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REPORT OF TOPOGRAPHIC SURVEY

Lake Hancock/Winter Haven Polk County, Florida

April 20, 2005

Prepared for

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TOPOGRAPHIC SURVEY

This topographic survey for Lake Hancock covering 190 square miles consists of the following:

1) Acquisition of lidar data for this area was acquired using a Leica ALS-40 Airborne Laser Scanner with the following parameters:
   a. 2-meter nominal post spacing
   b. Altitude of 6,000' AMT
   c. 25° sensor field of view
   d. 30% sidelap
   e. ~447 million first return data points

2) Acquisition of aerial photography to support the production of digital orthophotography for this area was acquired using a Wild RC-30 Aerial Camera with the following parameters:
   a. Color
   b. 1 ft. GSD
   c. Altitude of 4,100' AMT

This report and the digital data that were produced for this project or the copies thereof are not valid without the signature and the original raised seal of a Florida licensed surveyor and mapper, which can be found at the end of this report. Additions or deletions to this report or the delivered data by other than the signing party are prohibited without the consent of the signing party. The data and report are not full and completed without the other.

METHODS

Photogrammetric methods used for this topographic survey. Photogrammetry is a means of surveying and mapping that involves making precise measurements from a combination of ground control, aerial photographs, and elevation data sets. There are many pieces of equipment and many programs/software used to perform the various tasks for this project.

This process describes the method used to compile photogrammetrically derived breaklines to support the LIDAR digital elevation model data. The following procedures were utilized for breakline development. The breakline file contains 3D accurate line strings describing topographical features. The relationship of the LIDAR points to breaklines varies depending on the complexity and severity of the terrain. Break lines are collected where necessary to support the generation of contours. Examples of some such locations include along the edges of roads, stream banks and centerlines, ridges, and other features where the slope of the terrain changes.

The following is the specific technical method used to produce lidar bare-earth data:

Data Preprocessing

Figure 1 Lidar raw point cloud

Preprocessing is the reduction of raw lidar, IMU, and GPS data into XYZ points. This is a hardware-specific, vendor-proprietary process. Data preprocessing algorithms use a complex set of electronic timing signals and to compute ranges or distances to a reflective surface. The ranges must be combined with positional information from the GPS/IMU system to orient those ranges in 3D space and to produce XYZ points. As with any such electronic measuring system, systematic errors can be introduced from a variety of internal and external sources – instrument timing errors, effects of the atmosphere, initialization errors and so on.

Each flight mission was archived with a unique set of calibration parameters using the most optimally located GPS base station for that mission. During preprocessing, the entire flight mission was processed using this established calibration solution. All returns (1st, 2nd, 3rd, single, final, and last) were then extracted as separate sets of XYZ points.

At this point, the project cross flight lines, flown perpendicular to all mission flight lines, were used to detect and eliminate any lingering systematic errors in the preprocessed data. Ensuring consistency between overlapping and crossing flight lines constituted quality control for the preprocessing phase. Parameters used in preprocessing and the results of quality control checks were archived in the project database for future reference. The overlapping preprocessed data was merged and clipped into a seamless coverage for DTM production in the given area of interest.

Automated Data Post-Processing

Multiple-return lidar units such as the Leica ALS Airborne Laser Scanners contain measurements to the first vegetation canopy and building rooftops, as well as to intermediate levels of vegetation and bare ground. In this project, the number of lidar points totaled over 319 million. Interpreting the bare earth surface from the vast multitude of lidar points must be automated as much as possible to be of any practical value.

Automated data processing depends on mathematical filters to evaluate the lidar return data, removing points that are most likely to be non-bare earth points. Parameters were set in the software to control the size of the filter neighborhood and the aggressiveness with which it removed points appearing mathematically to be above the bare ground. The filter settings were optimized for the particular terrain type and land cover found in the flight line being processed.

