mm
K_2 =	-0.4012E-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 (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	159	113	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 are within 10 seconds of being parallel. This filter, in conjunction with the internal "B" filter, was used for the calibration.

V. Shutter Calibration

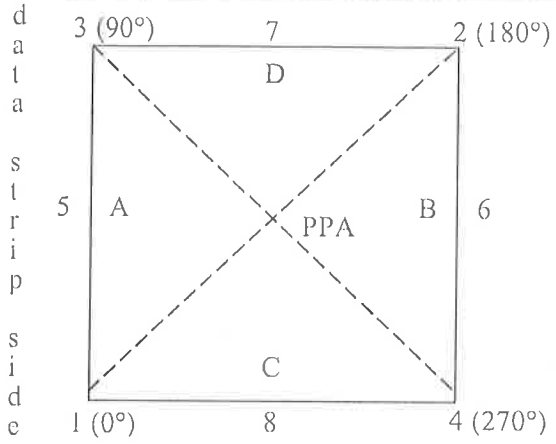
Indicated Time (sec)	Rise Time (μ sec)	Fall Time (μ	½ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	4100	4588	11.15	1/120	76
1/200	1982	2120	5.33	1/250	76
1/300	1285	1212	3.59	1/360	78
1/400	984	987	2.68	1/480	77
1/500	790	774	2.07	1/630	76

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

N/A

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	0.010	0.014
Indicated principal point, midside fiducials	-0.002	0.014
Principal point of autocollimation (PPA)	0.000	0.000
Calibrated principal point (point of symmetry)	0.011	0.013
Fiducial Marks		
1	-112.988	-112.990
2	113.008	113.018
3	-112.988	113.008
4	113.016	-112.990
5	-112.983	0.010
6	113.005	0.019
7	0.009	113.015
8	-0.013	-112.939

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2:	319.615 mm	3-4:	319.614 mm
Lines joining these markers intersect at an angle o 89° 59' 58"				
Midside fiducials	5-6:	225.988 mm	7-8:	225.954 mm
Lines joining these markers intersect at an angle o 89° 59' 32"				
Corner fiducials (perimeter)	1-3:	225.998 mm	2-3:	225.996 mm
	1-4:	226.005 mm	2-4:	226.008 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.

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