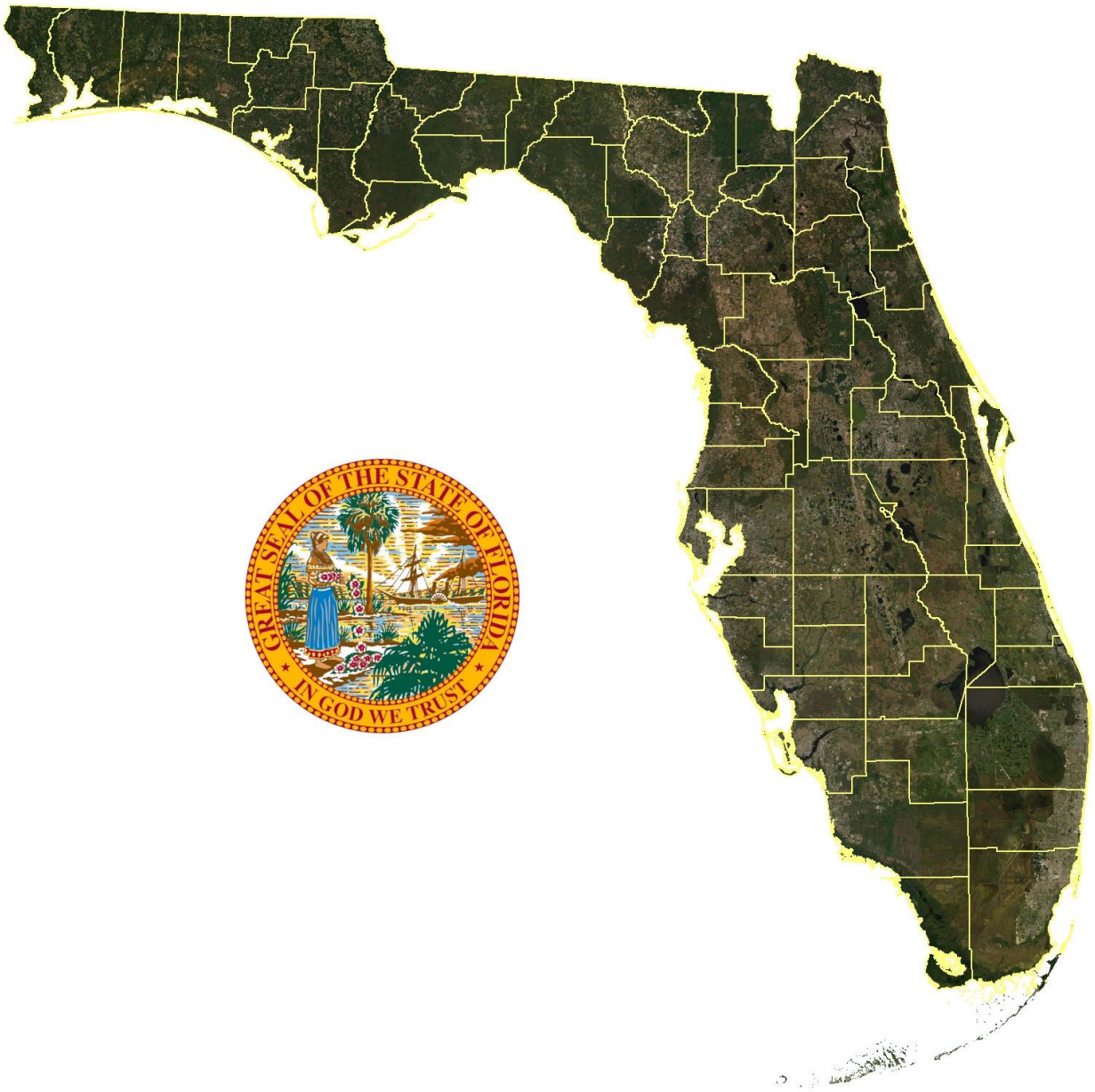
Florida County Digital Orthoimagery Program Standards



