United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA 22092

REPORT OF CALIBRATION
of Aerial Mapping Camera

July 30, 1993

Camera type: Zeiss RMK A 15/23
Lens type: Zeiss Pleogon A4
Nominal focal length: 153 mm

Camera serial No.: 124224
Lens serial No.: 124275
Maximum aperture: f/4
Test aperture: f/4

Submitted by: N.Z. Aerial Mapping Limited
Hastings, New Zealand

Reference: USGS letter dated July 22, 1993, from Mr. Jerry Mullins, and New Zealand Department of Survey and Land Information letter dated July 16, 1993, from Mr. William A. Robertson.

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: 152.871 mm

This measurement is considered accurate within 0.005 mm

II. Radial Distortion

Field angle	$\bar{D}_c$	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	1	4	2	-2	0
15	0	2	1	-1	-1
22.7	0	0	-1	0	0
30	1	2	-1	1	0
35	0	2	-1	2	-1
40	-1	0	-2	2	-2

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, a full least-squares solution is used to determine the calibrated focal length. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length referred to the calibrated principal point (point of symmetry) are listed for azimuths 0°, 90°, 180° and 270°. The radial distortion is given in micrometers and indicates the radial displacement away from the center of the field. These measurements are considered accurate within 5 um.

III. Resolving Power in cycles/mm

Area-weighted average resolution: 82

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial lines	134	134	113	95	95	67	67
Tangential lines	134	113	95	95	80	57	57

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 B No. 124379, the D No. 124433, and the KL No. 124332 filters accompanying this camera are within 10 seconds of being parallel. The B filter was used for the calibration.

V. Shutter Calibration

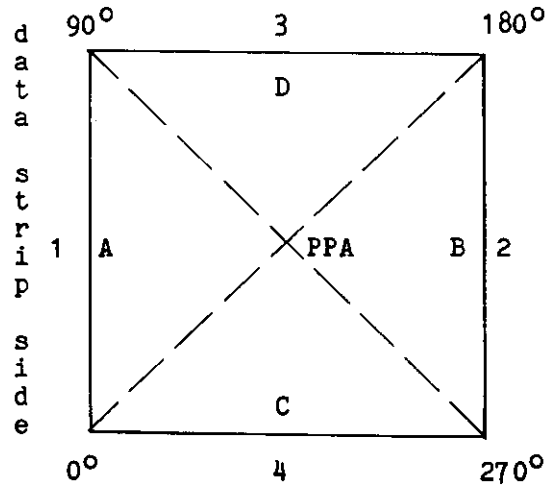
Indicated shutter speed	Effective shutter speed	Efficiency
1/200	3.60 ms = 1/275 s	72%
1/400	1.75 ms = 1/570 s	72%
1/600	1.21 ms = 1/825 s	72%
1/800	0.91 ms = 1/1100 s	72%
1/1000	0.72 ms = 1/1380 s	72%

The effective shutter speeds 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. Magazine Platen

The platens mounted in FK 24/120 film magazines No. 124834 and No. 124839 do not depart from a true plane by more than 13 um (0.0005 in).

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, midside fiducials	0.001 mm	-0.002 mm
Principal point of autocollimation	0.0	0.0
Calibrated principal point (point of symmetry)	-0.018	-0.012

Fiducial Marks		
1	-113.000 mm	-0.002 mm
2	112.997	-0.002
3	-0.010	112.982
4	0.011	-112.985

VIII. Distances Between Fiducial Marks

Midside fiducials

1-2: 225.998 mm 3-4: 225.967 mm

Lines joining these markers intersect at an angle of 90° 00' 19"

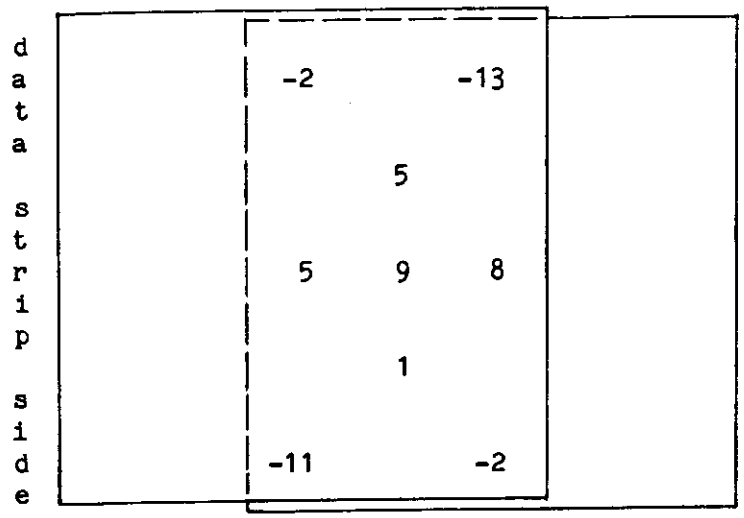
The method of measuring these distances is considered accurate within 0.005 mm.

