

**North Carolina**  
**Technical Specifications for**  
**Digital Orthophoto Base Mapping**

Land Records Management Division  
North Carolina Department of  
The Secretary of State  
Edited by Thomas W. Morgan

Adopted  
October 1, 2009

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*State of North Carolina*  
*Department of the Secretary of State*

ELAINE F. MARSHALL  
SECRETARY OF STATE

**Adoption of Orthophotography Standards**

The Department of the Secretary of State is required by G.S. §102-17 to adopt technical standards and detailed specifications to be used to achieve a greater degree of statewide standardization of land mapping for use in land records. Over the past year the Department has worked with stakeholders and has produced a set of proposed Standards for Orthophotography. The North Carolina Land Records Advisory Committee and the North Carolina Geographic Information Coordinating Council have passed motions recommending that the Secretary adopt the revised standards.

Notice of the proposed adoption of the proposed revised Orthophotography Standards was published in the North Carolina Register on September 15, 2009, along with a request for comments. No comments were submitted.

I have considered the recommendations of the staff of the Department of the Secretary of State, as well as the recommendations of the North Carolina Land Records Advisory Committee and the North Carolina Geographic Information Coordinating Council.

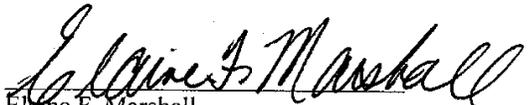
Pursuant to the authority granted me by G.S. §102-17, effective on this date, I hereby adopt the revised Orthophotography Standards for use to achieve a greater degree of statewide standardization of land mapping for use in land records in the State of North Carolina.

A copy of the adopted Orthophotography Standards is posted on the Department's website at <http://www.sosnc.com> or may be obtained by contacting the Department at:

Land Records Manager  
N.C. Department of the Secretary of State:  
P.O. Box 29626  
Raleigh, NC 27626-0626  
By Facsimile: (919) 807-2285  
By Email: [tmorgan@sosnc.com](mailto:tmorgan@sosnc.com)

This the 1st day of October 2009.

Signed

  
Elaine F. Marshall  
Secretary of State

## PREFACE

The "Land Records Management Program" (LRMP) was established in 1977 by the North Carolina Legislature in order to provide technical and financial assistance to local governments for the modernization of their land records systems. The Technical Specifications for Base, Cadastral, and Digital Mapping (Orthophotos)" is thus prepared as an essential element of the LRMP and is applicable to all county or municipal mapping projects. To the maximum extent practicable, these specifications should also be utilized by state agencies involved in mapping operations. Section 6, "Digital Orthophotos", was adopted on August 18, 2004, by the North Carolina Geographic Information Coordinating Council (GICC).

Invaluable guidance and assistance have been provided by the Standards Committee of the North Carolina Property Mappers Association and by representatives of local governments. Assistance was also provided by the North Carolina Geodetic Survey (NCGS), the Center for Geographic Information and Analysis (CGIA), the North Carolina Department of Transportation, and the North Carolina Department of Revenue.

# TECHNICAL SPECIFICATIONS FOR BASE, CADASTRAL, AND DIGITAL MAPPING (ORTHOPHOTOS)

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**SECTION 1**

**GENERAL**

Adopted October 1, 2009

## 1. **GENERAL**

### 1.01 **Definitions:**

- a. The Contracting Officer is the officially designated representative of the local government obtaining the mapping products or other services. This individual's authority and responsibilities shall be as prescribed by the County Board of Commissioners or appropriate municipal authority.
- b. The Contractor is that firm, company, or organization to which the mapping or service contract has been let. References to the Contractor in these specifications shall also apply in full to any subcontractor working for the named Contractor.
- c. References to "the Client" shall be construed to include not only county governments, but also municipal governments or any other agency or party wishing to enter into a mapping contract with a Contractor under the provisions of these specifications.
- d. The term photography and/or aerial photography shall be used inclusive of a film image or a digital sensor image, unless used specifically with film.
- e. Orthophotography and orthoimagery and their derivatives are to be considered to have the same meaning.
- f. "Raw" images are defined as the original captured image and metadata, devoid of the application of geometric and radiometric calibration and generally unfit for introduction into a production process. This data is typically in a proprietary format and its form and format readable only by sensor-specific processing software. This data must be post-processed by sensor-specific software.
- g. "Exploitation" images result from post-processing by sensor-specific software and are ready for introduction into the production process. All radiometric and geometric calibrations have been applied, but the images shall be in full (original) bit depth (e.g.: 8-16 bits per pixel) and all contracted bands. This imagery shall be supplied in TIFF format

with accompanying TFW (TIFF World) files establishing approximate position and orientation in the project reference frame. These images, combined with aerotriangulation (or geopositioning) data shall be directly viewable in a softcopy stereoscopic imagery workstation. A shape file shall also be delivered that represents the image exposure stations in the project reference frame. The shape file attributes shall include, at a minimum, the textual name of the camera system, the serial number of the camera system, the name of the image file, exposure date, exposure time, position (x,y,z), orientation (omega, phi, kappa), and focal length.

**1.02 Work Statement:**

The Contractor shall furnish all materials, superintendence, labor, equipment, and transportation and shall execute and complete all of the work required by the contract in conformance with these specifications and any contractual modifications to these specifications. Any deviation from these specifications, unless specifically authorized in writing by the Contracting Officer or his representative, shall be sufficient cause for rejection of any part or all of the work performed.

**1.03 General Mapping Specifications:**

- a. Orthophotography/orthoimagery is to be collected with an aerial digital sensor unless specifically authorized by the Client in writing.
- b. The Contractor will supply the Contracting Officer with a sample layout of each hardcopy map/overlay type and/or softcopy map/overlay mask type showing the placement and content of all border information for approval prior to final map and/or overlay production.

- c. All deliverable hardcopy maps/overlays and/or softcopy maps/overlays shall contain the following statement:

**“This map/overlay is correlated to the North Carolina State Plane Coordinate System, NAD83 (NSRS2007) North American Datum.”**

The contracting officer may require additional deliverables that are

converted to another datum. If so, the above statement will be modified to reflect that the product was so converted.

- d. All lettering on all deliverable hardcopy maps or overlays and softcopy maps or overlays shall be produced solely by mechanical or electronic means. Hand lettering will not be permitted.

**1.04 Visits to Contractor's Site:**

The Contract Officer or officially designated representatives or agents of the may visit the Vendor's site to inspect work in progress and verify that the procedures and equipment being used are in compliance with these Specifications and contract requirements. The Contractor agrees to allow access to its production facilities for periodic visits by the Client representatives or agents. These visits may be unannounced and/or may be upon short notice.

**1.05 Surveying Activities:**

All surveying activities, as defined in North Carolina General Statute § 89C, undertaken by the Contractor shall be conducted by surveyors licensed by the North Carolina Board of Engineers and Land Surveyors.

Photogrammetry services shall only be provided by a North Carolina licensed surveyor who are competent by virtue of education and experience in the discipline of photogrammetry. At the beginning of a project involving photogrammetric services, the Contractor shall identify the licensed surveyor who will sign and seal the completed project, and who will have direct supervisory control of the project. If in the course of the project the surveyor designated as being "In Responsible Charge" is replaced, the Contractor shall notify the contracting officer immediately in writing.

**1.06 Traditional Cadastral Mapping Activities:**

Traditional cadastral mapping activities as detailed in these specifications are not surveying services as defined in N.C.G.S. § 89C, and do not need to be provided by surveyors licensed by the North Carolina Board of Engineers and Land Surveyors.

**SECTION 2**

**AERIAL PHOTOGRAPHY**

Adopted October 1, 2009

## **2. AERIAL PHOTOGRAPHY**

### **2.01 Project Area and Client Contract Map:**

The location, size, and boundaries of the areas to be mapped will be outlined on a Client Map and further subdivided and designated in a way to show the number and scales of the final base maps to be prepared; the map shall be at a scale adequate for its purpose and shall be in hardcopy and electronic format. When the mapping project includes the entire county or portions along county boundary lines, the area to be mapped shall extend 2,000 feet beyond the county boundary. This marked Client Map shall be entitled "Client Contract Map" and shall be attached to and become a part of any contractual agreement. The flight plan proposed by the Contractor shall be drawn on a copy of this map and submitted to the Contracting Officer for approval prior to flying aerial photography (see subsection 2.04). The Client Contract Map may be prepared by the Client or by the Contractor at the request of the Client.

### **2.02 Conditions During Photography:**

Vertical photography shall be flown during the period when deciduous trees are barren and when the sun angle or elevation is not less than 33 degrees above the horizon. It shall be the contractor's responsibility to monitor atmospheric conditions such as haze, dust, fog, water vapor, etc., and adjust the flight time window to maintain visual image quality. If possible the flight window should be centered around solar noon. A Sun Angle Calculator can be found at: <http://aa.usno.navy.mil/data/docs/AltAz.php>

The Contracting Officer may require a higher sun angle to reduce the risk of long or objectionable shadows caused by relief or low solar angle.

Photography will not be undertaken when the ground is obscured by snow,

haze, fog, or dust; when streams are not within their normal banks; or when the clouds or cloud shadows will appear on more than five percent (5%) of the area in any one photograph. Photography shall be undertaken only when conditions meet capture specifications. The contracting officer may set additional project restrictions if it is felt that these restrictions would insure additional usefulness of the product. Lunar tide levels or whitecaps on large open bodies of water are examples that could be required.

**2.03 Scale of Aerial Photography Negatives:**

The altitude above average ground elevation for film aerial photography shall be such that the negatives will be at the scale specified in the following schedule:

| <u>Description</u> | <u>Map Scale</u> | <u>Negative Scale</u> |
|--------------------|------------------|-----------------------|
| Rural Class D      | 1" = 400'        | 1" = 2,400'           |
| Semi-Rural Class C | 1" = 200'        | 1" = 1,200'           |
| Urban Class B      | 1" = 100'        | 1" = 600'             |
| Urban Class A      | 1" = 50'         | 1" = 300'             |

Negatives deviating from the above scales by more than five percent (5%) may be rejected.

**2.04 Ground Sampling Distance for Map Scale:**

Map Class or Map Scale shall have the pixel size or raw ground sampling distance as specified in the following schedule:

| <u>Description</u> | <u>Map Scale</u> | <u>Ground Sampling Distance</u> |
|--------------------|------------------|---------------------------------|
| Rural Class D      | 1' = 400'        | 1.00 ft pixel                   |
| Semi-Rural Class C | 1" = 200'        | 0.50 ft pixel                   |
| Urban Class B      | 1" = 100'        | 0.25 ft pixel                   |
| Urban Class A      | 1" = 50'         | 0.125 ft pixel                  |

Ground Sampling Distance deviating by more than 10% numerically greater or 50% numerically smaller may be rejected. By way of example, this means that 1' GSD imagery be acquired in the range of 0.5' (smaller) to 1.1' (greater).

**2.05 Flight Plan:**

The Contractor's flight plan shall be overlaid on the Client Contract Map. The map may be digital or hard copy at the Client's discretion. Each flight

line will be flown continuously across the project area. Every effort shall be made to avoid breaks within individual flight lines. When 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, there shall be an overlap of at least 14000 times the Ground Sample Distance (GSD) to ensure a stereo model of overlap or tie. See 6.02 for the definition of (GSD). All photos within a single flight line shall be acquired with the same aerial camera and with the camera oriented in the same direction. The principal points of the first two and the last two exposures of each flight strip shall fall outside the boundaries of the area to be mapped. All side boundaries shall be covered by a minimum of twenty-five percent (25%) of the photo image format.

**2.06 Re-flights:**

Within one week of the flight mission, the Contractor shall submit a detailed quality control report to the Contracting Officer confirming compliance to the aerial photography specifications. If the Contractor can not meet the one week reporting time frame the Contractor shall inform the Contracting Officer in advance of the delay. Unacceptable aerial photography shall be corrected by the Contractor at no additional cost to the Client, with re-flight coverage overlapping the accepted photography by at least two stereo models. Replacement exposures shall be acquired with the same camera and platen (for film acquisition) or the same instrument make and model for digital acquisition 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. Re-flights shall be flown immediately (ideally within one week of the original flight), provided ground conditions have not yet terminated the photographic "season." An instrument substitution may be made if approved by the Client in writing.

**2.07 Spacing of Photographs:**

Overlapping photographs in each flight line shall provide full stereoscopic coverage of the area to be mapped.

**2.08 Forward Overlap:**

Photography used in the development of orthophoto maps shall have an endlap of sixty percent (60%). Forward overlap in the line of flight shall average not less than fifty-seven percent (57%) or more than sixty-three percent (63%) at the mean elevation of the terrain, unless otherwise specified. Individual forward overlaps shall not be less than fifty-five percent (55%) or more than sixty-five percent (65%), excepting the situation where in a forward overlap in areas of low elevation must exceed sixty-five percent (65%) to attain the minimum fifty-five percent (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.

