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Report of Special Purpose Survey

LiDAR Collection and Processing

Hillsborough County, Florida

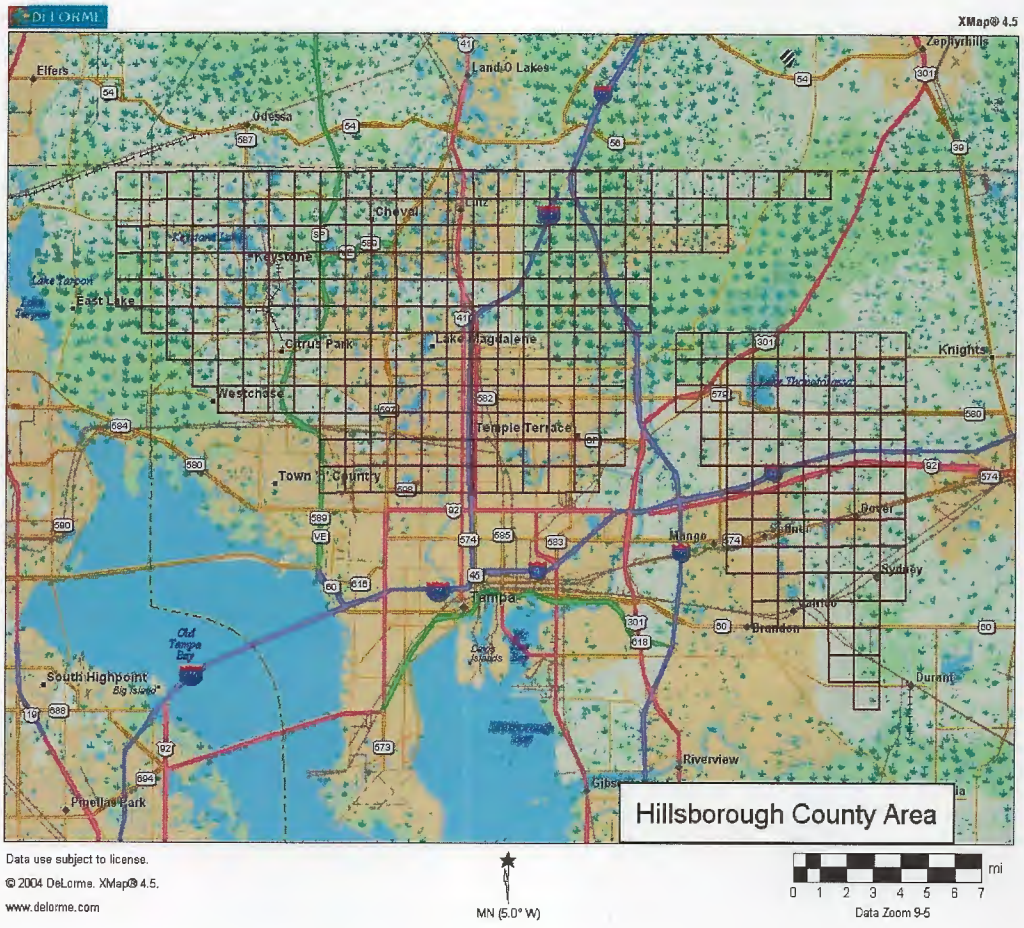
Southwest Florida Water Management District

FY2011 DIGITAL LIDAR (B813)
Purchase Order: 11POSOW0277

December 2011

This report is not valid without the original signature and original raised seal of a Florida Licensed Surveyor and Mapper.

Overall Project Area



Project Title and Reference Number

Southwest Florida Water Management District
FY2011 DIGITIAL LIDAR (B813)
Task Order: 11POSOW0277

Project Managers

Al Karlin, SWFWMD
Gary R. Florence, Photo Science, Inc.

Consultant Name and Address

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Executive Summary

The purpose of this project is to provide professional surveying and LiDAR services to the SWFWMD for the creation of a high-resolution digital elevation model for a 286 Square mile area of interest (AOI) in Hillsborough County, Florida (based on a 5,000-ft by 5,000-ft tiling scheme). The project area is shown in the graphic above and required 106 flight lines flown at 5,500' ASL.

All flights for the project were accomplished with two customized single-engine Cessna 206s' which provide an ideal, stable aerial base for LiDAR acquisition. This platform has relatively fast cruise speeds that are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which can prove ideal for collection of a high-density, consistent data posting.

