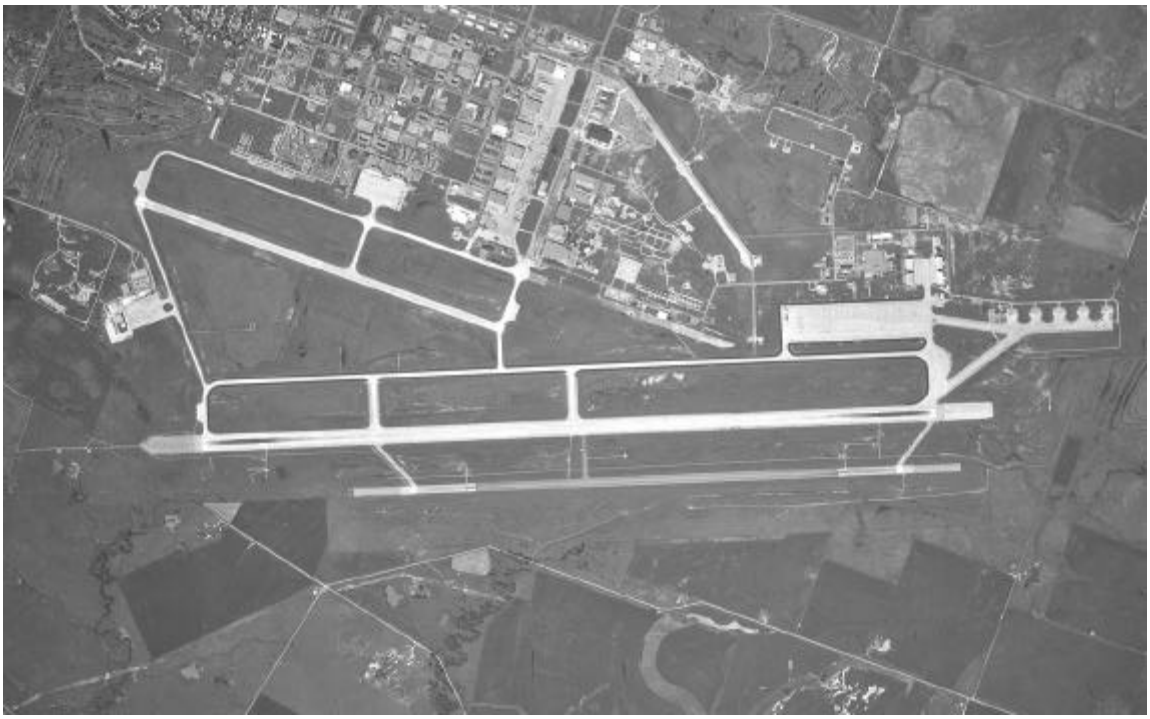
# General Specifications for Aeronautical Surveys

## Volume II
## Airport Aerial Photography

**Supplemental Instruction**
**Version 9A, April 18 2001**

http://www.ngs.noaa.gov/AERO/aero.html



Federal Aviation Administration

National Oceanic and Atmospheric Administration

National Geodetic Survey

VERSION 9A
April 18, 2001

# AERIAL PHOTOGRAPHY
# SUPPLEMENTAL INSTRUCTIONS
# FOR THE
# AERONAUTICAL SURVEY PROGRAM
# REMOTE SENSING DIVISION
# NATIONAL GEODETIC SURVEY

NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

TABLE OF CONTENTS


| SUBJECT | SECTION |
|---|---|
| GENERAL | 1 |
| DELIVERABLES | 2 |
| DELIVERY SCHEDULE | 3 |
| EQUIPMENT AND MATERIAL | 4 |
| CAMERA | 4.1 |
| FILM | 4.2 |
| AIRCRAFT | 4.3 |
| FLYING HEIGHT | 5 |
| WEATHER, SOLAR ALTITUDE, AND TIME OF YEAR | 6 |
| NAVIGATION | 7 |
| TILT | 8 |
| CRAB | 9 |
| OVERLAP AND SIDELAP | 10 |
| PHOTOGRAPH LABELING | 11 |
| FILM SHIPMENT AND PROCESSING | 12 |
| IMAGE QUALITY | 13 |
| EXPOSURE | 14 |
| REVIEW | 15 |
| ATTACHMENTS | |
| Photographic Flight Report | A1 |
| Photo. Flight Report Instructions | A2 |
| Electronic Exposure Data File Format | A3 |
| Way-Point File Format | A4 |
| Film Can Labels | A5 |
| Film Transmittal Letter | A6 |

# AERIAL PHOTOGRAPHY
# SUPPLEMENTAL INSTRUCTIONS
# FOR THE
# NATIONAL GEODETIC SURVEY
# AERONAUTICAL SURVEY PROGRAM

## 1. GENERAL

These Supplemental Instructions (SUPPINST) specify requirements for aerial photography needed to support the Aeronautical Survey Program (ASP). The ASP is administered by the National Geodetic Survey (NGS), National Ocean Service (NOS) in accordance with a Federal Aviation Administration (FAA)/ National Ocean Service Interagency Agreement.

