

1995 DRAFT Standards for Aerial Photography

ASPRS Professional Practice Division Specifications and Standards Committee

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1. Camera and Associated Equipment

1.1 Camera

1.1.1 This section refers to aerial cameras of nominal focal length of 152 mm with format dimensions of 230 x 230 mm only.

1.1.2 A metric quality survey camera shall be used, fitted with a lens that is designed to give an absolute radial distortion not exceeding 15 micrometers within 100 mm of the principal point. The film shall be held in the intended image plane during exposure to maintain sharp focus and hold image distortion to less than

that which will produce 20 microns of y-parallax after relative orientation anywhere in the model.

1.1.3 The lens shall be corrected for the spectral range of the film used.

1.2 Calibration

1.2.1 Each camera lens unit shall have been calibrated, tested, and certified by the camera manufacturer or by a calibration center, recognized internationally or approved by the camera manufacturer. The certificate shall show that the camera has been calibrated within three years of completion of the photography. However, when there is any reason to believe 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 the contractors expense.

1.2.2 The organization conducting the photo

mission shall hold a valid calibration certificate and shall supply a copy to the client or the user on request. The calibration certificate shall contain the following information:

- name and address of calibration facility
- date of calibration
- serial number of lens unit
- calibrated focal length (principal distance)
- radial distortion in micrometers at intervals not exceeding 10 mm along each of the four semi-diagonals referred to the axis of best symmetry
- distances between fiducial marks sides and diagonals or their rectangular coordinates
- position of the principal point of autocollimation or of best symmetry with respect to the fiducial center
- radial and tangential resolution for the lens, issued by the manufacturer or after optical readjustment of the lens unit
- measured reseau coordinates in a rectangular coordinate system

1.2.3 The measured distortion shall fall within the limit defined by the manufacturer for the lens type.

1.2.4 The camera shall be recalibrated if 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 resubmitted for recalibration.

1.3 Camera Mount

1.3.1 The camera shall be

installed in a mount which attenuates the effects of aircraft vibration. The mount should be regularly serviced and maintained.

1.4 Filters

1.4.1 Only optical filters provided by the lens manufacturer meeting the same optical specifications shall be used.

1.4.2 The light fall-off in cameras having an angle of view larger than 60 degrees shall be compensated by a graded (antivignetting) filter.

1.5 Photographic Windows

1.5.1 If an aircraft camera has a port glass it shall be preferably 50mm thick but not less than 37mm thick. The surface finish shall be 80/50 or better. Glass material shall be polished crown, group category M, Mil Specs Mil-W-1366F (ASG) October 1975, C-1 optical quality or better.

1.5.2 The camera window shall be mounted in material eliminating excessive mechanical stress to the window.

The opening shall be designed so that the field of view is unobstructed when the camera is mounted.

2. Flying Conditions and Photographic Coverage

2.1 Time of Photography

2.1.1 General Requirements

Aerial photography shall be secured based on the intended use of the photographs as stated in the specification. In general, photography shall not be secured when the ground

is obscured by haze, snow, smoke, dust, flood waters, or environmental factors that may obscure ground detail. Clouds and/or shadows of clouds shall not appear in the photograph. The solar altitude shall be defined by the application but in general it should not be less than 30 degrees when aerial negatives are exposed. Exceptions to the 30 degree requirement may be necessary, if photography is acquired in certain latitudes during winter months.

2.2 Aircraft and Crews

2.2.1 All aircraft shall be maintained and operated in accordance with regulations of the Federal Aviation Administration and the Civil Aeronautics Board. The recommended FAA preflight inspection of the aircraft and instruments must be performed prior to each photographic mission. Aircraft shall have a service ceiling (with operating load of crew, camera, film, oxygen, and other required equipment) not less than 5% above the highest altitude necessary to achieve the smallest photographic scale required. If the project is in controlled air space the appropriate Air Traffic Control Center (AIRTCC) must be contacted. If the project area includes a military installation, the contractor must comply with security regulations.