Photo Science utilized two Optech Gemini scanners on this project (Serial Numbers 246 and 247). The systems are capable of collecting data at a maximum frequency of 167 kHz, which affords elevation data collection of up to 167,000 points per second. The system utilizes a Multi-Pulse in the Air Option (MPIA). This sensor is also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd, and last returns. The intensity of the first three returns is also captured during the aerial acquisition.

See Appendix C (reference attached CD ROM made part of this report)for system calibration information for the particular sensors utilized for this project as well as a description of the process. Additionally, PSI consistently flies perpendicular cross flight as part of each lift across those planned lines that were captured during that lift For this project several cross flights were planned. Additionally a calibration site was set up at the BKV Airport (Hernando, County). Both sensors flew calibration lines prior to beginning collection and after all acquisitions were completed.

All work was produced under the direct supervision of a Florida Licensed Professional Surveyor and Mapper and was in accordance with the Minimum Technical Standards defined in Chapter 5J-17, Florida Administrative Code.

Project Area

Project area is comprised of a collection of 5000-ft-by-5000-ft cells that serve as the tiling scheme for LiDAR and topographic data deliverables. The LiDAR area to be mapped consists of 318 cells (approximately 286 square miles).

Projection/Datum

Horizontal Datum is Florida State Plane Coordinate System, West Zone (0902), Units US Survey Feet, North American Datum of 1983 (NSRS 2007). Vertical Datum is North American Vertical Datum of 1988 (NAVD 88) – presented as orthometric heights, Geoid09, U.S. Survey Feet.

LiDAR Production Specifications

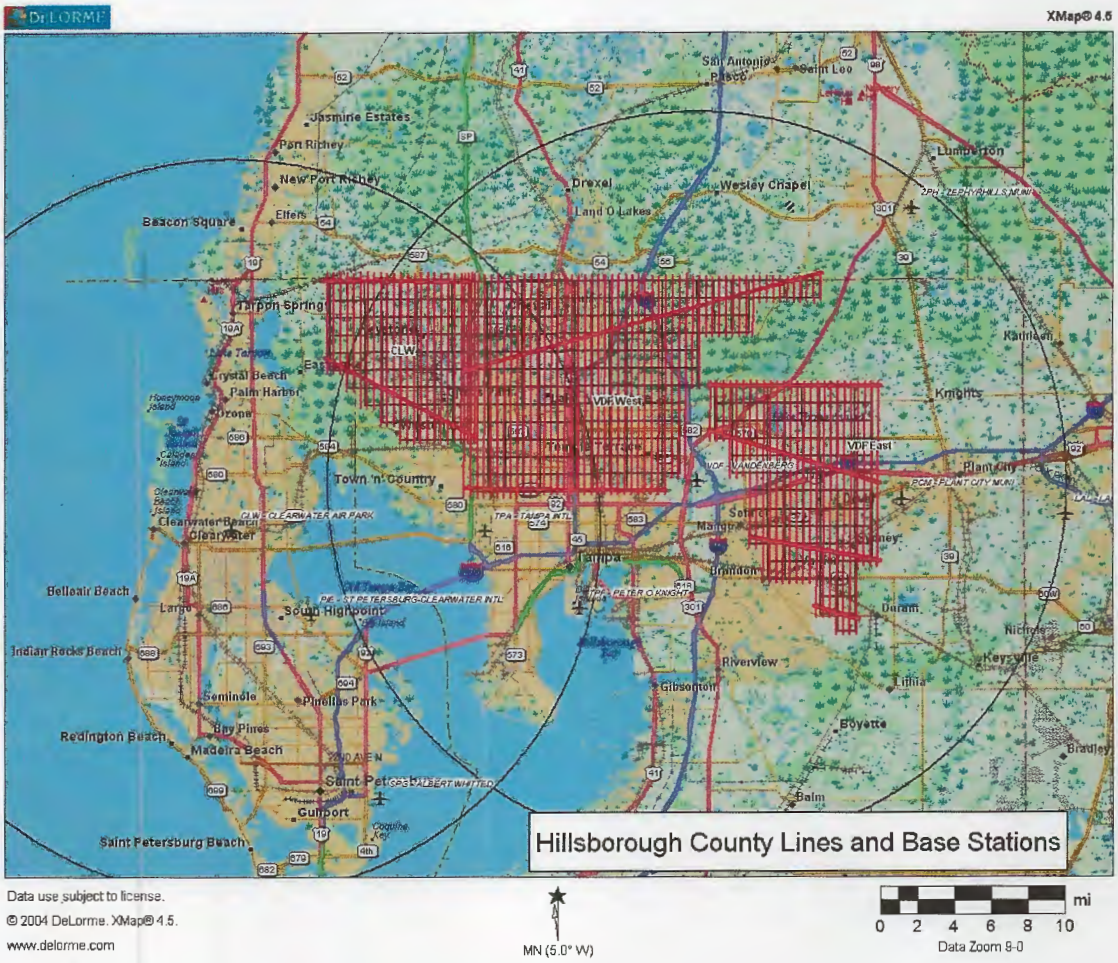
The scope stated that horizontal accuracies for the LiDAR data sets should meet or exceed a verified horizontal accuracy of 3.8-feet at the 95% confidence interval (2.20-feet RMSE) as specified in the FGDC Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA). A minimum of thirty independent checkpoints within the project area will be used for verification.

