MINIMUM TECHNICAL STANDARDS
FINAL REPORT OF SPECIFIC PURPOSE SURVEY

2006-2007 LIDAR DTM AND 1-FOOT CONTOURS FOR VOLUSIA COUNTY, FLORIDA

COUNTY OF VOLUSIA
PUBLIC WORKS DEPARTMENT

VOLUSIA COUNTY PROJECT NUMBER P-5409
TASK ORDER NO. 1

WOOLPERT, INC. PROJECT NO. 064919
October 30, 2007

MINIMUM TECHNICAL STANDARDS
FINAL REPORT OF SPECIFIC PURPOSE SURVEY

2006-2007 LIDAR DTM AND 1-FOOT CONTOURS FOR VOLUSIA COUNTY, FLORIDA

Prepared By:

Woolpert, Inc.
11315 Corporate Boulevard, Suite 115
Orlando, Florida 32817

LB Number 0006777

MINIMUM TECHNICAL STANDARDS

FINAL REPORT OF SPECIFIC PURPOSE SURVEY

LiDAR DTM and 1-Foot Contours

Volusia County, Florida

For:

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REPORT OF SPECIFIC PURPOSE SURVEY
DTM and 1-Foot Contours For Volusia County, Florida

Purpose/Type of Survey

To support engineering, hydrologic and environmental studies in Volusia County, Florida, the Public Works Department entered into contract with Woolpert, Inc. (Woolpert) to create a digital terrain model (DTM) suitable to generate 1-foot contours that meet 2-foot contour accuracy specifications. The approximate mapping area within the county was ±1,427 square miles (see Appendix A: Survey Limits/Tile Layout Map). The end product complies with the Florida Administrative Code 61G17, Minimum Technical Standards for Surveying and Mapping.

As part of this effort, Woolpert conducted a Topographic LiDAR Survey to support the DTM development. LiDAR data was acquired over the county limits, using the Leica ALS50 LiDAR system, at an average ground sample distance (GSD) of 3.3-feet. Additionally, color digital imagery was acquired over the project limits using the Leica ADS40 multi-spectral scanner (MSS) sensor, and it was utilized to support the photogrammetric quality control (QC) and enhancement of the LiDAR DTM, the photogrammetric compilation of the line-drawn (vector) topographic and limited planimetric features, and digital orthophoto image (DOI) development.

The horizontal accuracy of the DOI is 1"=100' scale NMAS (refer to MTS Report of Specific Purpose Survey, 2006 Digital Orthophoto Image Maps For Volusia County, Florida, dated January 4, 2007). As mutually agreed between the County and Woolpert, a triangulated irregular network (TIN) was generated from the DTM and contours, and the minimum vertical accuracy of the TIN was specified as ±0.6-feet at the 95% confidence level for well-defined points in unobscured areas. The accuracy of the contours was specified as NMAS for 2-foot contours or 1.2-feet at the 95% confidence level for unobscured contours in well-defined areas.

All LiDAR acquisition and processing methodologies were in conformance with the Federal Emergency Management Agency (FEMA) “Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying”.

The accuracy of the DTM/TIN and contours/TIN was field verified. One hundred and fifty-one (151) ground survey quality control (QC) checkpoints were randomly acquired throughout the project area, in 4 different land cover classes (bare earth, urban/hard surface, medium grass/vegetation and dense trees/vegetation), and used to confirm the accuracy of the DTM/TIN and contours/TIN. The accuracy analysis was based on methods outlined in the Geospatial Positioning Accuracy Standards, Part 3: National Standards for Spatial Data Accuracy (NSSDA) developed by the Federal Geodetic Data Committee (FGDC-STD-007.3-1998) see Appendix E, DTM/TIN Accuracy Analysis and Appendix F: Contour/TIN Accuracy Analysis.

Date of Survey

Ground control, LiDAR and aerial imagery acquisition for the survey was performed on the following dates:

- The ground control targeting and observations occurred between February 5 and February 10, 2006.
- The LiDAR data was acquired between March 2 and March 8, 2006 in eleven sessions.
- The aerial imagery was acquired between February 14 and March 15, 2006 in five sessions (see Aerial Triangulation Report, 2006 Volusia Countywide DOI Project, Dated December 2006).

Survey Area

The project area encompasses approximately ±1,427 square miles within Volusia County, Florida as depicted in Appendix A: Survey Limits/Tile Layout Map.

Map Reference

There are no deliverable hardcopy map sheets for this project.

Name of Responsible Surveyor

Christopher M. O'Neill, CP, PSM
Woolpert, Inc.
11315 Corporate Boulevard, Suite 115
Orlando, Florida 32817-8345
Professional Surveyor and Mapper Number LS-0006497

Name of Company

Woolpert, Inc.
11315 Corporate Boulevard, Suite 115
Orlando, Florida 32817-8345
Florida Certificate of Authorization No. LB-0006777

Abbreviations

2D – Two-Dimensional
3D – Three-Dimensional
ABGPS – Airborne GPS
AGL – Above Ground Level
ASCII – America Standard Code for Information Interchange
DTM – Digital Terrain Model
DOI – Digital Orthophoto Imagery
Dz – Residual Error
FEMA–Federal Emergency Management Agency
FGCC – Federal Geodetic Control Committee
GPS – Global Positioning System

GSD – Ground Sample Distance
ID – Identification
Inc. – Incorporated
IMU – Inertial Measurement Unit
LiDAR – Light Detection And Ranging
MSS – Multi-Spectral Scanner
NAD 83-HARN – North American Datum 1983 High Accuracy Reference Network Adjustment
NAVD 88 – North American Vertical Datum of 1988
NGS – National Geodetic Survey
NMAS – National Map Accuracy Standards
NOAA – National Oceanic and Atmospheric Administration
NSSDA – National Standards for Spatial Data Accuracy
PID – Photo Identifiable Point
PSM – Professional Surveyor and Mapper
QC – Quality Control
RABATS – Rapid Analytical Block Aerial Triangulation System
RMSE – Root Mean Square Error
RTK – Real Time Kinematic
STD – Standard
TIN – Triangulated Irregular Network
USGS – United States Geological Survey
US – United States
Woolpert – Woolpert, Inc
XYZ – Easting, Northing and elevation grid coordinates

Definitions

Bare Earth Coverage: A set of discrete XYZ values representing the terrain surface.

Digital Terrain Model: A three-dimensional model of the Earth's surface, provided in digital form, comprised of bare earth LiDAR mass points and breaklines.

LiDAR: Light Detection and Ranging is a technology that determines distance to an object or surface using laser pulses. The range to an object is determined by measuring the time between transmission of a pulse and detection of the reflected signal multiplied by the speed of light.

Obscured Area: An area on the Earth’s surface containing those natural or manmade features that are occluded from directly imaging or sampling the ground surface with an airborne optical imaging sensor. Obscure areas are clearly denoted in digital map files with polygons delineating the obscured area along with a text label. In addition, DTM/breakline polygons around obscured areas are stored within the obscured feature class of the personal geodatabase to further help the user identify areas of questionable accuracy.

TIN: Triangulated Surface Model, a surface representation derived from irregularly spaced points and breakline features. Each sample point has an x, y coordinate and a z value or surface value.

Unobscured Area: An area on the Earth’s surface that is not totally obscured. Unobscured areas include paved areas, dirt roads, cut grass, low scrub, and light to medium density forest. The elevation data captured through remote sensing methods within these areas meet or exceed the defined standards.

Map Data (DTM/TIN and 1-Foot Contours) Accuracy

DTM/TIN Horizontal Feature Accuracy: The horizontal accuracy of the LiDAR DTM/TIN is difficult to characterize due to the nature of the surface model. Specifically, the density of the point and breakline data within the DTM/TIN is not sufficiently dense to measure the horizontal location of features to a high degree of accuracy. As such, Woolpert has demonstrated through formal LiDAR system calibration (see Appendix D: ALS50 System Calibration) that the horizontal accuracy of the data should meet or exceed the design specifications of the system (flying height of aircraft/2000). **The horizontal accuracy of the DTM/TIN is estimated to be at least 1.3-feet RMSE for unobscured points.** Referring to the 2006 Volusia County DOI, MTS Report of Specific Purpose Survey**,** Appendix F: DOI Accuracy Analysis dated January 4, 2007, the horizontal accuracy the orthoimagery at PID locations is 1.3-feet RMSE in the XY direction, implying that the accuracy of the DTM/TIN used to rectify the imagery is at least this accurate.

The vertical accuracy of the DTM/TIN and contours was verified by comparison of the final deliverable surfaces to field survey QC data following NSSDA procedures. Field survey QC data (151 points) were randomly acquired over 4 land cover categories (bare earth, urban/hard surface, medium dense vegetation, and dense vegetation/tree canopy), and the elevations of these points were compared against the TIN generated from the deliverable DTM (see Appendix E: DTM/TIN Accuracy Analysis) and the TIN generated from the contours (see Appendix F: Contour/TIN Accuracy Analysis).

DTM/TIN Vertical Feature Accuracy of Unobscured Points: Per contract specifications, the vertical accuracy requirement of the TIN for this project is 0.6-feet RMSE at the 95% confidence level for well-defined points in unobscured areas. Based on Woolpert's accuracy analysis (see Appendix E, DTM/TIN Accuracy Analysis), the **vertical accuracy of the TIN is 0.6-feet at the 95% confidence level for unobscured points**.

DTM/TIN Vertical Feature Accuracy of Obscured Points: There is no county accuracy specification for obscured points on this project. Additionally, there exist no published National accuracy standards or industry standards for obscured points, as the ground is not measurable in these areas using photogrammetric methods. Therefore**, the user should exercise caution when working with mass points and breaklines within obscured/vegetation polygons as this data may not meet the accuracy requirements as set forth for well-defined points**. **The estimated vertical accuracy of obscured points is 0.7-feet at the 95% confidence level**.

Contour/TIN Vertical Feature Accuracy of Unobscured Points. Per contract specifications, the vertical accuracy requirement of the TIN for this project is 1.20-feet RMSE at the 95% confidence level for well-defined points in unobscured areas. Based on Woolpert's accuracy analysis (see Appendix F, Contour/TIN Accuracy Analysis), the **vertical accuracy of the TIN is 0.9-feet at the 95% confidence level for unobscured points, exceeding the project accuracy requirements by 0.3-feet**.