2.2.2 The camera shall be mounted vertically in the aircraft in a mount designed to isolate the camera from vibration of the aircraft. Angular vibration of the camera shall be reduced to such a level so as to have no significant detrimental effect on resolution.

2.2.3 Individual crew members shall have two years or more apprenticeship in flying photographic missions for aerial surveys. In addition, it is desirable crew members have had meaningful prior experience with the same type camera and aircraft to which assigned.

2.3 Photographic Mission

2.3.1 The camera should be checked to be sure it is properly secured onto the mount and that all cable connections are tight. The camera lens, filters, and camera port must be inspected to assure that the surfaces are not scratched, etched, or discolored and that they are free of foreign particles and condensation.

The camera magazine must be clean, firmly seated on the camera. The transport system must be operating properly and the correct information entered into the data block recording devices. Set the exposure, frame counter number, and fiducial lights for the sensitivity of the film type being used.

Cycle the camera to assure the drive mechanism and shutter are operating smoothly. Complete the basic data sections of the photographic flight report.

2.3.2 Forward overlap in the line of flight shall average not less than 57% or more than 62% at the mean elevation of the terrain, unless otherwise specified. Individual forward overlaps shall not be less than 55% or more than 68% excepting the situation where in a forward overlap in areas of low elevation must exceed 68% to attain the minimum 55% forward overlap in adjacent areas of higher elevation.

Wherever there is a change in direction between two flight lines (other than between adjacent parallel flight lines) junction areas between the adjoining flight lines shall be covered stereoscopically by both lines.

2.3.3 Side Overlap between adjacent parallel flight lines shall be 30% +/- 10% at the mean elevation of the terrain. In addition, any point on the flight line as flown shall not deviate from the flight plan location by a distance greater than 10% of the width of coverage of the photograph.

2.3.4 Departures from flight heights required to produce the desired photo scale shall not exceed -2% or +5% unless changed by Air Route Traffic Control Centers.

2.3.5 Changes in the course of the aircraft between successive overlapping photographs within a flight line shall not exceed 3 degrees.

2.3.6 While exposing aerial photography, the camera shall be compensated for crab of the aircraft, with a resultant error not exceeding 3 degrees.

2.3.7 The tilt within a single frame shall not exceed 4 degrees nor shall the difference in tilt between two consecutive overlapping frames within a flight line exceed 4 degrees. The average tilt for

all negatives of the same nominal scale shall not exceed 1 degree.

2.3.8 The combined effect of aircraft course corrections, crab and tilt shall result in an apparent crab not greater than 5 degrees on successive photographs. Apparent crab is defined as the angle between a line joining fiducial marks in the direction of flight and the line between the indicated principal point and the

conjugate image of the indicated principal point of the adjacent photograph within the same line of flight.

2.3.9 Exposure of the film shall be in accordance with the manufacturer's recommendations and with a goal toward achieving density requirements set forth in paragraph 3.5.3 (Aerial Film and Image Quality.) The negatives shall be clear and sharp in detail, free from light streaks and static marks, and of uniform tone and degree of contrast to permit ground details to show clearly in all scene reflectance, with particular emphasis on pattern recognition in the shadow areas.

2.3.10 All film shall be exposed using the fastest shutter speed possible when the aperture is set at its optimum value in consideration of the optical resolution and image motion.

2.3.11 Each roll of exposed aerial film shall be accompanied by a log containing the following static data:

a. Static Data

- Last names of crew members
- Camera type and serial number
- Lens type, serial number, and calibrated focal length
- Magazine number
- Film type, emulsion batch, roll, cut, and slit numbers and expiration date as shown on the manufacturer's packaging
- Filter type and number

b. Variable Flight Line Data

- Altitude correction data (required each time the aircraft ascends or changes/ altitude)
- Brief description of atmospheric conditions
- Aperture setting
- Shutter speed
- Nominal photo scale
- Area covered
- Date of exposure
- Direction of flight
- % of forward overlap
- Beginning and ending exposure numbers (referenced to the camera counter)
- Start and stop times (local standard time)
- Remarks including:

a. Complete or in-

complete flight
line

b. Blanks frames,

run-off, rejections, and reasons for rejections

c. Any unusual situation that occurs during the flightline.