**2.09 Sidelap:**

Sidelap between adjacent parallel flight lines shall average no less than thirty percent (30%) plus or minus three percent ( $\pm 3$  percent) greater side lap will help reduce building lean. Clients shall have the option when dealing with large changes in elevation due to natural ground elevation or man made differences such as a tall building of increased sidelap to a minimum of 40%. Placement of flight lines should be taken into consideration the location of the terrain and objects to obtain as near a nadir image as possible. Any parallel flight lines having sidelap of less than twenty-five percent (25%) shall be rejected and re-flown.

**2.10 Crab:**

Crab in excess of three degrees ( $3^\circ$ ) measured with respect to both lines of flight may be cause for rejection of a flight line or any portion thereof in which the excess crab occurs. This includes relative crab between any two successive exposures.

**2.11 Tilt:**

Tilt of the camera from verticality at the instant of exposure shall not exceed three (3) degrees, nor shall it exceed five (5) degrees between successive exposure stations. Average tilt over the entire project shall not exceed one (1) degree.

### **2.12 Aircraft:**

The aircraft to be used shall be equipped with all essential geodetic GPS navigational and photographic instruments and accessories necessary to satisfactorily produce the required photography and shall be operated by a well-trained and experienced crew. The aircraft is required to have a GPS navigation system to provide real time positioning and navigation along the proposed flight lines. Additional hardware and software for spatial orientation that a sensor manufacturer may specify is hereby required by these standards. The geodetic GPS navigation system must also have the capability to capture and store spatial positioning information for determining exterior orientation of the camera and geographic location of the photo center at the instant of exposure. The design of the aircraft shall be such that, when the camera is mounted with all of its parts above the outer structure, an unobstructed view is obtained, shielded from exhaust gases, oil, effluence, and air turbulence. 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. The aircraft shall have a proven service ceiling with an operating ceiling of not less than five percent (5%) above the highest altitude requirements to secure the specified photography. It shall be the responsibility of the Contractor to secure all licenses and authorizations for overflight of contract areas and to secure necessary permits or clearances for controlled or restricted airspace areas. If the flight area includes a military installation, the Contractor must comply with security regulations. The Contractor shall notify the Contracting Officer as soon as possible if difficulties in obtaining the appropriate authorizations are encountered. The Contractor shall be responsible for operating and maintaining the aircraft in accordance with all applicable regulations of the Federal Aviation Administration.

### **2.13 Film Aerial Camera:**

The aerial camera used must be a precision aerial mapping camera equipped with a low distortion, high-resolution lens. Camera characteristics must be such that the aerial photographs taken can be satisfactorily used in hardcopy and/or softcopy analytical measuring instruments and equipment. The camera system must be equipped with forward motion compensation (FMC). The camera system must be interfaced with airborne global positioning system (ABGPS) technology to provide horizontal and vertical control on each aerial exposure. A U.S. Geological Survey (USGS) camera calibration report no more than three years old is required for each camera used to obtain aerial photography. The camera calibration report shall be submitted to the Contracting Officer for approval before proceeding with work.

Calibration reports shall include calibration results for any film magazines to be used with the camera. Only those combinations of cameras and magazines shown on the calibration report shall be used in the project. If there is any reason to believe the dimensional stability of the camera has been disturbed by partial disassembly or unusual mechanical shock since its last calibration, the Contractor should have the camera recalibrated prior to acquisition of photography. The Contractor shall be ultimately responsible for errors caused as a result of incorrect calibration of the camera. The methods, procedures, and requirements described in this subsection shall be those utilized by USGS and will be included in the camera calibration report.

a. Camera and Lens.

The aerial camera shall be a precision aerial mapping camera equipped with a low distortion, high resolution lens. The characteristics of a nominal 6-inch camera shall be as follows:

1. Focal Length -  $153 \pm 3.0$  mm Universal Aviogon, Pleogon A or equivalent.
2. Usable Angular Field - At least ninety degrees.
3. Radial Distortion – The radial distortion in the usable angular field based on the calibrated focal length referred to the calibrated principal point (point of symmetry) shall not exceed ten microns (10  $\mu$ m) for any tested point. In addition, at least fifteen of the tested points shall have radial distortion values not exceeding five microns (5  $\mu$ m).
4. Resolution – The lens shall have an area weighted average resolution (AWAR) of at least ninety (90) line pairs per millimeter as determined by the USGS calibration report.

b. Filter. An appropriate glass filter with a metallic antivignetting coating shall be used. A microdensitometer trace shall be made and recorded of the antivignetting coating located on the lens side of the filter. A copy of this trace shall accompany the report of calibration to determine if any deterioration has occurred to the coating that would affect the uniformity of illumination in the image plane. The filter shall have surfaces parallel within ten (10) seconds of arc, and its optical quality shall be such that its addition to the camera shall not cause an undesirable reduction of image definition. A minus-blue glass filter shall be used with panchromatic emulsions.

c. Shutter speed and efficiency.

1. The camera shall be equipped with a between-the-lens shutter of variable speed as approved by the Contracting Officer. The range of speed settings shall be such that in conjunction with flight height, aircraft speed and illumination, the camera will produce negatives that will result in high definition photographs. The shutter shall also have a speed of 1/200 second or slower for laboratory testing.
  2. The effective exposure time and the efficiency of the shutter as mounted in the camera will be measured at maximum aperture and the shutter shall have a minimum efficiency of 70 percent at a speed of 1/200 second.
  3. This test shall be made in accordance with "Method I", American National Standard PH3-48-1972 (R1978).
- d. Platen flatness and identification. Cameras shall be equipped with an approved means of flattening the film at the instant of exposure. The platen against which the film is pressed shall not depart from a true plane by more than 13  $\mu\text{m}$  (0.0005 inch) when the camera/magazine vacuum is applied. The lens number, an alphanumeric mark (or symbol) which identifies the platen used, and the most recent calibrated focal length shall be recorded clearly on the film for each negative. Data markers that protrude inside 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 mark or reduce the usable image area.
- e. Fiducial marks.
1. Each camera body shall be equipped with means of recording eight fiducial marks on each exposure, the marks to be located in each corner of the format and at the center of each side.
  2. The corner fiducial marks shall form a quadrilateral whose sides are equal within 0.500 mm. The midside fiducial marks shall be equidistant within 0.500 mm from the adjacent corner fiducial marks. Lines joining opposite pairs of fiducial marks shall intersect at an angle of ninety (90) degrees  $\pm$  1 degree and indicate the position of the principal point of autocollimation within 0.030 mm. The fiducial centers and the point of symmetry shall fall within a 0.030 mm radius circle around the principal point of

autocollimation. For cameras with projection type fiducial marks, the projected images of all marks must be in focus on the emulsion surface. Any camera containing glass or plastic mounts of the fiducial marks will not be accepted.

3. All fiducial marks and other marks intended for precise measuring shall be clear and well defined on the negative and shall be of such a form that the standard deviation of repeated readings of the coordinates of each mark made on a comparator shall not exceed 0.002 mm.
4. The size of the negative image shall be 23 x 23 cm (9 x 9 inches).
- f. Stereomodel flatness. Cameras will be tested for stereomodel flatness by exposing two film negatives in the camera while mounted on the USGS multifollimator camera calibrator and analytically forming two stereomodels from them, using different halves of the exposures for each model. Each model thus formed will consist of a small fixed number of symmetrically arranged points. In either model, the deviation from flatness (elevation discrepancy at photography scale) at measured points may not exceed  $\pm 1/5000$  of the focal length of nominal 6-inch ( $153 \pm 3.0$  mm) cameras. If elevation discrepancies exceed this value, the camera will not be acceptable.

#### 2.14 Digital Sensor:

The digital sensor system shall have the following general, large-format characteristics:

- A capture width shall either be approximately 12,000 pixels or greater.
- Simultaneous capture of red, green, blue for each exposure. Infrared is desirable but not a requirement.
- A captured radiometric resolution of at least 12 bits/pixel (bpp) for each band/channel
- If utilized, a pan-sharpening ratio of 5:1 or better.
- The system shall use square pixels (ground footprint) at all times during processing. The technique of using aggregated detectors resulting in a rectangular pixel before blending with other channels shall not be used.
- The Contractor shall provide a successful Manufacturer's Certificate as issued by the USGS for digital sensor for all make/models of systems to be utilized. If a Manufacturer's Certificate has not been issued by USGS the Contractor may apply to the Client for a waiver. The Contractor shall

also provide calibration certificates for all systems to be used for acquisition.

**2.15 Aerial Film:**

All film utilized for this contract shall be from the same manufacturer and from the same lot or batch to insure minimal variation in chemical composition. The aerial film shall be a fine grain, high speed photographic emulsion on a dimensionally stable polyester base and shall be recognized within the photogrammetric industry as a source for the creation of digital orthophotos. Outdated film shall not be used. The film must be stored and handled in accordance with the manufacturer's instructions. Each roll of aerial film shall have an unexposed leader of at least ten frames in length. 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 of at least four frames in length shall be rolled forward just prior to the commencement of taking new photographs. An unexposed trailer of at least four frames or more in length shall be included at the end of each roll or partial roll of film.

**2.16 Flight Data:**

The following data will appear on the inter-frame margin of each negative as clear, uniformly illuminated images of the actual display instruments:

- Time of day clock, set to local time
- Altimeter reading in feet or meters above mean sea level
- Platen ID number
- Exposure counter, which shall also display the cameras identification number and the lens focal length in inches or millimeters

**2.17 Disposition of Aerial Film or Digital Image Data Files:**

The exposed aerial film or digital image data files and any interim or final products are the property of the Client. The Contractor will be responsible for storage of the film under proper conditions of controlled temperature and humidity at no cost to the Client for a period of at least five years. The Contractor will be responsible for storage of digital image data files under proper file maintenance and backup procedures for a period of at least 5 years. Digital data should be stored on negotiated media; portable hard

drives, secure FTP, DVD+/-R, DVD-ROM, CD-R, CD-ROM, or DLT. All digital media should be readable by both Windows and UNIX systems. All digital media should contain finalized closed sessions, no multi-session discs. All digital media should be properly labeled in standard cases (no slim-line or non-standard cases accepted). The Contractor shall not make, sell, or loan copies of the aerial negatives/digital image files or any other products without the expressed written approval of the Contracting Officer. The film or data file shall be handled carefully before, during, and after authorized use to ensure that the quality is not degraded and is safeguarded from defects. It is the Contractors' obligation to inform the Client if he is no longer able to meet the 5 year storage requirement due to going out of business and provide an opportunity to transfer the records to the Client or their designee.

**2.18 Roll Film Container:**

The container for each roll of aerial film shall be made of plastic, shall not exceed 6 inches in diameter, shall contain no more than 500 feet of film, and shall become the property of the Client. It shall be clearly labeled with the name of the Client; name of the Contractor; date of photography; flight and exposure numbers (sequential numbers of the first and last exposures); type and serial number of the camera; the type, serial number and calibrated focal length in millimeters of the camera lens; film roll number; and the approximate scale for the negatives. The film shall not be rolled tightly on spools or in any way stretched, buckled, or distorted.

**2.19 Digital Sensor Exposure History:**

A shape and text file should be a deliverable to include:

1. Position of exposure center (NC State Plane)
2. Date and time of exposure (GPS time)
3. Aircraft tail number
4. Camera name, model, serial number
5. Planned and actual altitude (MSL)
6. Sensor-specific settings (camera model dependent),

**2.20 Flight Log:**

For each flight day, the pilot or cameraman shall prepare a signed flight log containing the date, project name, aircraft used, and names of crew members. In addition, the following shall be prepared for each flight line: altitude, camera or digital sensor make and serial number, magazine serial number(film), f-stop(film), shutter speed(film), beginning and ending exposure numbers and times, and any other comments relative to the flight conditions. For a digital sensor, pertinent data about the sensor shall be substituted for the film camera specifics. These flight logs, or copies, shall be delivered to the Contracting Officer at the end of the project flights.

Adopted October 1, 2009

Adopted October 1, 2009

**SECTION 3**

**PHOTO LABORATORY  
PROCEDURES**

### **3. PHOTO LABORATORY PROCEDURES**

#### **3.01 General:**

All film and materials to be processed will be in accordance with the film manufacturer's recommended procedures for processing and developing. The film shall be handled as little as possible and as carefully as possible when laboratory processes are required. The Contractor is expressly forbidden to utilize this film for the production of any products not specified in these Specifications or in the contract with the Client.

#### **3.02 Image Quality:**

Images on the aerial negatives shall be clear and sharp in detail and free from light streaks, static marks, scratches, and other blemishes. Special care shall be exercised to insure proper developing and thorough fixing and washing of all film. The development, fixing, washing, and drying of all exposed photographic film shall result in a quality image with optimal contrast, tone, balance, resolution, uniformity in range density, and fine grain quality. All film processing must be performed in a state-of-the-art processor. The imagery of the film shall be clear and sharp and evenly exposed across the format. Special care should be exercised to prevent distorting the film during processing or drying. Film shall be exposed and processed with a target density range of  $1.0 \pm 0.2$  as measured in the neat image areas of each roll of film. Minimum density should not be less than 0.3 and the maximum density should not be greater than 1.5 as measured with a densitometer with a scale range of 0 to 3.0. Color film will be processed in accordance with the film manufacturer's recommendations. The color balance will be such that

the highest level of detail will be maintained throughout the full extent of the color spectrum. All fiducial mark images shall be clear and sharp.

