# United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

**REPORT OF CALIBRATION**
**of Aerial Mapping Camera**

October 28, 2015

| | | | |
|---|---|---|---|
| **Camera type:** | Zeiss RMK Top 15* | **Camera serial no.:** | 149998 |
| **Lens type:** | Zeiss Pleogon A3/4 | **Lens serial no.:** | 150018 |
| **Nominal focal Length:** | 153 mm | **Maximum aperture:** | f/4 |
| | | **Test aperture:** | f/4 |

**Submitted by:** RIGC (NI)
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**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: 152.802 mm

## II. Lens Distortion

| Field angle: | 7.5° | 15° | 22.7° | 30° | 35° | 40° |
|---|---|---|---|---|---|---|
| Symmetric radial (μm) | 0 | 1 | 1 | 1 | 0 | -1 |
| Decentering tangential (μm) | 0 | 0 | 1 | 2 | 3 | 4 |

| Symmetric radial distortion | | Decentering distortion | | Calibrated principal point | |
|---|---|---|---|---|---|
| $K_0$ | = -0.1400E-04 | $P_1$ | = 0.2389E-06 | $x_p$ | = -0.012 mm |
| $K_1$ | = 0.1011E-09 | $P_2$ | = 0.8298E-07 | $y_p$ | = 0.002 mm |
| $K_2$ | = 0.6530E-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: 103

| Field angle: | 0° | 7.5° | 15° | 22.7° | 30° | 35° | 40° |
|---|---|---|---|---|---|---|---|
| Radial Lines | 159 | 159 | 134 | 95 | 95 | 95 | 95 |
| Tangential Lines | 159 | 159 | 134 | 95 | 95 | 95 | 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 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

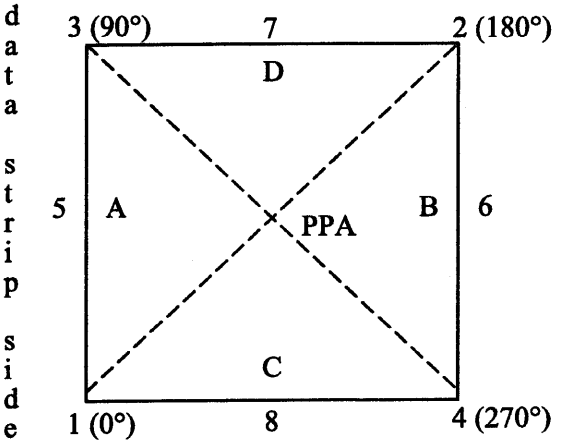
| Indicated Time (sec) | Rise Time (μ sec) | Fall Time (μ | ½ Width Time (ms) | Nom. Speed (sec) | Efficiency (%) |
|---|---|---|---|---|---|
| 1/100 | 4292 | 4040 | 10.41 | 1/130 | 75 |
| 1/200 | 1677 | 1921 | 5.18 | 1/250 | 78 |
| 1/300 | 1285 | 1183 | 3.42 | 1/380 | 77 |
| 1/400 | 910 | 947 | 2.56 | 1/510 | 77 |
| 1/500 | 731 | 728 | 2.05 | 1/630 | 78 |

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 | 0.015 | 0.002 |
| Indicated principal point, midside fiducials | 0.018 | -0.001 |
| Principal point of autocollimation (PPA) | 0.000 | 0.000 |
| Calibrated principal point (point of symmetry) | -0.012 | 0.002 |
| **Fiducial Marks** | | |
| 1 | -112.977 | -113.001 |
| 2 | 113.012 | 113.010 |
| 3 | -112.984 | 112.989 |
| 4 | 113.029 | -113.001 |
| 5 | -112.975 | -0.009 |
| 6 | 113.022 | 0.007 |
| 7 | 0.013 | 112.990 |
| 8 | 0.024 | -113.006 |

## VIII. Distances Between Fiducial marks

| | | | | |
|---|---|---|---|---|
| Corner fiducials (diagonals) | 1-2: | 319.612 mm | 3-4: | 319.614 mm |
| Lines joining these markers intersect at an angle o 90° 00' 01" | | | | |
| Midside fiducials | 5-6: | 225.997 mm | 7-8: | 225.996 mm |
| Lines joining these markers intersect at an angle o 89° 59' 55" | | | | |
| Corner fiducials (perimeter) | 1-3: | 225.990 mm | 2-3: | 225.996 mm |
| | 1-4: | 226.006 mm | 2-4: | 226.011 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.

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2876, dated November 1, 2002.

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