2.3.12 Each roll of aerial film shall have an unexposed leader at least ten frames in length. This unexposed leader will be used to expose a sensitometric wedge before processing. Whenever a roll of aerial film is used in a discontinuous fashion such as from one day to the next or from a morning flight to an afternoon flight, a spacer at least four frames in length shall be rolled forward just prior to the commencement of taking new photographs.

2.3.13 Every effort shall be made to avoid breaks within individual flight lines. Where breaks within a flight line are necessary, the entire flight line composed of the resulting segments shall meet all of the requirements set forth in these Specifications. Where breaks occur, these shall have an overlap of at least four frames to ensure a stereo model of overlap or tie. All photos within a single flight line shall be acquired with the same aerial camera and with the camera oriented in the same direction.

2.3.14 Exposures acquired to replace rejected, damaged, lost or otherwise destroyed exposures shall fully conform to these Specifications. Replacement exposures shall be acquired with the same aerial camera (s) used to acquire the original exposures and shall be exposed as nearly as possible to the same day and lighting conditions as the original exposures.

2.3.15 The final 10 frames (or more) on each roll shall be reserved for test processing purposes. These test frames shall be representative of the terrain covered on the exposed roll. The test frames should be exposed at the same altitude, relative aperture and shutter speed as used for majority of the roll. *When possible*, the process should be

adjusted for improper exposure.

2.4 Preliminary Checks

2.4.1 Each roll of aerial film shall be processed as soon as possible after it is exposed. Navigation of the flight lines and image quality shall be quick-checked for compliance with these Specifications.

2.4.2 As soon as possible after processing each roll of aerial film, diapositives shall be prepared for two consecutive stereo models. The models shall be selected at a random location within each roll of film. Each model pair shall be checked in a stereo-plotter for the ability to clear parallax and to transfer scale between models. Results of these tests shall be documented to identify model numbers tested, dates of tests, Z instrument readings for points read in the triple lap area. The purpose of the test is to determine if the camera functioned properly during the mission and the film was in good contact with camera platen at the time of exposure. If the test indicates a malfunction, the photography is to be reflown.

2.4.3 Reflights shall be immediately ordered for the purpose of securing replacement exposures for all frames which fail to meet minimum standards set forth in these specifications, provided ground conditions have not yet terminated the photographic "season."

3. Aerial Film and Image Quality

3.1 Aerial Film

3.1.1 The type of film to

be used shall be unexpired and have a dimensional stable polyester base.

3.1.2 Color and panchromatic emulsions shall be sensitive to the entire visible spectrum with an extended red sensitivity. Color infrared and black and white infrared emulsions shall be sensitive to the visible and near infrared spectrum from 400 to 900 nanometers.

3.1.3 Extreme care shall be exercised to insure proper exposure to minimize vignetting due to differential exposure. This differential shall not exceed that which would result from a basic 1/3 stop difference in exposure.

3.1.4 The conditions of the film stock to be used shall be such that when the unexposed film is processed:

- It shall be free of stains, discoloration, or brittleness that can be attributed to aging or improper storage: and
- The base-plus-fog density for all negative films and the minimum-density for all color reversal films shall conform to the manufacturers predicted density levels.

3.2 Storage and Handling

3.2.1 Storage and handling of all photographic film shall be in accordance with the manufacturer's recommendation. All aerial film shall be stored in the original containers to prevent any exchange in moisture between the rolls and their surroundings up to the time they are exposed. The film shall not be rolled tightly on spools or in anyway stretched, buckled, distorted, or exposed to direct sunlight or other sources of heat.

3.2.2 Adverse storage conditions can affect the color emulsion layers, as well as overall sensitivity. Unexposed color films that are to be stored for several

months, shall be stored at 0 to -10 degrees Fahrenheit (-18 to -23 degrees Celsius).

