

State of Kentucky
LiDAR and Imagery Procurement Group
Technical Committee

Digital Orthophoto Production
Technical Specifications

Latest Update: March 22, 2011

I. Project Area

A. General

The total Project Area includes the entirety of the state of Kentucky, subdivided into two project sub-areas. The “Base Resolution” project sub-area is defined as the **project region(s)** for which the imagery collection will be carried out at the lowest spatial resolution (see Section II.2.a below). The “Higher Resolution” project sub-area will be defined as **project region(s)** encompassing cities, counties, incorporated areas, regional groupings or other administrative jurisdictions subscribing to the buy-up option for acquiring imagery at higher spatial resolution with or without other options (see Section V below).

B. Buffering

Each **project region** shall cover the assigned area with a minimum 1000 feet buffer on all sides.

C. Geographic Extent

Region extents shall be computed by projecting the geographic corners and side midpoints to the appropriate projection, then adding the buffer on each side of the resulting minimum bounding rectangle.

II. Digital Orthophotography Production

The production of digital orthophotography to be acquired will be according to the following **requirements**:

1. Collection conditions:

- a. Three consecutive leaf-off seasons in the 2011-2013 triennium.
- b. Imagery shall be acquired during minimal shadow conditions. Imagery acquisition shall occur when the sun angle is greater than 30-degrees above the horizon.
- c. Imagery shall be acquired only under conditions free from clouds and cloud shadows, smoke, haze, light streaks, snow, ice on water bodies, foliage, flooding, and excessive soil moisture.

2. Image resolutions:

a. Ground (Spatial) Resolution:

1. Vertical color aerial digital photography will be captured for the “**Higher Resolution**” sub-area. This photography must be captured at a scale sufficient for producing 1” = 100’ stereo photogrammetric mapping meeting the American Society for Photogrammetry and Remote Sensing (ASPRS) Class 1 Accuracy Standards for Large Scale Maps and for production of color digital orthophotography at a resolution of 0.5 feet (6 inches).
2. Vertical color aerial digital photography will be captured for the “**Base Resolution**” sub-area. This photography must be captured at a scale sufficient for producing 1” = 200’ stereo photogrammetric mapping meeting the American Society for Photogrammetry and Remote Sensing (ASPRS) Class 1 Accuracy Standards for Large Scale Maps and for production of color digital orthophotography at a resolution of 1.0 feet (12 inches).

b. Spectral resolution:

The sensor or camera will capture light bands corresponding to natural color (red, green and blue or RGB), but will additionally capture the near infrared (NIR) band.

All imagery that contains both natural color and near-IR 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.

c. Radiometric resolution:

The digital aerial images shall be clear and sharp in detail and of high radiometric quality. The sensor shall capture the images in an uncompressed “lossless” image format. The sensor shall, at minimum, utilize a 12-bit per pixel radiometric resolution.

Imagery with greater than 8 bits per pixel is allowed providing that the following TIFF tags are included in the image header:

- SampleFormat
- MinSampleValue
- MaxSampleValue

d. Coordinate system:

All mapping products will be delivered in Kentucky Single Zone State Plane coordinates (parameters defined in FIPS 1600, and units of U.S. Survey Feet), NAD83* geometric datum (NSRS2007 or CORS96 adjustment), and NAVD88 vertical datum. GPS derived NAVD88 heights will use the Geoid09* model. [* Use most current adjustment and geoid model available from the National Geodetic Survey at time of data processing]

e. Horizontal Accuracy:

The horizontal accuracy of the orthorectified imagery shall be higher than 2-foot $RMSE_{XY}$ (1.41 foot RMSE - X or Y) in the case of 12-inch spatial resolution, and 1-foot RMSE (0.7 foot RMSE - X or Y) in the case of 6-inch spatial resolution.

f. DTM and Vertical Accuracy:

New digital elevation data will be produced for the entire project area and the vertical accuracy of the DTM(s) developed to support production of the digital orthophotos shall be sufficient to guarantee the horizontal accuracy specified above.

g. Control Points:

The plotted position of each control point shall lie to an accuracy of one-hundredth (1/100) of an inch of its true position, as expressed by the State Plane coordinate for that point. Control point coordinates will be submitted as a dataset.

3. **Aerotriangulation data:** Aerotriangulation data, if used in the orthorectification process, consisting of a minimum of refined plate coordinates, adjusted ground coordinates, and statistical summary report shall be submitted in both hardcopy and softcopy format.
4. **Elevation data:** Elevation data created or modified for use in the orthorectification process shall be submitted as a deliverable in a non proprietary format on portable media.
5. **Metadata:** Metadata shall be delivered as described in Section III.B.5 below.