The scope also defined the Fundamental Vertical Accuracy (FVA) at meeting or exceeding 0.6-foot at 95% confidence level (0.3-feet RMSE) in open well defined terrain. A minimum of thirty check points for each land cover category will be checked (Urban; Bare Ground/Short Grass; and Brush). Supplemental Vertical Accuracy (SVA) shall meet or exceed 1.19-feet (0.63-feet RMSE) with a minimum of thirty check points in the following land cover types, (Wet Prairies and Pine Flatwoods). Finally the Consolidated Vertical Accuracy (CVA) shall not exceed the above accuracy requirements when all the values are tested as a combined QC check.

Flight Planning

Detailed project planning was performed for this project. This planning was based on project specific requirements and the characteristics of the project site. The basis of this planning included the required accuracies, type of development, amount and type of vegetation within the project area, the required data posting, and potential altitude restrictions (if any), obstructions and restrictions for flights in the general area. A map showing the flight lines and a brief summary of the aerial acquisition parameters for this project are shown below:

Planned Flight Line Map



Actual Flight Line Maps

Due to the number of missions and the configuration of the actual flight lines, the actual flight lines flown have been included in as part of Appendix E (see attached CD ROM made part of this report) to view these maps.

Collection Parameters:

- **Terrain and Aircraft**
  Reference Height; 25 m
  Flying Height AGL; 1676.4 m; 5500 FT
  Altitude AMSL; 1676.4 m; 5500 FT
  Recommended Ground Speed (GS); 110 kts

- **Scanner**
  Field of View (FOV); 28 degrees
  Maximum Scan Rate; 34 Hz

- **Laser**
  Maximum Laser Pulse Rate; 150,000 Hz
  Laser Pulse Rate used; 71.429 Hz
  Multi Pulse in Air Mode; Enabled; Enabled;

- **Coverage**
  Full Swath Width; 834.7 m
  Minimum Sidelap; 30%

- **Point Spacing and Density**
  Maximum Point Spacing Across Track; 0.769 m
  Maximum Point Spacing Along Track; 0.832 m
  Average Point Density; 1.51 ppm^2

- **Accuracy**
  Estimated Across Track Accuracy; 0.22 - 0.25 m
  Estimated Along Track Accuracy; 0.21 - 0.24 m
  Estimated Height Accuracy; < 0.12 m

- **GPS**
  Maximum PDOP: 3.5
  Minimum Number of SV's: 6
  Ground Collection Epoch: 2Hz (0.5 Seconds)

Note: Reference the planned sensor summary information included in Appendix D (please see attached CD ROM made part of this report).