3.2.3 Color infrared film stored in the field prior to use shall be refrigerated at all times at a temperature of approximately 40 degrees Fahrenheit (4 degrees Celsius) or lower,

3.3 Processing and Drying

3.3.1 All black and white and color aerial film shall be processed in a sensitometrically controlled process using the manufacturers recommended process monitoring system. Prior to processing the film a calibrated, 21-step sensitometric wedge (in .15 nominal density increments) shall be exposed on one end of the roll of film and become a permanent part of the roll.

3.3.2 The film shall be thoroughly fixed and washed to insure archival quality. The residual thiosulfate content of the processed black and white film should not exceed 0.04 milligrams per square inch as measured using a Kodak Hypo Estimator and Hypo Test Solution HT-2 or other approved method.

3.3.3 Processing and drying of film shall be carried out without affecting the metric quality specified in paragraph 3.4.1. At no time shall the film be subjected to extreme temperature and humidity changes.

3.3.4 The processed film shall be free from chemicals, stains, tears, scratches, abrasions, water marks, finger marks, lint, dirt, light streaks, static marks, and any other physical defects that would interfere with the intended purpose of the photography.

3.4 Metric Quality of Processed Film

3.4.1 The original processed film or contact diapositives produced from them shall not contain residual Y-parallaxes after relative orientation in excess of 20 micrometers anywhere in the model. The dimensional change in any direction across a 9" distance shall not exceed 127 micrometers.

3.5 Image Quality of Processed Film

3.5.1 The imagery on the aerial film shall be clear and sharp and evenly exposed across the format. The film shall be free from clouds, cloud shadows, smoke, haze, snow, shadows, crimps, scratches, and any other blemishes which interfere with the intended purpose of photography. Allowances will be made for unavoidable shadows, permanent snow fields, or reflectance from water bodies.

3.5.2 When there is doubt concerning the sharpness (resolution) of images obtained on the original film, a comparison will be made of well-defined edges by:

- A 3X enlargement on film, and/or
- By comparison to a calibrated matrix in a visual edge-matched comparator, and/or
- By edge traces in a microdensitometer, and/or
- By a combination of these methods.

If the imagery is obviously degraded the original film shall be rejected for poor image quality.

3.5.3 Density measurements will be taken on processed film using a transmission densitometer with a 2mm probe for scales 1/36,000 and larger and with a 1mm probe for scale 1/36,000 and smaller. Readings will be made no closer than 1 1/2' from the image edge. Densities for black and white films shall be:

- a. Black and white negative film density measurement.

Max Base-Plus-Fog

.20 +/- .10

D-Min

.40 +/- .10

D-Max

1.50

Base plus fog shall be measured between and at the edges of the negative frame, and conform with the manufacturers predicted density value. The minimum usable density shall be no less than 0.30 and maximum usable density no more than 1.50 after deducting base plus fog density. The average

density range aim point should be 1.0 and the minimum no less than 0.55.

3.5.4 Maximum photographic image and color quality control is required when exposing and processing color infrared film. The color infrared film shall be exposed and processed to the manufacturers recommendations unless otherwise required in project specifications. It is recommended that the following color balance test be conducted prior to using the film on a project.

Remove approximately 3 feet of unexposed film from the outside wrap. Expose a 21-step sensitometric wedge (0.15 density increments) on the film strip and process it using the manufacturer's recommended process tolerances. The color balance shall be established by obtaining two points on the characteristic curve at $D=1.0$, one being at the mid point of the two visible-light curves, and the second at the point of

intersection of $D=10$ with the IR-curve. A color balance aim point of 20 has been determined empirically to be optimum for most applications. The processed stepwedge will become part of the roll from which they were removed. These stepwedges will be maintained on file and used as criteria for accept-able color balance of the exposed and processed film. Exposed and processed film which does not have a color balance within $\pm .06$ Log E of the color balance aim point will be cause for rejection.