**3.03 Film Labeling:**

Each exposure shall be clearly labeled by mechanical means in ink, or foil transfer if using a film filter, at the edge of the negative just inside the image area on the north edge for north-south flights or the west edge for east-west flights; no thermal processes shall be used. This labeling shall be at least 0.14 inches in height and shall include the following information as a minimum:

|             |             |             |              |              |
|-------------|-------------|-------------|--------------|--------------|
| Date of     | Scale of    |             |              |              |
| Photography | Photography | Client Name | Flight Strip | Exposure No. |

The "Scale of Photography" shall be given in inches and feet, e.g., 1" = 600', etc. "Flight Strip" numbers are not to be repeated anywhere within the photographic coverage of the contract, but will be numbered consecutively starting with Strip No. 1 and continued sequentially over all flight lines and scales. For reflights, the flight line will be further identified with an alpha character to designate the reflight. i.e. a, b, c, etc. "Exposure Numbers" for any flight strip will be numbered consecutively from "Exposure No. 1" and continued to the end of that flight line. On north to south flight lines, exposure numbers will begin at the north end of the flight line, and on east to west flight lines, exposure numbers will begin on the east end of the flight line.

**3.04 Photo Center Index:**

Coordinates derived from the ABGPS and/or Fully Analytical Aerial Triangulation (FAAT) will be used to produce a photo center index showing the locations of all photo centers. The photo center index will be in a format that can be used on the Client's GIS system or in an acceptable standard data exchange format. Each photo center shall be annotated with the x and y coordinates of its photo center point (nadir) and with its flight strip and exposure number. Each photo center index shall also include the following title information: name of the Client, name of the Contractor, date (month and year) and scale of aerial photography, type of camera and the focal

length of its lens, the scale of the photo index, and a north arrow. In the event two or more photo indexes are required for the Client at any one scale, a diagram showing the relationship of one photo index to the others will be drawn in each photo index's margin. Photo indexes shall be oriented to the north, and the title information should appear in the south or east margin of each index. All reflights of aerial photography will be indexed. A paper plot of the photo center index as well as the photo center index digital file shall be delivered to the Client.

**3.05 Contact Prints of Aerial Photography:**

If contact prints are produced as a part of the project, the contact prints of the original aerial negatives shall be prepared on double-weight, semi-matte paper or equivalent weight resin-coated paper. All prints will be clear and free from chemicals, stains, blemishes, fog, streaks, or any defects which would render them unusable. 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. All prints shall show camera fiducial marks. Contact prints shall be prepared for the Client only if requested by the Contracting Officer in writing.

Adopted October 1, 2009

**SECTION 4**

**HORIZONTAL AND VERTICAL  
CONTROL**

#### **4. HORIZONTAL AND VERTICAL CONTROL**

##### **4.01 General:**

Sufficient horizontal and, if applicable, vertical control surveys shall be established by the Contractor for all photogrammetric mapping purposes. Prior to the establishment of the necessary basic horizontal and vertical control, the Contractor shall make a thorough search of the project area for existing control of second order accuracy or better, as established by the National Geodetic Survey (NGS, formerly the United States Coast and Geodetic Survey [CGS]), North Carolina Geodetic Survey (NCGS), or the North Carolina Department of Transportation (NC DOT). North Carolina Geodetic Survey (NCGS) Station Recovery Forms are to be filled out and submitted to NCGS on monuments that a recovery effort was made. This includes both monuments found and monuments not recovered or destroyed. Additional control points established by the Contractor will be monumented with permanent monuments as described in subsection 4.05. All such control recovered or established shall be utilized to the fullest extent. All control used in the project will be paneled prior to flying the aerial photography unless such control is clearly a photo-identifiable point. The Contractor will indicate on a copy of the Client Contract Map the horizontal control stations (existing and to be established). Control previously established in an adjacent county will be utilized by the Contractor to the fullest extent possible to assure compatibility of maps from county to county. The Contractor will provide the Contracting Officer a brief description of the equipment and methods to be used for new ground surveys prior to conducting any control surveys. All horizontal and vertical control surveys shall be performed using procedures and/or accuracy standards consistent

with professional surveying and photogrammetric practices. The use of Airborne Global Positioning System (ABGPS) in combination with ground survey is required; the amount of ground control may be reduced but not eliminated by the use of ABGPS technology. All non-photogrammetric surveying activities will be directed, approved, and certified by a North Carolina Professional Land Surveyor whose area of expertise is surveying.

**4.02 Horizontal Control Surveys:**

All basic horizontal control shall be established by GPS (Global Positioning System). At a minimum, all horizontal ground control placed as a result of this project shall be established at an accuracy level of First Order or better. NCGS and FGDC standards as applicable to the order and class of survey shall be followed. All horizontal control shall be correlated to the North Carolina State Plane Coordinate System, North American Datum NAD83(NSRS2007).

**4.03 Vertical Control Surveys:**

All basic vertical control shall be established by GPS (Global Positioning System) using NGS-58 guidelines. At a minimum, all vertical ground control placed as a result of this project shall be established at an accuracy level of Third Order Class I or better. NCGS, NGS, and FGDC standards as applicable to the order and class of survey shall be followed. All vertical control shall be correlated to the North Carolina State Plane Coordinate System, National Geodetic Vertical Datum (NAVD), 1988.

**4.04 Photo Control Points:**

The Contractor is required to establish a sufficient number of control points to meet the accuracy requirements of the project prior to the acquisition of photography. Control points may be photo-identifiable points or targeted control points. Control points may be marked and targeted for aerial photography and then surveyed after the photography has been flown. Control points that are not painted or paneled targets may also be used. Permanent features such as parking lot corners, sidewalk or driveway intersections, street corners, cattle guard corners, fence intersections, and so forth can often be used. These points can then often be used for subsequent acquisition of city, state, or national programs such as NAIP since they do

not need to be repainted or paneled. Control points shall be situated on well defined, distinct, and photo-identifiable features or points that have been targeted by the Contractor (see 4.10). Control points shall be:

- a. Situated at or very near ground level, *not* on an elevated surface.
- b. Have a clear view of the sky
- c. Located in relatively level terrain, away from steep embankments.
- e. Located in areas where the target has a high probability of remaining undisturbed during the project.

Note: if photo-identifiable points are use, the accompanying location description shall be sufficient to positively identify the designated point.

Please refer to the following NAIP Control documents:

[http://www.fsa.usda.gov/Internet/FSA\\_File/naip\\_cpr\\_final.pdf.pdf](http://www.fsa.usda.gov/Internet/FSA_File/naip_cpr_final.pdf.pdf)

[http://www.fsa.usda.gov/Internet/FSA\\_File/scntrlpttable.pdf.pdf](http://www.fsa.usda.gov/Internet/FSA_File/scntrlpttable.pdf.pdf)

#### **4.05 Permanent Monuments:**

If requested by the Contracting Officer in writing, some or all control points established by the Contractor will be monumented with permanent monuments which meet the requirements for permanent monuments established by the NCGS. Said monument information is to be submitted by the Contractor to NGS Opus database for publication.

#### **4.06 Survey Records:**

The following information shall be delivered to the Contracting Officer as hard copy and a digital (ASCII) file:

- a. Field Notes and Observation Logs. Field Notes and Observation Logs shall be carefully and neatly prepared, identified, indexed and preserved. All data regarding the establishment and extension of horizontal and vertical control, including descriptions of all established and recovered monuments, shall be recorded. Where existing control points are recovered by the Contractor in extending the basic control, the field notes shall contain:
  - (1) Information as to the general condition of the recovered mark,

- (2) The original description,
- (3) Exact letter and numbers stamped on (not cast in) the mark;
- (4) Amended description, if applicable,
- (5) Additional tie data, if any,
- (6) A sketch of the location as appropriate to facilitate future recovery.

Observation Logs shall contain:

- (1) Monument name and location
- (2) Name and title of the observer
- (3) Time of arrival at monument
- (4) Height of instrument at beginning of observation (in feet and meters)
- (5) Type and serial number of the GPS receiver(s)
- (6) Type and serial number of the Tribrach(s) or type of fixed height pole
- (7) Observation period (indicate if programmed)
- (8) Epoch rate
- (9) Satellites observed
- (10) Height of instrument at end of observation (in feet and meters)
- (11) Additional notes describing problems encountered during the observation period

An additional sheet containing an obstruction diagram shall be provided for each existing and/or new monument observed. North Carolina Geodetic Survey (NCGS) Station Recovery Forms are to be filled out and submitted to NCGS on searched for monuments. Each baseline shall be identified by a number and brief description in the field notes. If the field notes are electronically recorded, printouts of the electronically recorded field notes shall be provided.

- b. Computations. The Contractor shall provide Least Squares adjustments of all horizontal control data. Adjustment output for both unconstrained and constrained adjustments shall contain the following information referenced to observed stations:
  - (1) Fixed coordinates (Northings and Eastings) in U.S. Survey feet
  - (2) Adjusted coordinates (Northings and Eastings) in U.S. Survey feet

- (3) Station error ellipse values (semi-major and semi-minor axis values) in feet
- (4) Relative (baseline) error ellipse values (semi-major and semi-minor axis values) in feet
- (5) Precisions (ppm) of observed baselines
- (6) Number of Degrees of Freedom (Redundancy).

All field records and computations, and all results, shall be delivered to the Client with the control data upon completion of the work. Computations must be made in accordance with the published standards of the FGCC.

- c. Control Diagram. The Contractor shall furnish a schematic control diagram indicating all horizontal and vertical control pertinent to this project on a copy of the Client Contract Map (subsection 2.01). This schematic diagram shall show all existing and established control points properly identified in their approximate location. It shall also show all observed baselines with their designations to include the beginning and ending points. The Control Diagram shall be in digital and hardcopy.
- d. Control Data. The Contractor shall provide the Contracting Officer with the complete information as listed below for all monumented control points established and/or recovered by the Contractor:
  1. Information on control points established by the Contractor shall include the following information.
    - (a) Designation of station (County name and sequential number).
    - (b) Establishing agency (name of Contractor or subcontractor who established the control point).
    - (c) Date of establishment.
    - (d) Horizontal and/or vertical control data.
    - (e) A complete description of the nature and location of the point to include a "to reach" description referenced to nearby landmarks (e.g. proceed from the intersection of Aker Road [SR 1010] and Stagecoach Road [SR 1012]...; proceed from US 64 bridge over Neuse River...) and identified by field survey ties (bearing and distance) to three or more definable photo image points in the immediate vicinity.

- (f) The location of each marked horizontal control point, symbolized on the face of the appropriate photograph by a triangle and annotated on the back with reference to its station designation as in (a) above.
- 2. Information on existing points recovered by the Contractor. The information will be submitted on a completed NCGS Station Recovery Form (see the web based form at NCGS's web site).
- e. GPS Observation Summary. The observation summary shall contain a discussion of the results of the ground GPS survey, including accuracies achieved, problems encountered, and a statement of the overall quality of the survey. The summary must contain the signature and seal of the Professional Land Surveyor certifying that the survey meets accuracy requirements and is tied to the proper datums.

**4.07 Feet/Meter Conversions:**

The U. S. Survey Foot (1 meter = 3.2808333333 feet) shall be used in all conversions of North Carolina State Plane Coordinates from meters to feet or feet to meters. All final control data shall be in feet, and the datum used (e.g. NAD83(NSRS2007)) will be noted on any sheets bearing coordinates.

**4.08 Global Positioning System (GPS):**

All basic horizontal and vertical control shall be established by GPS (Global Positioning System). All GPS network design, observation techniques, and data adjustments must be according to the specifications in the most current FGCC "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques" and the specifications and standards of the NCGS.

**4.09 Airborne Global Positioning System (ABGPS):**

The use of airborne GPS (ABGPS) in combination with ground survey is required; the amount of ground control may be reduced but not eliminated by the use of ABGPS technology. The following specifications shall be met for airborne GPS:

- (a.) General. Airborne GPS solutions shall be required to utilize dual-frequency GPS systems during the aerial photography missions.

The Contractor shall post-process the airborne GPS data relative to simultaneous observations collected at fixed land-based reference stations. Geodetic positions corresponding to the photo centers at the instant of exposure shall be calculated and (later) combined with ground control point values in an analytical aerotriangulation solution.