Dates Flown

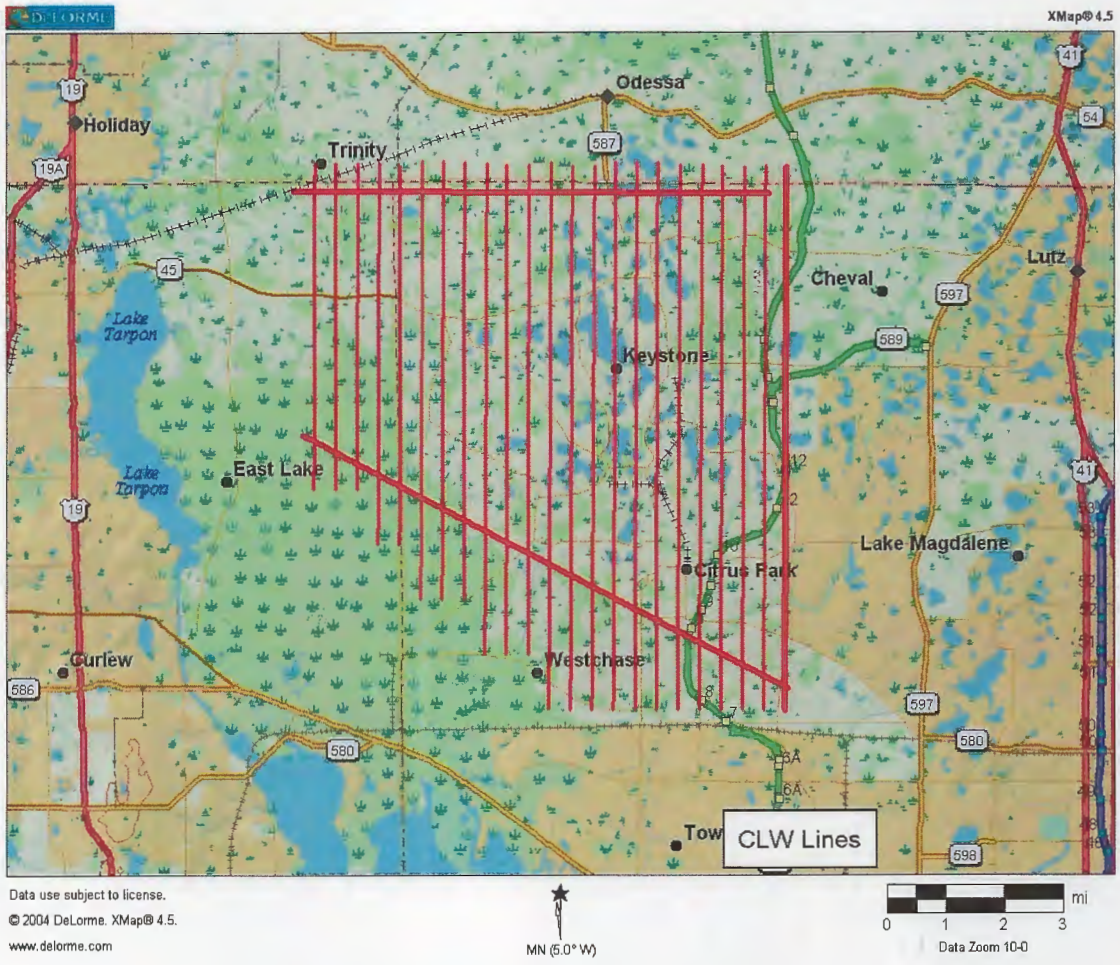
Collection occurred as weather permitted and ground conditions were within required tolerances (<0.5" rainfall within proceeding 72 hours and normal water conditions). Hillsborough County was flown by two aircraft over a 2 day period (February 12, 2011 and February 13, 2011).