3.5.5 The camera instrument panel and all fiducial marks shall be sharp and clearly legible on all processed film.

3.5.6 All exposed color films should be processed as soon as possible to avoid undesirable color balance shifts.

4. Deliverable Products

4.1 Aerial Film

4.1.1 The exposed/processed aerial film should be delivered in accordance with the stipulations of delivery schedule and delivery address. All flight maps used for the acquisition should accompany the aerial film, as an aid for the quality control inspection.

4.1.2 Each processed roll or partial roll of aerial film shall be kept in roll form, on the spool, and in the metal or plastic container supplied by the film manufacturer. Rejected exposures shall not be removed from any roll.

4.2 Photo Index Prints and Original Index Negatives

4.2.1 A photo index can be assembled from positive photographic prints made from the accepted aerial photos. If a photo index is required it shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address.

4.2.2 The prints shall be trimmed as specified by the user and without removing the fiducial marks. The prints shall be matched by overlapping corresponding images along the flight line. The prints for each adjacent flight line shall overlap in the same direction. Air base lengths shall be averaged in the course of matching successive pairs of photographic images along the flight line. Adjoining flight line assemblies shall be adjusted in length, until all adjacent flight strip images can be matched as completely as is practicable throughout the entire project area. Upon completion, the assembly shall show clearly the labeling of each photograph.

4.2.3 Appropriate notations identifying several important and prominent geographic and cultural features shall appear on the index. The roll number of the film and the exposure number on every tenth (10th) photograph as well as the first and last exposure on each line of each index sheet shall be accentuated by the use of a narrow, short, strip overlay of white paper on which the appropriate numbers have printed. The flight line number shall be prominently accentuated at each end of each strip of photographs on each index sheet. All overlay lettering and numbering shall be neat and legible on both the index assembly and its photographic copies, and shall not interfere with the principal map features or with the symbols, nomenclature and numbers which are not accentuated on the individual photographs.

4.2.4 A title/legend shall be included on each photo index sheet including the following information:

Project designation, period of photography, scale of index (graphic scale), scale of photography, indication of North, aerial camera type and focal length, owner's name, vendor's name, approximate geographical or grid coordinates of center of project.

4.2.5 The assembly of photographs shall be copied onto photographic film so that prints can be made. Whenever the photo index cannot be fully represented on one sheet, it shall be reproduced sequentially on as many sheets as necessary. The photographic images of each sequential sheet of the photo index shall overlap the photographic images of the adjoining sheet by at least two (2) inches as measured at the delivery scale of the photo indexes.

4.3 Flight line map index

4.3.1 A photo spot index shall be produced for all the accepted aerial photography obtained under this contract. The photo spot index will be drawn on new, clean, 7-1/2 minute quad sheets, unless another map base is specified elsewhere within this contract. The photo spot index shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address.

4.3.2 All actual flight lines of the acceptable aerial photography shall be accurately located and drawn on the photo spot index and numbered. All photo center points shall be indicated along the flight lines. The first and last exposure of each flight line shall be shown by a filled in circle and numbered by the roll, flight line, and frame number, (e.g., first 1-5-1, last 1-5-28). Every fifth exposure shall be shown by a filled in circle and numbered by frame number only (e.g., 5, 10, 15, 20). All other exposures shall be indicated by dash across the flight line without a number.

The center point of each frame of photography shall be accurately plotted to represent as nearly as possible its true location and connected by a line representing the actual flight line.

4.3.3 A title/legend shall be included on each spot index sheet including the following information: Project designation, period of photography, scale of index (graphic scale), scale of photography, indication on North, aerial camera type and focal length, owners name, vendor's name, approximate geographical or grid coordinates of center of project.

4.4 Contact prints

4.4.1 One set of contact prints shall be made on an automatic dodging printer on medium weight resin-coated paper on which ink and pencil can be used on both sides. The contact prints shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address.

4.4.2 The photographic emulsion shall be of fine grain and have a suitable light sensitivity range and contrast for the making of prints from the aerial film exposed under this contract. Outdated materials shall not be used.