Contour/TIN Vertical Feature Accuracy of Obscured Points. There is no county accuracy specification for obscured points on this project. Additionally, there exist no published National accuracy standards or industry standards for obscured points, as the ground is not measurable in these areas using photogrammetric methods. Therefore**, the user should exercise caution when working with contours within obscured/vegetation polygons as this data may not meet the accuracy requirements as set forth for well-defined points**. **The estimated vertical accuracy of obscured points is 0.8-feet at the 95% confidence level**.

Datums/Coordinate Systems

The DTM, line-drawn (vector) topographic features, and limited planimetric features map data are in reference to the State Plane Coordinate System, Florida East Zone, in units of US Survey Feet. The horizontal datum is NAD83/90-HARN, and the vertical datum is NAVD88.

Data Sources

Original Control Point Coordinates:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
Phone: (301) 713-3242
Fax: (301) 713-4172
Email: info_center@ngs.noaa.gov
http://www.ngs.noaa.gov/

Woolpert, Inc.
11315 Corporate Boulevard, Suite 115
Orlando, Florida 32817-8340
Phone: (407) 381-2192
Fax: (407) 384-1185

Methodology

To support engineering, hydrologic and environmental studies in Volusia County, Florida, the Public Works Department entered into contract with Woolpert, Inc. (Woolpert) to create a digital terrain model (DTM) suitable to generate 1-foot contours that meet 2-foot contour accuracy specifications. The approximate mapping area within the county was ±1,427 square miles (see Appendix A: Survey Limits/Tile Layout Map). The end product complies with the Florida Administrative Code 61G17, Minimum Technical Standards for Surveying and Mapping.

To support the DTM development, 60 flight lines of true color and color infrared digital imagery were acquired at a pixel resolution of 0.66-feet (see MTS Report of Specific Purpose Survey, 2006 Volusia County Digital Orthophoto Image Maps, dated January 4, 2007), and 143 flight lines (swaths) of high density LiDAR data (average 3.3-foot GSD) were obtained from an altitude of 3,280-feet AGL (see Exhibit C: LiDAR and Ground Control Layout Map). The aerial imagery was acquired using the Leica ADS40 MSS sensor, and the LiDAR data was acquired using the Leica ALS50 LiDAR system. All equipment is owned and operated by Woolpert.

Using the triangulated 0.66-foot pixel resolution aerial imagery, photogrammetric methods were employed to assist in the QC and enhancement of the LiDAR data and to compile breakline and limited planimetric features. Stereomodels were generated on a softcopy photogrammetric workstation. LiDAR data was imported into the workstation and superimposed over the stereomodels. Hard and soft breaklines and limited planimetric features were photogrammetrically captured, and the LiDAR data was stereoscopically verified to be on the ground surface.

Aerial Imagery Ground Control Survey

The photogrammetric ground control network was comprised of 44 control points located to second-order horizontal and third-order vertical accuracies. Each photo control station, except for the PID's, was targeted with an 8' x 8'x 2' fiberglass reinforced cloth material target or a painted target of similar size prior to acquiring aerial photography. For a detailed overview of the ground control survey, refer to: Woolpert's Florida MTS Report of Photogrammetric Ground Control Survey: *LiDAR Surveys, Digital Topographic Data and Digital Orthophotography, 2006 Volusia County Project No. P-5409 – Task Order 1, April 26, 2006.*

QC Checkpoint Ground Control Survey

To support the accuracy analysis of the DTM and contours, Woolpert acquired 151 new field survey QC checkpoints. The QC checkpoints were established at random locations throughout the project limits within bare earth, urban/hard surface, low grass, medium grass/vegetation, and dense trees/vegetation ground cover classifications. Rapid static GPS techniques, to second-order horizontal and third-order vertical accuracies, were utilized to capture QC checkpoints in all ground cover classifications except dense trees. In dense treed areas, conventional methods (total station) were used to establish point coordinates to second-order horizontal and third-order vertical accuracies. Each QC checkpoint was provided with 3-dimensional coordinate values and these values were withheld from the Photogrammetry Department until the LiDAR processing was complete. After which, the coordinate values were released for accuracy verifications. Each observation session utilized a 5-second sync rate, and the observations ran between 10- 35 minutes using Trimble R7 GPS receivers, fixed height tripods, and ground plane L1/L2 antennas (see Woolpert's Florida MTS Report of Photogrammetric Ground Control Survey: *LiDAR Surveys, Digital Topographic Data and Digital Orthophotography, 2006 Volusia County Project No. P-5409 – Task Order 1, April 26, 2006.*

Aerial Photography

Panchromatic, red, green, blue and near infrared imagery was acquired using the Leica ADS40 multi-spectral scanner (see Appendix B: Aerial Imagery and Ground Control Layout). The imagery was captured from an altitude of 6,336' AGL, providing a raw ground sample distance of 0.66-feet. A total of 60 flight lines of imagery (see Appendix B: Aerial Imagery and Ground Control Layout) were acquired over 5 sessions conducted between February 14 and March 15, 2006 (see Aerial Triangulation Report, 2006 Volusia Countywide DOI Project, Dated December 2006).

LiDAR

LiDAR data was acquired using a Leica ALS50 (see Appendix C: LiDAR and Ground Control Layout). The data was captured at an average GSD of 3.28-feet and used to support orthophoto rectification and DTM development throughout project area.. A total of 143 flight lines of LiDAR data were acquired in eleven sessions between March 2 and March 8, 2006.

The ABGPS data was reduced using the GrafNav software package by Waypoint Consulting, Incorporated. The IMU data was reduced using the PosProc software package by Applanix Corporation. The initial LiDAR "point cloud" was derived through the ALS Post Processor software package by Leica Geosystems.

Once the initial LiDAR "point cloud" was derived, Woolpert performed QC to look for any systematic error within the LiDAR flights using proprietary software. After systematic error was identified and removed, the individual LiDAR flights were clipped to remove overlap between adjacent flight lines to

provide a homogeneous coverage over the project extents. Using the homogeneous coverage, above ground features were classified and removed using proprietary software to produce the bare-earth coverage.

Aerial Triangulation

Aerial triangulation was performed to extend or densify the network of control points established by the ground control survey. Aerial triangulation provides the proper number and pattern of control points for each flight line. This data is necessary to orient the imagery to the ground for accurate photogrammetric QC of the DTM data.

Soft-copy triangulation was performed on the aerial imagery. Ground control and triangulation points were measured digitally on the imagery. Mensuration was performed using SOCET SET software on a Pentium III, 500 MHz workstation. SOCET SET is distributed by LH Systems, LLC, of San Diego, California.

The soft-copy triangulation solution was calculated using the ORIMA software package on a Pentium III, 600 MHz workstation. For a complete description of the aerial triangulation, refer to the Woolpert Aerial Triangulation Report, 2006 Volusia Countywide DOI Project, dated December 2006.

LiDAR QC/Photogrammetric Compilation

The bare-earth LiDAR data was subdivided into stereomodel units derived from triangulated imagery over the project area. These units were imported into a softcopy stereoplotter and superimposed over their respective stereo-imagery. The technician then verified stereoscopically that the LiDAR data was consistent with the ground.

Hard and soft breaklines and limited planimetric features were compiled, as 2D and 3D features, in the soft-copy environment using DATEM software on a dual Pentium III, 600 MHz photogrammetric workstation.

The LiDAR data was delivered in the LAS file format, and the breaklines and polygons were organized into ESRI Personal Geodatabase based on the 2006 Volusia County Topographic Database Design.

Accuracy Checks

The vertical accuracy of the DTM/TIN was field verified through GPS and conventional survey methods. Results of those field verifications are included in Appendix E: DTM/TIN Accuracy Analysis.

The vertical accuracy of the contours was field verified through GPS and conventional survey methods. Results of those field verifications are included in Appendix F: Contour/TIN Accuracy Analysis.

Refer to Map Data Accuracy Section on Page 3 of this report.

References

http://rockyweb.cr.usgs.gov/nmpstds/nmas.htm – USGS Internet Site for National Map Accuracy Standards.

Report of Photogrammetric Ground Control Survey

Minimum Technical Standards
2006 Volusia County LiDAR Surveys, Digital Topographic Data and Digital Orthophotography
Project No. P-5409 – Task Order 1
Volusia County Public Works Department
April 26, 2006.

Woolpert Aerial Triangulation Report
2006 Volusia Countywide DOI Project
Project No. P-5409 – Task Order 1
Volusia County Public Works Department
December 2006

Woolpert MTS Report of Specific Purpose Survey - DOI
2006 Volusia Countywide DOI Project
Project No. P-5409 – Task Order 1
Volusia County Public Works Department
January 4, 2007

General Notes

1. This report is not complete without the DVDs of the digital mapping, and vice versa.

2. Intended display scale – This mapping is intended to be displayed at a scale of 1:1,200 (1"=100') or smaller.

3. This map complies with National Standards for Spatial Data Accuracy.

4. This map complies with the Federal Emergency Management Agency (FEMA) "Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying".

