United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

May 12, 2000

Camera type:	Wild RC30*	Camera serial no.:	5325
Lens type:	Wild Universal Aviogon /4-S	Lens serial no.:	13366
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Keystone Aerial Surveys, Inc.
Philadelphia, Pennsylvania

Reference: LH Systems, LLC, purchase order No. 9018, dated January 6, 1999.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 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: 153.287 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	1	2	3	4	6

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
$K_0 = 0.8043 \times 10^{-4}$	$P_1 = -0.1221 \times 10^{-6}$	$x_p = 0.006$ mm
$K_1 = -0.9280 \times 10^{-8}$	$P_2 = 0.3633 \times 10^{-6}$	$y_p = -0.001$ mm
$K_2 = 0.1860 \times 10^{-12}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 124

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	159	159	159	159	134	113	113
Tangential lines	159	159	159	134	113	95	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 Wild 420 No. 7764 and the 525 No. 7766 filters accompanying this camera are within 10 seconds of being parallel. The 525 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 (%)
1/125	1722	1710	8.33	1/140	87
1/250	875	878	4.30	1/270	87
1/500	452	441	2.16	1/530	87
1/1000	238	228	1.10	1/1050	87

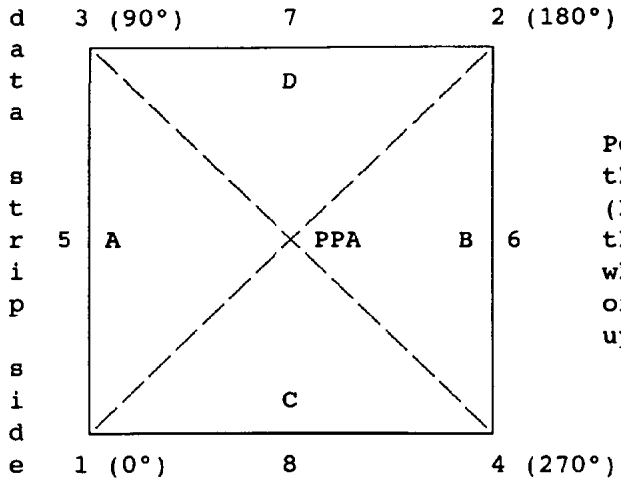
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Film Platen

The film platen mounted in Wild RC30 drive unit No. 5325-707 does not depart from a true plane by more than 13 um (0.0005 in).

This camera is equipped with a platen identification marker that will register "707" 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.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	-0.004 mm	0.014 mm
Indicated principal point, midside fiducials	-0.007	0.018
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.006	-0.001

Fiducial Marks		
1	-106.011 mm	-105.984 mm
2	106.002	106.012
3	-106.001	106.014
4	105.991	-105.984
5	-112.002	0.019
6	111.994	0.016
7	-0.002	112.005
8	-0.012	-111.977

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)
1-2: 299.820 mm 3-4: 299.806 mm
Lines joining these markers intersect at an angle of 90° 00' 06"

Midside fiducials
5-6: 223.996 mm 7-8: 223.983 mm
Lines joining these markers intersect at an angle of 89° 59' 54"

Corner fiducials (perimeter)
1-3: 211.998 mm 2-3: 212.003 mm
1-4: 212.002 mm 2-4: 211.996 mm

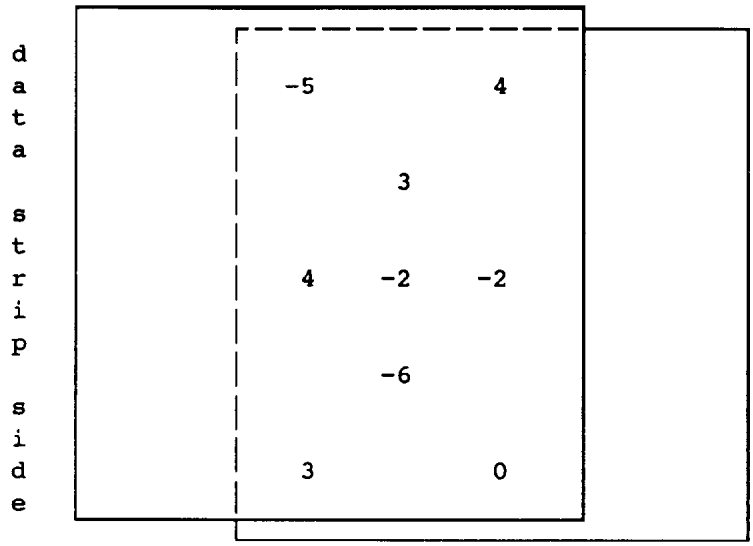
The method of measuring these distances is considered accurate within 0.003 mm

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 278 mm.

IX. Stereomodel Flatness

FMC Drive unit No.: 5325-707 Base/Height ratio: 0.6

Platen ID: 707 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 contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as ± 5 μm from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 56 Film: Type 2405

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

LENS/FILM DISTORTION PARAMETERS

FMC Drive unit No.: 5325-707 Base/Height ratio: 0.6

Platen ID: 707 Maximum angle of field tested: 40°

XI. Calibrated Focal Length: 153.281 mm

XII. Lens/Film Distortion

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

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
$K_0 = -0.4277 \times 10^{-4}$	$P_1 = 0.8679 \times 10^{-7}$	$x_p = 0.006$ mm
$K_1 = -0.1858 \times 10^{-8}$	$P_2 = 0.1917 \times 10^{-6}$	$y_p = -0.001$ mm
$K_2 = 0.3522 \times 10^{-12}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

The above measurements were computed from contact glass positives made from Kodak 2405 film exposed in the magazine.

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.

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