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1. CONTENTS

1. ABBREVIATIONS AND DEFINITIONS

- **AT** - Aerotriangulation
- **ASPRS** – American Society for Photogrammetry & Remote Sensing
- **CADD** – Computer Aided Design & Drafting
- **CSDGM** – Content Standard for Digital Geospatial Metadata
- **DEM** – Digital Elevation Model
- **ESRI** – Environmental Systems Research Institute
- **F.A.C.** – Florida Administrative Code
- **FGDC** – Federal Geographic Data Committee
- **FIPS** – Federal Information Processing Standards
- **FCDOP** – Florida County Digital Orthoimagery Program
- **FDOT** – Florida Department of Transportation
- **FPRN** – Florida Permanent Reference Network (established and maintained by FDOT)
- **F.S.** – Florida Statutes
- **GeoTIFF** – Raster image file. GeoTIFF fully complies with the TIFF 6.0 specifications, and its extensions do not in any way go against the TIFF recommendations, nor do they limit the scope of raster data supported by TIFF. GeoTIFF uses a small set of reserved TIFF tags to store a broad range of georeferencing information, catering to geographic as well as projected coordinate system needs.
- **GNSS** – Global Navigation Satellite System (includes GPS)
- **GSD** – Ground Sample Distance
- **IMU** – Inertial Measurement Unit
- **INS** – Inertial Navigation System
- **Lidar** – Light Detection and Ranging
- **LAS –** A binary file standard supported by ASPRS for storing point location and attribute information primarily used for Lidar data.
- **NAD83 (2011)** - North American Datum of 1983, NGS 2011 realization
- **NAVD88 –** North American Vertical Datum of 1988
- **NGS** - National Geodetic Survey
- **NSRS –** National Spatial Reference System
- **NSSDA –** National Standard for Spatial Data Accuracy
- **Orthoimagery (Digital)** – Digital orthoimages are georeferenced images of the earth's surface that have been collected by a sensor and then, by correcting for sensor distortions and orientation as well as terrain relief, have had image object displacement removed. They encode the optical intensity of sensed radiation in one or more bands of the electromagnetic spectrum as discrete values in an array of georeferenced pixels that model the scene observed. ***Federal Geographic Data Committee FGDC-STD-014.2-2015 Geographic Information Framework Data Content* Standard Part 2: Digital Orthoimagery**

- **Orthorectification –** A special case of image resampling whereby the effects of image perspective and relief displacement are removed so that the resulting orthoimage has uniformly scaled pixels, resembling a planimetric map. (Source: American Society for Photogrammetry and Remote Sensing *Manual of Photogrammetry Fifth Edition*, 2004, page 963)
- **Photogrammetry** – The art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording measuring and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena. (Source: American Society for Photogrammetry and Remote Sensing *Manual of Photogrammetry Fifth Edition*, 20, page 2)
- **PSM** – Professional Surveyor and Mapper
- **RMSE** – Root Mean Square Error
- **RTK** – Real Time Kinematic
- **RTN** – Real Time Network
- **USft** – United States Survey Feet
- **USGS** – United States Geological Survey
- **XML** – Extensible Markup Language

2. INTRODUCTION

Since 1972, Florida Statutes have stipulated cooperation between USGS, FDOT, and the State Water Management Districts to facilitate statewide topographic mapping efforts. Currently, the horizontal component of the statewide topographic map is being accomplished through the Florida County Digital Orthoimagery Program (FCDOP). The FCDOP is supported by partnerships and agreements between several state and county agencies. The current FCDOP mapping efforts consist of statewide orthoimagery coverage of Florida on a three-year cycle, with a maximum GSD resolution of 0.5 feet.

3. PURPOSE

This document defines the minimum standards for providing Florida county digital orthoimagery products for inclusion into the FCDOP.
Any exceptions to these standards may be requested in writing from FDOR before commencement of work.
All final data will be considered public record as defined by applicable Florida Statutes.
Any products created from oblique aerial imagery acquired during the orthoimagery project collection are beyond the scope of this document.
All work performed must be in accordance with the ***Standards of Practice*** as set forth in ***Rule Chapter* 5J-17*, F.A.C.***, pursuant to ***Chapter 472, F.S.***

4. ORTHOIMAGERY SPECIFICATIONS

4.1. DIGITAL CAMERA

All imagery shall be collected using a digital aerial camera capable of collecting multispectral imagery in natural color (RGB) bands and near infrared band (N)**.** The sensor must also have a documented bore-sight calibration performed within six months of image acquisition.