- (b.) Accuracy. Camera perspective centers must have accurately located position offsets with respect to the GPS antenna positions.
- (c.) Ground Stations. Simultaneous to the aerial photography and use of airborne GPS, a minimum of two static GPS reference receivers must be used to record satellite data over known geodetic control points on the ground. CORS maintained by North Carolina Geodetic Survey may be used to meet this requirement. These additional receivers must be active during the entire flight mission. The base stations must be in the most appropriate locations within the project area.
- (d.) Satellite Geometry. The PDOP or GDOP shall not be greater than three (3) for 90 percent of the flight lines and not greater than five (5) for the remaining 10 percent.
- (e.) Post-processing Software. The GPS post-processing software must be capable of backward and forward processing.
- (f.) Reporting. At the conclusion of Airborne GPS collection, the Contractor shall be required to submit a report of GPS observations and results data, observation logs, and data analysis and adjustments. This report shall be kept for reference. The Client reserves the right to obtain any and all data, readings, records, or any other information relating to the conduct of the survey for this project from the Contractor, should there be a question about the validity of the survey.

#### **4.10 Targeting:**

It is the responsibility of the Contractor to place the ground control targets (panels), to monitor and repair the targets to ensure that targets have not been damaged or removed before the aerial photography has been completed, and to remove the targets in a timely fashion once the aerial photography has been completed. Targets shall be of an appropriate size,

color, and shape to adequately appear on the selected scale of aerial photography.

**4.11 Property Entry:**

Targets and ground control points should be placed on public property whenever possible; however, it is recognized that it may be desirable or necessary to locate some targets and control points on private property. It is the Contractor's responsibility to obtain owner's permission when it is necessary to pass through or locate targets or control points on private property. At the written request of the Contractor, the Contracting Officer will assist in any reasonable effort to attain permission for entry to private property.

**4.13 Target Removal:**

Paneling material shall be removed by the Contractor, at the Contractor's expense within 30 days after final flight approval. If the targets are painted, the paint should be such a type that is biodegradable and will wash away over a relatively short time.

Adopted October 1, 2009

Adopted October 1, 2009

**SECTION 5**

**ANALYTICAL TRIANGULATION**

## **5. ANALYTICAL TRIANGULATION:**

**5.01** Aerotriangulation is essentially an interpolation tool, capable of extending control points to areas between ground survey control points using several contiguous uncontrolled stereomodels. The Contractor shall use fully analytical aerotriangulation to extend the horizontal control from relatively few ground survey control points to additional supplemental control points – pass points. Each stereomodel is to be scaled and leveled using the adjusted coordinate values of the pass points located in the stereomodel. Ground control should be located along the perimeter of the project area; within the project area; should be added as necessary to limit error propagation in the adjusted pass point coordinates. The use of airborne GPS (ABGPS) in combination with ground survey is required. The amount of ground control may be reduced but not eliminated by the use of ABGPS technology. An aerotriangulation solution should never be extended beyond the ground control of the project area. In conducting the aerotriangulation, the Contractor shall perform a fully analytical simultaneous bundle adjustment using a weighted least squares adjustment to meet accuracy requirements.

### **5.02 Nominal Scales for Triangulation:**

Aerial triangulation may be used for horizontal scaling to produce maps of 1" = 400', 1" = 200', and 1" = 100'. The nominal scale of the film aerial photographs will be 1" = 2,400' for 1" = 400' maps, 1" = 1,200' for 1" = 200' maps, and 1" = 600' for 1" = 100' maps.

**5.03 Ground Coordinate Systems:**

All ground positions determined by aerial triangulation will be in the North Carolina State Plane Coordinate System, NAD83(NSRS2007) and NAVD 1988. The contracting officer may require additional deliverables that are converted to another datum.

**5.04 Softcopy Aerotriangulation:**

Aerotriangulation shall be accomplished by softcopy procedures that involve softcopy workstations, fully analytical aerotriangulation software, and high-resolution scanners (film only). All interior orientation, and control point mensuration shall be read from the scanned images (film only). The Contractor must follow accepted softcopy aerotriangulation procedures and utilize equipment that will achieve the aerotriangulation accuracy required to meet or exceed required orthophoto accuracy standards. Software and hardware used by the Contractor must be capable of model orientation in both the stereo and monoscopic modes, capable of interior, relative, and absolute orientation, as well as single photo resection. Once acceptable scanned images are created, the softcopy aerotriangulation process used by the Contractor shall conceptually follow the process used with a traditional analytical stereoplotter. Latitude will be used in allowing the Contractor to use specific expertise in softcopy aerotriangulation as it relates to the number and type of pass points selected. Individual scanned photo frames will carry a minimum of nine (9) pass points, with the exception of end frames of flight lines which will carry a minimum of six (6) pass points; however, it is assumed that more pass points per frame will be selected to improve the triangulation solution. The Contractor is ultimately responsible for designing the aerotriangulation scheme that will meet the accuracy requirements of the project.

**5.05 Aerial Triangulation Report:**

Immediately upon completion of all aerial triangulation, the Contractor will prepare a formal aerial triangulation report for submission to the Contracting Officer. Two copies of the report are required and shall include, but not be limited to, the following:

- a. Control and Flight Line Indexes.  
Flight lines

- Exposure stations or model layout
- All control points appropriately labeled with station designations, computer designations (if any), agency responsible for establishing the stations, and orders of accuracy

All indexes will be generated on suitable materials at a scale suitable for presentation. The indexes will contain grid lines labeled with their corresponding northing and easting coordinate grid values. The indexes will also be labeled with the County name, map scale, title, and date.

b. Aerial Triangulation Results.

1. Sigma naught.
2. GPS accuracy of camera station.
3. Standard errors of adjusted tie-point terrain coordinates (RMS errors in x, y for horizontal coordinates) referenced to photo scale in micron and ground units.
4. Standard error of adjusted tie-point terrain coordinates (RMS errors of z vertical coordinates) referenced to photo scale in micron and ground units.
5. RMS errors (absolute accuracy) of x, y and z at independent checkpoints in microns at photoscale and in ground units.
6. Space resection parameters for each frame of aerial photography included in the aerial triangulation adjustment.
7. Photogrammetric measurements for each camera fiducial mark and photo center measured for each frame included in the aerial triangulation adjustment.
8. All misclosures at ground control points with and without use of checkpoints.
9. Computer printout of the final adjusted aerial triangulation solution to horizontal and vertical ground control. The printout should contain the final State Plane Coordinates for all ground control points, pass points, and checkpoints.
10. Identification of all points which were included in the initial solution and were subsequently discarded, with an explanation of the reasons for being discarded.
11. Identification of the weighting factors applied to all points used in the final solution.

12. An ASCII file on approved electronic media containing the coordinate data and the results of the FAAT adjustments.
- c. Narrative. The report shall include a brief narrative tying together items 5.05 a. and b. as well as descriptions of equipment, procedures, and computer programs used. Root-mean square (RMS) error summaries shall be provided for bundle adjustment photographic measurement residuals or strip tie point residuals and misclosures and misclosures at control/check points. In addition, significant misfits encountered at control points, and steps taken to analyze such misfits and to rectify the discrepancies, will be described. All control shall be listed in the report with an explanation of how the control was used in the FAAT. Also, the report shall contain a statement signed and sealed by the North Carolina Professional Land Surveyor (photogrammetrist) in charge of the project that the aerial triangulation solution will provide sufficient control to produce orthophotos that meet the accuracy requirements of the project.

**5.06 Drop Points:**

Drop points may be used to control lower altitude flights for direct compilation from photography of larger scale. These points shall be marked, measured, and carried as extra pass points in the aerial triangulation of the higher altitude photography.

**5.07 Checkpoints:**

Checkpoints are horizontal control points that have been established through ground control procedures by the Contracting Officer for accuracy checking purposes and will not be used in the analytical adjustment. These points are for quality control and not to be shared with the Contractor.

Adopted October 1, 2009

**SECTION 6**

**DIGITAL ORTHOPHOTOS**

## **6. DIGITAL ORTHOPHOTOS**

### **6.01 General:**

A digital orthophoto is a digital image that has the properties of an orthographic projection. It is digitized from a perspective aerial photograph by differential rectification so that image displacements caused by camera tilt and terrain relief are removed. The digital orthophoto is created by scanning a film aerial photograph diapositive transparency or an aerial photograph negative with a precision image scanner, or using an aerial image captured by a digital sensor. The digital image file is then rectified to an orthographic projection by processing each image pixel through photogrammetric space resection equations. This process requires, as input, ground control points acquired from ground surveys and airborne GPS and developed in aerotriangulation, camera orientation parameters, and a digital terrain/elevation model. A digital image, developed by scanning a traditional hardcopy orthophoto, is not considered a digital orthophoto under these specifications and is not acceptable as a digital orthophoto.

### **6.02 Definitions:**

Band – a range of wavelengths of electromagnetic radiation. Also, image data gathered at this wavelength range.

Brightness value – a number (normally 0-255) representing a discrete intensity gray level of a pixel in an image.

Chip – each separate piece of an image mosaic that contributes to the final image.

Clipping – The presence of pixels exhibiting the minimum or maximum digital count in an image's dynamic range.

Dodging – manipulation of the intensity of part of a photograph by selectively shading or masking.

Field – refers only to the entire field, including the value, of the geokey (as defined in the TIFF Specification).

Ground Sample Distance (GSD) – the area of ground represented in each pixel in x and y components.

Image File Directory (IFD) – contains information about the image. There must be at least 1 IFD in a TIFF file and each IFD must have at least one entry.

Metadata – a description of the content, quality, condition, and other characteristics of the data.

Resample – interpolation of pixel values based upon neighboring pixel values.

Tag – refers only to the identifying number portion of the geokey (as defined in the TIFF Specification).

### **6.03 Traditional Digital Orthophotography In Built Up Areas:**

Any aerial photograph will exhibit a characteristic known as relief displacement. Relief displacement is the geometric distortion that occurs due to elevation differences in the terrain being photographed. Objects of higher elevation, like buildings, hills, and trees, will be displaced radially outward from the center of the photograph. The greater the elevation of the object, and the further it is from the center-of-view, the greater the radial distortion. The process of ortho-rectification corrects these distortions by performing, on the image, a mathematical transformation that takes into account the shape of the terrain depicted in the form of a digital terrain model (DTM). In traditional digital orthophotography, objects like buildings and bridges are not modeled in the DTM. Therefore, these features are displaced from their true location in the final orthophotography. This displacement shows up in the form of

leaning buildings and warped bridges. In severe cases, this displacement can be aesthetically displeasing and may impact the usefulness of the orthophotography. For example, a tall building may “lean” over a street, hiding information like manholes, fire hydrants, and utility poles. Complex, multi-level freeway interchanges appear badly deformed. When a vector GIS layer is overlaid with the imagery, building outlines do not match up with the imagery representing the tops of the buildings, and vector road edges will appear as passing through buildings.

In the production of orthophotography the vendor shall use Best Management Practices to minimize relief displacement. For tall buildings, the image nearest to nadir should be used. Horizontal displacement along seamlines in images shall be held to no more than  $\pm 3$  pixels along transportation features, unless project specifications specifically state otherwise. Clipping of features (e.g. radio towers, water tanks, buildings) at tile boundaries shall be held to a minimum. Smearing shall be held to a minimum. Structure warping (bridges) shall be adjusted for viewing.

#### **6.04 Orthophoto Accuracy Standards:**

Orthophotos shall meet or exceed the ASPRS horizontal accuracy standards as Follows:

1.0' GSD - 1"=400' scale - use ASPRS Class I - limiting RMSE X or RMSE Y of 4.0 feet

0.5' GSD - 1"=200' scale - use ASPRS Class I - limiting RMSE X or RMSE Y of 2.0 feet

0.25' GSD - 1"=100' scale - use ASPRS Class II - limiting RMSE X or RMSE Y of 2.0 feet

0.125' GSD - 1"=50' scale - use ASPRS Class II - limiting RMSE X or RMSE Y of 1.0 feet

All orthophotos may be subject to quality control testing by the Contracting Officer, by independent third parties, and/or by the Contractor working under the direct review of the Contracting Officer to ensure that orthophotos

comply with the accuracy requirements. See **Addendum 2 NC Orthoimagery Quality Assurance (QA) Procedures.**

Reporting of Horizontal Accuracy shall be as follows:

1. "This county orthophoto project was checked and found to have a RMSE X value of \_\_\_\_\_Feet and a RMSE Y value of \_\_\_\_\_feet which conforms to the ASPRS horizontal accuracy standard as defined in section 6.04 of Technical Specifications for Base, Cadastral and Digital Mapping (Orthophotos) by The Land Records Management Division of The North Carolina Department of the Secretary of State"

And

2. "This county orthophoto project was tested using the Case 1 formula and procedures set forth in FGDC-STD-007-1998. The result of that test was \_\_\_\_\_feet horizontal accuracy."

Horizontal accuracy quality control shall be implemented under the following guide lines located at:

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part1/chapter1>

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>

#### **6.05 Aerial Photography:**

The aerial photography used to develop digital orthophotos shall be vertical photography flown during the period when deciduous trees are barren and when the sun angle or elevation is not less than 33 degrees above the horizon. The photography shall have an endlap of sixty percent (60%); sidelap between adjacent parallel flight lines shall average thirty percent (30%); crab shall not be in excess of three (3) degrees; and, tilt of the camera from verticality at the instant of exposure shall not exceed three (3) degrees.