The following conventions have been adopted for this document. The term “should” implies that compliance is not required, but is strongly recommended. The term “shall” and “will” mean that compliance is required. All times will be recorded in Coordinated Universal Time (UTC).

## 2. DELIVERABLES

CONTRACTOR:

a. LABOR, EQUIPMENT AND SUPPLIES - The Contractor will provide all labor, equipment (including aircraft and metric camera), supplies and material (including film) to produce and deliver exposed film and related products as required under this SUPPINST.

b. FILM - The Contractor will deliver both an Exposure Test and Regular Production (see Section 3). For both cases, the Contractor will deliver the original, exposed, near-vertical, metric quality, undeveloped aerial photography over airports. For the Exposure Test the Contractor will determine a flight line approximately over the center of a convenient airport. For Regular Production, the Contractor will fly pre-determined flight lines supplied by the Government (see list of airports with separate Project Instructions). For further film requirements, see Sections 3, 4.2 and 12.

c. FLIGHT REPORTS - Submit the original Photographic Flight Reports (NOAA Form 76-15) marked “ORIGINAL” in blue ink, with the film, and a copy directly to NGS. For samples see Attachments 1 & 2, and for delivery instructions see Section 14.

d. ELECTRONIC EXPOSURE DATA (EED) FILES - Send an EED file for each roll of film. Submit the original, raw EED data files with the film and the final EED files with the Final Report. Explain all changes to the raw data files in the Final Report. See EED format in Attachment 3, and delivery instructions in Section 14.

e. TRANSMITTAL LETTERS - Send film transmittal letters with each film shipment (see sample in Attachment 6), and a transmittal letter with the Final Report.

f. CAMERA CALIBRATION - Supply the USGS Camera calibration certificate for each camera planned for use, directly to NGS.

g. CAMERA MAINTENANCE - Provide a preventive maintenance certification for each camera to be used to acquire aerial photography directly to NGS (see Section 4.1).

h. CAMERA WINDOW - Report the physical characteristics of any camera window used to NGS (see Section 4.3).

i. FILM SHIPMENT - See Sections 3 and 12 for instructions.

j. FILM SHIPMENT REPORTING - The Contractor will notify NGS of each film shipment's contents and date of shipment by transmitting to NGS a paper or digital copy of the Photographic Flight Report (marked "copy" at the top) and a copy of the film transmittal letter via email or facsimile. This will be done the same day the film is shipped to the film processing contractor. See Section 12.

k. UNUSUAL CIRCUMSTANCES - The Contractor will also notify NGS of any unusual circumstances that occur during the performance of this SUPPINST which might affect the deliverables or their quality and especially of any deviation from this SUPPINST. This may be included in the weekly email required below, unless urgent.

l. STATUS REPORTS - The Contractor will submit project status reports via email to the contacts in Section 16 every week, until the work is complete. These reports will include a list of airports where photography is completed, with dates completed; film shipped, and dates; and any unusual circumstances, deviations from this SUPPINST, equipment malfunctions, and/or any disturbance of the camera.

m. FINAL REPORT - The Contractor will supply to NGS a Final Report including, at least, these sections:

1. Work performed under this SUPPINST, discuss each

deliverable including: the maximum range from the base station, the mean overlap, the mean tilt, the mean crab, and an explanation of the photograph labeling;

2. Equipment used to perform this work, including hardware models and serial numbers, and software names and versions;
3. Discussion of exposure settings used, filters used, etc;
4. Discussion of the Contractor's Quality Control Plan.
5. Any unusual circumstances or problems, including equipment malfunctions, (including those already reported);
6. Any deviations from this SUPPINST (including those already reported); and
7. Any recommendations for changes in the SUPPINST for future work.

Requests to exceed or deviate from these SUPPINST or the Project Instructions will be considered if written justification is provided to NGS in advance.