4.2. IMAGE SPATIAL RESOLUTION

The consultant shall deliver images that have been resampled to the desired resolution of 0.5 feet. The original imagery must have native sensor resolution finer than or equal to the desired final resolution of the orthoimagery. Images of higher resolution can be used to create orthoimages of lower resolution but the reverse is not acceptable. The allowable RMSEx and RMSEy shall be less than or equal to 1.0 feet (2 pixels)

FGDC-STD-014.2-2015 2.8.2 Resolution

4.3. HORIZONTAL AND VERTICAL DATUM

Orthoimagery and other topographic products shall be referenced to the most current national datum, which presently is the NAD83 (2011). The map projection referenced shall be the appropriate Florida State Plane Coordinate System in units of USft. Orthoimagery and other topographic products shall be referenced to the NAVD88 in units of USft.

Unless otherwise stated, the horizontal and vertical accuracy of orthoimagery products shall be meet the requirements of the ***ASPRS Positional Accuracy Standards for Digital Geospatial Data***[1].

[1] American Society for Photogrammetry and Remote Sensing. (2014, November). ASPRS Positional Accuracy Standards for Digital Geospatial Data. Photogrammetric Engineering & Remote Sensing, Vol. 81, No. 3, pp. A1–A26. Retrieved from https://www.asprs.org

4.4 ACCURACY

Figure 1 – Accuracy Table for .50 ft GSD Orthoimagery

Common Ortho Image Pixel Size (Feet)	Horizontal Accuracy Class RMSEx and RMSEy (Feet)	Ortho Image RMSEx and RMSEy in terms of pixels	Horizontal Accuracy RMSEr (Feet)	Maximum Ortho Image Mosaic Seamline Mismatch (Pixels)	Maximum Ortho Image Mosaic Seamline Mismatch (Feet)	Allowable Aerotriangulation (AT) or INS-based (in feet)		Allowable Ground Control RMSE (Feet)		NSSDA Horizontal Accuracy at the 95% Confidence Level (Feet)
						RMSEx and RMSEy	RMSEz	Horizontal x and y	Vertical z	
0.50	0.5	≤1-pixel	0.707	2	1.0	0.250	0.50	0.125	0.250	1.22
	1.0	**2-pixels**	**1.414**	**4**	**2.0**	**0.500**	**1.00**	**0.250**	**0.500**	**2.45**
	1.5	3-pixels	2.121	6	3.0	0.750	1.50	0.375	0.750	3.67
	2.0	4-pixels	2.828	8	4.0	1.000	2.00	0.500	1.000	4.90

*****The maximum allowable orthoimage mosaic seamline mismatch is 3 pixels for all transportation infrastructure features, unless approved in writing by FDOR or FDOT.

Horizontal accuracy of orthoimagery products shall be tested to meet 2.5 feet at the 95% confidence interval. The ASPRS standards require direct comparison to checkpoints from an independent source of at least three times greater accuracy. The minimum number of well distributed check points should meet the ASPRS recommendations see *Table C.1*.

Figure 2 – Recommended Number of Checkpoints Based on Area

Project Area (Square Kilometers)	Horizontal Accuracy Testing of Orthoimagery and Planimetrics
	Total Number of 2D/3D Checkpoints (Clearly Defined Points)
≤500	20
501-750	25
751-1000	30
1001-1250	35
1251-1500	40
1501-1750	45
1751-2000	50
2001-2250	55
2251-2500	60

Note- Some project conditions may dictate the need for greater or fewer checkpoints to satisfy the testing of project accuracy. When less than the minimum checkpoints are proposed, or when distribution of checkpoints is limited, an exception to the ASPRS recommendations may be approved if requested in writing from FDOR or FDOT. The request shall include a digital map file (*.kml) displaying proposed locations of AT control and checkpoints, aerial imagery footprints, and a written explanation of why the exception is necessary.

4.5 DIGITAL ELEVATION MODEL

A surface model adequate to support orthoimagery accuracy specifications identified for this project must be created to accurately orthorectify the imagery. The consultant is responsible for evaluating the accuracy of the DEMs used in the orthorectification process and if necessary, collect supplemental data to further enhance the DEM.

Bridges and overpasses requiring surface edits shall be properly represented as a 3d surface and the resulting surface shall be utilized in the orthorectification process. These elevated features will not be included as part of the delivered DEM data.

One DEM file per tile matching approved index tile scheme is required to be delivered. All DEM will be delivered according to the tile index provided.

Approved Formats

- USGS DEM
- Raster GeoTIFF
- ERDAS IMAGINE (IMG) Format
- Floating Point Raster File (.flt)
- ASCII XYZ
- LAS/LAZ

The consultant will submit information in the final survey report and metadata which documents the source, enhancements made, and density of the surface data utilized for the orthoimage mapping project.