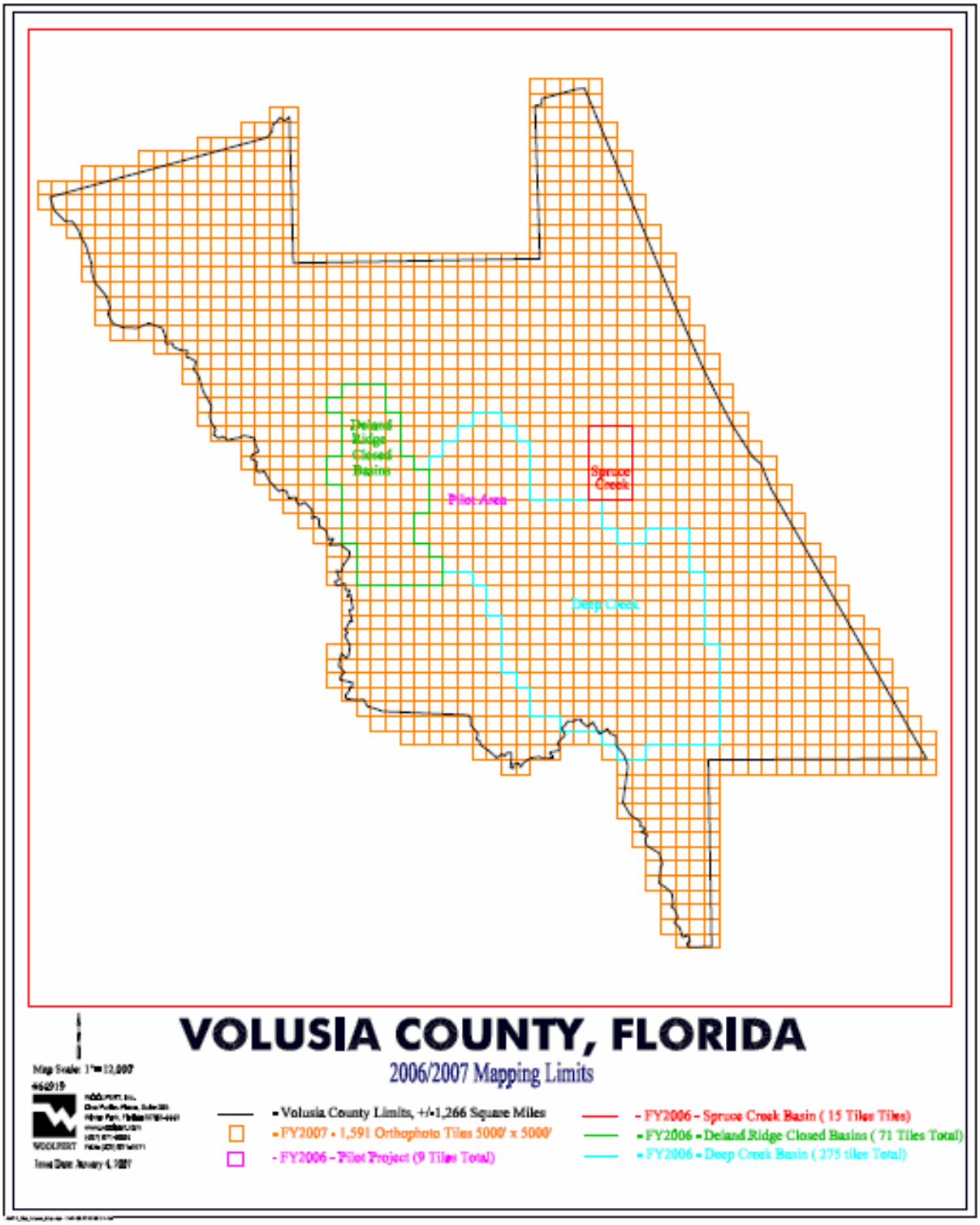
5. **THIS PHOTOGRAMMETRIC MAPPING DATA AND REPORT IS CERTIFIED TO THE VOLUSIA COUNTY PUBLIC WORKS DEPARTMENT AS MEETING OR EXCEEDING, IN QUALITY AND PRECISION, THE STANDARDS APPLICABLE FOR THIS WORK, AS SET FORTH IN CHAPTER 61G17-6, FLORIDA ADMINISTRATIVE CODE.**

THIS REPORT IS NOT VALID WITHOUT THE SIGNATURE AND RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER IN RESPONSIBLE CHARGE.

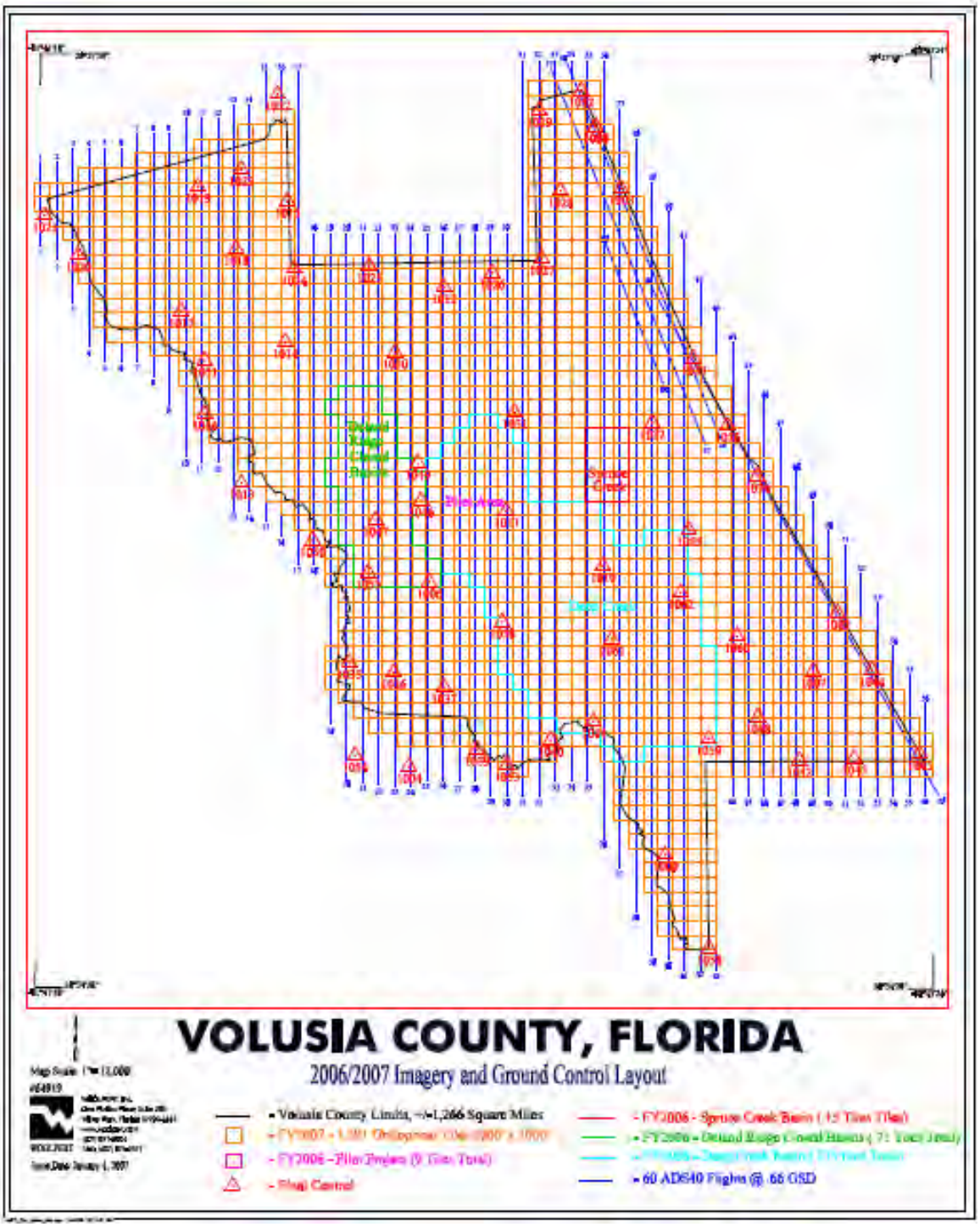
Surveyor and Mapper in Responsible Charge:
Christopher M. O'Neill, CP, PSM
Professional Surveyor and Mapper
License #LS-0006497

Signed:_____ Date:_____ Seal:

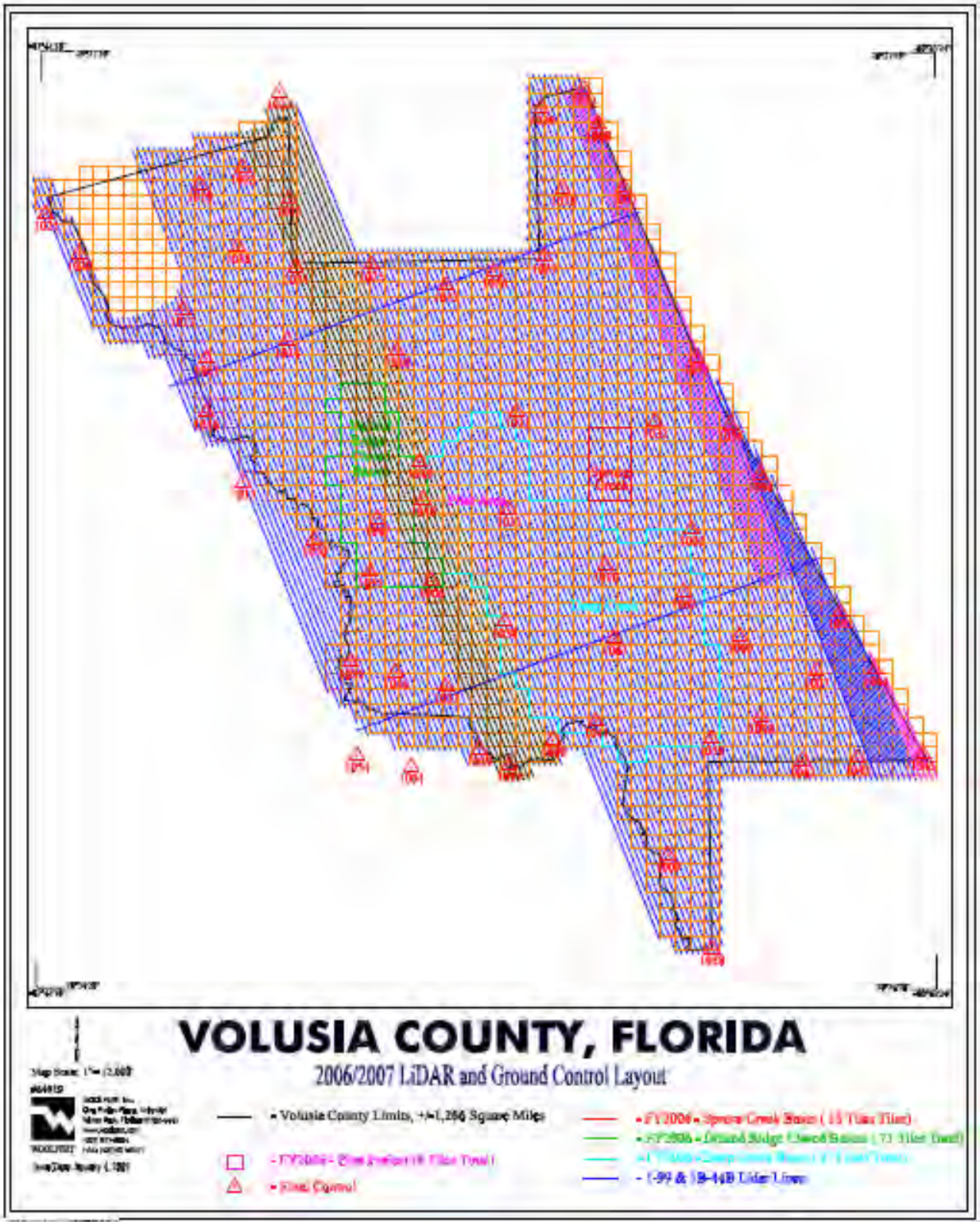
APPENDIX A: SURVEY LIMITS/TILE LAYOUT



APPENDIX B: AERIAL IMAGERY AND GROUND CONTROL LAYOUT



APPENDIX C: LIDAR AND GROUND CONTROL LAYOUT



APPENDIX D: ALS50 SYSTEM CALIBRATION REPORT

Introduction

This Leica ALS50 LiDAR System Calibration Report shall be used to represent confirmation of the LiDAR system specifications, performance, and requirements. The system functionality, elevation, and horizontal accuracy performance shall be demonstrated for calibration purposes.

