United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

February 15, 2006

Camera type: Jena LMK 2015*
Lens type: Jena Lamegon PI/E
Nominal focal length: 153 mm

Camera serial no.: 275839E
Lens serial no.: 275839E
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Aerial Surveys International, LLC
Watkins, Colorado

Reference: Aerial Surveys International, LLC letter of authorization, dated February 8, 2006. Signed by Mr. Ron Macke.

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: 152.492 mm

II. Lens Distortion

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

Symmetric radial distortion parameters

$K_0 = 0.1004 \times 10^{-3}$
$K_1 = -0.2176 \times 10^{-7}$
$K_2 = 0.9425 \times 10^{-12}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.5132 \times 10^{-7}$
$P_2 = -0.8800 \times 10^{-7}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = 0.004$ mm
$y_p = 0.005$ mm

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: 103

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	113	113	95	95
Tangential lines	113	134	113	95	113	80	95

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 Jena 405 filter No. 275568, the 490 filter No. 276002 and the 530 filter No. 52028 accompanying this camera are within 10 seconds of being parallel. The 490 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	3061	3166	9.06	1/140	79
1/250	1490	1591	4.44	1/290	79
1/500	740	777	2.25	1/565	79
1/1000	366	387	1.12	1/1135	79

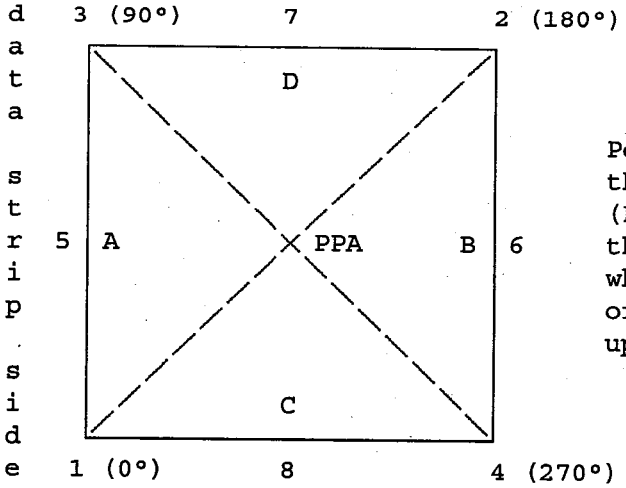
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

VI. Magazine Platen

The platens mounted in LMK-K 24/120 film magazines No. 273410C and No. 273506 do not depart from a true plane by more than 13 um (0.0005 in).

These film magazines are equipped with identification markers that will register "273410" for magazine No. 273410C, and "273506" for magazine No. 273506 in the film edge 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	0.003 mm	-0.002 mm
Indicated principal point, midside fiducials	0.000	0.000
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.004	0.005

Fiducial Marks		
1	-110.004 mm	-110.001 mm
2	110.013	110.001
3	-109.989	110.001
4	109.992	-110.001
5	-112.002	0.001
6	111.995	0.000
7	0.012	111.997
8	-0.011	-112.013

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 311.141 mm 3-4: 311.115 mm

Lines joining these markers intersect at an angle of 89° 59' 57"

Midside fiducials

5-6: 223.998 mm 7-8: 224.010 mm

Lines joining these markers intersect at an angle of 89° 59' 41"

Corner fiducials (perimeter)

1-3: 220.003 mm 2-3: 220.003 mm

1-4: 219.996 mm 2-4: 220.003 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 241 mm.

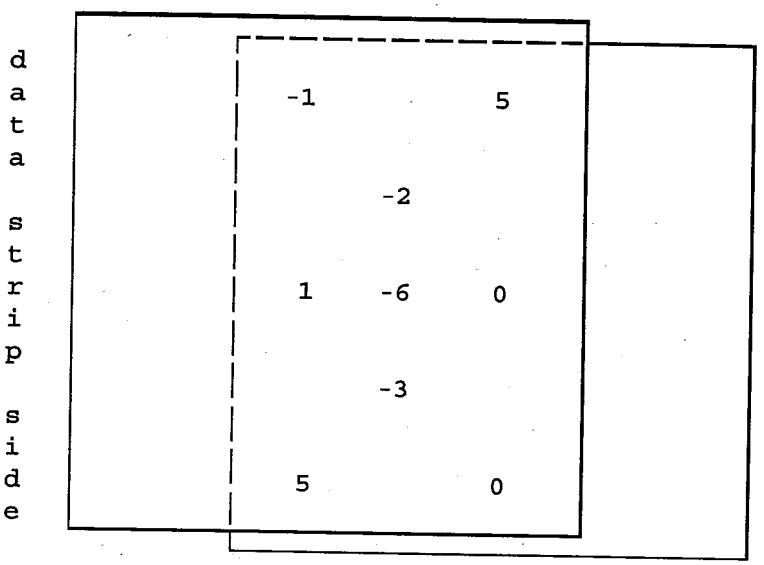
IX. Stereomodel Flatness

FMC Magazine No.: 273410C

Platen ID: 273410

Base/Height ratio: 0.6

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 film exposures. These measurements are cinsidered accurate to within 5 μm.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 44

Film: Type 2405

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

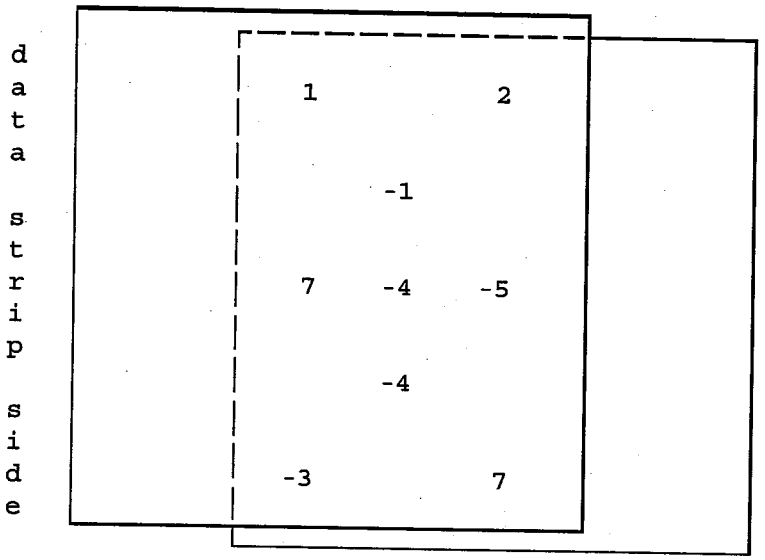
IX. Stereomodel Flatness

FMC Magazine No.: 273506

Platen ID: 273506

Base/Height ratio: 0.6

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 film exposures. These measurements are cinsidered accurate to within 5 μm.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 43

Film: Type 2405

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2920, dated March 3, 2003.

Gregory L. Stensaas
Remote Sensing Technologies Project Manager
Geography Discipline