In addition, if lidar data is acquired as part of the project, the classified scan data must be provided in LAS file format as per ASPRS LAS Specification 1.4 with associated metadata.

4.6 IMAGE RECTIFICATION

Image rectification methodology must be compliant with the FGDC Geographic Information Framework Data Content Standard

FGDC-STD-014.2-2015 2.9 Image rectification and restoration

Supplemental Photo Editing

- Edit Polygon File. A shapefile shall be provided that contains polygons designating the areas where image anomalies and warping were photogrammetrically corrected and edited into the orthoimage using photo editing software. The description of this photo editing process will be included in the tile metadata and orthoimagery reports provided by the consultant. Polygons will be assigned unique ID numbers and coordinate values for each occurrence. Individual orthoimage tile metadata will reference only those polygon IDs that occur within that image tile

4.7 GROUND CONTROL

Enough ground control points shall be established to support orthoimage mapping. All control shall meet the requirements of the FCDOP, see *Attachment A.*

4.8 GNSS/INS SOLUTIONS

Unless otherwise approved, all GNSS/INS measurements shall be differentially processed to the FPRN, the resulting solutions shall be included in the aerotriangulation bundle adjustment.

4.9 FLIGHT SEASON

The specified flight season will be from October 1st through March 15th. Every effort should be made to collect imagery prior to January 30th. Imagery collected outside of this flight season will require written approval from contracting agency.

4.10 IMAGE QUALITY

Imagery shall be acquired to minimize excessive tilt/lean in buildings, obstruction by shadows, image smear, environmental conditions (clouds, haze, smoke, glare, solar reflection over water bodies, etc.), vegetative conditions, etc. Every effort should also be made to acquire imagery under optimum tide conditions. Radiometric and color balancing of the imagery is described in Section *5: Orthoimage Deliverables*. All images must be collected with a sun angle no less than 30°. Imagery shall be acquired at sufficient overlap coverage in “high-rise” urban areas to ensure all transportation infrastructure is clearly visible.

5 ORTHOIMAGERY DELIVERABLES

All deliverables will be the property of the contracting agency and are considered public record. The consultant will document all data deliveries with an itemized transmittal letter.

Written permission from the agency must be obtained to release data to any party prior to final publication. Per ***Rule Chapter 5J-17, F.A.C.***, the consultant shall keep a copy of the original data for a minimum of six (6) years. The consultant shall contact the agency before destroying the data.

5.1 FILE FORMATS AND IMAGE TYPES

5.1.1. ORIGINAL SOURCE IMAGERY

Original source imagery shall be delivered as uncompressed four-band TIFF images consisting of natural color (RGB) and near infrared (N) at the native bit-depth per band of the sensor.

5.1.2 TILED ORTHOIMAGERY

The consultant shall deliver ortho-rectified, uncompressed four-band GeoTIFF image tiles. These image tiles shall consist of natural color (RGB) and near infrared (N) bands at a bit-depth of 8-bits per band, with valid projection header information. Orthoimagery tiles shall be produced using a four-band workflow meaning all processes affecting final orthoimagery tile shall be performed using the aforementioned four-band imagery. Tiled orthoimagery shall meet the requirements set forth in the ***Federal Geographic Data Committee FGDC-STD-014.2-2015 Geographic Information Framework Data Content* Standard Part 2: Digital Orthoimagery**.

- *Natural Color Imagery* – The natural color, RGB, bands will be color balanced across the entire area of interest to allow viewing of the image tiles as a seamless mosaic. During radiometric processing care shall be taken to avoid loss of detail in shadows and overexposure on bright surfaces such as bare ground and light-colored building roofs.

- *Color Infrared Imagery* – The near infrared band will be radiometrically processed in a manner that preserves original image characteristics. Corrections for seasonal variations in ground cover are not to be performed. However, care should be taken to ensure appropriate coloration of different vegetation types (e.g., deciduous, evergreen, etc.) is evident.

- All orthoimagery tiles should have a neutral color balance and should closely represent the natural color of the ground at the time of image collection.

One GeoTIFF file per tile matching approved index tile scheme is required. All orthoimages will be delivered according to the tile index provided.

Tiles will be contiguous and non-overlapping and will be suitable for creating a seamless image mosaic that includes no data void cells or gaps. Tile naming convention is as follows:

YYYY__NNNNNN.TIF
Where:
YYYY = Ending year of the flying season that typically ends in March.
NNNNNN = Appropriate tile (cell) index number values from project tiling index provided.