**6.06 Scale of Film Aerial Photography Negatives:**

The altitude above average ground elevation for film aerial photography shall be such that the negatives will be at the scale specified in the following schedule:

| <u>Description</u> | <u>Orthophoto Scale</u> | <u>Film Negative Scale</u> |
|--------------------|-------------------------|----------------------------|
| Rural              | 1" = 400'               | 1" = 2,400'                |
| Semi-Rural         | 1" = 200'               | 1" = 1,200'                |
| Urban              | 1" = 100'               | 1" = 600'                  |
| Urban              | 1" = 50'                | 1" = 300'                  |

Film negatives deviating from the above scales by more than five percent (5%) may be rejected.

**6.07 Negatives/Diapositives For Scanning:**

The original aerial photography negatives and/or one set of diapositives made from the original film aerial photography negatives (not from duplicate negatives) shall be used for the scanning operation.

- a. Original aerial photography negatives. The negatives are to be handled with the utmost care to ensure maximum image quality. The scanned images will preserve the clarity and detail of the original negatives to the maximum extent possible. The scanning process will be done in such a manner (dodging) as to eliminate the incidence of "hot spots" in the resulting scanned images. Care will be taken to prevent lint from collecting on the original negatives. Fiducial marks shall be included in the resulting scanned images.
- b. Diapositives. The diapositives are only to be used for scanning and are to be handled with the utmost care to ensure maximum image quality. The diapositives shall not contain defects such as out of focus imagery, dust marks, scratches, extraneous marks or annotation, discontinuities in tone, or other inconsistencies except those resulting from corresponding defects in the original aerial negatives which cannot be remedied during image processing. The diapositives and the resulting scanned images will preserve the clarity and detail of the original negatives to the maximum extent possible. Care will be taken to prevent lint from

collecting on the original negatives and diapositives. Fiducial marks shall be included in the diapositives and the resulting scanned images. Image artifacts introduced during the scanning process and appearing in the final orthophotos are unacceptable, except for very minimal artifacts.

**6.08 Processed Digital Imagery:**

The finished digital orthophoto shall have an image quality the same as or better than the original unrectified input image. The degradation of image quality by reprocessing shall be grounds for rejection of the project.

**6.09 Scanning Device (film only):**

The device used for scanning shall be a precision instrument designed and manufactured for use on aerial film and/or diapositives with an aperture which can produce a scanning resolution of at least 9.5 microns (approximately 2600 dots per inch), geometric accuracy of less than 5 microns RMSE, and a capability of resolving 256 levels of gray and 256 hue levels each of red, green, and blue bands. Scanner specifications, a scanner calibration report, diagnostic reports, and/or other test results showing accuracy, resolution, and ability to distinguish tonal qualities shall be submitted to the Contracting Officer for approval before proceeding with the scanning phase.

**6.10 Scanning Resolution (film only):**

Negatives and/or diapositives will be scanned so that the resultant pixel resolution for 1" = 300 aerial photography shall be 0.125 feet, 1" = 600' aerial photography shall be 0.25 foot, 1" = 1200' aerial photography shall be 0.50 foot, and 1" = 2400' aerial photography shall be 1 foot. Pixel resolution shall not be interpolated to a finer resolution than that developed through the initial scanning; interpolation of pixel resolution to a coarser resolution is allowed.

**6.11 Digital Terrain Model/Digital Elevation Model:**

- a. A Digital Terrain Model (DTM)/Digital Elevation Model (DEM) shall be developed at a density level necessary to support the orthophoto production. Terrain/elevation data used in the development of the

DTM/DEM shall be captured by photogrammetric techniques using a 1st order analytical stereoplotter or a softcopy workstation or derived from recent LIDAR data. The Statewide DTM generated by North Carolina Floodplain Mapping Program is one example of an acceptable LIDAR product. If an existing LIDAR data set is used, the project area must be reviewed to determine if significant terrain altering activity has occurred since the LIDAR data was acquired. If such an area is identified the contractor shall update the DTM. The DTM/DEM will consist of points spaced at regular intervals along a grid, points of significant high or low elevations, and ortho specific breaklines at all significant terrain breaks. It is not necessary to capture breaklines at all curbs, ditches, stream banks, or other similar minor terrain breaks. Elevation/terrain data shall be captured at a density level sufficient to accurately represent the shape of the ground and to meet the required orthophoto accuracy standards of ASPRS Class I or Class II as defined in the contract. A DTM/DEM developed either wholly or in part from autocorrelation shall not be utilized in the production of the digital orthophotos.

- b. The DTM/DEM data is not to be stored as a record (Z component) for each pixel of the orthophoto image.
- c. The Contractor shall provide to the Client the DTM/DEM in a format that can be used on the Counties' GIS system or in an acceptable standard data exchange format. Note: The DTM/DEM data will be used for the draping of images and data sets, and it is acknowledged that the DTM/DEM is not suitable for detailed engineering activities.
- d. DTM/DEM data from a prior orthophoto project shall not be used for a new project. If approved by the Contracting Officer, DTM/DEM data from a prior ortho project may be used for a new project after extensive updating by the Contractor.

#### **6.12 Image Completeness:**

There shall be no areas of an orthophoto where ortho production process was incomplete due to incomplete data (i.e., lack of DTM/DEM data, image gaps, etc.).

#### **6.13 Ground Resolution:**

The horizontal ground resolution (pixel - x and y components) of the finished digital orthophoto image (both hardcopy and softcopy) shall be at a minimum of 1 foot for 1" = 400' orthophotos, 0.50 foot for 1" = 200' orthophotos, 0.25 foot for 1" = 100' orthophotos and 0.125 foot for 1" = 50' orthophotos.

**6.14 Image Rectification Algorithm:**

Image rectification shall be carried out using either cubic convolution or better algorithm.

**6.15 Softcopy Coverage Area:**

The geographic extent of each softcopy digital orthophoto shall be based on the North Carolina Land Records Management Program's "Basic Modular Unit" and shall cover the same geographic area. The softcopy digital orthophoto shall only contain the neat image of the corresponding map unit, and there shall be no image overlap between adjacent softcopy digital orthophotos.

**6.16 Image Mosaicking:**

Mosaicking shall be accomplished using both automated and interactive (manual) methods; the sole use of fully automated methods is not acceptable. Mosaic join lines shall not cross through building, bridges, or other structures or items which could be considered as a visual entity and shall try to follow features such as roads, tree lines, water bodies, etc when possible. Acceptable mosaicking must produce quality orthophoto imagery of consistent tone and contrast and must do so without obvious join lines.

- a. Interior mosaicking. Interior mosaicking occurs when an orthophoto cannot or is not made from a single digital aerial photograph, and the orthophoto is made from two or more digital aerial photographs. The join line between photograph images shall be chosen so as to minimize the obtrusiveness of the join itself and to reduce the difference in brightness, tone and contrast between the different photograph images. Interior mosaicking shall not affect the positional accuracy of the orthophoto. The Contractor shall provide the Contracting Officer with sample softcopy images to evaluate. The Contracting Officer will select one mosaicked image that will become the reference to which

all subsequent softcopy orthophotos will be compared for interior mosaicking acceptance/rejection.

- b. Edge mosaicking and feathering. Mosaicking and feathering at/near the edge lines of adjacent orthophotos is permitted in order to create a nearly seamless image of the entire project area and to minimize any visual edge lines of adjacent orthophotos due to tonal variations. The mosaicked edge line between adjacent orthophotos shall be chosen so as to minimize the obtrusiveness of the edge line itself. If feathering (a process used on the join between two adjacent orthophotos to help reduce the difference in tone and contrast between the adjacent orthophotos) is used along the edge line, it shall not result in any noticeable image degradation such as image blurring or double imagery. Edge mosaicking and feathering shall not affect the positional accuracy of the orthophoto. The Contractor shall provide the Contracting Officer with samples of edge mosaicking and feathering to evaluate. The Contracting Officer will select one image set (four adjacent orthophotos) which will become the reference to which all sequent softcopy orthophotos will be compared for edge mosaicking and feathering acceptance/rejection.

- (1) Radiometry Balance. When a mosaic of two or more chips is made, the brightness and color values of the other chips will be adjusted to match that of the principal chip. The join lines between the overlapping chips will be chosen to minimize tonal variations. Localized adjustment of the brightness and color values will be done to reduce radiometric differences between join areas.

- (2) Edge-Matching. All chips shall not have more than  $\pm 3$  pixels offset between the principal chip.

#### **6.17 Mapping Basic Modular Unit:**

The 1" = 400' map is the smallest scale map included in these specifications and is designated the "Basic Modular Unit" in a series of maps which provide for four map scales, as follows:

- a. 1" = 400'. The boundaries of each Basic Modular Unit shall be the grid ticks of the North Carolina State Plane Coordinate System evenly divisible by 10,000 ft. in north-south and east-west directions.

- b. 1" = 200'. Each map will be one-quarter (1/4) of a Basic Modular Unit (see subsection 6.16 a. and Attachment 3). The neat image area shall be bounded by the North Carolina grid ticks whose eastings and northings are evenly divisible by 5,000 feet.
- c. 1" = 100'. Each map shall be one-sixteenth (1/16) of a Basic Modular Unit (see subsection 6.16 a. and Attachment 3). The neat image area of this unit shall be bounded by the North Carolina grid ticks with eastings and northings evenly divisible by 2,500 feet.
- d. 1" = 50'. Each map shall be one sixty-fourth (1/64) of a Basic Modular Unit (see subsection 6.16 a. and Attachment 3). The neat image area of this unit shall be bounded by the North Carolina grid ticks with eastings and northings evenly divisible by 1,250 feet.

Final map tiles will conform to the Basic Modular Units as defined in this section.

#### **6.18 Numbering of the Basic Modular Units:**

Each Basic Modular Unit map shall be identified by a map number derived from selected paired digits of the east and north coordinates of the southwest corner of the module. For example, a map with the lower left corner coordinates of E = 640,000 and N = 530,000 will be known as Map Number 6543. The digit "6" in the 100,000th place of the east coordinate is paired with the digit "5" in the 100,000th place of the north coordinate; the digit "4" in the 10,000th place of the east coordinate is paired with the digit "3" in the corresponding position in the north coordinate. These four digits uniquely define the modular map unit in any one county. This map numbering system also forms an integral part of the parcel identifier number (PIN) system (see subsection 10.06). In counties where the coordinate values equal or exceed 1,000,000 feet, the digit in the millionth place is redundant and will be dropped. However, the map must be clearly identified with its proper county name. Thus, the map in Gates County having coordinates for its southwest corner of E = 2,660,000 and N = 1,010,000 can be identified as Gates County Map Number 6061. The map numbers at the 1" = 400' scale will contain only four digits. The map numbers at the 1" = 200' scale and the 1" = 100'

scale will contain only six digits. For these larger scales, the first four digits of the map numbers shall be those of the Basic Modular Unit with the addition of a two-digit suffix determined according to the chart in Attachment 3. There will be a decimal point between the four digits of the Basic Modular Unit and the suffix, for example Gates County Map Number 6061.15. (See Attachment 3)

**6.19 Border Data:**

Traditional hardcopy map border data such as map number, north arrow, grid ticks, grid coordinate values, etc shall not be a part of the softcopy digital orthophoto image.

**6.20 Reference Product:**

Prior to initiating check plots and final digital production, the Contractor shall provide the Contracting Officer with sample digital image sets to evaluate and accept as examples of overall image quality. This Reference Product will be project visual quality control reference standard. If quality control issues arise during final review this Reference Product will be used as the project standard. The Contracting Officer will select one or more image sets that will become the reference to which all subsequent softcopy orthophotos will be compared for image quality acceptance/rejection. The sets will consist of four or more adjacent, like scale orthophotos and also three or more adjacent, unlike scale (e.g. 100' and 200') orthophotos.

**6.21 Orthophoto Image Quality:**

The digital orthophoto image shall be compared to the original aerial negative image or exploitation image to determine if the orthophoto image has the same or better image quality as the original aerial image. All digital images shall have proper histograms and tone balance. Color imagery shall also have proper color balance and saturation.

- (a) Clipping. The images shall have a tonal range that prevents the clipping of highlight or shadow detail from the image. When calculated against the luminosity histogram, the cumulative pixel count between the first and last five histogram bin values (5 and 250 respectively for 8-bit depth) shall not be less than 98.0%, with a preferred value greater than 99.0%.