This SUPPINST does not require ground-survey field work, cartographic data compilation, aero-triangulation, or establishing/photo-identifying ground control.

All original aerial negatives, from the instant of exposure, and other deliverables required through this SUPPINST, are and shall remain the property of the United States Government. These items include the Contractor-furnished film containers, film spools, and 3.5 inch floppy disks. However, film is the responsibility of the contractor until it is delivered to the NOAA film processing contractor.

GOVERNMENT:
The government will provide to the Contractor:

a. Project Instructions (a separate document) providing specific project information, containing any unique project requirements and the following attachments:

i. a listing of airports to be photographed.
ii. flight maps, showing the labeled flight lines
iii. digital way-point files, indicating the two end-points of the required flight lines for each airport (see Attachment 4 for the way-point file format).
iv. Blank film processing instruction labels, "Do Not Expose To" labels, and address labels, see Section 12 and Attachment 5.

b. Supplemental Instructions (this document)

c. The government will assign unique camera designators (see

Section 4.1).

## 3. DELIVERY SCHEDULE

EXPOSURE TEST - An exposed film sample is required prior to beginning the project. After test flight(s) over the approximate center of a convenient airport, the Contractor will cut the films and ship the exposed sections with their corresponding original Photographic Flight Report, original raw EED file, and transmittal letter directly to the NOAA film-processing Contractor. This data will be processed by the NOAA film processing Contractor and then forwarded to NGS for review. NGS will review this data as soon as possible and notify the Contractor of the results of the processing and the review. The Contractor will not proceed with production until they have received approval from NGS.

REGULAR PRODUCTION - Exposed film, with its corresponding, original Photographic Flight Report, original raw EED file, and transmittal letter will be shipped directly to the NOAA film-processing Contractor within 20 days of exposure. If necessary to meet this time constraint, the Contractor may cut the film and ship the exposed section. Normally FULL exposed rolls should be shipped to the processing Contractor. However, rolls approximately 2/3 full will be acceptable, if necessary, to allow for faster turn-around for review. The 3.5 inch floppy disk containing the original raw EED file shall be taped to the outside of the film canister lid for shipment. See Section 12, FILM SHIPMENT AND PROCESSING, for shipping address and additional requirements.

All deliverables will be received by the film processing Contractor and/or NGS, as specified, no later than the date in the Project Instructions .

## 4. EQUIPMENT AND MATERIAL

### 4.1 CAMERA

The aerial camera used for this SUPPINST will meet the following specifications:

- Single lens metric camera with quality equivalent to or better than a Wild RC 20/30 or Zeiss RMK-A 15/23, with Forward Motion Compensation.

- 9 inch x 9 inch format

- Between-the-lens, variable speed shutter

- Six inch (153 ±3 mm) focal length lens having a usable angular field not less than 90 degrees.

- Minimum resolution of 15 lines/mm with an Area Weighted Average Resolution (AWAR) not less than 55 lines/mm.

- Decentering (formerly called tangential) distortion will not exceed 0.008 mm and radial distortion will not exceed 0.010 mm.

- Model Flatness; total difference, +/- 0.019mm

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

- 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 0.030 for all others.

- Equipped with a vacuum or pressure device for holding film flat against a platen at the instant of exposure. Platen departure from a true plane will not exceed +/- 0.0005 in. (0.013 mm) when the camera/magazine vacuum is applied.

- Record on each exposure at least 8 fiducial marks. Marks will be located in each corner of the format and at the center of each side. The fiducial marks shall be clearly visible and sharp on every negative.

- TIMES AND DATES - Record on each exposure a clock displaying correct Coordinated Universal Time (UTC), and the correct date, if data recording is available. Note, the time is also recorded in the EED file and on the Photographic Flight Report. **ALL THREE REQUIRE UTC TIME (SAME AS GMT), ACCURATE WITHIN TWO MINUTES.** Recommend a daily time check for all clocks. Also ensure that all dates recorded are correct (double check that the clocks are not set 12 hours off so that the date cycles incorrectly at noon).

- Record on each exposure the lens identification number and focal length, see also Section 11.

- Record a level bubble on each exposure, if possible.

- Record a film title on each exposure, if camera capable (see Section 11). Note, any label(s) on the photographs shall conform to the specifications in Section 11.

The camera shall be installed in a mounting which attenuates the effects of aircraft vibration.

The camera’s Forward Motion Compensation feature shall be used for all photography under this SUPPINST.