III. Deliverables

A. Source Imagery:

1. **Calibration Reports:** Camera Calibration Report(s) for Aerial Camera(s), or in the case of digital sensors, a current Product Characterization Report of the instrument used shall be included as a deliverable.
2. **Camera Station Control:**
 - i. **Airborne GPS:** Positional data and statistical summary report shall be submitted on portable media, in a non-proprietary format. A statistical report shall be produced and delivered, summarizing the results of the airborne GPS adjustment.
 - ii. **IMU Data:** If IMU exterior orientation data is part of the Technical Proposal. Sensor orientation data and a statistical summary report will be prepared and submitted on portable media, in a nonproprietary format. A statistical report summarizing the overall accuracy of the adjusted IMU data will also be submitted.
3. **Supplemental Ground Control:** Differentially corrected GPS Ground Control used to supplement the Airborne GPS positional data shall be delivered on portable media, in a non-proprietary format.
4. **Flight Diagram:** A Flight Diagram that illustrates the project area outline, the location of the flight lines and the approximate location of image centers, if relevant, shall be included as a deliverable. This diagram shall be provided in hardcopy and softcopy as a feature class in a file geodatabase, suitable for loading into ArcGIS.
5. **Photography and Supplemental Report(s):** A Photography Supplemental Report of all the imagery flown shall be produced for the project. The report shall show the flight line numbers and exposure station

or strip numbers. The contractor shall use the USGS Aerial Photography Supplemental Report form. An example of this form is included in Attachment B of this document.

6. **Digital Frames:** One set of digital photo frames will be prepared from the original digital exposures. These digital frames shall be in uncompressed TIFF image format containing the full 16 bit (per band) radiometric pixel values for each of the four (4) wavelengths that are collected, and shall be sent to the Division of Geographic Information for evaluation purposes within two weeks after the date of aerial photography. All digital photo frames will remain the property of the state of Kentucky.

B. Processed Images:

1. **Digital Orthorectified Image Tile Size:** The orthorectified GeoTIFF files shall be organized as representing "tiles" on a tile grid compatible with the 2006 Kentucky Tiling Grid for aerial orthophotography. The orthophoto files must be produced directly from the digital data. Tiles shall be accompanied by an index sheet and as a feature class in a file geodatabase suitable for loading into ArcGIS. Index sheet shall include tile boundary and filename. The Index sheet collar shall include a graticule with latitude and longitude reference coordinates and a grid with the 10K or 5K US Survey Feet (SPCS), corresponding to the Kentucky tiling scheme grid.
2. **Digital Orthorectified Image Characteristics:** Relative join (misalignment) of transportation features between adjacent image chips/tiles shall not exceed 3 pixels. Orthophotos shall be tonally balanced to produce a uniform contrast and tone across the image tiles of the entire project. Changes in color balance across the project, if they exist, shall be gradual. Abrupt tonal variations between tiles are not acceptable. Building tilt shall be corrected to the extent that transportation features are not obscured. Ground features appearing in the orthophoto imagery, such as building roof tops, water towers, and radio towers, shall not be clipped at seamlines or between individual tiles.
3. **Digital Orthorectified Image Format:** Images shall be submitted in uncompressed, untiled, ArcGIS readable, GeoTIFF file format, Version 1.8.2, (<http://www.remotesensing.org/geotiff/spec/geotiffhome.html>) with no internal tiling or overviews. Data shall not be compressed during ANY PHASE of the production process. Presence of compression artifacts will be cause for rejection. GeoTIFF files shall include (as a minimum) the following GeoTIFF tags and keys:

- ModelTiepointTag
 - ModelPixelScaleTag
- OR**
- ModelTransformation Tag

AND

- GTModelTypeGeoKey
- GTRasterTypeGeoKey
- ProjectedCSTypeGeoKey
- PCSCitationGeoKey
- ProjLinearUnitsGeoKey

The address referencing system is area. GTRasterTypeGeoKey will be set to "RasterPixelsArea."

4. **Delivery Medium and Format:** Digital Orthorectified Images, in GeoTIFF format, shall be submitted on portable media.
5. **Metadata:** FGDC-compliant metadata shall be provided in extensible markup language (.xml) format for each orthorectified tile. Additionally, an FGDC-compliant project-level metadata (xml format) shall be provided.

The following ftp site contains information pertaining to the content and creation of the required metadata:

<ftp://ftpext.usgs.gov/pub/cr/mo/rolla/mcmc/release/xmlinput>

This site contains the following files designed to define and support production of FGDC-compliant orthoimage metadata:

- i. **XmlInput1_64.zip.** Application for reading and creating .xml metadata files. Included in this file are a sample metadata file which shows how these data elements should be addressed (**133UAExample.xml**) and the metadata template (**133UAtemplate.xml**).
- ii. **Help.pdf** The users guide for XmlInput.

IV. Quality Assurance and Quality Control:

It will be performed to ensure that all processes and procedures used, and metadata produced were adequate to meet all specifications cited as deliverables. Visual inspection of the data will be performed for the following:

- a. Atmospheric artifacts: cloud cover, smoke and haze should be absent
- b. Misalignment: excessive horizontal displacement relative join (misalignment) of transportation features between adjacent image chips/tiles or seamlines

shall not exceed 3 pixels – unless a buy-up option stipulating stricter specifications state otherwise (e.g. 2 pixels or less).