This report contains various test results and information pertaining to the system. It should be noted that all numbers shown in this report are in **meters** unless otherwise stated. All coordinates stated in the report are in the WGS84 coordinate system with ellipsoidal elevation.

System Model Number: ALS50

Client Name: Volusia County, Florida Public Works Department

Calibration Date January 7, 2006
February 13, 2006

Report Prepared By: Qian Xiao

System Specifications and Requirements

The ALS50 LiDAR systems, built by Leica Geosystems for Woolpert, Inc. have the following specifications:

Nominal	
Operating Altitude	400 – 3,000 meters
Elevation accuracy	15cm single shot
Range Resolution	1 cm
Scan angle	Variable from 0 to 75°
Swath width	Variable from 0 to 1.5 X altitude
Angle resolution	0.01°
Scan frequency	Variable based on scan angle
Horizontal Accuracy	Better than 1/2000 X altitude
Supported GPS receivers	Ashtech Z12, Trimble 7400, Novatel Millenium
Laser repetition rate	58 kHz
Beam divergence	0.3 mrads
Laser classification	Class IV laser product (FDA CFR 21)
Eye safe range	400m single shot depending on laser repetition rate
Power requirements	28 VDC @ 25A
Operating temperature	10-35°C
Humidity	0-95% non-condensing

On Site Antenna Offsets and Location

Aircraft GPS Antenna

The following measurements were calculated for Woolpert's aircraft (both Cessna 404) N404CP and N7079F equipped with LiDAR. The POS/AV and ALS50 processing numbers were calculated from internal measurements completed in Leica's lab, and the positioning of the GPS antenna on the aircraft was field surveyed by Woolpert using a total station.

N7079F: Cessna 404

Reference Point to GPS Antenna	
X	**0.742 m**
Y	**-0.011 m**
Z	**-1.344 m**

N404CP: Cessna 404

Reference Point to GPS Antenna	
X	**0.646 m**
Y	**0.014 m**
Z	**-1.304 m**

The following measurements were calculated in the lab at Leica and will remain constant.

User to IMU Lever Arm (POS/AV) for AIMU	
X	**-0.269 m**
Y	**0.139 m**
Z	**-0.017 m**

User to IMU Lever Arm (POS/AV) for LN200	
X	**-0.273 m**
Y	**0.161 m**
Z	**-0.017 m**

Aircraft N7079F is equipped with AIMU and Aircraft N404CP is equipped with LN200.

Base Station GPS Antenna

Monument Description:	
GPS Receiver Type: Trimble 4700 Antenna Type: Trimble	Epoch Interval: 0.5 sec Elevation Mask: 10 degrees Observation Type: Static
Station Names used in processing the acceptance data:	
#1: Woolpert N 39 45 54.33136 Lat. W 84 11 09.52816 Long. 211.861 Ellipsoidal. HI. #2: XHHR N 44 02 41.51817 Lat. W 103 03 54.27483 Long 952.519 Ellipsoidal. HI.	

Flight Calibration Methodology

Data Collection

To accomplish the formal calibration, Woolpert has established a calibration range consisting of an airport runway. The calibration range has been ground surveyed to an accuracy of better than 1 cm. Four flight lines with two different altitudes and opposing headings (see Figure 7-3) are required in order to capture pitch, roll, heading (see Figure 7-1) and torsion errors (see Figure 7-2).

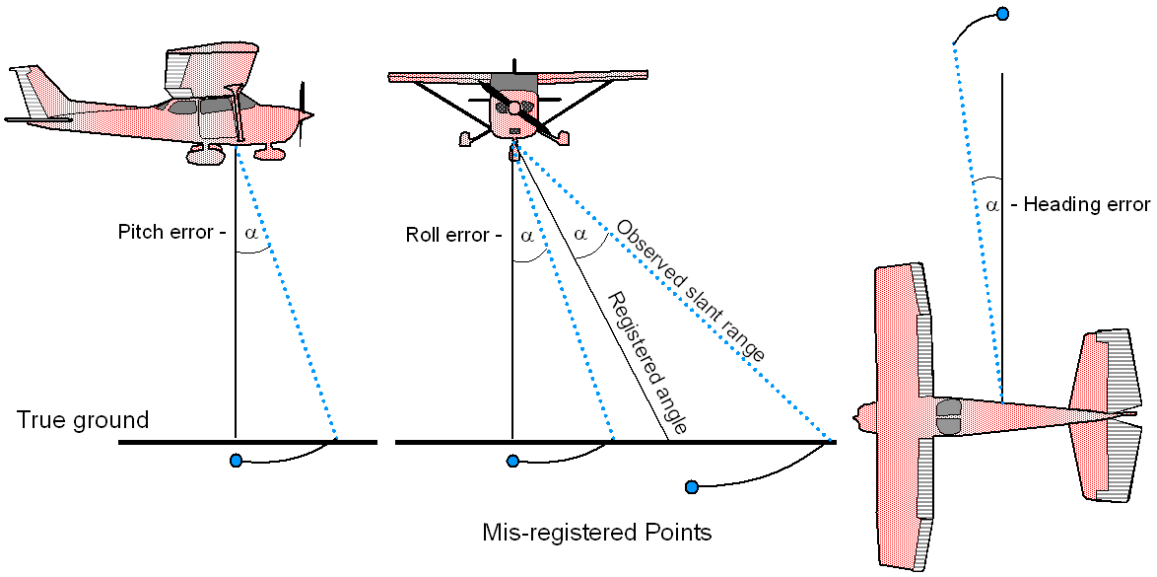


Figure 7-1: Misalignment Errors.

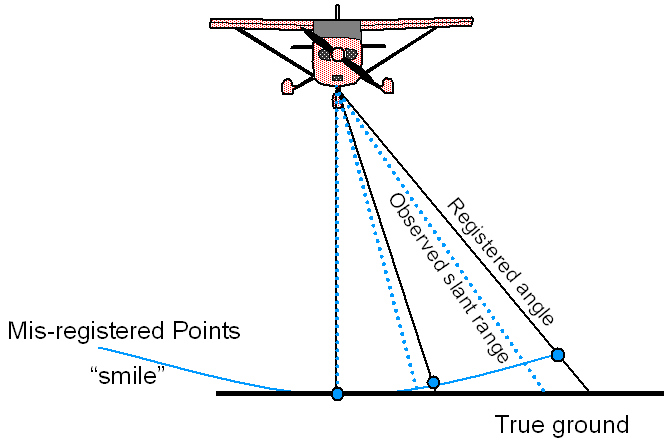


Figure 7-2: Torsion Error

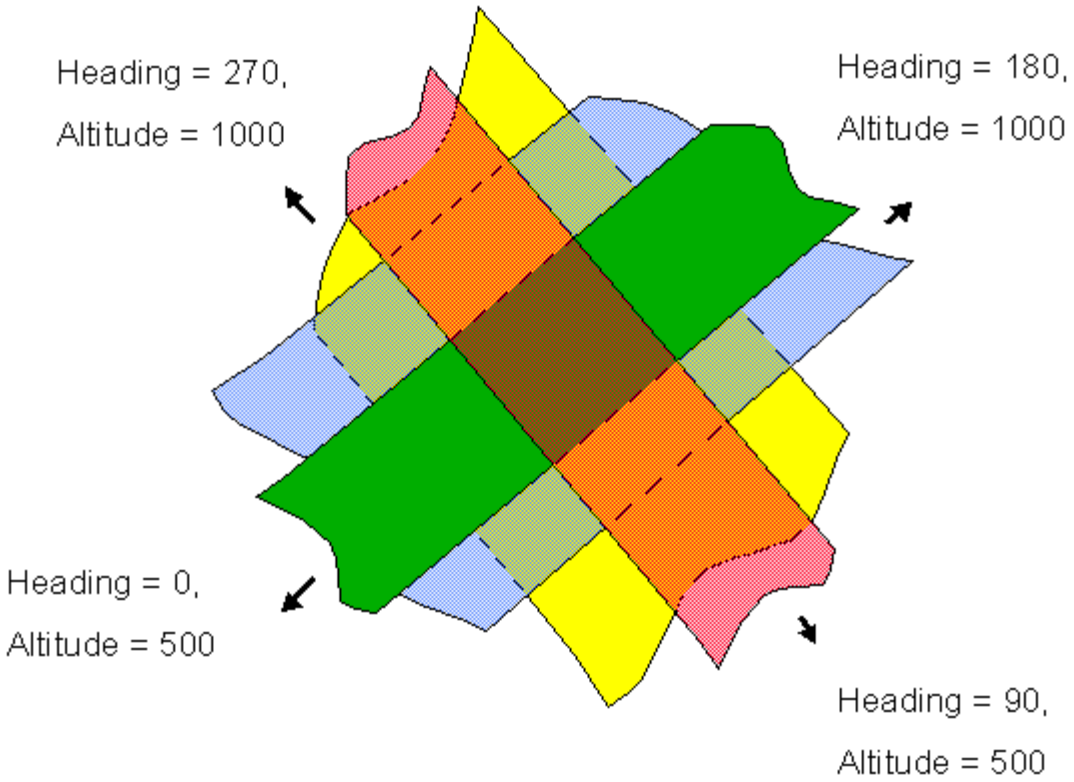


Figure 7-3: Optimal Flight Pattern for Calibration

Intensity Images

Four images from LiDAR intensity reflectance are generated in order to pick up tie points (see Figure 7-4). A least square adjustment (LSA) is performed using AutoBoresighting software provided by system manufacturer. Pitch, roll, heading, and torsion errors are calculated by LSA.