Determination of filter parameters was automated to some extent by statistically characterizing the lidar data itself. A skilled operator contributed his own judgment and experience by testing small samples before letting the filters run on each entire flight line. The lidar analyst selected representative areas and established the appropriate parameters for effective processing based on terrain and vegetation type. For example, very aggressive parameters were applied to vegetated areas with thick under story; moderate parameters for vegetated areas with clear ground, and very conservative parameters for relatively clear areas.

Interactive Data Post Processing

Vegetation and artifacts remaining after automatic data post-processing were removed manually through interactive editing. These artifacts are often difficult to interpret based only on a TIN or shaded relief view of the lidar data. For example, a lone high point in the TIN could either be a tree or a rock outcrop in rugged terrain. For this reason, it is considered "best practice" to refer to aerial photography for resolution of ambiguous artifacts in the post-processed terrain model. Our experience on similar project indicates that monoscopic viewing of digital orthophotography is a cost-effective way to ensure the most accurate interpretation and editing of the lidar data. This step also affords the opportunity to visually check the final DTM quality before delivery. For this project, the digital imagery flown was used in this step.

Software visualization tools enabled the analyst to quickly scan through a deliverable sector, identify areas where additional points or artifacts needed to be removed and be reclassified in the database. The surface was then redrawn allowing the analyst to immediately see the result of the edit and make further corrections, including 'undoing' previous steps. Removed points were stored in the database where they may be retrieved at a later date, if necessary. The final result of interactive data post-processing was the bare earth point file deliverables required for this project.

Data Sources

The ground control used for this project was collected by Kevin J. Chappell, Florida PSM Lic. No. LS5818. A singed and sealed copy of their report is attached as part of this report. The lidar data used for this project was collected in two lifts on February 02, 2004 and February 03, 2004. The digital imagery used for this project was collected in two lifts on March 8, 2004.

Datum

All data for this project has been collected and provided in the Florida State Plane Coordinate System, West Zone in units of U.S. Survey Feet. The horizontal datum is North American Datum 1983 (NAD 83) HARN. The vertical datum is North American Vertical Datum 1988 (NAVD 88).

Accuracies

The raw lidar DEM will have a nominal post spacing of 2 meters. The vertical accuracy of the DEM data will be +/- 20 cm RMSE. Contours will meet published NSSDA accuracy standards for 2' contours. The digital orthophotography will meet national mapping accuracy standards and be within +/- 5 feet in the horizontal.

Deliverables

The deliverables for this project include:

1) **Ground Control report:** A signed and sealed copy is attached to this report. This lists the ground control points and coordinates used in the collection, rectification and geo-referencing of the data.

2) **TINs**: ESRI TINs were created from spot elevations and break lines of "bare earth". The geographic area covered by each TIN are by section, township and range. All were delivered in ArcInfo ASCII generate input file format together with accompanying ArcInfo Macro Language files for automating the TIN creation process.

File Name	Description
(STR) SP.PNT	Mass points for non-obscured areas. Feature ID of 1, MASSPOINT
(STR) R.LIN	Break lines for paved road features. This file shall not contain break lines for bridges and overpasses. Feature ID of 3, HARDLINE. These break lines shall be captured only for those features necessary to define one foot contours
(STR) T.LIN	Break lines for all soft features. Soft features include ridges, valleys, top of banks, etc. Feature ID of 2, SOFTLINE
(STR) W.POL	Break lines defined the land water boundary for lakes or other closed water bodies. These break lines must be assigned the elevation of the water surface. These break lines shall be closed polygons. Feature ID of 5, HARDREPLACE
(STR) V.POL	Break lines that define the boundaries of vegetated areas that are considered to be obscured to the extent that adequate vertical data cannot clearly be determined to the extent to accurately define the DTM. These break lines shall be closed polygons. Features ID of 9, HARDERASE
(STR) IS.POL	Break lines defining the shoreline of islands within water bodies. These break lines shall be polygons. Feature ID of 3, HARDLINE
(STR) SH.LIN	Break lines defining the shoreline of islands within water bodies. These break lines shall be polygons. Feature ID of 3, HARDLINE
(STR) CA.LIN	Break lines defining the shoreline of canal and ditches. Feature ID of 3, HARDLINE. Features eight feet or wider shall be represented by two lines. Smaller features shall be represented by single lines.
(STR)CO.POL	Break line defining a tidal boundary. This must be a polygon and shall be used to clip the seaward boundary when creating a TIN. Feature ID of 7, HARDCLIP
(STR) V.PNT	Mass points found within vegetative spots in vegetative void areas. Feature ID of 1, MASS
(STR) BR.LIN	Break lines defining overpasses and bridges. Feature ID of 3, HARDLINE