Example: Orthoimage tile that was acquired during the 2020-2021 flying season.
2021_200001.tif

5.2 GEOSPATIAL METADATA

A metadata file in XML format must be delivered for each GeoTIFF image file, the DEM used for orthoimage production, and any other relevant mapping files.

ISO Compliant metadata

- Metadata must be compliant with the International Organization for Standardization requirements: ISO 19115-2**,** Schema ISO-19139

The following information will be provided in all orthoimagery tile metadata:

- Date of flight information included in metadata should reference the date(s) of image collection for each orthoimage tile. Range of dates will not be accepted
- QA/QC Processes
- Project name and usage
- Citations, abstract, and purpose
- Minimum bounding rectangle entry
- Geospatial information (coordinate system, units, horizontal datum).
- All processing steps and software utilized
- All image corrections should be well documented in the metadata
    - Photo editing polygon ID and coordinates will be included in description
- Accuracy statement. RMSE and confidence interval at 95% should be reported
- Aircraft type and tail number
- Average flying/acquisition height (AGL)
- Sensor manufacturer and model
- Camera calibration process
- Raw imagery pixel resolution and bit depth
- Final pixel resolution of product
- Total bands of data acquired
- Sources of elevation data used and detailed process description for terrain editing

5.3 IMAGE SEAMLINE FEATURE CLASS

The consultant will include a file "ProjectName_Seamlines" in shapefile format, containing a feature class of non-overlapping polygons with no data voids for the area of interest. Each polygon will delineate images by capture date and time used in the mosaicking of images to produce orthoimagery.

The feature class should conform to the area of interest, and have the following attributes:

FRAME CAMERA

DOF = Date of Flight
EXPOSURE = Exposure filename
TIMESTAMP = GNSS time in HH:MM:SS
HEIGHT = Approximate height of aircraft at time of exposure

Figure 3 – Frame Camera Attributes

	FID	Shape	NAME	DOF	EXPOSURE	TIMESTAMP	HEIGHT
	0	Polygon	035_0067	12-Feb-2016	6409_035_0067	19:14:59	4525
	1	Polygon	033_0067	12-Feb-2016	6409_033_0067	19:40:01	4516
	2	Polygon	016_0041	17-Feb-2016	6409_016_0041	16:09:09	4562
	3	Polygon	017_0067	17-Feb-2016	6409_017_0067	15:53:49	4576
	4	Polygon	019_0067	17-Feb-2016	6409_019_0067	15:27:24	4566
	5	Polygon	023_0067	13-Feb-2016	6409_023_0067	17:14:11	4567
	6	Polygon	018_0042	17-Feb-2016	6409_018_0042	15:42:43	4590
	7	Polygon	015_0067	17-Feb-2016	6409_015_0067	16:20:22	4578
	8	Polygon	032_0041	12-Feb-2016	6409_032_0041	19:55:05	4505
	9	Polygon	029_0067	13-Feb-2016	6409_029_0067	15:53:47	4537
	10	Polygon	022_0041	13-Feb-2016	6409_022_0041	17:29:45	4506
	11	Polygon	021_0067	13-Feb-2016	6409_021_0067	17:40:42	4507

PUSHBROOM SENSOR

DOF = Date of Flight
IMAGE = Image Filename
START TIME = GNSS time in HH:MM:SS for Line Begin
END TIME = GNSS time in HH:MM:SS for Line End
HEIGHT = Approximate height of aircraft at time of exposure

Figure 4 – Push Broom Sensor Attributes

FID	SHAPE	IMAGE	DOF	START TIME	END TIME	HEIGHT
0	POLYGON	088_20190110_184413	5-Feb-19	11:05:04	11:06:55	1341
1	POLYGON	092_20190110_180412	5-Feb-19	11:11:58	11:14:19	1341
2	POLYGON	086_20190110_190142	5-Feb-19	11:20:15	11:22:52	1341
3	POLYGON	090_20190110_182422	5-Feb-19	11:27:33	11:30:27	1341
4	POLYGON	096_20190110_171635	5-Feb-19	11:35:23	11:38:34	1341
5	POLYGON	094_20190110_174345	5-Feb-19	11:42:58	11:46:09	1341
6	POLYGON	098_20190110_165912	5-Feb-19	11:50:38	11:54:04	1341
7	POLYGON	095_20190110_172538	5-Feb-19	11:58:14	12:01:55	1341
8	POLYGON	085_20190110_190934	5-Feb-19	12:07:12	12:12:53	1336
9	POLYGON	097_20190110_170714	5-Feb-19	12:15:22	12:20:19	1336
10	POLYGON	099_20190110_165107	5-Feb-19	12:24:15	12:29:13	1336
11	POLYGON	099_20190110_165107	5-Feb-19	12:32:35	12:37:30	1336
12	POLYGON	093_20190110_175342	5-Feb-19	12:41:16	12:46:13	1336
13	POLYGON	091_20190110_181435	5-Feb-19	12:49:38	12:54:21	1336
14	POLYGON	089_20190110_183354	5-Feb-19	12:57:18	13:02:46	1336
15	POLYGON	087_20190110_185345	5-Feb-19	13:05:18	13:10:46	1333
16	POLYGON	084_20190118_193502	5-Feb-19	13:13:18	13:18:46	1333