4.4.3 Processing, including exposure, development, fixation, washing, and drying of all photographic materials, shall result in finished photographic prints having a fine grain quality, a normal, uniform density, and such tone and contrast that all photographic details shall show clearly within the dark and light tone areas as well as in areas with intermediate tones. Adequate grades of contact paper and proper laboratory procedures shall be used to achieve the best prints possible. Excessive variance in tone or contrast between adjoining prints shall be cause rejection.

4.4.4 Photographic prints shall be trimmed as specified by the user. When trimmed always leave the camera fiducial marks, GPS and other data recorded in the border of each image. Prints showing fiducial marks of inadequate clarity and definition, or prints omitting fiducial marks, shall be rejected.

4.4.5 All prints shall be clear and free from chemical stains, blemishes, uneven spots, air bells, light streaks or fog, and other defects which would, in the opinion of the owner, interfere with their intended purpose. Prints shall be delivered to the owner in a smooth, flat, and usable condition.

4.5 Film diapositives

4.5.1 Diapositives shall be made on an automatic dodging printer on stable base 9-1/2" x 9-1/2" sheet film, 0.007 inches thick, and specifically intended for diapositive use. The image portion of the aerial negative shall be centered on the diapositive. The diapositives shall be delivered to the owner in accordance with the delivery schedule and delivery address.

4.5.2 The photographic emulsion shall be of fine grain and have a suitable light sensitivity range and contrast for the making of diapositives from the aerial film exposed under this contract. Outdated materials shall not be used. The diapositive film will have been stored and transported in a clean, smooth, and flat condition from the moment of manufacture.

4.5.3 Processing, including exposure, development, fixation, washing, and drying of all photographic materials, shall result in finished diapositives having a fine grain quality, a normal, uniform density, and such tone and contrast that all photographic details shall show clearly within the dark and light tone areas as well as in areas with intermediate tones. Adequate grades of diapositive film and proper laboratory procedures shall be used

to achieve the best diapositive possible. Excessive variance in tone or contrast between adjoining diapositives shall be cause rejection.

4.5.4 All diapositives shall be clear and free from chemical stains, blemishes, uneven spots, air bells, light streaks or fog, and other defects which would, in the opinion of the owner, interfere with their intended purpose. Prints shall be delivered to the owner in a clean, smooth, flat, and usable condition.

5. Film Titling and Documentation

5.1 General requirements

All lettering shall be positioned as closely as possible to the inside leading edge of the format of the exposure. The characters used for making the exposures shall be 3/16 inch, drafted or stamped with opaque ink to avoid deformation of the film as what is manifested with heat embossed titlers. The lettering shall clearly show on all copies of the photographs and in the positions specified by the requester.

5.2 Documentation

5.2.1 Each exposure shall be marked beginning in the left-forward corner of the format with the numerical abbreviation of the date in either the American or European usage as specified.

5.2.2 The time of day in hours and minutes shall be shown on the first and last exposures of each flight line midway between the date and the middle forward fiducial.

5.2.3 The roll-strip-exposure number shall be marked at the right-forward corner of the format.

a. All film on a single spool shall bear the same unique roll number.

b. The photographic strips shall be flown and numbered as specified in the Detail Sheet in an unbroken series.

5.2.4 The scale of the imagery rounded to the nearest whole thousand (e.g. 1:31680 will be 32) shall be positioned immediately to the right of the middle forward fiducial.

5.2.5 The designated project symbol as specified in the data sheet shall be placed midway between the forward middle fiducial and the right forward corner.

5.2.6 The initials of the Contracting Agency (e.g. BLM) shall be positioned immediately left of the forward middle fiducial.

NOTE: *The material for Camera and Associated Equipment has been adapted from:*

"Specifications for Vertical Aerial Photography, 2nd Edition," The British Air Survey Association and the Land Surveyors Division of the Royal Institution of Chartered Surveyors, July, 1984.