- (b) Contrast. When calculated against the luminosity histogram, the difference between the histogram bin value that contains 99.0% of the cumulative pixel count and the value that contains 1.0% shall be greater than 120, with a preferred value of greater than 150. If the cumulative pixel count percentage falls between two histogram bin values, the close value shall be used. For example, if the luminosity value 222 contains 99.0% of the cumulative pixel count and value 44 contains 1.0% count, therefore the difference is 178.
- (c) Histogram Peak. All images shall have a pixel count peak within  $\pm 15\%$  of the median peak value allowed for the bit depth.
- (d) Color Balance. All images should have a neutral tonal range without the dominance of any individual color. The difference between the minimum and maximum value in a RBG triplet of any nearly neutral objects within the image shall be less than 10, with a preferred value greater than 5.
- (e) Band-to-Band Registration Accuracy. Misregistration between any color bands shall not exceed 1 pixel.
- (f) Image blemishes, scratches and artifacts. Imagery shall be free of blemishes, scratches, and artifacts that obscure ground feature detail. The following table defines the maximum acceptable limits for blemishes, scratches, and artifacts. Clusters of blemishes, scratches, and artifacts that do not individually meet these criteria may be considered unacceptable.

**Acceptable Image blemishes, scratches and artifacts**

|               |                     |
|---------------|---------------------|
| 1 pixel wide  | 50 pixels in length |
| 2 pixels wide | 30 pixels in length |
| 3 pixels wide | 10 pixels in length |

**6.22 Radiometric Resolution:**

- (a) Color Imagery. All color imagery shall be an 8-bit RGB image in accordance with Section 6, RGB Full Color Images, of the TIFF Specification.
- (b) Color Infrared Imagery. All color infrared imagery shall be an 8-bit Near-IR, RG image in accordance with Section 6, RGB Full Color Images, of the TIFF Specification.
- (c) 4-Band Imagery. All imagery that contains both natural color and CIR shall meet the same requirements as color imagery specified in the paragraph above and shall have the bands saved in the following order: Red, Green, Blue, and Infrared.

**6.23 File Compression:**

The Contractor shall deliver to the Client a complete set of uncompressed digital orthophoto images in a format (GeoTIFF or TIFF with world file) and media (e.g. tape, DVD or portable hard drive) selected by the Contracting Officer. In addition to the uncompressed images, the Contractor shall also deliver to the Client two sets of compressed orthophoto images using an industry accepted compression tool and format agreed upon by the Contracting Officer. The Contractor shall prepare a set of sample compressed images of two adjacent orthophotos with compression ratios of 1:10, 1:20, 1:30, 1:40, and 1:50 on the media. The Contractor shall create two sets of the compressed orthophotos using the Contracting Officer's chosen compression ratios for delivery.

**6.24 Deliverable Product Format:**

- (a) The Contractor will only provide digital data to the Client in a format that can be used on the Client's GIS system or in an acceptable standard data exchange format. If the Contractor's GIS system either uses or can produce digital files in the same format that is used by the Client, the information shall be transferred in that format. If there is a specific intermediate format that will facilitate the transfer of the data between the two computer mapping systems, then the intermediate format may be used with the written approval

of the Contracting Officer. Care will be taken by the Contractor in the construction of the data files to assure that data is compatible with and will work on the Client's GIS system. Data will not be considered as delivered until the data has been successfully loaded and utilized on the Client's system. (This assumes that the Client has an operating GIS system at the time of delivery and that problems are wholly data related and not hardware or software related.)

- (b) The Contractor shall transfer the digital data to the Client on a media agreed upon between the Contracting Officer and the Contractor. Each media item will be accompanied by a report or label that specifies the name of each file, the size of each file, the map number of each map on the media, and the name of the Contractor.

**6.25 Deliverable Items by Contractor:**

At the completion of the mapping project as specified in the project contract or at a time which facilitates the flow of work (delivery dates may be specified in the project contract, the Contractor shall deliver to the Contracting Officer for his/her acceptance the following items:

- (a) One copy of each digital orthophoto image and its associated georeferencing/header file on the selected media. The georeferencing/header file shall contain the following items and shall be in the format as shown in attachment 1:
  - (1) Georeferencing information
  - (2) Map name or number
  - (3) Nominal map scale
  - (4) Location of Map - (county)
  - (5) Name of Contractor
  - (6) Name and license number of land surveyor/photogrammetrist in charge of project
  - (7) Coordinate system of map - (NC State Plane)
  - (8) Horizontal datum
  - (9) Map unit - (feet)
  - (10) Feet / meter conversion – (US Survey Foot)
  - (11) Image pixel resolution
  - (12) Lower left map coordinate
  - (13) Upper left map coordinate

- (14) Upper right map coordinate
  - (15) Lower right map coordinate
  - (16) Aerial camera type or digital sensor type
  - (17) Lens serial number or sensor serial number
  - (18) Lens resolving power (AWAR) (film only)
  - (19) Lens focal length (film only)
  - (20) System resolving power (AWAR) (film only)
  - (21) Photography film type (film only)
  - (22) Acquisition scale of photography
  - (23) Photography date
  - (24) Map horizontal accuracy
  - (25) DEM development
  - (26) Mapping standards used – (NC Land Records Management Mapping Specifications, 2009)
- (b) One copy of each softcopy mask on the selected media (Optional).
  - (c) One Mylar copy of each digital orthophoto with its corresponding softcopy of mask if specified by the Contracting Officer at the beginning of the project.
  - (d) One copy of the DTM/DEM used in the development of the digital orthophotos in uncompressed ASCII format on the selected media.
  - (e) Metadata compliant with FGDC standard for both project levels (bounding coordinates for the full project) and individual images, See an example in Attachment 2 and at [Http://www.nconemap.com/Home/metadata/tabid/280/default.aspx](http://www.nconemap.com/Home/metadata/tabid/280/default.aspx)
  - (f) Map index in hardcopy (paper) and digital form showing the layout/location of the orthophotos.
  - (g) Two compressed sets of orthophoto files at the specified compression ratios for each orthophoto on the specified media.
  - (h) Project Report as described in Section 6.23.
  - (i) The original aerial film (at the Client's request).
  - (j) The diapositives as described in Section 6.05, if made.
  - (k) Original raw sensor data (at the Client's request)
  - (l) AT Report, including ASCII file
  - (m) Post Processed Exploitation Images for all contracted bands at pixel depth (bits/band). (at the Client's request)

**6.26 Hardcopy Orthophotos:**

If specified by the Contracting Officer at the beginning of the project, one positive reproducible of each digital orthophoto shall be provided on polyester material with a minimum thickness of .003 inch. The hardcopy orthophotos shall be prepared from the digital orthophoto files and the corresponding softcopy masks. The hardcopy orthophotos are to be high quality products using a “filmwriter” or a comparable photographic imaging process; hardcopy orthophotos produced from a plotter are not acceptable.

**6.27 Media/Packaging:**

The Contractor will deliver the digital orthophoto image files on the exchange media as agreed upon between the Contracting Officer and the Contractor.

**6.28 Project Report:**

At the completion of the project, the Contractor shall deliver to the Contracting Officer two copies of a project report. One copy of the project report shall be hardcopy (paper); the second copy of the project report shall be softcopy (as a PDF file) and shall accompany and be a part of the digital orthophoto delivery. The project report shall contain the following information:

- (1) Date of photography by scale.
- (2) Altitude of camera or digital sensor and camera focal length.
- (3) Date of data set compilation by scale.
- (4) Coordinate system for horizontal and vertical control denoting metric or English units (i.e., NAD83(NSRS2007), assumed, or other coordinate system).
- (5) A list of the ground control points used for the project. The minimum data shown for each point shall include: physical attributes (i.e. iron rod, railroad spike, etc), X and Y Grid coordinates, and elevation, as applicable.
- (6) A statement of accuracy of the orthophotos.
- (7) A county map of suitable scale and detail depicting the individual orthophotos prepared by scale and map number and a count of the total number of orthophotos prepared by scale.

- (8) Company name, address and phone number.
- (9) The name of the Client agency for whom the project was conducted.
- (10) A statement that the orthophotos meet the Land Record Management Program Mapping Specifications with Specifications date and, if applicable, a listing of exceptions to the Mapping Specifications.
- (11) A certificate, substantially in the following form or a form required by the North Carolina Board of Engineers and Land Surveyors, signed, sealed, and dated by the surveyor in control of the project:

“ I, \_\_\_\_\_, certify that this project was completed under my direct and responsible charge from an actual photogrammetric survey made under my supervision; that this survey was performed to meet Land Records Management Program Standards as applicable; that the imagery and/or original data was obtained on \_\_\_\_\_; that the survey was completed on \_\_\_\_\_.”.

- (12) Identify sensor used and bands collected

A project is not considered completed until a Project Report has been submitted to and accepted by the Contracting Officer.

*Adopted October 1, 2009*

# Attachment 1

## ORTHOPHOTO GEOREFERENCING/INFORMATION HEADER FILE

0.50000000000000  
0.00000000000000  
0.00000000000000  
-0.50000000000000  
200000.500000  
439999.500000  
MAP NAME/#=040301  
NOMINAL MAP SCALE=1 INCH EQUALS 200 FEET  
LOCATION=CUMBERLAND COUNTY, NORTH CAROLINA  
IMAGE PRODUCED BY =ORTHO MAPPING CO. RALEIGH, NC  
LAND SURVEYOR/PHOTOGRAMMETRIST IN CHARGE=JOE CAROLINA, NC PLS #123456  
COORDINATE SYSTEM=NC STATE PLANE  
HORIZONTAL DATUM=NAD83(NSRS2007)  
MAP UNIT=US FEET  
FEET/METER CONVERSION=US SURVEY FOOT (1 METER = 3.2808333333 FT)  
IMAGE PIXEL RESOLUTION=0.50 FOOT  
LOWER LEFT MAP COORDINATE=E2000000 N435000  
UPPER LEFT MAP COORDINATE=E2000000 N440000  
UPPER RIGHT MAP COORDINATE=E2005000 N440000  
LOWER RIGHT MAP COORDINATE=E2005000 N435000  
AERIAL CAMERA TYPE=WILD RC-30  
LENSE SERIAL NUMBER=13328  
LENS RESOLVING POWER (AWAR)=113 CYCLES/MM AREA-WEIGHTED AVERAGE RESOLUTION  
LENS FOCAL LENGTH=153.462 MM  
SYSTEM RESOLVING POWER (AWAR)=55 CYCLES/MM AREA WEIGHTED AVERAGE RESOLUTION  
PHOTOGRAPHY FILM TYPE=KODAK 2405, BLACK & WHITE  
NEGATIVE SCALE OF PHOTOGRAPHY=1:14000 (1"=1200')  
PHOTOGRAPHY DATE=03/08/2008  
MAP HORIZONTAL ACCURACY= LIMITING RMSE IS 2 FEET IN X OR Y; MEETS OR EXCEEDS ASPRS  
CLASS I ACCURACY STANDARDS  
DEM=THE DIGITAL ELEVATION MODEL FOR THIS ORTHOPHOTO WAS DEVELOPED FROM LIDAR  
DATA FROM THE NC FLOODPLAIN MAPPING PROJECT. BREAKLINE DATA WAS COMPILED USING  
ANALYTICAL DIGITAL PHOTOGRAMMETRIC TECHNIQUES AND IS INTENDED TO SUPPORT  
ORTHOPHOTO PRODUCTION ONLY - IT IS NOT SUITABLE FOR THE CREATION OF ACCURATE  
CONTOUR MAPPING.  
MAPPING STANDARDS=MAP COMPILED AND PRODUCED TO NC LAND RECORDS MANAGEMENT  
PROGRAM MAPPING SPECIFICATIONS, 2009

## Attachment 2

### Metadata Example

Identification\_Information:

Citation:

Citation\_Information:

Originator: BBBB

Publication\_Date: 20081130

Title: ZZZZ County, NC, 0.5-foot-resolution digital color ortho imagery (2008)

Edition: 1.0

Geospatial\_Data\_Presentation\_Form: Raster digital data

Publication\_Information:

Publication\_Place: ZZZZ County, NC

Publisher: ZZZZ County, NC

Description:

Abstract: This metadata record describes the color digital ortho imagery for ZZZZ County, NC. This 200-scale imagery is comprised of natural color orthophotography with a GSD (Ground Sample Distance) of 0.5'. Imagery was collected with the CCCC and processed with SSSS software.

Purpose: A digital orthophoto is a geometrically accurate photographic record of landscape conditions at the time of the corresponding aerial photography. As such, the digital orthophoto is useful for a variety of applications, such as environmental monitoring, facility engineering/maintenance, city/county planning, property line review, etc. The digital orthophoto can be used alone or as a raster basemap for corresponding vector line mapping.

Supplemental\_Information: The bounding coordinates in this metadata file represent the bounding coordinates for all image tiles in project area as a whole, not an individual tile. FOR more information, see the Project Report RRRRR.