- c. Tonal balance: orthophotos shall be tonally balanced to produce a uniform contrast and tone across the block and the entire project. Extreme tonal or color variation across seamlines will be avoided. Changes in color balance across the project, if they exist, shall be gradual. Abrupt tonal variations between tiles or inconsistencies in tone and density between individual orthophotos and/or adjacent sheets are not acceptable.
- d. Building tilt: excessive tilt in bridges, buildings, and other raised structures shall be corrected particularly to the extent they obscure transportation features
- e. Transportation feature occultation: transportation features should not be obscured by shadows or buildings
- f. Ground features: appearing in the orthophoto imagery, such as building roof tops, water towers, and radio towers, shall not be clipped at seamlines or between individual tiles.
- g. Clipping: features such as radio towers, water tanks, buildings and similar, should not be clipped at tile boundaries.
- h. Image mosaicking/tiling and quality: the image with the best contrast shall be used as a reference image when the color digital orthophoto tiles are created. All other images shall have their brightness values adjusted to that of the reference image.
- i. Image artifacts: the delivered color digital orthophotos will not contain defects such as out-of-focus imagery, blurs, whorls, twists, color blemishes, dust or lint marks, or scratches. The images shall also be free from image blurs, smears, voids, image artifacts, “cold” or “hot” pixels, color distortion, color balance or tonal problems, or any other kind of “digital blemish” or data corruption. All fiducial mark images shall be visible, clear and sharp. Evidence of oversaturation or undersaturation as a result of image processing or histogram manipulation should be avoided.
- j. Evidence of image compression: artifacts due to image compression should be absent.
- k. Building/structure warp: an indication of bad elevation data - should be absent
- l. Completeness: data are to cover the specified geographic extent, with no omissions or corrupt data. The image tiles delivered will contain neither background data nor NODATA pixels

- m. Ground Sampling Distance: GSD will ensure that it meets the specified resolution
- n. Perform Horizontal Accuracy Test: Testing is performed if suitable test-point control is furnished as part of the deliverables. Test-point control must be completely independent of control used during data production.
- o. Verify Metadata Adequacy: Verify that accompanying metadata is complete as defined by FGDC metadata standards (<http://www.fgdc.gov/metadata>).

V. Buy-Up Options

This effort supports the acquisition of more detailed, accurate, or value-added data that exceeds the base specification. A list of common “buy-up” options is provided below for those geographic extents which require more stringent specifications.

Buy-up options are those specifications that will apply to the “**Higher Resolution**” project sub-area, beyond the minimum requirements for one-foot orthoimagery to be produced for the “**Base Resolution**” project sub-area. The cost of a buy-up option is based on the increased level of effort over the cost for baseline imagery. The following are considered examples of buy-up options:

1. color-infrared composite
2. panchromatic band acquisition
3. four-band composite
4. increased radiometric resolution or bit depth (e.g. from 8-bit to 16-bit)
5. increased footprint
6. better horizontal accuracy
7. increased spatial resolution (ex. – 6-in)
8. reduced spatial resolution (requires resampling)
9. better elevation resolution

VI. References

- USGS. Urban Area Minimum Requirements for Imagery Acquisition and Production; May 2009 (classified).
- USGS. Base Orthoimagery Specification (draft); June 2009. (classified).
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- Content Standards for Digital Orthoimagery. Federal Geographic Data Committee, Subcommittee on Base Cartographic Data. February 1999.
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- (NKAPC) Acting on behalf of The LINK-GIS Partnership - Kenton and Campbell Counties, Kentucky, .November 13, 2006.
- Request for Proposal to provide Photogrammetric Services for Scott County, Kentucky. Department of Geographic Information Systems. Georgetown-Scott County Planning Commission GIS. November 2004.
 - Traditional Aerial Film Camera vs. Digital Camera. Statewide Mapping Advisory Committee. Working Group for Orthophotography Planning. North Carolina Geographic Information Coordinating Council. April 7, 2008.
 - Neumann, K.J. 2008. Trends for Digital Aerial Mapping Cameras. Commission I, WG I/4 *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B1. Beijing 2008*
 - Billups, C.L. 2004. Digital Sensors vs. Film Cameras: Collier County, Florida Test Drives Digital Sensor. Directions Magazine, July 14, 2004.
 - Gruber, M., M. Ponticelli, S. Bernögger, and F. Leberl. 2008. Ultracam X. The Large Format Digital Aerial Camera System by Vexcel Imaging/Microsoft. Commission I, WG I/4 *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B1. Beijing 2008.*
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 - City of Cambridge. GIS Data Standards and Specifications. On-line document. http://gis.ci.cambridge.ma.us/gisdictionary/gis_standards.html#Orthophotographs
 - Kentucky Geography Network: <http://kygeonet.ky.gov> .
 - Geospatial Positioning Accuracy Standards - National Spatial Data Infrastructure. Part 3: National Standard for Spatial Data Accuracy Subcommittee for Base Cartographic Data Federal Geographic Data Committee. FGDC-STD-007.3-1998. <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>
 - RFP-10-89 Indiana 2010 Orthophotography Program Section One. General Information and Requested Products/Services. 2010. <http://www.igic.org/projects/orthos2010/rfp-10-89.pdf>