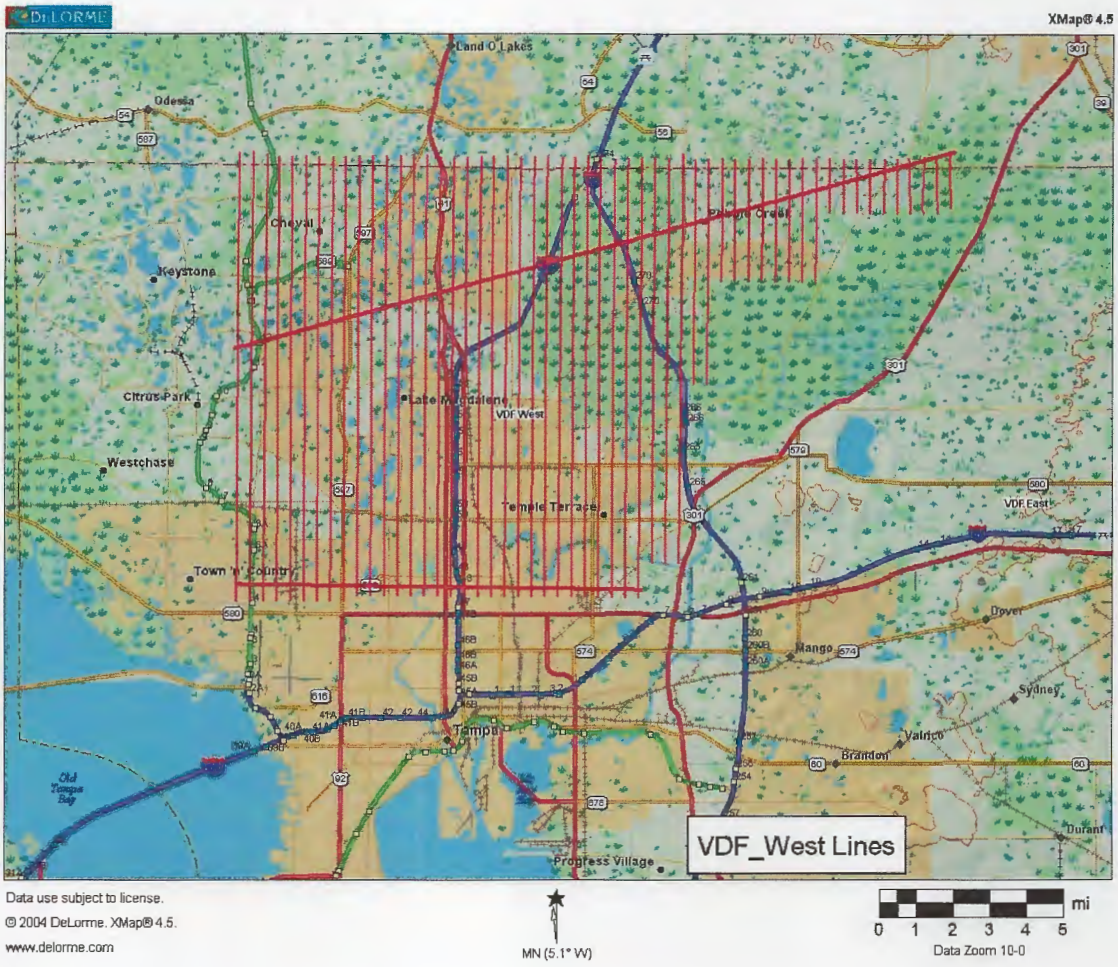
Flight Line Layout

The flight line layouts included above indicate the lines for each of the block areas. There were 106 flight lines covering 55.69 square miles in the CLW area to cover the area of interest for Hillsborough County.

The VDF_East lines were totally within the AOI for Hillsborough County. The VDF_West area included 145.52 square miles within the AOI for Hillsborough County.

The planned flight lines and cross strips for the three areas are shown below.