In addition to the specific camera requirements, a valid certificate of calibration (no older than three years) from the Optical Science Laboratory of the U.S. Geological Survey (USGS) will be submitted to NGS for each camera to be used during this contract. The fee for the tests and the arrangements to have the tests performed are the responsibility of the Contractor. The calibration certificate(s) shall be submitted to and approved by NGS prior to camera use under this contract. Upon approval of a calibration certificate, NGS will assign a unique camera designator for the camera and notify the Contractor. The Contractor will ensure that the correct camera designator appears on each exposure (see Section 11 and Attachment 3).

Also, the Contractor will supply certification to NGS that preventive maintenance has been satisfactorily completed within the last two years for each camera to be used for this SUPPINST.

All camera system malfunctions shall be recorded, and NGS notified. A malfunction is defined as a failure anywhere in the camera system that causes an interruption to the normal operation of the camera. Also, record and report any malfunctions in the EED collection system.

After any disturbance of the camera that might affect its calibration, or 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 Contractor will notify NGS, the camera will be recalibrated before further use - at the Contractor's expense, and the Contractor will submit the new certificate of calibration to NGS.

## 4.2. FILM

The Contractor should submit only full (or nearly full) rolls of film, unless meeting the 20 day deadline discussed in Section 3. However, rolls approximately 2/3 full will be acceptable, if necessary, to allow for faster turn-around for review.

The film used for the SUPPINST will be AGFA 200 PE, or equivalent, and will be purchased by the Contractor. A proposal for the use of "equivalent" film will be submitted to NGS prior to use. NGS will notify the Contractor if the "equivalent" film is approved, and also the appropriate gamma for that film. A roll of film will not be exposed after its expiration date.

Only optical filters provided by the lens manufacturer or meeting the same optical specifications shall be used. An antivignetting filter will be used during all photography under this SUPPINST. AGFA 200 PE has an extended red layer in the emulsion allowing the use of a 420 Nanometer (Color) filter. The 420 nanometer filter will facilitate photography of yellow, red, and orange leaves in autumn. All filters used under this SUPPINST should have been checked during the most recent camera calibration. See also Section 14.

Film will be stored, handled, and shipped in accordance with manufacturers recommendations, especially regarding the storage temperature. Film will be treated with extreme care both before and after photography, especially with regard to temperature and humidity. Keep film in its original container until as close to flight time as possible to reduce moisture transfer once the container is opened. Photographic film containers shall not be exposed to direct sunlight or other sources of heat. At the end of each flying day, film (including loaded film magazines and

cassettes) will be removed from the aircraft if the inside temperature of the aircraft is expected to exceed 85 degrees Fahrenheit. Likewise remove the film if the temperature may go below freezing.

The beginning of each roll of film should have a 7 foot leader of blank film, and a 3 foot leader at the end. Note, unexposed film that exceeds 10 feet in length should be cut from a roll of film before shipping for processing. A roll of aerial film shall consist only of exposures made with the same camera system (lens, cone, and magazine). Film spools having a flange diameter of approximately 5 3/16 inches (13.3 cm) shall be used, and only that length of film which can be wound on a spool without strain, leaving at least 1/8 inch (3 mm) of flange exposed, shall be placed on each spool.

Accompanying each roll of film will be a filled-in film processing instruction label defining the characteristics of the film (wrap inside/outside, leader lengths, etc.), a “DO NOT EXPOSE TO” label, and an address label. Instructions for these labels are included in Section 12, the shipping address in Section 2, and samples in Attachment 5.

## 4.3 AIRCRAFT

The type of aircraft used shall be stated on the Photographic Flight Report (Attachment 2, Item #12) and all aircraft used in the performance of this SUPPINST will be maintained and operated in accordance with all regulations required by the Federal Aviation Administration. Any inspections or maintenance of the aircraft for performance of this SUPPINST which results in missed photographic weather will not be considered as an excusable cause for delay.

The design of the camera opening in the aircraft shall be such that the field of view is unobstructed when a camera is mounted with all its parts above the outer structure. The field of view shall, so far as is practicable, be shielded from air turbulence and from any outward flows, such as gases and oil.

NGS recommends that a camera port window not be used. If a camera port window is used, it shall be: (1) mounted in material eliminating mechanical stress to the window; (2) free of blemishes, dirt, significant scratches, etc.; (3) and shall not degrade the resolution or the accuracy of the camera (see Section 4.1). The physical characteristics of the window (such as size, thickness, smoothness, flatness, parallelism, glass quality, and optical transmissivity) shall be reported to NGS prior to use.