Figure 7-4: Ortho photo generated from LiDAR intensity reflectance.

Ground Control Points

Ground control points were collected along and across an airport runway. A total of 116 runway points were surveyed. The LiDAR collects scan data over the control points and the data is then used to determine the absolute Z accuracy of the system. The distribution of the runway points can be found in Figure 7.5.

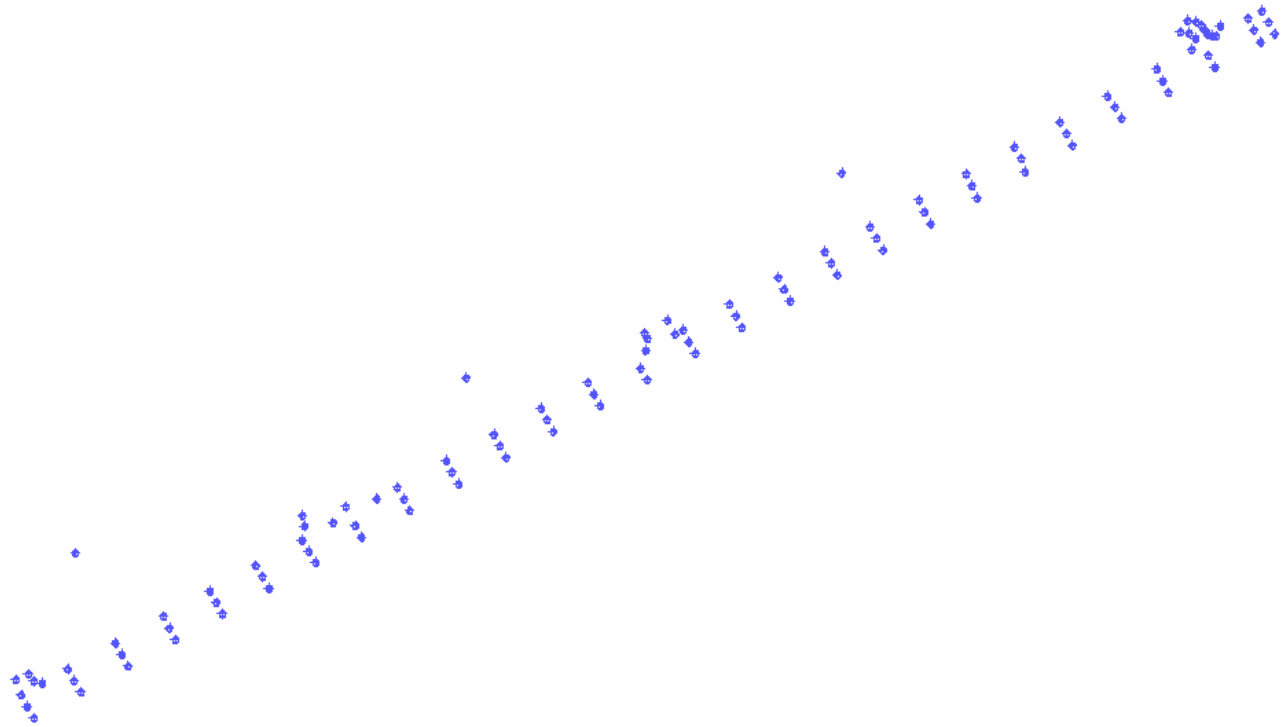


Figure 7-5: Ground control points on the runway

Flight over Ground Control Points

Flight lines, flown parallel and perpendicular to the runway control points were used to determine the elevation (Z) error of the LiDAR data as well as pitch, roll, heading, and torsion can be seen in Figure 7-6. Each day the runway was flown, multiple overlapping strips were performed to assure that most control points were covered and to increase the likelihood that a laser point would strike within 0.5 meters of a control point.

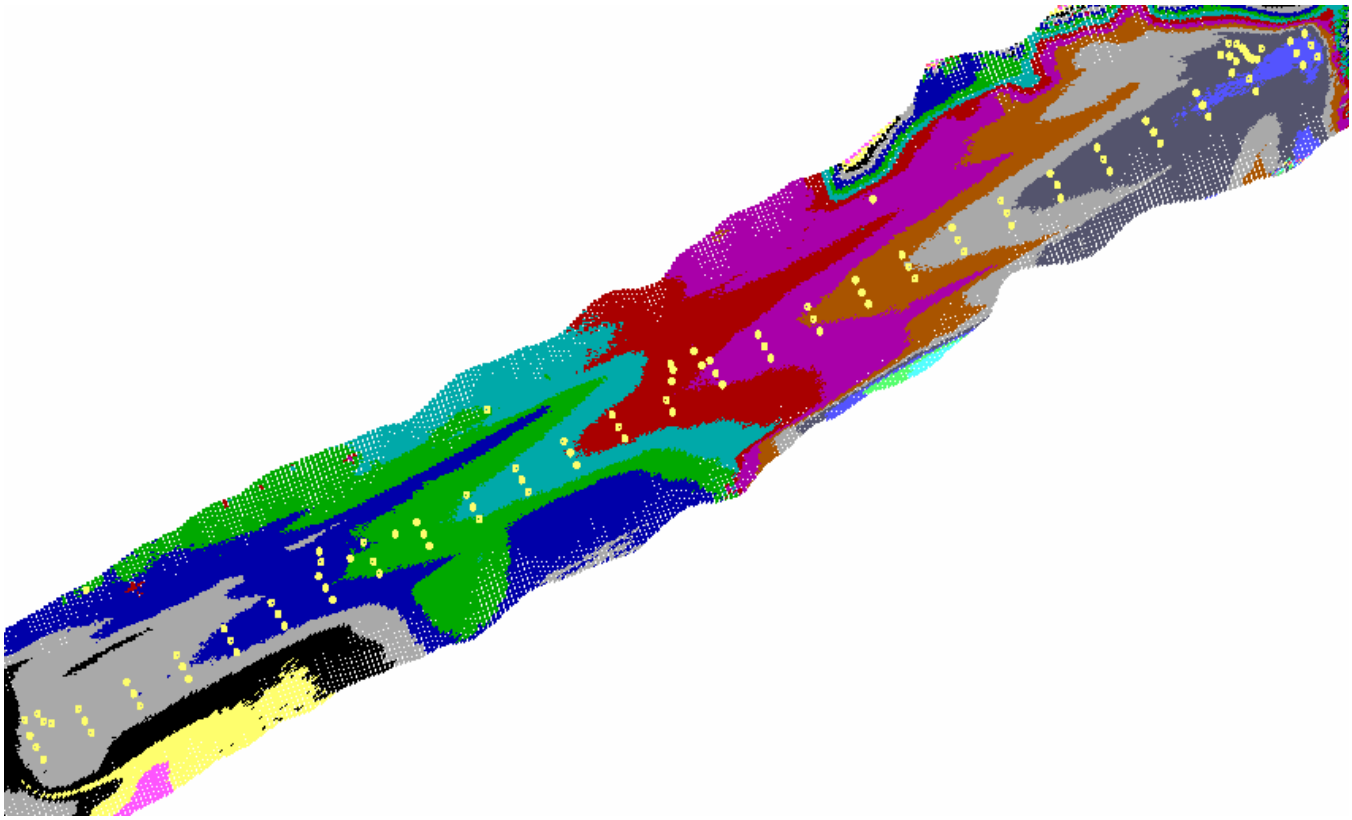


Figure 7-6: One flight line parallel to the runway ground control points. The LiDAR data was collected at about 500 meters AGL.

CALIBRATION RESULTS

The following numbers were derived by Leica through lab calibration and also by Woolpert using data acquired over Woolpert's LiDAR calibration site. These parameters might have been refined using data collected for the project.

N7079F: Cessna 404 (Woolpert)

Parameter	Value	Format
Lab fixed parameters		
Range 1 Correction	2.400 m	0.000
Range 2 Correction	2.400 m	0.000
Range 3 Correction	2.400 m	0.000
Encoder Latency	0.00 mcr sec	0.00
Ticks Per Revolution	8401818 ticks	0000000
Attitude		
*Roll (radian)	0.040857800	0.000000000
*Pitch (radian)	-0.002981712	0.000000000
*Heading (radian)	0.001416112	0.000000000
*Scan angle correct	-12613 ticks	00000
Mechanic		
*Torsion (no unit)	-85000	00000

N404CP: Cessna 404 (Woolpert)

Parameter	Value	Format
Lab fixed parameters		
Range 1 Correction	2.446 m	0.000
Range 2 Correction	2.446 m	0.000
Range 3 Correction	2.446 m	0.000
Encoder Latency	0.00 mcr sec	0.00
Ticks Per Revolution	8389996 ticks	0000000
Attitude		
*Roll (radian)	0.002224375	0.000000000
*Pitch (radian)	0.014947456	0.000000000
*Heading (radian)	0.000319404	0.000000000
*Scan angle correct	17500 ticks	00000
Mechanic		
*Torsion (no unit)	23000	00000

*Value calibrated on site from calibration data

Based on the analysis of the LiDAR data the accuracy of the system meets the required specifications.

