USGS AERIAL CAMERA SPECIFICATIONS

PRECISION AERIAL MAPPING CAMERA

Tested and calibrated aerial cameras for taking aerial photographs are required. Camera systems must be compatible with precision stereoscopic mapping instruments and with analytical mensuration procedures used in photogrammetric surveys and in preparing accurate topographic maps.

1. Camera System "Report of Calibration"

One copy of the "Report of Calibration" from the U.S. Geological Survey, for any camera system to be used, is required to be either on file at the USGS, or submitted with contractor's solicitation bid. A camera system "Report of Calibration" will not be acceptable if more than three (3) years old at the scheduled opening date of the solicitation.

2. Calibration Tests

Tests to determine compliance with these specifications will be performed by the Optical Science Laboratory of the U.S. Geological Survey. The fee for the tests and the arrangements to have the tests performed are the responsibility of the contractor. Delays encountered in having camera systems tested by the USGS Optical Science Laboratory will not be considered reason for the USGS to accept bids lacking such reports. Each camera system submitted for calibration shall be accompanied by all magazines and filters that might be used with the camera. Controls and camera mounts should not be submitted unless requested by the calibrating laboratory.

2.1. Interval Between Tests

The interval between tests for camera system calibrations shall not exceed three (3) years, unless otherwise approved by the Contracting Officer. However, when there is any reason to believe that the dimensional relationship of the lens, fiducial marks, and film plane have been disturbed by partial disassembly or unusual mechanical shock, the camera must be submitted for recalibration at contractor expense.

2.2. Contact for Calibration Tests

U.S. Geological Survey
Optical Science Laboratory
518 National Center
Reston, Virginia 20192
Attention: Chief, Optical Science Laboratory
Phone: (703) 648-4793

2.3. Shipping Address for Calibration Tests

U.S. Geological Survey
Optical Science Laboratory
12201 Sunrise Valley Drive
Reston, Virginia 20192
Attention: Scott Stephens (703) 648-4793

3. Constructional Design Necessary to Permit Testing

To permit testing for determination of calibrated focal length, distortion, resolving power, fiducial mark locations, and stereomodel flatness, the constructional design of the camera shall be as follows:

3.1. Focal Plane

The focal plane shall be accessible from the rear so that a telescope placed behind the camera may view objects in front of the lens, limited only by the size of the focal plane opening. It shall be possible to place the surface of an optical flat having a thickness of 31 mm (1 1/4 in.) on the focal plane of the camera.

3.2. Focal Plane Frame

The focal plane frame shall be so constructed as to permit placement of a glass photographic plate on its surface so that the emulsion surface of the glass photographic plate lies in the true focal plane of the camera. The size of the frame image shall be 23 x 23 cm (9 x 9 inches).

4. Camera Components Required for Testing

4.1. Lens Cone Assembly

The lens cone assembly must be so constructed that the lens and fiducial marks comprise an integral unit. The design of the lens cone shall be such that it maintains the required precise relationship between the lens, fiducial marks, and focal plane on which the film platen shall be positioned. Construction shall be such as to maintain the dimensional relationship of these components under normal conditions of transportation, handling, and use, which can include considerable mechanical and thermal shock. The structure holding these components shall be supported in use in such a manner that stresses likely to change the required dimensional relationships cannot be transmitted to it from the supporting body or mount. The lens cone assembly shall be so designed and manufactured that all parts will return precisely to their original positions, should it be necessary for any reason to disassemble it. However, any disassembly of the lens cone assembly shall require recalibration at contractor's expense before further use.

4.2. Film Platen

Cameras shall be equipped with an approved means of flattening the film at the instant of exposure. The platen against which the film is held shall not depart by more than " 0.013 mm from a true plane, when the camera/magazine vacuum is applied.

4.3. Shutter

The camera shall be equipped with a between-the-lens shutter of the variable-speed type. The range of speed settings shall be such that, for all anticipated combinations of flight heights, aircraft speeds, film speeds, and light conditions, the camera will produce high-resolution photographs. The effective exposure time and efficiency of the shutter as mounted in the camera will be measured at a maximum aperture and shall have a minimum efficiency of 70 percent at a speed of 1/200 second. This test shall be made in accordance with International Standard ISO 516:1999(E). The shutter shall have a speed of 1/400 second and slower for exposing film negatives during calibration.

4.4. Fiducial Marks

Eight fiducial marks are required. The corner fiducial marks shall form a quadrilateral whose sides are equal within "0.50 mm. The midside fiducial marks shall be equidistant within "0.50 mm from the adjacent corner fiducial marks. All fiducial marks and other marks intended for precise measuring shall be clear and well-defined on the aerial film and shall be of such a form and contrast that the standard deviation of repeated reading of the coordinates of each made on a precision comparator shall not exceed 0.002 mm. For cameras with projection type fiducial marks the projected images of all marks must be in sharp focus on the emulsion surface. Drawings in figure 1 show acceptable fiducial marks and their arrangements. Fiducials without a center point mark or intersecting lines will not be acceptable. Glass or plastic mounts for fiducial marks will not be acceptable.