## 5. FLYING HEIGHT

The flying height above the airport elevation should be calculated from the scale provided in the way-point files. Normally the flying height is between 14,700 feet and 15,500 feet above the airport elevation. Departures from specified flight height shall not exceed 2 percent low or 5 percent high for all flight heights up to 12,000 feet above mean ground elevation. Above 12,000 feet, departures from specified flight height shall not exceed 2 percent low or 600 feet high. Note, the altitudes entered into the Photographic Flight Report (see Attachment 2) and the EED file (see Attachment 3) are the altitudes above mean sea level (MSL), both in feet.

Note, altimeter corrections for barometric pressure, temperature, etc. may be required in order to meet the above tolerances. NGS will verify the flying height by multiplying the focal length of the camera (in feet) by the denominator of the calculated scale of the aerial film. The photographic scale is calculated by dividing the distance between two identifiable points as measured on one of the photographs (as near as possible at the mean ground elevation) by the actual ground distance as measured from the best available map or from known ground coordinates.

## 6. WEATHER, SOLAR ALTITUDE, AND TIME OF YEAR

Note, all photography under this SUPPINST is to show full tree leaf coverage to facilitate photogrammetric tree height determination.

No clouds or cloud shadows will appear on the photographs. High, thin overcast will be permitted above the flying altitude if it does not cause ground mottling or a discernable reduction in light levels and/or ground object shadows. Under no

circumstances shall Black & White Panchromatic (B/W Pan) films be exposed under a solid overcast sky.

Photography shall be undertaken only when well-defined images can be obtained. In addition to no clouds, photography shall not be attempted where the ground is obscured by haze, smoke, smog, dust, or falling: snow, sleet, rain, etc. Also, photography shall not be conducted when the ground is covered by water (flood), snow, or ice.

The minimum visibility at the time of exposure is 10 miles. Visibility is determined by looking at objects on the ground toward the sun. The distance at which the detail of ground objects is clearly defined is the visibility. If the visibility is satisfactory, details of ground objects will be clearly defined at the edge of the view through the drift sight.

Sun angle will not be less than 30 degrees above the horizon at the time of exposure. Ideally, the sun angle will be between 30 and 60 degrees above the horizon because of the intermediate-size shadows produced. Sun angle for a given day can be determined from a "Solar Altitude Diagram" or from appropriate computer software. See the U.S. Naval Observatory's WWW site: http://aa.usno.navy.mil/AA/ which computes sun altitudes and sun azimuths for U.S. locations and world-wide positions.

## 7. NAVIGATION

The aircraft will be navigated using pseudo-range GPS, or another system with equivalent accuracy or better. The cross-track flight-line deviation from the lines specified in the way-point files shall not exceed X, where X = flying height/20 (750 feet for normal flying height of 15,000 feet). Changes in the course of the aircraft between successive overlapping photographs within a flight line shall not exceed three (3) degrees.

Exposure stations will be positioned to approximately the absolute accuracy of +/- 20 meters, or better. An electronic pulse will be used to accurately mark the mid-point of the exposure. These exposure station positions and other information will be recorded in the EED file (see Attachment 3).

The NGS supplied waypoint files will automatically center one photograph over (or near) the center of the airport.

Note flight lines may be flown in either direction, but adjacent lines should be flown in opposite directions.

All flight lines will be continuous. No flight lines may be broken or patched. Note, a line reflown will have the original flight line number.

The datum for the horizontal positions is the North American Datum of 1983 (NAD 83). The vertical datum is the North American Vertical Datum of 1988 (NAVD 88).

## 8. TILT

Care shall be taken to keep tilt (departure from the vertical) of the camera to a minimum. Tilt will not exceed +/- three (3) degrees for any photographic frame. The average tilt for the entire project shall not exceed +/- one (1) degree.

## 9. CRAB

While exposing aerial photography, the camera shall be compensated for crab of the aircraft, with a resultant error not exceeding +/- five (5) degrees, as measured from the average line of flight, and the differential between any two successive exposure will not exceed +/- five (5) degrees.

## 10. OVERLAP AND SIDELAP

Forward overlap will be 60 percent, plus 5% to minus 2% percent between consecutive exposures.

Sidelap is defined by the flight line, way-point files (normally about 50%).