IX. Stereomodel Flatness

Magazine No.: 124834

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 stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. Resolving Power in cycles/mm

Area-weighted average resolution: 41

Film: Type 2405

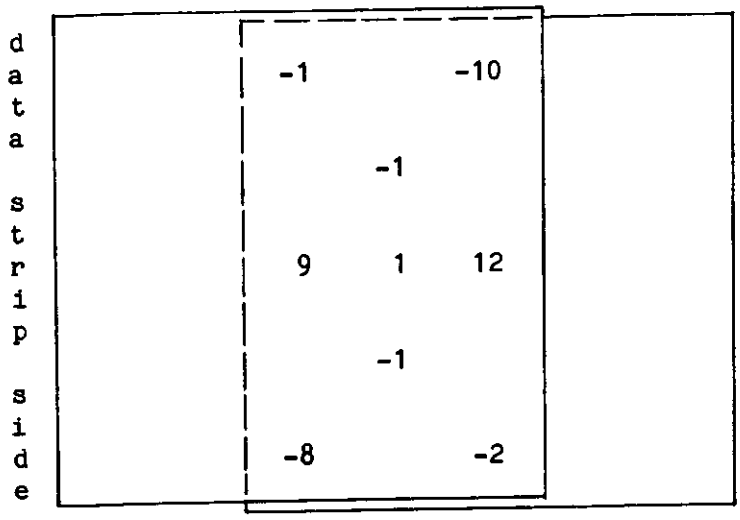
Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial lines	57	57	48	48	40	40	34
Tangential lines	57	57	48	48	40	34	28

IX. Stereomodel Flatness

Magazine No.: 124839

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 stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. Resolving Power in cycles/mm

Area-weighted average resolution: 40

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial lines	57	57	48	48	40	34	34
Tangential lines	57	57	48	48	40	34	28

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FILM RADIAL DISTORTION, STEREOMODEL FLATNESS AND RESOLVING POWER

Magazine No.: 124834

Base/Height ratio: 0.6
Maximum angle of field tested: 40°

Calibrated Focal Length

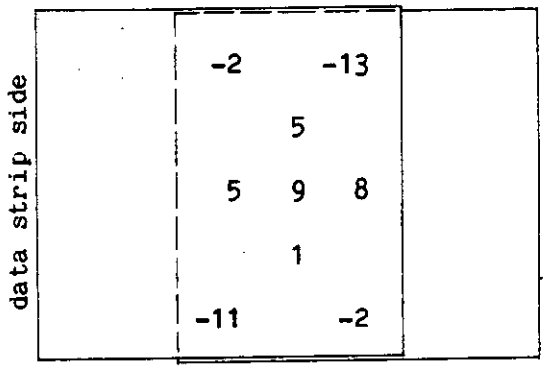
flash plate: 152.871 mm
film: 152.882 mm

IX. Radial Distortion

Field angle	$\bar{D}_c$	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	2	2	0	2	2
15	3	5	2	2	2
22.7	3	5	4	1	0
30	2	5	2	0	2
35	0	-1	1	0	0
40	-4	-7	-3	-4	-1

X. Stereomodel Flatness

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.



Stereomodel test point array
(values in micrometers)

XI. Resolving Power in cycles/mm

Area-weighted average resolution: 41 Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial lines	57	57	48	48	40	40	34
Tangential lines	57	57	48	48	40	34	28

FILM RADIAL DISTORTION, STEREOMODEL FLATNESS AND RESOLVING POWER

Magazine No.: 124839

Base/Height ratio: 0.6
Maximum angle of field tested: 40°

Calibrated Focal Length

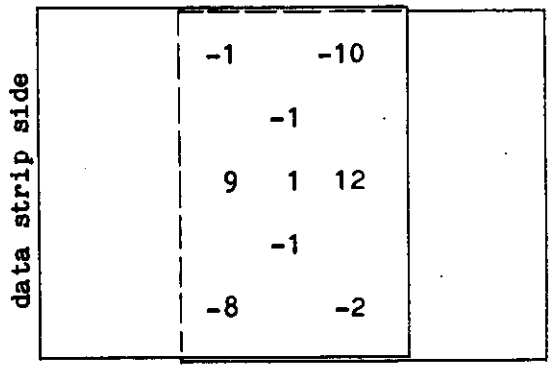
flash plate: 152.871 mm
film: 152.876 mm

IX. Radial Distortion

Field angle	$\bar{D}_c$	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	2	1	0	1	4
15	2	4	1	0	4
22.7	3	5	4	-2	4
30	2	1	2	1	4
35	1	0	3	0	0
40	-4	-8	-3	-5	-1

X. Stereomodel Flatness

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.



Stereomodel test point array
(values in micrometers)

XI. Resolving Power in cycles/mm

Area-weighted average resolution: 40 Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial lines	57	57	48	48	40	34	34
Tangential lines	57	57	48	48	40	34	28

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