4.4.1. Fiducial Pairs

The lines joining opposite pairs of fiducial markers shall intersect at an angle within one minute of 90 degrees. (See figure 2.)

4.4.2. Fiducial Intersections

The intersection of lines between fiducials --the indicated principal point--shall not be further than 0.030 mm from the point of autocollimation. (See figure 2.)

4.5. Filter

Only glass filters with metallic antivignetting coating shall be used to reduce the illumination for uniform distribution of light over the focal plane format. A microdensitometer trace will be made from the antivignetting coating side of the filter to determine if any deterioration is present that would affect the uniformity of illumination in the focal plane. Deteriorations in excess of 50% of the height of the nominal curve for a lens type will be reason for rejection of a filter. The surface with the antivignetting coating shall be toward the camera lens. The filter shall have surfaces parallel within 10 seconds of arc, and its optical quality shall be such that its addition to the camera shall enhance the uniformity of focal plane illumination and not cause a reduction in image resolution.

5. Lens and Platen/Magazine Identification

The camera or lens number, and the most recent calibrated focal length shall be recorded clearly on the film for each frame either on the inside of the focal plane frame or on a data strip between frames. An alpha numeric mark (or symbol) contained in the platen/magazine which identifies the platen/magazine shall also be recorded on each frame of film. Data markers located on the inside of the focal plane frame shall not exceed 6.35 mm (0.25 inch) in height and 25.4 mm (1.0 inch) in length and shall not obscure any part of the fiducial marks.

6. Optical Requirements

Cameras will be given both a static and an operational type test made after final assembly of all parts of the camera system with the light filter in place on the lens. All tests of the lens cone assembly for determination of the calibration constants, calibrated focal length, distortion and resolution will be made using high contrast targets and AGFA APX Calibration Plates. Cameras will be operationally tested for stereomodel flatness and resolution by exposing Eastman Kodak Double -X Aerographic film 2405 in the camera while mounted on a multicollimator camera calibrator. (The optical requirements for distortion, model flatness, and resolution for various focal length cameras are defined and tabulated in table 1.)

6.1. Distortion

6.1.1. Radial

The distortion in image position as measured along radial lines from the principal point of symmetry. The value of the average radial distortion referred to the calibrated focal length shall not exceed the amount shown in table 1.

6.1.2. Decentering

Decentering distortion is the distortion in image position as measured perpendicular to radial lines from the principal point of symmetry. The value of the decentering distortion shall not exceed the amount shown in table 1.

6.2. Point of Symmetry

The calibrated principal point C the point of symmetry C shall not be further than 0.015 mm from the point of autocollimation for 153 mm focal length lenses and no further than 0.030 mm for all other focal length lenses. (See figure 2 and table 1.)

6.3. Resolution

Radial and tangential resolving power, in line pairs per millimeter, shall be no less than the value listed in table 1 for each focal length lens.

6.4. Test Aperture

All camera-lens calibration tests shall be made at the maximum aperture specified by the manufacturer for that lens.

6.5. Model Flatness

The model flatness test will be performed only for 153 mm and 88 mm cameras. Diapositives will be printed from two film exposures of the collimator targets on micro flat glass plates. Two stereomodels will be analytically formed from these using different halves of the exposures for each model. Each model thus formed will consist of a small fixed number of symmetrically arranged points. The allowable deviation from flatness, taken as the range between the maximum negative and the maximum positive value shall be no greater than " 1/8000 of the focal length of a nominal 6-inch (153-mm) camera, or " 1/5000 of the focal length of a nominal 3 1/2- inch (85-88 mm) camera. If elevation discrepancies exceed this value, the camera will not be acceptable. (See table 1.)