Approved By:			
Title	**Name**	**Signature**	**Date**
LiDAR Specialist Certified Phohogrammetrist	**Qian Xiao**		**10/30/2007**

APPENDIX E
DTM/TIN ACCURACY ANALYSIS

The accuracy of the TIN generated from the DTM was verified using field survey methods. The results of the accuracy analysis are as follows:

Volusia County Florida
FY2006 Digital Orthophoto and LiDAR
Contour DTM Accuracy Analysis - October 30, 2007

Horizontal Datum: NAD83 HARN
Vertical Datum: NAVD88
Projection: State Plane Coordinates, Florida East Zone
Working Units: US Survey Feet

Overall Statistical Summary:					
All Unobscured Points			**All Obscured Points**		
RMSE Z	0.31	ft	RMSE Z	0.37	ft
Stdev	0.30	ft	Stdev	0.36	ft
Ave Error	0.07	ft	Ave Error	-0.08	ft
Min Error	-0.67	ft	Min Error	-0.87	ft
Max Error	0.71	ft	Max Error	0.89	ft
Count	96		Count	55	

Statistical Summary By Class					
All Points			**Bare Earth - Unobs**		
Average	-0.01	ft	Average	-0.02	ft
RMSE	0.34	ft	RMSE	0.31	ft
Stdev	0.33	ft	Stdev	0.31	ft
Max Error	0.80	ft	Max Error	0.71	ft
Min Error	-0.77	ft	Min Error	-0.67	ft
Count	151		Count	33	
Hard Surfaced - Unobs			**Cut Grass - Unobs**		
RMSE	0.29	ft	Average	0.18	ft
Stdev	0.29		RMSE	0.33	ft
Average	0.06	ft	Stdev	0.28	ft
Max Error	0.60	ft	Max Error	0.71	ft
Min Error	-0.59	ft	Min Error	-0.50	ft
Count	37		Count	26	
LowMed Vegetation - Obs			**Dense Vegetation - Obs**		
Average	-0.21	ft	Average	0.08	ft
RMSE	0.38	ft	RMSE	0.36	ft
Stdev	0.32	ft	Stdev	0.35	ft
Max Error	0.62	ft	Max Error	0.89	ft
Min Error	-0.87	ft	Min Error	-0.63	ft
Count	31		Count	24	

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3001	1745060.35	545437.85	57.49	57.09	0.40		BARE EARTH	AW-21
3002	1745166.03	545438.06	59.55	59.25	0.30		BARE EARTH	AW-21
3020	1664961.62	598696.23	49.42	48.93	0.49		BARE EARTH	BG-38
3021	1708438.01	572957.68	68.80	68.77	0.03		BARE EARTH	BB-29
3022	1709522.58	573010.79	68.13	67.42	0.71		BARE EARTH	BB-29
3025	1709684.35	576861.89	62.58	62.17	0.41		BARE EARTH	BC-29
3028	1709057.06	571527.01	59.77	59.45	0.32		BARE EARTH	BB-29
3041	1722050.77	630099.65	27.53	27.49	0.04		BARE EARTH	BN-26
3046	1726763.13	633794.27	21.30	21.12	0.18		BARE EARTH	BN-25
3047	1723101.56	632548.93	25.60	25.57	0.03		BARE EARTH	BN-26
3049	1719998.77	636549.29	22.43	22.22	0.21		BARE EARTH	BO-26
3063	1712627.79	565856.57	73.83	73.80	0.03		BARE EARTH	BA-28
3067	1707589.74	573234.35	67.51	67.80	-0.29		BARE EARTH	BB-29
3084	1678839.03	588732.49	30.15	30.28	-0.13		BARE EARTH	BE-35
3086	1682333.43	595258.21	47.69	48.36	-0.67		BARE EARTH	BG-34
3089	1684670.97	595758.15	55.24	55.60	-0.36		BARE EARTH	BG-34
3091	1682605.81	595764.21	60.71	60.96	-0.25		BARE EARTH	BG-34
3092	1785116.44	510251.43	74.78	75.10	-0.32		BARE EARTH	AP-13
3093	1715238.95	574801.99	65.89	66.20	-0.31		BARE EARTH	BB-27
3100	1685134.37	560562.95	67.82	67.94	-0.12		BARE EARTH	AZ-33
3101	1684734.45	560561.67	68.77	69.01	-0.24		BARE EARTH	AZ-34
3104	1685500.33	555277.30	43.36	43.42	-0.06		BARE EARTH	AY-33
3109	1689662.22	560248.81	46.90	46.71	0.19		BARE EARTH	AZ-33
3128	1662398.19	601781.72	44.44	44.72	-0.28		BARE EARTH	BH-38
3130	1664144.84	602006.28	40.62	40.84	-0.22		BARE EARTH	BH-38
3140	1658139.26	634118.09	26.59	26.24	0.35		BARE EARTH	BN-39
3142	1661655.68	634365.23	28.11	28.16	-0.05		BARE EARTH	BN-38
3144	1660602.48	634676.56	26.92	26.85	0.07		BARE EARTH	BN-38
3148	1662108.50	633943.23	27.39	27.39	0.00		BARE EARTH	BN-38
3223	1688685.79	582507.18	57.09	57.48	-0.39		BARE EARTH	BD-33
3227	1690981.14	580871.71	75.32	75.61	-0.29		BARE EARTH	BD-32
3230	1689748.13	580952.89	70.98	71.44	-0.46		BARE EARTH	BD-33
3231	1689637.69	580564.35	68.60	68.60	0.00		BARE EARTH	BD-33
2001	1803893.54	633374.78	3.65	3.74	-0.09		PID QC	BN_10
2002	1795594.12	631993.22	5.52	5.81	-0.29		PID QC	BN_11
2003	1802831.89	641163.34	12.71	12.84	-0.13		PID QC	BP_10
2004	1802682.96	636548.15	13.18	13.41	-0.23		PID QC	BO_10
2005	1796377.44	637698.38	5.53	5.23	0.30		PID QC	BO_11
2007	1785539.65	513476.30	52.47	52.42	0.05		PID QC	AP_13
2008	1785731.66	507176.90	67.81	68.19	-0.38		PID QC	AO_13
2009	1783665.23	507641.99	77.44	77.93	-0.49		PID QC	AO_14
2010	1783771.10	511594.24	62.76	63.35	-0.59		PID QC	AP_14
2012	1714843.74	574130.66	67.75	67.24	0.51		PID QC	BB_28

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
2013	1715483.17	574849.90	65.18	64.80	0.38		PID QC	BB_27
2014	1714527.00	575599.73	64.16	64.07	0.09		PID QC	BC_28
2015	1713499.92	573555.29	71.42	71.09	0.33		PID QC	BB_28
2016	1708712.83	682969.93	5.50	5.04	0.46		PID QC	BX_29
2017	1706680.09	681180.77	4.18	3.91	0.27		PID QC	BX_29
2018	1706493.99	678890.56	7.49	6.99	0.50		PID QC	BW_29
2019	1705166.42	678232.95	7.11	6.73	0.38		PID QC	BW_29
2020	1702941.33	682446.75	4.55	3.95	0.60		PID QC	BX_30
2021	1668425.92	594241.30	27.61	27.81	-0.20		PID QC	BF_37
2022	1667089.46	586991.06	57.46	57.17	0.29		PID QC	BE_37
2023	1663574.76	586732.56	29.53	29.44	0.09		PID QC	BE_38
2024	1663211.81	593055.40	30.57	30.42	0.15		PID QC	BF_38
2025	1665087.33	595796.10	28.46	28.35	0.11		PID QC	BG_37
6001	1761891.02	626941.76	27.37	27.11	0.26		PID QC	BM_18
6002	1757499.40	628660.12	27.51	27.29	0.22		PID QC	BM_19
6003	1754082.05	631286.50	29.80	30.05	-0.25		PID QC	BN_20
6005	1766891.31	636450.82	29.53	29.25	0.28		PID QC	BO_17
6006	1757513.06	635744.14	25.76	25.82	-0.06		PID QC	BO_19
6007	1759258.51	643360.27	25.87	25.91	-0.04		PID QC	BP_19
6008	1764365.32	644138.89	15.65	15.87	-0.22		PID QC	BP_18
6009	1770385.05	643580.73	8.23	8.26	-0.03		PID QC	BP_16
6010	1772729.83	648892.66	10.64	10.71	-0.07		PID QC	BQ_16
6011	1768903.59	652726.36	6.26	6.01	0.25		PID QC	BR_17
6012	1762625.71	649718.64	6.35	6.26	0.09		PID QC	BR_18
6013	1766026.01	659082.72	11.10	11.16	-0.06		PID QC	BS_17
6014	1770782.50	656741.31	10.60	10.75	-0.15		PID QC	BS_16
6015	1775700.38	654996.79	14.65	14.63	0.02		PID QC	BS_15
3023	1707205.67	575036.08	63.11	62.72	0.39		URBAN	BC-29
3026	1710757.24	576334.46	63.42	62.99	0.43		URBAN	BC-29
3043	1727961.60	637444.11	23.93	23.33	0.60		URBAN	BO-25
3045	1729237.17	633367.42	21.33	20.83	0.50		URBAN	BN-25
3048	1720201.77	636714.87	22.56	22.40	0.16		URBAN	BO-26
3061	1713167.71	562225.70	69.46	69.22	0.24		URBAN	AZ-28
3064	1710195.92	566299.14	85.96	85.83	0.13		URBAN	BA-28
3068	1720182.92	571633.70	77.16	76.55	0.61		URBAN	BB-26
3080	1682204.44	595245.14	45.46	44.75	0.71		URBAN	BB-26
3082	1680275.46	589351.23	38.79	38.32	0.47		URBAN	BE-34
3083	1680048.73	591215.56	36.59	36.37	0.22		URBAN	BF-34
3102	1683500.95	560556.97	66.02	65.96	0.06		URBAN	AZ-34
3103	1683071.03	558016.89	47.21	47.46	-0.25		URBAN	AY-34
3105	1685375.09	565112.07	23.89	23.94	-0.05		URBAN	BA-33
3108	1689697.29	560322.32	47.66	47.65	0.01		URBAN	AZ-33
3124	1661232.68	601435.90	40.10	40.16	-0.06		URBAN	BH-38
3125	1661138.58	600701.71	41.82	41.78	0.04		URBAN	BH-38