Time\_Period\_of\_Content:

Time\_Period\_Information:

Single\_Date/Time:

Calendar\_Date: 200803

Currentness\_Reference: Ground condition

Status:

Progress: Complete

Maintenance\_and\_Update\_Frequency: Unknown

Spatial\_Domain:

Bounding\_Coordinates:

West\_Bounding\_Coordinate: -81.070404

East\_Bounding\_Coordinate: -80.546088

North\_Bounding\_Coordinate: 35.526142

South\_Bounding\_Coordinate: 34.996167

Keywords:

Theme:

Theme\_Keyword\_Thesaurus: None

Theme\_Keyword: Aerial image

Theme\_Keyword: Orthoimagery

Theme\_Keyword: Basemap

Theme\_Keyword: Natural color

Theme\_Keyword: Digital orthophoto

Theme\_Keyword: Orthophoto

Theme:

Theme\_Keyword\_Thesaurus: ISO 19115 Topic Category  
Theme\_Keyword: imageryBaseMapsEarthCover, 010  
Place:  
Place\_Keyword\_Thesaurus: William S. Powell, The North Carolina GAZETTEER, A  
Place\_Keyword: ZZZZZ County  
Place\_Keyword: TTTTT  
Place\_Keyword: North Carolina  
Access\_Constraints: None  
Use\_Constraints: None  
Point\_of\_Contact:  
Contact\_Information:  
Contact\_Person\_Primary:  
Contact\_Person: P P P P P  
Contact\_Organization: ZZZZZ County  
Contact\_Position: W W W W W  
Contact\_Address:  
Address\_Type: mailing and physical  
Address: A A A A A  
City: T T T T T  
State\_or\_Province: NC  
Postal\_Code: 99999  
Country: U.S.  
Contact\_Voice\_Telephone: N N N N N  
Contact\_Facsimile\_Telephone: F F F F F  
Contact\_Electronic\_Mail\_Address: E E E E E  
Hours\_of\_Service: 0800-1700 M-F EST  
Data\_Quality\_Information:  
Logical\_Consistency\_Report:  
Compliance with the accuracy standard was ensured by the placement of GPS ground control prior to the acquisition of aerial imagery. The following checks were performed:  
1. The ground control and airborne GPS/INS data stream were validated through an aerotriangulation bundle adjustment using SSSSS. The residuals of the adjustment met the required standards with the results fully outlined in an AT report.  
2. Digital orthophotography was validated through a visual inspection of control points, edge matching and general image quality.  
Completeness\_Report:  
The following methods were used to ensure image quality:  
1. Use of targeted ground control during image acquisition.  
2. Use of GPS/INS during image acquisition.  
3. Checking of controls against ortho product.  
4. Post ortho accuracy approval checks for overall image quality (tone, color balance, etc.).  
Positional\_Accuracy:  
Horizontal\_Positional\_Accuracy:  
Horizontal\_Positional\_Accuracy\_Report: This image complies with ASPRS Class II standards. It has been tested at 95% confidence level to have an RMS positional displacement within 2 feet of well defined ground features in obscured areas. Does not apply to vertical surface features, such as structures, appearing in the digital orthophotography due to inherent lean. Tested horizontal RMSE on controls within the project area is 0.77'.  
Vertical\_Positional\_Accuracy:  
Vertical\_Positional\_Accuracy\_Report: There is no vertical component for orthos.  
Lineage:  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: B B B B B  
Publication\_Date: Unpublished material

Title: Aerial photography  
Edition: 1.0  
Geospatial\_Data\_Presentation\_Form: Remote-sensing image  
Publication\_Information:  
Publication\_Place: None  
Publisher: None  
Type\_of\_Source\_Media: disc  
Source\_Time\_Period\_of\_Content:  
Time\_Period\_Information:  
Multiple\_Dates/Times:  
Single\_Date/Time:  
Calendar\_Date: 20080308  
Single\_Date/Time:  
Calendar\_Date: 20080305  
Single\_Date/Time:  
Calendar\_Date: 20080304  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: IMG  
Source\_Contribution: The aerial imagery was captured with CCCCC. The aerial images are used to AT the project and the production of orthophotos.  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: BBBB  
Publication\_Date: Unpublished material  
Title: Ground control  
Edition: 1.0  
Geospatial\_Data\_Presentation\_Form: Vector digital data  
Publication\_Information:  
Publication\_Place: None  
Publisher: None  
Type\_of\_Source\_Media: disc  
Source\_Time\_Period\_of\_Content:  
Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: CONT  
Source\_Contribution: Targeted ground control is used to create a digital control file and control report as well as QC check of ortho accuracy. Predefined points (usually NGS) within the county are targeted, making the points visible in the photography. These points along with their precise coordinates are used in the AT process and to check the horizontal accuracy of the resulting orthophotos. 30 existing ground control points were used for this project.  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: BBBB  
Publication\_Date: Unpublished material  
Title: Digital elevation model  
Edition: 1.0  
Geospatial\_Data\_Presentation\_Form: Vector digital data  
Publication\_Information:  
Publication\_Place: None  
Publisher: None  
Type\_of\_Source\_Media: disc  
Source\_Time\_Period\_of\_Content:

Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: DEM  
Source\_Contribution: A new LiDAR survey output to a 20-ft spaced grid was produced by BBBB for the project area. This DEM was used in the orthophoto production process.  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: ZZZZ County  
Publication\_Date: Unpublished material  
Title: Tile definition  
Edition: 1.0  
Geospatial\_Data\_Presentation\_Form: Vector digital data  
Publication\_Information:  
Publication\_Place: none  
Publisher: none  
Type\_of\_Source\_Media: disc  
Source\_Time\_Period\_of\_Content:  
Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: TLDEF  
Source\_Contribution: The tile definition is used to cut orthorectified imagery into manageable, usable images. It was provided by ZZZZ County, NC and references NAD83 SPCS North Carolina. Each tile is 5000' X 5000'.  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: BBBB  
Publication\_Date: Unpublished material  
Title: Orthorectified imagery  
Edition: 1.0  
Geospatial\_Data\_Presentation\_Form: Remote-sensing image  
Publication\_Information:  
Publication\_Place: None  
Publisher: None  
Type\_of\_Source\_Media: disc  
Source\_Time\_Period\_of\_Content:  
Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: OIMG1  
Source\_Contribution: This first level of orthorectified images are the product of using the AT solution and the DEM in SSSS. They are large 4GB swaths that have yet to be mosaicked into manageable tiled orthos.  
Source\_Information:  
Source\_Citation:  
Citation\_Information:  
Originator: BBBB  
Publication\_Date: Unpublished material  
Title: Tiled Orthophoto  
Edition: 1.0

Geospatial\_Data\_Presentation\_Form: Remote-sensing image  
Publication\_Information:  
Publication\_Place: None  
Publisher: None  
Source\_Scale\_Denominator: 1200  
Type\_of\_Source\_Media: disc, DVD or online  
Source\_Time\_Period\_of\_Content:  
Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Source\_Currentness\_Reference: Ground condition  
Source\_Citation\_Abbreviation: OIMG2  
Source\_Contribution: The tiled orthophoto is the result of mosaicking orthorectified imagery and using the tile definition to cut into manageable, usable orthophotos.  
Process\_Step:  
Process\_Description: At selected locations throughout the site, accurate GPS coordinates and elevations are surveyed and the points are marked with targets which will be visible in the aerial photography.  
Source\_Used\_Citation\_Abbreviation: None  
Process\_Date: 2008  
Source\_Produced\_Citation\_Abbreviation: CONT  
Process\_Step:  
Process\_Description: New digital, color aerial imagery of the site is acquired using the CCCCC. Airborne GPS/IMU data is recorded along with the imagery.  
Source\_Used\_Citation\_Abbreviation: None  
Process\_Date: 2008  
Source\_Produced\_Citation\_Abbreviation: IMG  
Process\_Step:  
Process\_Description: Imagery and GPS/IMU data is downloaded from disc on the plane to disc on the ground. GPS/IMU mission data is processed together with simultaneously collected ground-based GPS base station data in forward and reverse directions. This precisely determines the aerial camera's position and orientation in the terrain (project) coordinate system and allows for correct orientation of the imagery.  
Source\_Used\_Citation\_Abbreviation: IMG  
Process\_Date: 2008  
Source\_Produced\_Citation\_Abbreviation: IMG  
Process\_Step:  
Process\_Description: Using the processed GPS/IMU data and correctly oriented imagery, a bundle adjustment is computed (AT) in SSSSS software.  
Source\_Used\_Citation\_Abbreviation: IMG, CONT  
Process\_Date: 2007  
Source\_Produced\_Citation\_Abbreviation: None  
Process\_Step:  
Process\_Description: Orthorectified imagery is produced using SSSSS software. They are large 4GB swaths that have yet to be mosaicked into manageable tiled orthos.  
Source\_Used\_Citation\_Abbreviation: IMG, DEM  
Process\_Date: 2008  
Source\_Produced\_Citation\_Abbreviation: OIMG1  
Process\_Step:  
Process\_Description: Orthorectified imagery is mosaicked, locally color-balanced and cut to the tile definition boundaries. The tiled orthos are checked for accuracy against the surveyed ground control before further image editing.  
Source\_Used\_Citation\_Abbreviation: OIMG1, CONT  
Process\_Date: 2008  
Source\_Produced\_Citation\_Abbreviation: OIMG2  
Process\_Step:

Process\_Description: Tiled orthophotos then go through a rigorous manual QC process to evaluate for remaining hotspots (sun reflectance over water), tone quality, color balance and the feathering area between flightlines. Any imperfections at this point are manually edited. If necessary, the tiled images are then converted to required format. All images are either recorded on DVD, transferred to HD or posted on FTP for client access.

Source\_Used\_Citation\_Abbreviation: OIMG2

Process\_Date: 2008

Source\_Produced\_Citation\_Abbreviation: OIMG2

Cloud\_Cover: 0

Spatial\_Data\_Organization\_Information:

Direct\_Spatial\_Reference\_Method: Raster

Raster\_Object\_Information:

Raster\_Object\_Type: Pixel

Spatial\_Reference\_Information:

Horizontal\_Coordinate\_System\_Definition:

Planar:

Grid\_Coordinate\_System:

Grid\_Coordinate\_System\_Name: State Plane Coordinate System 1983

State\_Plane\_Coordinate\_System:

SPCS\_Zone\_Identifier: 3200 North Carolina

Lambert\_Conformal\_Conic:

Standard\_Parallel: 34.333333

Standard\_Parallel: 36.166667

Longitude\_of\_Central\_Meridian: -79.000000

Latitude\_of\_Projection\_Origin: 33.750000

False\_Easting: 2000000.0

False\_Northing: 0.000000

Planar\_Coordinate\_Information:

Planar\_Coordinate\_Encoding\_Method: Coordinate pair

Coordinate\_Representation:

Abscissa\_Resolution: .05

Ordinate\_Resolution: .05

Planar\_Distance\_Units: U.S. Feet

Geodetic\_Model:

Horizontal\_Datum\_Name: North American Datum of 1983

Ellipsoid\_Name: Geodetic Reference System 80

Semi-major\_Axis: 6378137.0

Denominator\_of\_Flattening\_Ratio: 298.25722210088

Entity\_and\_Attribute\_Information:

Overview\_Description:

Entity\_and\_Attribute\_Overview: Color orthophotos are comprised of pixels. Each pixel is assigned a value of 0 to 255. That number will refer to a color look-up table which contains red, green and blue (RGB) values, each from 0 to 255, for that pixel within the image.

Entity\_and\_Attribute\_Detail\_Citation: None

Distribution\_Information:

Distributor:

Contact\_Information:

Contact\_Person\_Primary:

Contact\_Person: P P P P P

Contact\_Organization: Z Z Z Z Z County

Contact\_Position: W W W W W

Contact\_Address:

Address\_Type: mailing and physical

Address: A A A A A

City: T T T T T

State\_or\_Province: NC

Postal\_Code: 99999  
Country: U.S.  
Contact\_Voice\_Telephone: NNNNN  
Contact\_Facsimile\_Telephone: FFFFF  
Contact\_Electronic\_Mail\_Address: EEEEE  
Hours\_of\_Service: 0800-1700 M-F EST  
Resource\_Description: ZZZZZ County, NC 1:1200, 0.5' pixel digital color orthophotography (2008)  
Distribution\_Liability: ZZZZZ County GIS provides the geographic data "as is". This organization makes no guarantee or warranty concerning the accuracy of information contained in the geographic data. Also, this organization makes no warranty, either expressed or implied, regarding the condition of the product or its fitness for any particular purpose. The burden for determining fitness for use lies entirely with the user. Although these files have been processed successfully on computers at this organization, no warranty is made by this organization regarding the use of these data on any other system, nor does the fact of distribution constitute or imply such a warranty.  
Standard\_Order\_Process:  
Digital\_Form:  
Digital\_Transfer\_Information:  
Format\_Name: MrSID  
Digital\_Transfer\_Option:  
Online\_Option:  
Computer\_Contact\_Information:  
Network\_Address:  
Network\_Resource\_Name: <http://www.nconemap.com>  
Access\_Instructions: FTP  
Offline\_Option:  
Offline\_Media: CDROM, DVD, USB hard drive  
Recording\_Capacity:  
Recording\_Density: 700, 4400  
Recording\_Density\_Units: mb  
Recording\_Format: Unknown  
Fees: unknown  
Ordering\_Instructions: Contact ZZZZZ County GIS, or visit the website  
Custom\_Order\_Process: Contact ZZZZZ County GIS, or visit the website  
Technical\_Prerequisites: unknown  
Available\_Time\_Period:  
Time\_Period\_Information:  
Single\_Date/Time:  
Calendar\_Date: 2008  
Metadata\_Reference\_Information:  
Metadata\_Date: 20090128  
Metadata\_Review\_Date: 20090130  
Metadata\_Contact:  
Contact\_Information:  
Contact\_Person\_Primary:  
Contact\_Person: PPPPP  
Contact\_Organization: ZZZZZ County  
Contact\_Position: WWWW  
Contact\_Address:  
Address\_Type: mailing and physical  
Address: AAAAA  
City: TTTTT  
State\_or\_Province: NC  
Postal\_Code: 99999  
Country: U.S.