## 11. PHOTOGRAPH LABELING

When the camera is equipped for titling, each usable frame shall be titled within the image area between 1/16 and 1/4 inch from the format border using machine lettering approximately 1/5 inch high. Each title will consist of the agency initials (NOAA), date of photography, Contractor camera designator (see Section 4.1 and Attachment 3), film type (P for panchromatic), lens serial number, and exposure number. Also, including the latitude, longitude, height, aperture, shutter speed, etc. in the labeling is desirable. Note, any label(s) on the photographs shall conform to the above specifications.

Example: NOAA 06-23-99 XXP UAG332 No 2501

The title may be along any edge of the frame but the preferred location is along the leading edge. See also Section 4.1.

For each lens system used, usable exposures shall be numbered in an unbroken sequence starting at 0001 for the first exposure and continuing through the last exposure by that lens system. The numbering sequence shall not be broken even though more than one airport is photographed, or more than one roll of film is used.

Splicing should not be performed.

Blanks and test exposures should not be included in the exposure numbering sequence and shall not be labeled. Rejected exposures will keep their numbering.

## 12. FILM SHIPMENT AND PROCESSING

PROCESSING - The Contractor will ship completed film rolls, the original Photographic Flight Reports (marked “ORIGINAL” in blue ink), original raw EED files, and transmittal letters via next-day air freight directly to the NOAA film processing Contractor. If requested by the Contractor, NGS will have the NOAA film processing Contractor ship duplicate roll(s) of film to the Contractor’s office for review. Copies of the Photographic Flight Report and the raw EED files may be made and used by the Contractor to produce and check the final deliverables. Ship to:

HAS Inc.
136 North Clair Street
Suite 300
Dayton, OH 45402
937-222-3856
hasimage@ix.netcom.com

The following labels will be typed or neatly lettered by the Contractor with the required data and securely affixed to each film container:

(1) Commercial or HAS, Inc. shipping label
(2) Film processing instruction label (see Attachment 5)
(3) “DO NOT EXPOSE TO” label (see Attachment 5)

All rolls of aerial film shall be shipped in sturdy, cylindrical containers in such a manner that will ensure acceptance by common carrier and safe delivery at destination. Containers and closures shall comply with the Interstate Commerce Commission Regulations,

Uniform Freight Classification Rules, or regulations of other carriers as applicable to the mode of transportation.

The Contractor should not ship film on a Friday. The photographic processing Contractor does not receive film on Saturdays or Sundays, so the film could be subject to excessive environmental conditions during temporary storage.

NGS NOTIFICATION - The same day as shipping, the Contractor will notify NGS of each film shipment's contents and date of shipment by transmitting to NGS a paper or digital copy of the Photographic Flight Report (marked "COPY" at the top) and a copy of the film transmittal letter via email or facsimile.

## 13. IMAGE QUALITY

Image quality on the original negative film will meet the highest professional standards. Dark areas shall not bleed together and individual objects shall be readily discernable. Detail shall be sufficiently sharp to allow photogrammetric measurement of tree heights, compilation of runway/taxiway edges and other fine map features, and accomplishment of other intended uses for the film. Photographic products shall also be free of abrasions, blemishes, scratches, tears, and irregularities. Fiducial marks shall be clearly visible and sharp on every negative. The camera panel of instruments and titling recorded on the film shall be clearly legible on all processed negatives.

## 14. EXPOSURE

Extreme care shall be exercised to insure proper exposure. Use an ASA of 200 with the AGFA 200 PE film.

The film exposure settings normally will be controlled from the camera's Photographic Exposure Meter (PEM) and should produce a gamma at processing time of 1.5, +/- 0.05. Base fog density will not exceed 0.10 with a minimum density above base fog of 0.30 and maximum density above base fog of 1.35. For those areas where abnormal exposure objects exist, such as snow, water, etc., the PEM shall be manually overridden to produce an equivalent exposure without the abnormality. A shutter speed shall be chosen that meets the requirements of minimal image movement, at an adequate lens aperture for the prevailing lighting conditions.

## 15. REVIEW

Photography and other deliverables not meeting these specifications may be rejected.

## 16. POINTS OF CONTACT:

George E. Leigh
Contract Coordinator
National Geodetic Survey, NOAA
ATTN: N/NGS; SSMC3, Sta. 8613
1315 East-West Highway
Silver Spring, Maryland 20910
301-713-3167
email: gleigh@ngs.noaa.gov

CDR Jon W. Bailey, NOAA
Chief, Remote Sensing Division
National Geodetic Survey, NOAA
ATTN: N/NGS3, SSMC3, Sta. 8142
1315 East-West Highway
Silver Spring, Maryland 20910
301-713-2663
email: jbailey@ngs.noaa.gov