5.4 SURVEY REPORT

The consultant PSM will prepare a digitally signed survey report that documents all processes and is compliant with relevant ***Standards of Practice*** as set forth in ***Rule Chapter 5J-17, F.A.C.***, pursuant to ***Chapter 472, F.S.*** and shall, at a minimum, include the following items:

- Project title and reference number
- Name and address of corporation
- Certificate of authorization number
- Surveyor in responsible charge, including contact information
- Abbreviations
- Data sources
- Final deliverable listing of files stating filename with extension and delivery date in the appendix of the survey report.
- Survey date(s) (first and last date of field measurements)
- Introduction, purpose and objectives
- Reference to ground control survey by title, survey date, corporation, and certifying PSM.
- Describe all equipment, software, etc.
- Image sensor description and factory sensor calibration and boresight calibration reports
- Digital orthoimage image acquisition dates and flight logs
- DEM acquisition (identify source and accuracy)
- If lidar data is collected, then the following items shall be included:
  - Data acquisition dates and logs
  - Sensor description and calibration report
- Digital orthoimagery image accuracy NSSDA analysis according to the ***FGDC National Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998)***.
- List of field and office personnel
- Map overlay which will display the following items:
  - All horizontal and vertical ground control identifying which points were constrained during aerial triangulation and which points were used for check during NSSDA analysis
  - Aerial triangulation blocks
  - Digital orthoimagery tile limits and layout
  - Lidar quality control locations and accuracy (if applicable)
  - Base map features (ex: county boundaries, cities, major roads)

5.5 DIGITAL SUBMITTALS

Digital files shall be submitted on an external hard drive (USB version 3.0 or later) and be accompanied by an itemized transmittal letter. All deliverables will become the property of the agency.

5.6 CONTENTS

The hard drive shall contain:

- Digitally signed copy of the orthoimagery survey report
- Digitally signed copy of the control survey report (if separate from orthoimagery report)
- Four-band (RGBN) original source imagery
- Survey control and checkpoint locations as kml\kmz files and comma delimited coordinate file.
- Four-band (RGBN) orthoimagery image tiles
- Metadata XML file for each image tile
- Final elevation data used to rectify imagery
- Metadata XML for Digital Elevation Model
- Delivery of breaklines collected and used in support of the project are required for FCDOP projects. This includes breaklines used for bridge surface modeling. Breaklines will be as shapefile format including PolylineZ and PolygonZ feature classes.
- Classified lidar data files (*.LAS) (if applicable) Airborne sensor trajectory/exterior orientation report
- Image sensor calibration documentation
- Boresight calibration files
- Aerial triangulation control coordinates and aerial triangulation blocks along with statistical summaries
- Flight Index map in .kml/kmz format. This shall include the project area outline, flight lines, and image centers.
- All horizontal and vertical ground control identifying of which points were constrained during aerial triangulation and which points were used for check during NSSDA analysis
- Outline polygon of each aerotriangulation block
- Digital orthoimagery seamlines and dates associated with the photographs (see *Section 5.3*)
- Digital orthoimagery tile limits and layout
- Scope of Work, aka Scope of Services, from contracting agency

5.7 LABEL

The drive shall be labeled on the outside with the following information:

- Project title
- Consultant name and contact information
- Contracting agency contract number
- Date of survey
- Mobile Survey Tracking System (MSTS) number (FDOT) if available

6 GROUND CONTROL SURVEY REQUIREMENTS

6.1 PURPOSE

The purpose of this document is to specify the requirements for a geodetic control survey to support 0.5-foot ground sample distance resolution county aerial orthoimagery mapping. The positional accuracy required for this imagery resolution is 2.5 feet at the 95% confidence level.