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3126	1661441.26	598736.36	26.67	26.35	0.32		URBAN	BG-38
3127	1663721.50	601052.18	40.84	40.93	-0.09		URBAN	BH-38
3129	1662515.41	601961.02	43.95	43.76	0.19		URBAN	BH-38
3131	1664140.12	602108.53	39.54	39.38	0.16		URBAN	BH-38
3146	1662255.03	634073.56	27.06	26.98	0.08		URBAN	BN-38
3149	1656723.26	633994.34	26.33	26.31	0.02		URBAN	BN-39
3221	1689421.27	582284.80	60.37	60.87	-0.50		URBAN	BD-33
3226	1690404.26	582100.48	56.45	56.29	0.16		URBAN	BD-32
3228	1688458.38	581986.49	57.26	57.02	0.24		URBAN	BD-33
3024	1707154.08	575044.18	60.38	60.95		-0.57	BRUSH	BC-29
3027	1709052.34	571507.81	58.73	59.22		-0.49	BRUSH	BB-29
3029	1709253.82	571590.62	60.18	60.41		-0.23	BRUSH	BB-29
3040	1723423.58	633051.83	24.81	24.88		-0.07	BRUSH	BN-26
3042	1726827.97	638035.82	20.00	19.58		0.42	BRUSH	BO-25
3044	1729012.85	634169.42	20.10	19.82		0.28	BRUSH	BN-25
3060	1713196.89	561740.34	54.91	55.08		-0.17	BRUSH	AZ-28
3062	1713444.58	564659.88	73.71	73.65		0.06	BRUSH	AZ-28
3065	1716364.41	566537.94	66.11	66.20		-0.09	BRUSH	BA-27
3066	1718110.71	568173.61	67.20	67.47		-0.27	BRUSH	BA-27
3085	1678817.92	588856.14	29.10	29.33		-0.23	BRUSH	BE-35
3087	1682075.21	595460.23	53.62	53.91		-0.29	BRUSH	BG-34
3088	1683334.80	595972.32	62.21	62.73		-0.52	BRUSH	BG-34
3090	1683338.30	596671.48	57.37	57.96		-0.59	BRUSH	BG-34
3106	1691031.83	559753.36	36.46	36.30		0.16	BRUSH	AY-32
3107	1688096.12	556700.09	23.81	23.95		-0.14	BRUSH	AY-33
3110	1688158.58	560676.90	61.79	62.04		-0.25	BRUSH	AZ-33
3111	1688147.35	560729.97	60.79	60.55		0.24	BRUSH	AZ-33
3112	1688165.81	561059.08	58.30	58.76		-0.46	BRUSH	AZ-33
3121	1664951.88	598922.49	44.14	44.69		-0.55	BRUSH	BG-38
3122	1662845.90	602539.30	40.40	40.61		-0.21	BRUSH	BH-38
3123	1662586.54	602429.66	43.19	43.57		-0.38	BRUSH	BH-38
3132	1666809.90	601659.37	48.28	47.66		0.62	BRUSH	BH-37
3141	1658104.84	634112.20	26.92	26.82		0.10	BRUSH	BN-39
3143	1661594.36	634372.39	26.95	27.39		-0.44	BRUSH	BN-38
3145	1660602.50	634624.76	26.09	26.21		-0.12	BRUSH	BN-38
3150	1656699.93	633881.76	24.29	24.74		-0.45	BRUSH	BN-39
3222	1689369.62	582875.01	55.51	55.78		-0.27	BRUSH	BD-33
3224	1688882.43	582279.01	58.45	58.79		-0.34	BRUSH	BD-33
3225	1688247.01	581259.03	57.66	57.96		-0.30	BRUSH	BD-33
3229	1689139.03	582153.45	59.83	60.70		-0.87	BRUSH	BD-33
3003	1744910.61	545486.67	58.64	58.94		-0.30	WOODED	AW-22
3004	1744911.64	545520.27	59.35	59.35		0.00	WOODED	AW-22
3005	1744912.81	545549.80	59.71	59.74		-0.03	WOODED	AW-22
3006	1744908.64	545576.21	60.24	60.20		0.04	WOODED	AW-22

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3007	1744911.09	545605.71	60.93	60.65		0.28	WOODED	AW-22
3008	1744907.71	545633.80	61.03	61.05		-0.02	WOODED	AW-22
3009	1744906.57	545666.08	61.70	61.70		0.00	WOODED	AW-22
3010	1744904.48	545691.57	62.33	62.19		0.14	WOODED	AW-22
3011	1744906.62	545716.21	62.43	62.54		-0.11	WOODED	AW-22
3012	1744907.70	545741.97	62.93	62.88		0.05	WOODED	AW-22
3013	1744908.53	545765.72	63.23	63.09		0.14	WOODED	AW-22
3030	1709432.71	571069.92	60.70	60.63		0.07	WOODED	BB-29
3031	1709443.13	571462.72	60.20	60.24		-0.04	WOODED	BB-29
3032	1709463.59	571920.91	58.67	58.35		0.32	WOODED	BB-29
3033	1709478.56	572352.67	60.25	59.36		0.89	WOODED	BB-29
3034	1709472.79	573071.51	68.18	67.79		0.39	WOODED	BB-28
3035	1709664.94	573052.50	67.41	67.14		0.27	WOODED	BB-28
3036	1710148.74	572926.57	67.64	66.82		0.82	WOODED	BB-28
3037	1710593.23	572929.06	67.19	66.71		0.48	WOODED	BB-28
3038	1711198.14	572901.20	67.67	67.75		-0.08	WOODED	BB-28
3039	1711598.77	572891.64	66.66	66.58		0.08	WOODED	BB-28
3050	1720135.71	636367.18	21.52	22.15		-0.63	WOODED	BO-26
3051	1722668.90	632807.96	22.18	22.48		-0.30	WOODED	BN-26
3052	1723238.69	632335.52	24.93	25.46		-0.53	WOODED	BN-26

APPENDIX F
CONTOUR/TIN ACCURACY ANALYSIS

The accuracy of the TIN generated from the Contours was verified using field survey methods. The results of the accuracy analysis are as follows:

Volusia County Florida
FY2006 Digital Orthophoto and LiDAR
Contour DTM Accuracy Analysis - October 30, 2007

Horizontal Datum: NAD83 HARN
Vertical Datum: NAVD88
Projection: State Plane Coordinates, Florida East Zone
Working Units: US Survey Feet

Overall Statistical Summary:					
All Unobscured Points			**All Obscured Points**		
RMSE Z	0.44	ft	RMSE Z	0.40	ft
Stdev	0.43	ft	Stdev	0.40	ft
Ave Error	-0.08	ft	Ave Error	0.07	ft
Min Error	-1.25	ft	Min Error	-1.00	ft
Max Error	1.22	ft	Max Error	0.87	ft
Count	96		Count	55	

Statistical Summary By Class					
All Points			**Bare Earth - Unobs**		
Average	0.00	ft	Average	-0.04	ft
RMSE	0.42	ft	RMSE	0.47	ft
Stdev	0.42	ft	Stdev	0.48	ft
Max Error	1.05	ft	Max Error	1.22	ft
Min Error	-1.13	ft	Min Error	-1.13	ft
Count	151		Count	33	
Hard Surfaced - Unobs			**Cut Grass - Unobs**		
RMSE	0.35	ft	Average	-0.27	ft
Stdev	0.35		RMSE	0.51	ft
Average	0.02	ft	Stdev	0.43	ft
Max Error	0.65	ft	Max Error	0.54	ft
Min Error	-0.55	ft	Min Error	-1.25	ft
Count	37		Count	26	
Low/Med Vegetation - Obs			**Dense Vegetation - Obs**		
Average	0.20	ft	Average	-0.10	ft
RMSE	0.41	ft	RMSE	0.39	ft
Stdev	0.36	ft	Stdev	0.38	ft
Max Error	0.87	ft	Max Error	0.60	ft
Min Error	-0.64	ft	Min Error	-1.00	ft
Count	31		Count	24	

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3001	1745060.35	545437.85	57.49	57.06	-0.43		BARE EARTH	AW-21
3002	1745166.03	545438.06	59.55	59.29	-0.26		BARE EARTH	AW-21
3020	1664961.62	598696.23	49.42	48.93	-0.49		BARE EARTH	BG-38
3021	1708438.01	572957.68	68.80	68.65	-0.15		BARE EARTH	BB-29
3022	1709522.58	573010.79	68.13	67.00	-1.13		BARE EARTH	BB-29
3025	1709684.35	576861.89	62.58	63.00	0.42		BARE EARTH	BC-29
3028	1709057.06	571527.01	59.77	59.00	-0.77		BARE EARTH	BB-29
3041	1722050.77	630099.65	27.53	27.00	-0.53		BARE EARTH	BN-26
3046	1726763.13	633794.27	21.30	21.00	-0.30		BARE EARTH	BN-25
3047	1723101.56	632548.93	25.60	25.49	-0.11		BARE EARTH	BN-26
3049	1719998.77	636549.29	22.43	22.46	0.03		BARE EARTH	BO-26
3063	1712627.79	565856.57	73.83	73.53	-0.30		BARE EARTH	BA-28
3067	1707589.74	573234.35	67.51	67.72	0.21		BARE EARTH	BB-29
3084	1678839.03	588732.49	30.15	30.03	-0.12		BARE EARTH	BE-35
3086	1682333.43	595258.21	47.69	48.91	1.22		BARE EARTH	BG-34
3089	1684670.97	595758.15	55.24	55.71	0.47		BARE EARTH	BG-34
3091	1682605.81	595764.21	60.71	61.00	0.29		BARE EARTH	BG-34
3092	1785116.44	510251.43	74.78	75.00	0.22		BARE EARTH	AP-13
3093	1715238.95	574801.99	65.89	66.16	0.27		BARE EARTH	BB-27
3100	1685134.37	560562.95	67.82	67.96	0.14		BARE EARTH	AZ-33
3101	1684734.45	560561.67	68.77	69.02	0.25		BARE EARTH	AZ-34
3104	1685500.33	555277.30	43.36	43.43	0.07		BARE EARTH	AY-33
3109	1689662.22	560248.81	46.90	46.59	-0.31		BARE EARTH	AZ-33
3128	1662398.19	601781.72	44.44	44.57	0.13		BARE EARTH	BH-38
3130	1664144.84	602006.28	40.62	40.76	0.14		BARE EARTH	BH-38
3140	1658139.26	634118.09	26.59	26.14	-0.45		BARE EARTH	BN-39
3142	1661655.68	634365.23	28.11	28.00	-0.11		BARE EARTH	BN-38
3144	1660602.48	634676.56	26.92	26.00	-0.92		BARE EARTH	BN-38
3148	1662108.50	633943.23	27.39	27.33	-0.06		BARE EARTH	BN-38
3223	1688685.79	582507.18	57.09	58.00	0.91		BARE EARTH	BD-33
3227	1690981.14	580871.71	75.32	75.45	0.13		BARE EARTH	BD-32
3230	1689748.13	580952.89	70.98	71.44	0.46		BARE EARTH	BD-33
3231	1689637.69	580564.35	68.60	68.39	-0.21		BARE EARTH	BD-33
2001	1803893.54	633374.78	3.65	4.00	0.35		PID QC	BN_10
2002	1795594.12	631993.22	5.52	6.00	0.48		PID QC	BN_11
2003	1802831.89	641163.34	12.71	12.91	0.20		PID QC	BP_10
2004	1802682.96	636548.15	13.18	13.61	0.43		PID QC	BO_10
2005	1796377.44	637698.38	5.53	5.03	-0.50		PID QC	BO_11
2007	1785539.65	513476.30	52.47	52.55	0.08		PID QC	AP_13
2008	1785731.66	507176.90	67.81	68.00	0.19		PID QC	AO_13
2009	1783665.23	507641.99	77.44	77.94	0.50		PID QC	AO_14
2010	1783771.10	511594.24	62.76	63.25	0.49		PID QC	AP_14
2012	1714843.74	574130.66	67.75	67.44	-0.31		PID QC	BB_28