Figure 1
EXAMPLES OF ACCEPTABLE FORMS OF FIDUCIAL MARKS

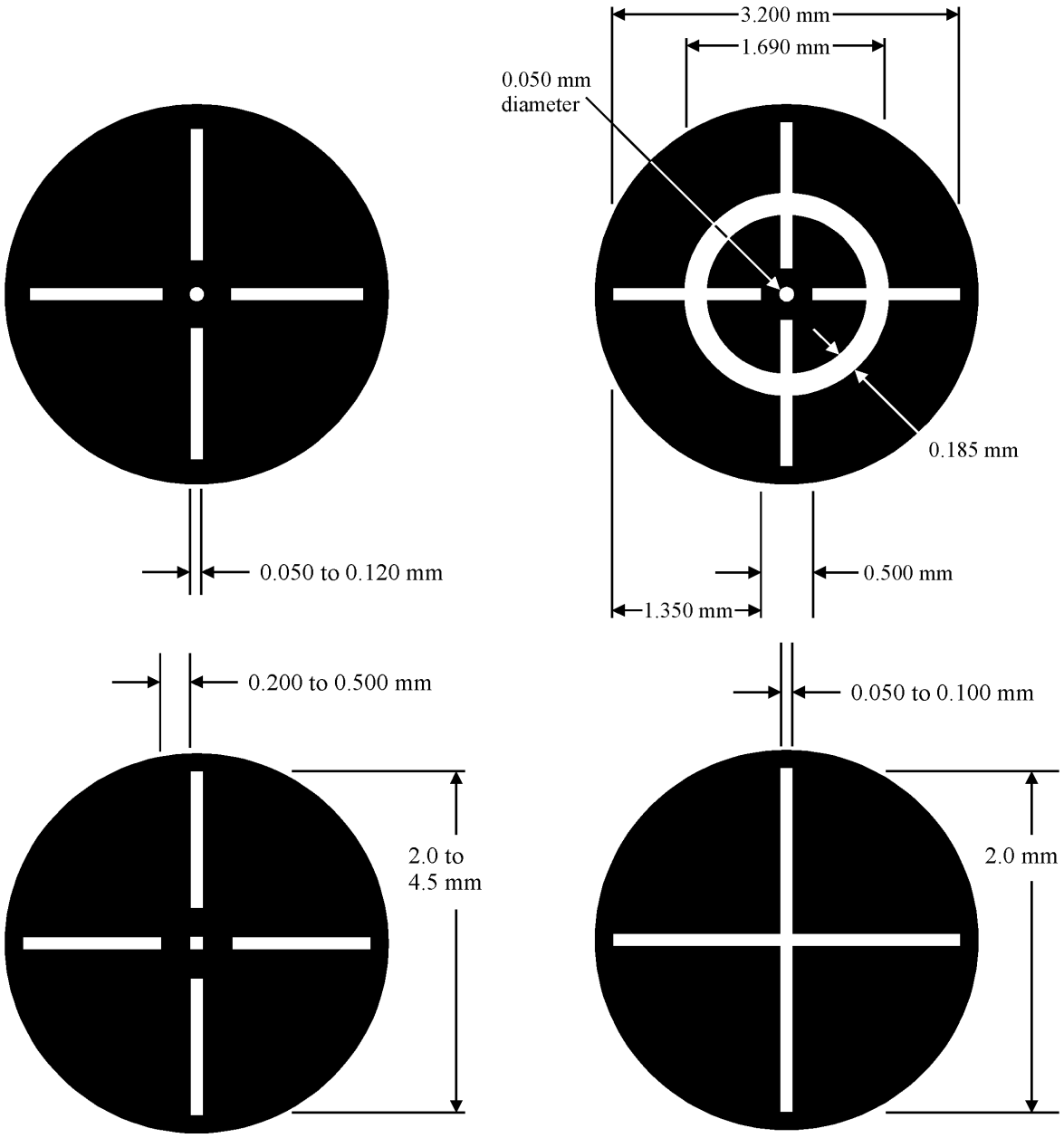
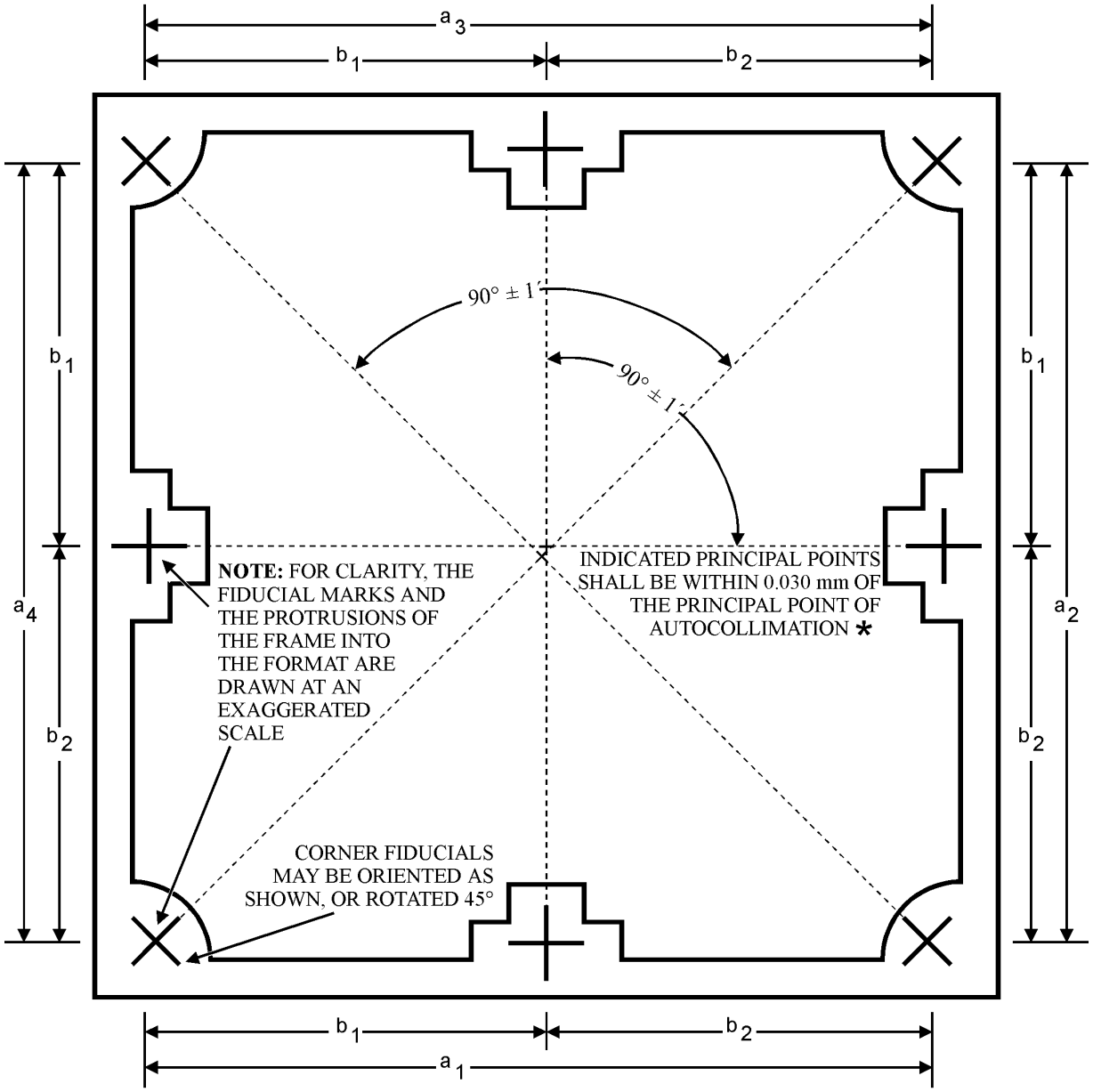