All surveying and mapping work performed shall meet the ***Standards of Practice*** set forth in ***Chapter 5J-17, F.A.C.,*** pursuant to ***Chapter 472, F.S.***

6.2 SURVEY CONTROL

- GNSS techniques shall be used to establish horizontal and vertical positions on targeted and/or well-defined photo identifiable points that will be used as control for aerial photogrammetric mapping. New photo control point positions shall be identified in the field by a survey mark.
- Positions may be established by static, rapid-static or RTK/RTN methods. If real-time methods are used, a minimum of two observations at least 60 minutes apart are required.
- When aerial panels are used, the vertical offset from top of mark to the panel surface shall be measured and recorded.
- Ground control shall be referenced to NAD83(2011) based on redundant ties to the FPRN.
- The photogrammetric ground control network shall meet the horizontal and vertical accuracies necessary to support the required map accuracy of the orthoimagery. The ASPRS standards require direct comparison to checkpoints from an independent source of at least three times greater accuracy.
- A minimum of four published NAVD88 benchmarks shall be included in the control network to ensure accurate elevations can be computed from GNSS measurements through local network adjustment using the latest FPRN Geoid Model.
- Where conditions dictate differential leveling may be used to establish elevations on photo control points from the nearest ground control network station or published NSRS vertical station within a 5-mile radius from the photo control point. Leveling procedures adequate to support vertical accuracy specifications of orthoimagery shall be observed and documented.
- In rare circumstances where the photo identifiable control point cannot be occupied directly, either horizontally and/or vertically, offset distances of less than 0.5 feet from the occupied survey mark may be used. Field survey measurements of sufficient precision must be collected and recorded to allow accurate coordinate computation of the photo identifiable point from the offset mark.
- With prior approval of the orthoimage project surveyor, ground control points may be moved from their original proposed locations to ensure safety, or if the proposed point is ambiguous or no longer exists. Such control points shall be documented as moved.

- A field sketch with survey date, GNSS satellite visibility and weather conditions at the time of GNSS data collection shall be prepared for each ground control and check point site.
- Digital photo(s) shall be taken showing the exact location of the ground control and check point, preferably while the point is occupied by the GNSS unit setup. Digital photo filenames shall include the control point name.
- Point names shall be consistent in all delivered files.

6.3 SUBMITTAL ITEMS

6.3.1 SURVEY REPORT

The PSM will prepare a digitally signed and sealed control survey report that shall at a minimum include the following items:

- Project title and reference number
- Name and address of corporation
- Certificate of authorization number
- Surveyor in responsible charge, including contact information
- Abbreviations
- Final deliverable listing of files stating filename with extension and delivery date in the appendix of the survey report.
- Introduction, purpose and objective
- Description and scope of work
- Describe equipment, software, etc.
- Describe the accuracy standards and specifications, procedures and methodology for establishing ground control
- Describe and list the geodetic control (existing and newly established), displaying the horizontal and vertical coordinates, datum used, geoid model and individual point errors (RMSE, standard deviation or 95% confidence level)
- List the field and office personnel
- Survey dates (first and last date of field measurements)
- Describe monumentation recovered and set
- Map overlay which will display the following items:
    - GNSS baseline network, indicate repeated measurements
    - Existing horizontal and vertical geodetic control
    - Newly established photogrammetric control
    - Base map features (ex: county boundaries, cities, major roads)
- When revisions are made, a note will be made indicating that the report has been revised and will reference the date of the original report

6.3.2 DIGITAL SUBMITTALS

Digital files shall be packaged and delivered with the final orthoimagery submittal as described in *Section 1.15* of this document and shall include:

- Digitally signed and sealed copy of the control survey report
- Existing geodetic control recovery/to-reach descriptions. Condition of NSRS marks should be reported to the National Geodetic Survey.
- All ground control and check point documentation as stated in ***Section 2.0*** above.
- Copies of GNSS data logs and a listing of GNSS occupations
- All GNSS data observed and produced during the survey (digital format), including the raw observation data, processed baselines, loop closures and least squares adjustments (free and fixed)
- A Microsoft EXCEL spreadsheet file list of final control with datum header information along with point name, geographic (Latitude, Longitude), grid (State Plane Zone Northing and Easting), and elevation values for control points. Grid coordinates and elevations shall be in units of USft. Errors at the 95% confidence interval should be included. See Figure 5 below.