Contact\_Voice\_Telephone: NNNNN  
Contact\_Facsimile\_Telephone: FFFFF  
Contact\_Electronic\_Mail\_Address: EEEEE  
Hours\_of\_Service: 0800-1700 M-F EST  
Contact\_Information:  
Metadata\_Standard\_Name: FGDC CSDGM  
Metadata\_Standard\_Version: FGDC-STD-001-1998

Adopted October 1, 2009

## Attachment 2a

### Using the Ortho Imagery Metadata Template

This template is designed for the most common ortho imagery data publication in North Carolina where a contractor produces the data, a county agency publishes and distributes the data, and compressed images are shared through NC OneMap.

Before importing the template using ArcCatalog or other GIS tool, use the text version of the template to find and replace as follows (use a text editor to edit/replace; do not use MS WORD with metadata to avoid inadvertent formatting).

### Find and Replace

Replace BBBBBB with the name of the contractor for data creation (and usually origination of the metadata record)

Replace ZZZZZZ with the name of the county.

Replace CCCCCC with the name of the camera or type of camera used for the imagery

Replace RRRRRR with the title of the Project Report and online link if available (Project Report is described in section 6.23 of the Secretary of State Technical Specification for Ortho Imagery).

Replace SSSSSS with the name of the software used in processing the TIF images

Replace GGGGGG with the name of the county department (contact organization, e.g., Land Records Department, Information Technology Services, GIS Department, etc.)

Replace PPPPPP with the name of the county contact person

Replace WWWWWW with the position of the county contact person (e.g., Land Records Supervisor, Tax Assessor, Information Technology Services Director, GIS Coordinator, etc.)

Replace AAAAAA with the street address of your office (number name suffix)

Replace TTTTTT with the name of your city or town (address)

Replace 999999 with the postal zip code of your office

Replace NNNNNN with contact telephone number

Replace FFFFFFFF with contact fax number

Replace EEEEE with contact email address

## Editing Notes

Check and edit all dates using the format YYYYMMDD, YYYYMM or YYYY depending on the availability of year, month and day.

Edit dates shown as examples in the template to be consistent with data capture and other dates specific to your project. Note that “Publication date” represents the release of the dataset or the last update of the dataset.

Online access is shown as [www.nc.onemap](http://www.nc.onemap) (the image server and FTP for MrSID compressed files for counties participating in NC OneMap).

Check and edit the resolution (set at 0.5 foot resolution or “200-scale ” in template). One metadata record per resolution (scale) is needed.

Check and edit the attribute accuracy report to reflect your procedures.

Check “source contribution” examples and edit to reflect your specific data and processes.

Under Data Quality, check process steps and edit the examples to reflect your specific steps.

Check to see if the last process step is "import metadata" which you do not need to keep (delete the process step).

Under Identification Information, check and edit access constraints and use constraints to be consistent with your jurisdiction’s policies.

Check for unintended wording and add detail where practical.

Use the online metadata validator to check for errors—go to:

<http://geo-nsdi.er.usgs.gov/validation/>

and browse to the metadata file and click the “validate” button. The error report describes each error (if any) and the line in the text where it occurred.

For more information, contact [dataq@ncmail.net](mailto:dataq@ncmail.net)

# Attachment 3

CHART SHOWING THE SUFFIXES TO BE ADDED TO THE MODULAR UNIT NUMBER FOR 1" = 200', 1" = 100' and 1" = 50' SCALES OF MAPPING

1" = 200'

|    |    |
|----|----|
| 01 | 02 |
| 03 | 04 |

1" = 100'

|    |    |    |    |
|----|----|----|----|
| 05 | 06 | 07 | 08 |
| 01 |    | 02 |    |
| 09 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 |
| 03 |    | 04 |    |
| 17 | 18 | 19 | 20 |

1" = 50'

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 05 |    | 06 |    | 07 |    | 08 |    |
| 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 09 |    | 10 |    | 11 |    | 12 |    |
| 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 |
| 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 13 |    | 14 |    | 15 |    | 16 |    |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 |
| 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 |
| 17 |    | 18 |    | 19 |    | 20 |    |
| 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |

THE LARGER SQUARES CENTERED WITH CIRCLED NUMBERS REPRESENT THE LIMITS AND SUFFIX NUMBERS OF THE MAP AT THE NEXT LARGER SCALE.

## Addendum 1

### List of deliverables

1. Contractor will indicate on a copy of the County Contract Map the horizontal control stations (existing and to be established) that will be paneled. (4.01)
2. The Contractor will provide the Contracting Officer a brief description of the equipment and methods to be used for new ground surveys prior to conducting any control surveys. (4.01)
3. The camera calibration report shall be submitted to the Contracting Officer for approval before proceeding with work. (2.13-2.14)
4. The flight logs, or copies, shall be delivered to the Contracting Officer at the end of the project flights. (2.18)
5. Within one week of the flight mission, the Contractor shall submit a detailed quality control report to the Contracting Officer confirming compliance to the aerial photography specifications. If the Contractor can not meet the one week reporting time frame the Contractor shall inform the Contracting Officer in advance of the delay. (2.06)
6. The Contractor will provide the Contracting Officer hard copy and digital (ASCII) files of survey records:
  - a. Field notes and observation Logs (4.06 a.)
  - b. North Carolina Geodetic Survey (NCGS) Station Recovery Forms are to be filled out and submitted to NCGS on searched for monuments. (4.06a)
  - c. Computations (4.06 b.)
  - d. Control Diagram (4.06 c.)
  - e. Control Data (4.06 d.)
  - f. GPS Observation Summary (4.06 e.)
  - g. At the conclusion of Airborne GPS collection, the Contractor shall be required to submit a report of GPS observations and results data, observation logs, and data analysis and adjustments. (4.09 f.)
7. The Contractor will provide the Contracting Officer the Aerial Triangulation Report. (5.05)

8. Scanner specifications, a camera(s) calibration report, diagnostic reports, and/or other test results showing accuracy, resolution, and ability to distinguish tonal qualities shall be submitted to the Contracting Officer for approval before proceeding with the scanning phase. (6.08)

9. Reference Product (see 6.19)

10. At the completion of the mapping project or at a time which facilitates the flow of work, the Contractor shall deliver to the Contracting Officer for his/her acceptance the items listed in (6.25).

11. At the completion of the Project the Contractor shall deliver to the Contracting Officer two copies of the Project Report. (6.28)

Adopted October 1, 2009

## **Addendum 2**

### **NC Orthoimagery Quality Assurance (QA) Procedures**

#### **1. Inventory**

A data delivery inventory is required at the beginning of the QA process. Deliverables are checked against the Statement of Work (SOW)/ State Standard and task order to verify that all delivery specifications were met. Specific items inventoried include:

- Verify shipping manifest against materials received.
- Verify that all Orthoimage files expected in delivery have been received.
- Verify that all media can be read and Orthoimages transferred.
- Verify that all orthoimages have been correctly named as stated in the contract or partnership agreement.
- Verify any use or distribution restrictions with the data and document in the project file.

Notify Contractor of any discrepancies/problems immediately, before the rest of the QA process is begun.

#### **2. Visual Inspection**

Software packages that may be used to perform this task include Global Mapper, ArcMap, or ArcView. Every image tile within a project is visually inspected for:

- Tonal balancing problems across the block.
- Radiometry; flag if there appears to be problems (color tone, contrast, overexposed, underexposed).
- Check Ground Sample Distance to ensure that it meets the specified resolution.
- Check for cloud cover, smoke/haze, corrupt data, and void areas.
- Check for extreme tonal or color variation across seamlines.
- Check for excessive horizontal displacement along seamlines in images (more than  $\pm 3$  pixels along transportation features, unless project specifications specifically state otherwise).
- Check for excessive tilt in bridges, buildings, and other raised features.

- Check for transportation features obstructed by buildings or shadows.
- Check for clipping of features (e.g. radio towers, water tanks, buildings) at tile boundaries.
- Check for building/structure distortion or warp that may indicate bad elevation data.
- Check for transportation feature distortion of warp that may indicate bad elevation data.
- Check for smearing.
- Check for evidence of oversaturation or undersaturation as a result of image processing or histogram manipulation.
- Check for evidence of image compression.

Note: All edges are checked. During this inspection, individual images are checked for problems. The maximum allowable mis-join between transportation features is  $\pm 3$  pixels, unless project specifications specifically state otherwise. Smearing that affects cultural features will be corrected by the Contractor. The Reference Product (6.19) will be project visual quality control reference standard. If quality control issues arise during final review, this Reference Product will be used as the project standard.

### **3. Spatial Domain**

- Verify format for orthoimages and header file.
- Verify pixel size (as specified).
- Verify Geospatial referencing (datum and projection) and units of measure.

### **4. Horizontal Accuracy Assessment.**

When test point control is available and “suitable”, a horizontal accuracy check is performed to verify the veracity of the data producer’s accuracy statement. In the interest of clarity, “suitable” test point control is defined to be:

- Completely independent of data used in the production of the base dataset.
- Independent accuracy of test point control should ideally be at least *three times* more accurate than the dataset being tested whenever possible. At an absolute minimum, test points must have a horizontal accuracy better than the ground sample distance (or pixel size), of the imagery being tested.

- Situated on well defined, distinct, and photoidentifiable features.
- Situated at or very near ground level, *not* on an elevated surface.
- Preferably obtained by an entity other than the producer of the base data.
- Located in relatively level terrain, away from steep embankments.

Test points should be dispersed throughout the project area as much as possible. If the dataset to be tested covers a rectangular area, at least 20% of the points should fall in each quadrant (NW, NE, SW, SE). The spacing between points should be at least 10% of the diagonal distance across the rectangular area.<sup>1</sup> The minimum spacing guideline can be waived if more than the minimum number of independent test points are established; however, the logic behind the spacing requirement is to ensure that the points are not clustered in a few regions of the project dataset, and that requirement remains.

Reporting of Horizontal Accuracy shall be as follows:

1. "This county orthophoto project was checked and found to have a RMSE X value of \_\_\_\_\_Feet and a RMSE Y value of \_\_\_\_\_feet which conforms to the ASPRS horizontal accuracy standard as defined in section 6.04 of Technical Specifications for Base, Cadastral and Digital Mapping (Orthophotos) Land Records Management Division North Carolina Department of the Secretary of State"

And

2. "This county orthophoto project was tested using the Case 1 formula and procedures set forth in FGDC-STD-007-1998. The result of that test was \_\_\_\_\_feet horizontal accuracy."

Horizontal accuracy quality control shall be implemented under the following guide lines.

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part1/chapter1>

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>

## 5. Metadata Inspection

- Verify that each Orthoimage tile has a corresponding header file.
- Verify the existence and content of project-level metadata.
- Check for proper FGDC metadata structure and mandatory elements.
  - Check for correct project/urban area name usage.
  - Check for proper citations, abstract, and purpose.
  - Check for appropriate dates for time period, production and metadata.
  - Check for minimum bounding rectangle entry.
  - Check for Data Credits.
  - Check for pertinent placekey entries.
  - Check for production platform/software.
  - Check for a production process description narrative.
  - Check for an accuracy report narrative and RMS entry.
  - Check for image, elevation, and control entries in the lineage.
  - Check for data quality entries (logic and completeness).
  - Check for accurate geospatial entries (coordinate system, units, horizontal datum)

## **References**

<sup>1</sup>“Positional Accuracy Handbook; Using the National Standard for Spatial Data Accuracy to measure and report geographic data quality;” Minnesota Planning Land Management Information Center; October 1999.

[http://www.mnplan.state.mn.us/pdf/1999/lmic/nssda\\_o.pdf](http://www.mnplan.state.mn.us/pdf/1999/lmic/nssda_o.pdf)

Checkpoint location cited in ASPRS Accuracy Standards for Large Scale Maps, July 1990

“Guidelines and Specifications for Flood Hazard Mapping Partners; Appendix A: Guidelines for Aerial Mapping and Surveying; FEMA; April 2003.

<http://www.fema.gov/library/viewRecord.do?id=2206>

“Geospatial Positioning Accuracy Standards; Part 3: National Standard for Spatial Data Accuracy”; Federal Geographic Data Committee; 1998

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>

Adopted October 1, 2009