3) **Contours:** At the request of SWFWMD, digital, 1' contours were created from the TINs referenced above and produced as ArcInfo coverage's (point and line) in ArcInfo Export format (*.e00). Accuracy standards for 2' contours were used as guidelines in the generation of the 1' contours due to the limitations of the source data collected. The aerial photography was flown at an elevation suitable for 2' contours and the LIDAR data resulted in a horizontal accuracy of 2'.
The contour coverage meets the following criteria:
   a. Contour interval of one foot
   b. Fuzzy tolerance of 0.0001 meters
   c. Coverage was fully built and contains no edit masks
   d. Contours were merged into a single line coverage
   e. Coverage Name: CONTOURS

Coverage Items: Item Descriptions

Column	Item Name	Width	Output	Type	N.DEC
1	FNODE#	4	5	B	
5	TNODE#	4	5	B	
9	LPOLY#	4	5	B	
13	RPOLY#	4	5	B	
17	LENGTH	8	18	F	5
25	CONTOURS#	4	5	B	
29	CONTOURSID	4	5	B	
33	C2TYPE	1	1	I	
34	C2DESC1	1	1	I	
35	C2DESC2	1	1	I	
36	C2CONT	3	3	I	
39	C2ELEV	4	12	F	2
43	C2LOW	4	12	F	2
47	C2INT	2	5	B	

CONTOURS.AAT attribute descriptions

C2TYPE	Contour type: 1-Normal, 2-Carrying, 3-Supplemtary
C2DESC1	Contour description: 1-Depression, 2-Approximate
C2DESC2	Contour description: 1-Depression, 2-Approximate
C2CONT	Elevation of contour in integer format.
C2ELEV	Elevation of contour in decimal format
C2LOW	Used only for carrying contours.
C2INT	Contour interval. Units are feet

4) **Spot Elevations:** All spot elevations were merged into a single point coverage. The coverage name item definitions for the spot elevations were defined as:
   a. Coverage Name – SPOT

Coverage Items: Item Descriptions

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	N. DEC.
1	AREA	8	18	F	5
9	PERIMETER	8	18	F	5
17	SPOT#	4	5	B	
21	SPOT-ID	4	5	B	
25	C2SPOT	4	12	F	2

SPOT.PAT attribute descriptions

(Columns 1-21 are the Arc/Info coverage default items)

C2SPOT	Spot elevations

5) **Orthophotography:** Ground orthophotography was produced and delivered for this portion of the project, derived from a Wild RC-30 Aerial Camera. The imagery was collected at 4,100' AMT. The final orthophoto products met the following specifications:
   a. Color imagery
   b. 1"=200' – scale
   c. 1' GSD
   d. Delivered in GeoTIFF format on CD-ROM.

Several qualified photogrammetrists accomplished the production of the products for this project. I as the signing surveyor and mapper have not done any of the production. I have supervised and checked the work produced. To the best of my knowledge and review, all of the products meet or exceed the accuracy and quality as required.

Notes:
To the best of my knowledge this survey and report meet all applicable requirements of the Florida Minimum Technical Standards as contained in Chapter 61G17-6 FAC.

Surveyor and Mapper in Responsible Charge:
Brian A. Wegner
Professional Surveyor and Mapper
License Number LS 5422

Signed: Brian A. Wegner

Seal:

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Professional Surveyor and Mapper
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Signed: Brian A. Wegner

Seal: BRIAN A. WEGNER CERTIFICATE NO. 5422 STATE OF FLORIDA PROFESSIONAL SURVEYOR