Figure 5 – Ground Control Table Example

FINAL ADJUSTED HORIZONTAL AND ORTHOMETRIC HEIGHT VALUES FOR MARION COUNTY (PD6027) POST FLIGHT PHOTO POINT

UNITS ARE US Survey Feet (USft)

HORIZONTAL DATUM IS NAD 83 (2011)

STATE PLANE ZONE IS FLORIDA WEST ZONE 0902

ORTHOMETRIC HEIGHT DATUM IS NAVD 88

ALL CONTROL STATION VALUES ARE DERIVED BY STATIC GNSS OBSERVATIONS FROM PUBLISHED NGS CONTROL

	GPS Control Station - Geographic			GPS Control Station - USft			Error (specify RMSE, SD or 95%)	
PHOTO_ID	LATITUDE	LONGITUDE	ELLIP_HGT (meters)	NORTHING	EASTING	ORTHO_HGT	Horizontal Error	Vertical Error
D510S010	29 29 44.73172	-82 24 24.26473	1.757	1876786.20	526773.97	97.18	0.07	0.11
D510S011	29 28 42.07552	-82 3 20.32535	-4.497	1870232.35	638460.51	77.18	0.04	0.08
D510S012	29 30 29.98811	-81 51 49.10517	10.530	1881156.88	699540.72	127.11	0.05	0.09
D510S013	29 19 32.46883	-81 58 11.18511	-5.832	1814716.87	665798.44	72.96	0.04	0.09
D510S014	29 21 52.50874	-81 44 25.40237	-16.367	1828952.74	738861.52	39.27	0.06	0.10
D510S015	29 17 40.65095	-81 39 9.97229	-27.655	1803585.22	766847.02	2.34	0.04	0.07

SUMMARY OF CHANGES

1. ABBREVIATIONS AND DEFINITIONS (Page 3)

- Added RTK and RTN

4.4 ACCURACY (Page 6-7)

- Accuracy table added. Highlighted horizontal accuracy requirements
- Maximum seamline mismatch for transportation features defined as 3 pixels
- Checkpoint requirement description modified to include approval from FDOT for any deviation from ASPRS recommendations for total number and distribution of checkpoints

4.5 DIGITAL ELEVATION MODEL (Page 7)

- Removed requirement for bridge and overpasses to be integrated into the DEM for delivery.
- Reinforced requirement for DEM to be delivered as tiles matching the approved 5000ft x 5000ft tile index
- Added ASCII XYZ and LAS/LAZ as approved delivery formats

4.6 IMAGE RECTIFICATION (Page 8)

- Section has been added to the 2021-2022 FCDOP standards
- Added reference to FGDC image rectification methodology
- Defined requirements for the delivery of photo edit polygon file

4.8 GNSS/INS SOLUTIONS (Page 8)

- Added reference to utilizing FPRN solutions in aerotriangulation

4.10 IMAGE QUALITY (Page 8)

- Removed previous section 4.10 description referencing historical images

5.1.2 TILED ORTHOIMAGERY (Page 9)

- Defined color balancing requirements

5.2 GEOSPATIAL METADATA (Page 10)

- Added requirement for compliance to latest ISO Standards for metadata: ISO 19115-2
- Added list of required information for orthoimagery tile metadata deliveries

5.4 SURVEY REPORT (Page 12)

- Added requirement for digitally signed survey report

5.6 CONTENTS (Page 13)

- Added requirements for the delivery of:
  - Survey control and checkpoint locations kmz files and comma delimited coordinate files.
  - Breaklines captured as part of surface modeling utilized for image rectification to be delivered in shapefile format
  - Index Map in .kml format
  - Outline polygons for each aerotriangulation block in shapefile format

5.6 LABEL (Page 13)

- Mobile Survey Tracking System (MSTS) number (FDOT) if available

6. GROUND CONTROL SURVEY REQUIREMENTS (Page 14)

- Removed this section from "ATTACHMENT A" in 2020-2021 FCDOP standards

6.2 SURVEY CONTROL (Page 14-15)

- Detailed the requirements for Survey Control methodology
- Requirement added for consistent naming of survey control points in all deliverables

6.3.1 SURVEY REPORT (Page 15)

- Added a reference to a digitally signed and sealed control survey report
- Specified the requirements for the delivery of revised reports

6.3.2 Digital Submittals (Page 16) and Figure 5 (Page 17)

- Removed reference to control point offsets and added point error columns