DeLORME
XMap® 4.5
Land O Lakes
Odessa
Cheval
Keystone
Citrus Park
Lake Magdalene
VDF West
Westchase
Temple Terrace
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Town 'n' Country
Dover
Mango
Sydney
Tampa
Valrico
Brandon
Old Tampa Bay
Progress Village
Durant
VDF_West Lines
Data use subject to license.
© 2004 DeLorme. XMap® 4.5.
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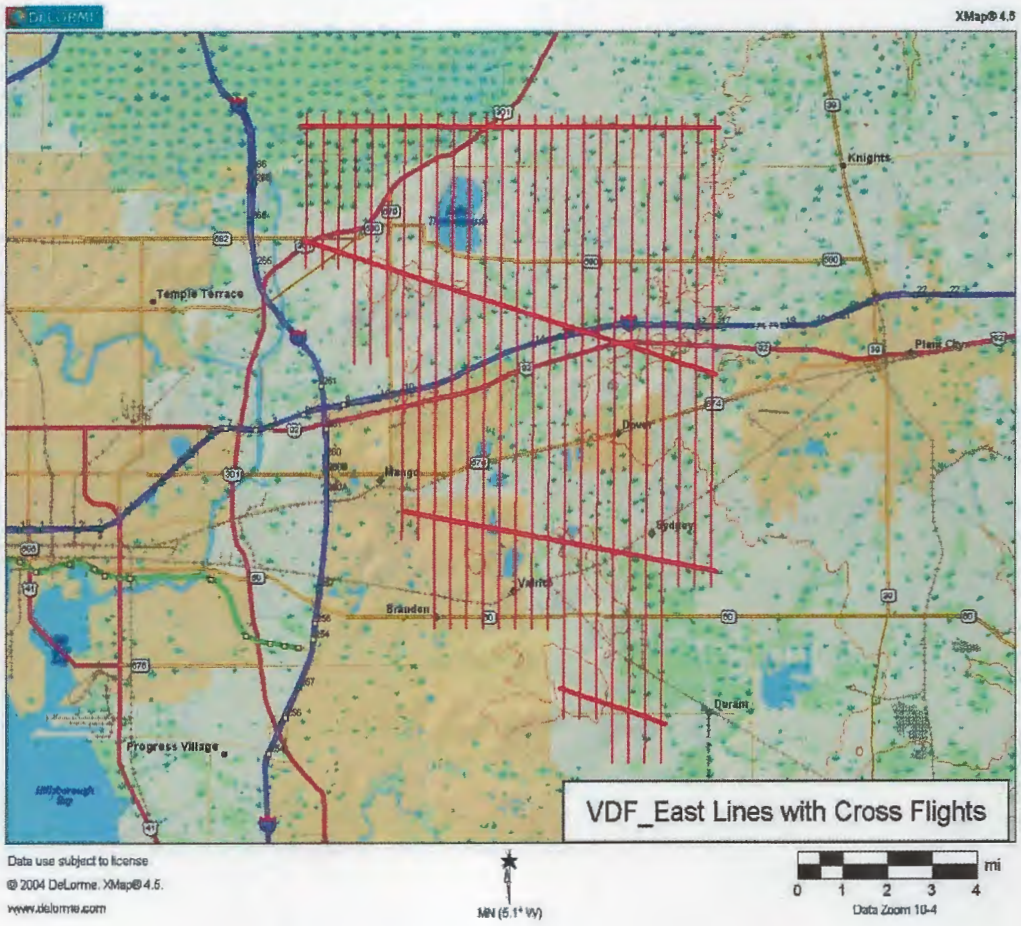

Limiting Factors

There are several limiting factors to LiDAR data collection which include:

The typical weather related requirements for an aerial LiDAR missions are that there should be no clouds or excess moisture (rain, fog or excessive humidity) between the sensor and the ground that is being profiled. Additionally, high winds blowing perpendicular to the flight lines can provide for excessive crab resulting in "slivers" or "holidays" between flight lines. These winds can also create unsafe flight conditions such as wind shear or clear air turbulence. As shown in Appendix "B", (see attached CD ROM made part of this report), the flight logs indicate the weather was "calm and clear" during the entire mission.

Additionally, the ground conditions should be such that there is no standing water from recent heavy rains, or excessive "ponding"/"pooling" of water which will affect the accuracy of the LiDAR returns. For this project we were to verify that no rain of more than .5" had fallen 72 hours prior to collection. PSI, verified this condition through the National Weather Service.

As for the satellite configuration: Typically LiDAR should not be collected during time of high PDOP, this is due to the GPS configuration providing accuracy less than desired. For this project, PSI set the parameters that no data

was to be collected during periods of PDOP above 3.5 or periods with less than 6 visible satellites. To these end, PDOP was checked prior to each mission with a fresh almanac and newly updated satellite health status from the US Coast Guard Navigation Center website. During this project there were never less than seven (7) satellites visible in the constellation and the PDOP was never above 3.0 (See Appendix "E" on the attached CD ROM made part of this report).

Data Processing

Optech DASHmap software was used in the post-processing of the airborne GPS and inertial data. This software suite includes the Applanix POSPac and Waypoint's GrafNav solutions. POSPac provides the smoothed best estimate of trajectory (SBET) that is necessary for Optech's post processor to develop the point cloud from the Lidar missions.

The point cloud was created using Optech's Post Processor software. GeoCue's TerraScan was used in the creation of files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. The TerraScan and TerraModeler software packages are then used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel flight lines. All data were manually reviewed and any remaining artifacts removed using TerraScan and TerraModeler. QT Modeler was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable LAS 1.2 files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files.

Field Survey

The horizontal quality control points established in the field were completed by Cooner and Associates (CA). Appendix "A" (see attached CD ROM made part of this report) contains the survey report for the field portion of this effort developed by CA.

QA/QC Analysis

A total of 150 points were obtained by Cooner & Associates for vertical QC analysis, 90 of these points were utilized to determine the Fundamental Vertical Accuracy (FVA) and 60 were used to determine the Supplemental Vertical Accuracy (SVA). We combined all the points for the Consolidated Vertical Accuracy assessment.