Figure 2
ARRANGEMENT OF FIDUCIAL MARKS



$a_1 = a_2 = a_3 = a_4$ (within 0.500 mm)

$b_1 = b_2$ (±0.500 mm)

* THE CALIBRATED PRINCIPAL POINT - THE POINT OF SYMMETRY - SHALL BE WITHIN 0.015 mm OF THE PRINCIPAL POINT OF AUTOCOLLIMATION FOR 153 mm LENSES AND 0.030 mm FOR ALL OTHER FOCAL LENGTH LENSES.

USGS OPTICAL REQUIREMENTS

Table 1

TABULATION OF OPTICAL REQUIREMENTS

Focal Length	88mm	153mm	210mm	305mm
Focal Length Within	" 4mm	" 3mm	" 4mm	" 5mm
Usuable Angular Field	120E	90E	70E	50E
Field Angle-From Axis out to:	54.5E	40E	30E	22.7E
DISTORTION - At Maximum Aperture				
Radial Distortion - Tolerance (Fm)	" 15	" 10	" 20	" 20
Decentering Distortion - Tolerance (Fm)	-	# 8	-	-
MODEL FLATNESS - (Fm) Total Difference	" 17	" 19	-	-

INDICATED PRINCIPAL POINTS (Fiducial Centers)

The indicated principal points - fiducial centers - shall fall within a 0.030mm radius circle around the principal point of autocollimation.

CALIBRATED PRINCIPAL POINT (Point of Symmetry)

The calibrated principal point - point of symmetry - shall fall within a 0.015mm radius circle around the principal point of autocollimation for 153mm focal length lenses and 0.030mm for all others.

RESOLUTION
Measured on Spectroscopic Plate at Maximum Aperture

Minimum Radial & Tangential Resolution in Line Pairs per mm
LENS HALF ANGLE

Lens		0E	7.5E	15E	22.7E	30E	35E	40E	45E	50E	54.5E
86mm	Wild Super Aviogon II Zeiss S-Pleogon A or equivalent	59	59	49	42	35	30	17	14	12	12
153mm	Wild U. Aviogon Zeiss Pleogon A Jena Lamegon Pl or equivalent	80	80	67	57	57	48	40			
	Wild N-Aviogon II										

210mm	Zeiss Topargon or equivalent	49	49	42	35	29					
305mm	Wild N. Aviotar Zeiss Topar or equivalent	48	48	28	24						