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
2013	1715483.17	574849.90	65.18	65.00	-0.18		PID QC	BB_27
2014	1714527.00	575599.73	64.16	64.75	0.59		PID QC	BC_28
2015	1713499.92	573555.29	71.42	71.49	0.07		PID QC	BB_28
2016	1708712.83	682969.93	5.50	5.00	-0.50		PID QC	BX_29
2017	1706680.09	681180.77	4.18	4.00	-0.18		PID QC	BX_29
2018	1706493.99	678890.56	7.49	7.00	-0.49		PID QC	BW_29
2019	1705166.42	678232.95	7.11	7.00	-0.11		PID QC	BW_29
2020	1702941.33	682446.75	4.55	4.00	-0.55		PID QC	BX_30
2021	1668425.92	594241.30	27.61	27.94	0.33		PID QC	BF_37
2022	1667089.46	586991.06	57.46	57.38	-0.08		PID QC	BE_37
2023	1663574.76	586732.56	29.53	29.48	-0.05		PID QC	BE_38
2024	1663211.81	593055.40	30.57	30.38	-0.19		PID QC	BF_38
2025	1665087.33	595796.10	28.46	28.29	-0.17		PID QC	BG_37
6001	1761891.02	626941.76	27.37	27.00	-0.37		PID QC	BM_18
6002	1757499.40	628660.12	27.51	27.00	-0.51		PID QC	BM_19
6003	1754082.05	631286.50	29.80	30.00	0.20		PID QC	BN_20
6005	1766891.31	636450.82	29.53	29.00	-0.53		PID QC	BO_17
6006	1757513.06	635744.14	25.76	26.00	0.24		PID QC	BO_19
6007	1759258.51	643360.27	25.87	26.00	0.13		PID QC	BP_19
6008	1764365.32	644138.89	15.65	15.89	0.24		PID QC	BP_18
6009	1770385.05	643580.73	8.23	8.32	0.09		PID QC	BP_16
6010	1772729.83	648892.66	10.64	10.69	0.05		PID QC	BQ_16
6011	1768903.59	652726.36	6.26	6.05	-0.21		PID QC	BR_17
6012	1762625.71	649718.64	6.35	7.00	0.65		PID QC	BR_18
6013	1766026.01	659082.72	11.10	11.00	-0.10		PID QC	BS_17
6014	1770782.50	656741.31	10.60	11.00	0.40		PID QC	BS_16
6015	1775700.38	654996.79	14.65	14.87	0.22		PID QC	BS_15
3023	1707205.67	575036.08	63.11	62.73	-0.38		URBAN	BC-29
3026	1710757.24	576334.46	63.42	62.17	-1.25		URBAN	BC-29
3043	1727961.60	637444.11	23.93	23.00	-0.93		URBAN	BO-25
3045	1729237.17	633367.42	21.33	20.53	-0.80		URBAN	BN-25
3048	1720201.77	636714.87	22.56	22.00	-0.56		URBAN	BO-26
3061	1713167.71	562225.70	69.46	69.07	-0.39		URBAN	AZ-28
3064	1710195.92	566299.14	85.96	85.48	-0.48		URBAN	BA-28
3068	1720182.92	571633.70	77.16	77.00	-0.16		URBAN	BB-26
3080	1682204.44	595245.14	45.46	45.00	-0.46		URBAN	BB-26
3082	1680275.46	589351.23	38.79	38.28	-0.51		URBAN	BE-34
3083	1680048.73	591215.56	36.59	37.00	0.41		URBAN	BF-34
3102	1683500.95	560556.97	66.02	66.00	-0.02		URBAN	AZ-34
3103	1683071.03	558016.89	47.21	47.75	0.54		URBAN	AY-34
3105	1685375.09	565112.07	23.89	23.00	-0.89		URBAN	BA-33
3108	1689697.29	560322.32	47.66	47.00	-0.66		URBAN	AZ-33
3124	1661232.68	601435.90	40.10	40.16	0.06		URBAN	BH-38
3125	1661138.58	600701.71	41.82	41.69	-0.13		URBAN	BH-38
3126	1661441.26	598736.36	26.67	26.52	-0.15		URBAN	BG-38

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3127	1663721.50	601052.18	40.84	40.94	0.10		URBAN	BH-38
3129	1662515.41	601961.02	43.95	43.69	-0.26		URBAN	BH-38
3131	1664140.12	602108.53	39.54	39.70	0.16		URBAN	BH-38
3146	1662255.03	634073.56	27.06	26.97	-0.09		URBAN	BN-38
3149	1656723.26	633994.34	26.33	26.00	-0.33		URBAN	BN-39
3221	1689421.27	582284.80	60.37	60.85	0.48		URBAN	BD-33
3226	1690404.26	582100.48	56.45	56.29	-0.16		URBAN	BD-32
3228	1688458.38	581986.49	57.26	57.00	-0.26		URBAN	BD-33
3024	1707154.08	575044.18	60.38	60.01		0.37	BRUSH	BC-29
3027	1709052.34	571507.81	58.73	58.46		0.27	BRUSH	BB-29
3029	1709253.82	571590.62	60.18	60.36		-0.18	BRUSH	BB-29
3040	1723423.58	633051.83	24.81	24.62		0.19	BRUSH	BN-26
3042	1726827.97	638035.82	20.00	20.00		0.00	BRUSH	BO-25
3044	1729012.85	634169.42	20.10	20.39		-0.29	BRUSH	BN-25
3060	1713196.89	561740.34	54.91	54.74		0.17	BRUSH	AZ-28
3062	1713444.58	564659.88	73.71	73.86		-0.15	BRUSH	AZ-28
3065	1716364.41	566537.94	66.11	65.96		0.15	BRUSH	BA-27
3066	1718110.71	568173.61	67.20	66.40		0.80	BRUSH	BA-27
3085	1678817.92	588856.14	29.10	28.68		0.42	BRUSH	BE-35
3087	1682075.21	595460.23	53.62	53.32		0.30	BRUSH	BG-34
3088	1683334.80	595972.32	62.21	61.72		0.49	BRUSH	BG-34
3090	1683338.30	596671.48	57.37	56.83		0.54	BRUSH	BG-34
3106	1691031.83	559753.36	36.46	36.88		-0.42	BRUSH	AY-32
3107	1688096.12	556700.09	23.81	23.67		0.14	BRUSH	AY-33
3110	1688158.58	560676.90	61.79	61.58		0.21	BRUSH	AZ-33
3111	1688147.35	560729.97	60.79	60.84		-0.05	BRUSH	AZ-33
3112	1688165.81	561059.08	58.30	57.68		0.62	BRUSH	AZ-33
3121	1664951.88	598922.49	44.14	43.81		0.33	BRUSH	BG-38
3122	1662845.90	602539.30	40.40	39.80		0.60	BRUSH	BH-38
3123	1662586.54	602429.66	43.19	43.38		-0.19	BRUSH	BH-38
3132	1666809.90	601659.37	48.28	48.92		-0.64	BRUSH	BH-37
3141	1658104.84	634112.20	26.92	27.12		-0.20	BRUSH	BN-39
3143	1661594.36	634372.39	26.95	26.90		0.05	BRUSH	BN-38
3145	1660602.50	634624.76	26.09	25.98		0.11	BRUSH	BN-38
3150	1656699.93	633881.76	24.29	23.58		0.71	BRUSH	BN-39
3222	1689369.62	582875.01	55.51	55.25		0.26	BRUSH	BD-33
3224	1688882.43	582279.01	58.45	57.90		0.55	BRUSH	BD-33
3225	1688247.01	581259.03	57.66	57.36		0.30	BRUSH	BD-33
3229	1689139.03	582153.45	59.83	58.96		0.87	BRUSH	BD-33
3003	1744910.61	545486.67	58.64	58.34		0.30	WOODED	AW-22
3004	1744911.64	545520.27	59.35	59.34		0.01	WOODED	AW-22
3005	1744912.81	545549.80	59.71	59.68		0.03	WOODED	AW-22
3006	1744908.64	545576.21	60.24	60.31		-0.07	WOODED	AW-22
3007	1744911.09	545605.71	60.93	61.30		-0.37	WOODED	AW-22
3008	1744907.71	545633.80	61.03	60.98		0.05	WOODED	AW-22

Station	Survey (US SV FT)			LiDAR Elev.	Residual Err (US SV FT)			
Name	Northing	Easting	Elevation	(US SV FT)	Unobscured	Obscured	Feature	Tile
3009	1744906.57	545666.08	61.70	61.68		0.02	WOODED	AW-22
3010	1744904.48	545691.57	62.33	62.50		-0.17	WOODED	AW-22
3011	1744906.62	545716.21	62.43	62.36		0.07	WOODED	AW-22
3012	1744907.70	545741.97	62.93	63.01		-0.08	WOODED	AW-22
3013	1744908.53	545765.72	63.23	63.46		-0.23	WOODED	AW-22
3030	1709432.71	571069.92	60.70	60.74		-0.04	WOODED	BB-29
3031	1709443.13	571462.72	60.20	59.98		0.22	WOODED	BB-29
3032	1709463.59	571920.91	58.67	59.24		-0.57	WOODED	BB-29
3033	1709478.56	572352.67	60.25	61.25		-1.00	WOODED	BB-29
3034	1709472.79	573071.51	68.18	68.57		-0.39	WOODED	BB-28
3035	1709664.94	573052.50	67.41	67.70		-0.29	WOODED	BB-28
3036	1710148.74	572926.57	67.64	68.46		-0.82	WOODED	BB-28
3037	1710593.23	572929.06	67.19	67.78		-0.59	WOODED	BB-28
3038	1711198.14	572901.20	67.67	67.43		0.24	WOODED	BB-28
3039	1711598.77	572891.64	66.66	66.63		0.03	WOODED	BB-28
3050	1720135.71	636367.18	21.52	20.92		0.60	WOODED	BO-26
3051	1722668.90	632807.96	22.18	22.15		0.03	WOODED	BN-26
3052	1723238.69	632335.52	24.93	24.41		0.52	WOODED	BN-26