See Appendix F for the spreadsheets. In summary we found the following:

- FVA – RMSE of 0.264-feet or an NSSDA @ 95% of 0.517-feet
- SVA – RMSE of 0.446-feet or an NSSDA @ 95% of 0.875-feet
- CVA – RMSE of 0.349-feet of an NSSDA @ 95% of 0.684-feet

Additionally PSI was to collect thirty horizontal QC points evenly distributed in the AOI. This was completed by Cooner and Associates and a comparison of the horizontal accuracy was completed. The results of that comparison show an accuracy of 3.61 at 95% confidence with an RMSE of 2.08. This is within the allowable tolerance; however, we believe one horizontal control point (Number 124) was not described correctly in the field notes. If we remove that single point from the analysis, we obtain an RMSE of 1.56 or 2.71 at a 95% confidence level. See Appendix F in the attached CD ROM made part of this report..

Problems Encountered

No problems were encountered during this project. No issues were documented in the LAS tile development phase of production. The entire project was collected in two separate lifts.

Metadata Information

Metadata was provided as part of the deliverable. There were 311- XML Files: 311 LAS files *.xml).

Date(s) of Project:

Data acquisition took place February 12, 2011 and February 13, 2011; LiDAR Processing began on February 22, 2011 and TMatch, and adjustment to control was finished on April 26, 2011. Clean up and QC continued through September, 2011. The data was originally submitted to the client on September 16, 2011. On September 28, 2011 comments were received; these were corrected and re-submitted November 11, 2011 as a final deliverable.

LiDAR Deliverables

The 5000 x 5000 foot tiles were delivered as LAS, DEM, and Breakline data files. The deliverable formats for the files are in the table below:

- Classified LAS (311-Las Version 1.2 files for Hillsborough County)
- 5-ft DEM Files (311 – ESRI Grid Format for Hillsborough County)
- Breakline GDB File (HILLSBOROUGH_BL_EnhancementTopographicData.gdb)
- Metadata (311- XML Files: 311 LAS files *.xml)

Attachments

Please note that Appendix A – F referenced below and throughout this report are contained within the attached CD ROM made part of this report.

Appendix A:	Cooner Survey Report
Appendix B:	Flight and Mission Logs
Appendix C:	Calibration Reports
Appendix D:	Planned Flights and Swath
Appendix E:	Trajectory Report
Appendix F:	Accuracy Repots

Acronyms

AGL	Above Ground Level
AMSL	Above Mean Sea Level
ASPRS	American Society For Photogrammetry & Remote Sensing
BKV	Brooksville
CA	Cooner & Associates, Inc.
CD ROM	Compact Disk - Read Only Memory
CLW	Clearwater
CP	Certified Photogrammetrist (ASPRS)
CVA	Consolidated Vertical Accuracy
DEM	Digital Elevation Model
dba	Doing Business As
FGDC	Federal Geographic Data Committee
FOV	Field of View
FT	Feet
FVA	Fundamental Vertical Accuracy
GPS	Global Positioning System
GS	Ground Speed
Hz	hertz
kHz	kiloHerz
LAS	LASer (LAS) file format exchange
LiDAR	Light Detection and Ranging
m	meter
MPIA	Multi-pulse in the Air option
NSSDA	National Standard for Spatial Accuracy
PDOP	Position Dilution of Precision
ppt	parts per million
PSI	Photo Science, Incorporated
PSM	Professional Surveyor and Mapper
QA	Quality Assurance
QC	Quality Control
RMSE	Root Mean Square Error
SBET	Smoothed Best Estimate Trajectory
SV	Satellite Vehicle
SVA	Supplemental Vertical Accuracy
SWFWMD	Southwest Florida Water Management District
U.S.	United States
VDF	Vandenberg Airport
XML	Extensible Markup Language
ZPH	Zephyrhills

Prepared For:

Southwest Florida Water Management District

Prepared By:

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Surveyor and Mapper in Responsible Charge:

Gary R. Florence, CP
Professional Surveyor and Mapper
License Number LS 6757

This LiDAR derived product and report is certified to the Southwest Florida Water Management District as meeting or exceed, in quality and precision, the standards applicable for this work as set forth in Chapter 5J-17, Florida Administrative Code.

Gary R. Florence, PSM, CP

SEAL

12/15/2011
Date