AIRBORNE LIDAR TASK ORDER REPORT

SHELBY COUNTY TN 1M NPS LIDAR/FEATURE EXTRACT TASK ORDER

UNITED STATES GEOLOGICAL SURVEY (USGS)

CONTRACT NUMBER: G10PC00057

TASK ORDER NUMBER: G12PD00127

Woolpert Project Number: 72124
June 2012

WOOLPERT
DESIGN | GEOSPATIAL | INFRASTRUCTURE

AIRBORNE LIDAR TASK ORDER REPORT

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USGS CONTRACT: G10PC0057

TASK ORDER NUMBER: G12PD00127

For:

United States Geological Survey
(USGS)
National Geospatial Technical Operations Center
(NGTOC)
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SECTION 1: OVERVIEW

TASK ORDER NAME: SHELBY COUNTY TN 1M NPS LIDAR/FEATURE EXTRACT TASK ORDER

WOOLPERT PROJECT #71665

This report contains a comprehensive outline of the airborne LiDAR data acquisition consisting of a 798 square mile area in and near Shelby County, Tennessee with an additional minimum buffer of 200 meters as well as a 233 square mile area with an additional minimum buffer of 200 meters over Memphis, TN; Contract Number G10PC00057; Task Order Number G12PD00127, for the United States Geological Survey (USGS). The LiDAR was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 1.0 meter. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath. In addition, breaklines defining waterbodies and streams were used to hydrologically flatten the DEM surface. This surface will be inserted into the 1/9 arc-second (3-meter) National Elevation Database.

The data was collected using a Leica ALS50-II 150 kHz Multiple Pulses in Air (MPiA) LiDAR sensor installed in a shock isolator sled mount. The ALS50-II 150 kHz sensor collects up to four returns (echo) per pulse, recording attributes such as time stamp and intensity data, for the first three returns. If a fourth return was captured, the system does not record an associated intensity value. The aerial LiDAR was collected at the following sensor specifications:

Post Spacing (Minimum):	3.28 ft / 1.0 m
AGL (Above Ground Level) average flying height:	6,500 ft / 1,981.2 m
MSL (Mean Sea Level) average flying height:	6,650 ft / 2,026 m
Average Ground Speed:	130 knots / 149 mph
Field of View (full):	40 degrees
Pulse Rate:	115.6 kHz
Scan Rate:	41.8 Hz
Side Lap (Minimum):	27.7%

LiDAR data was processed and projected in UTM 16N, North American Datum of 1983 (NAD83) in units of Meters. The vertical datum used for the task order was referenced to NAVD 1988, Meters, Geoid09. In addition LiDAR data including Memphis AOI data from Woolpert project number 71665, contract Number G10PC00057; Task Order Number G11PD00057 was processed and projected in NAD83, U.S. State Plane Tennessee (FIPS4100) Survey Feet, NAVD88, geoid 09, Survey Feet.

Figure 1.1 Task Order and LiDAR Flight Layout Memphis AOI

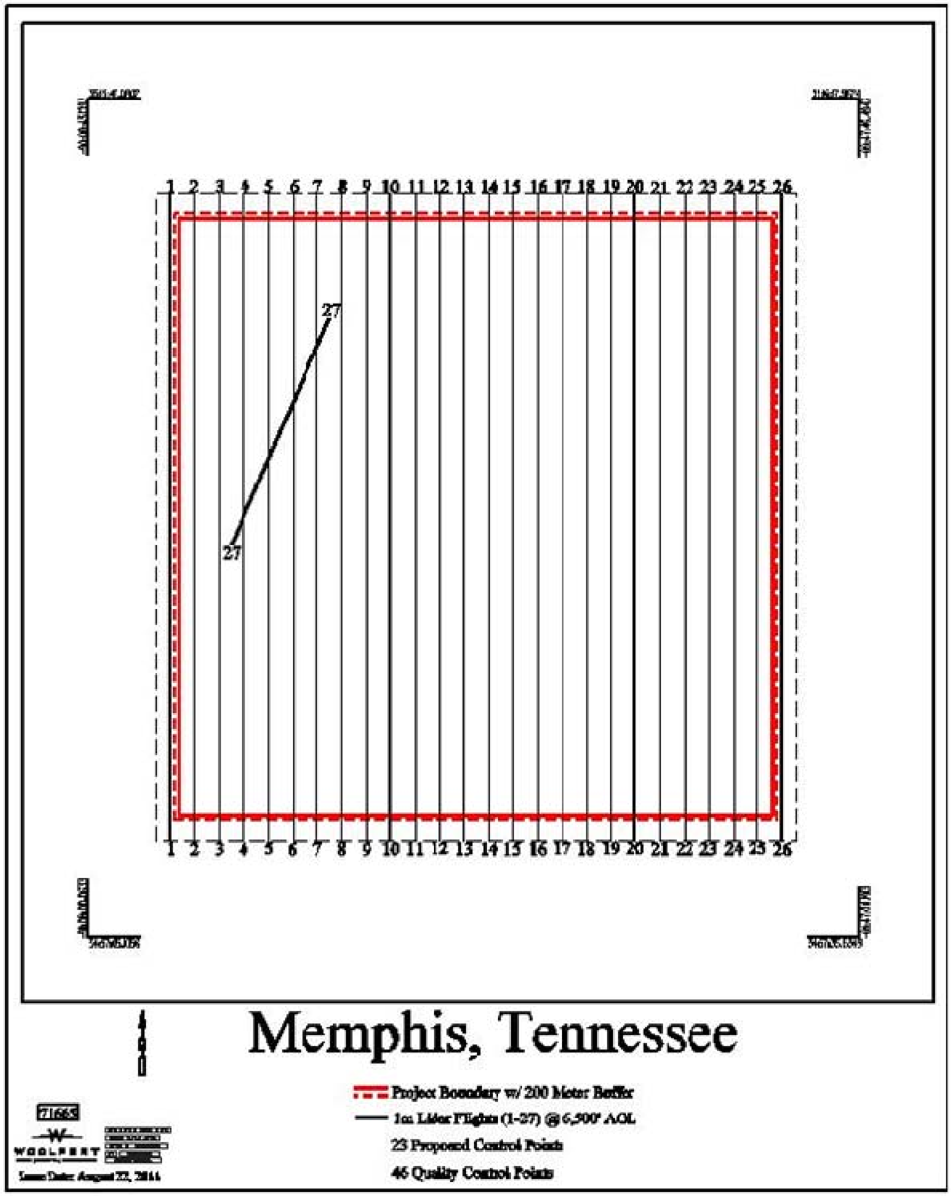
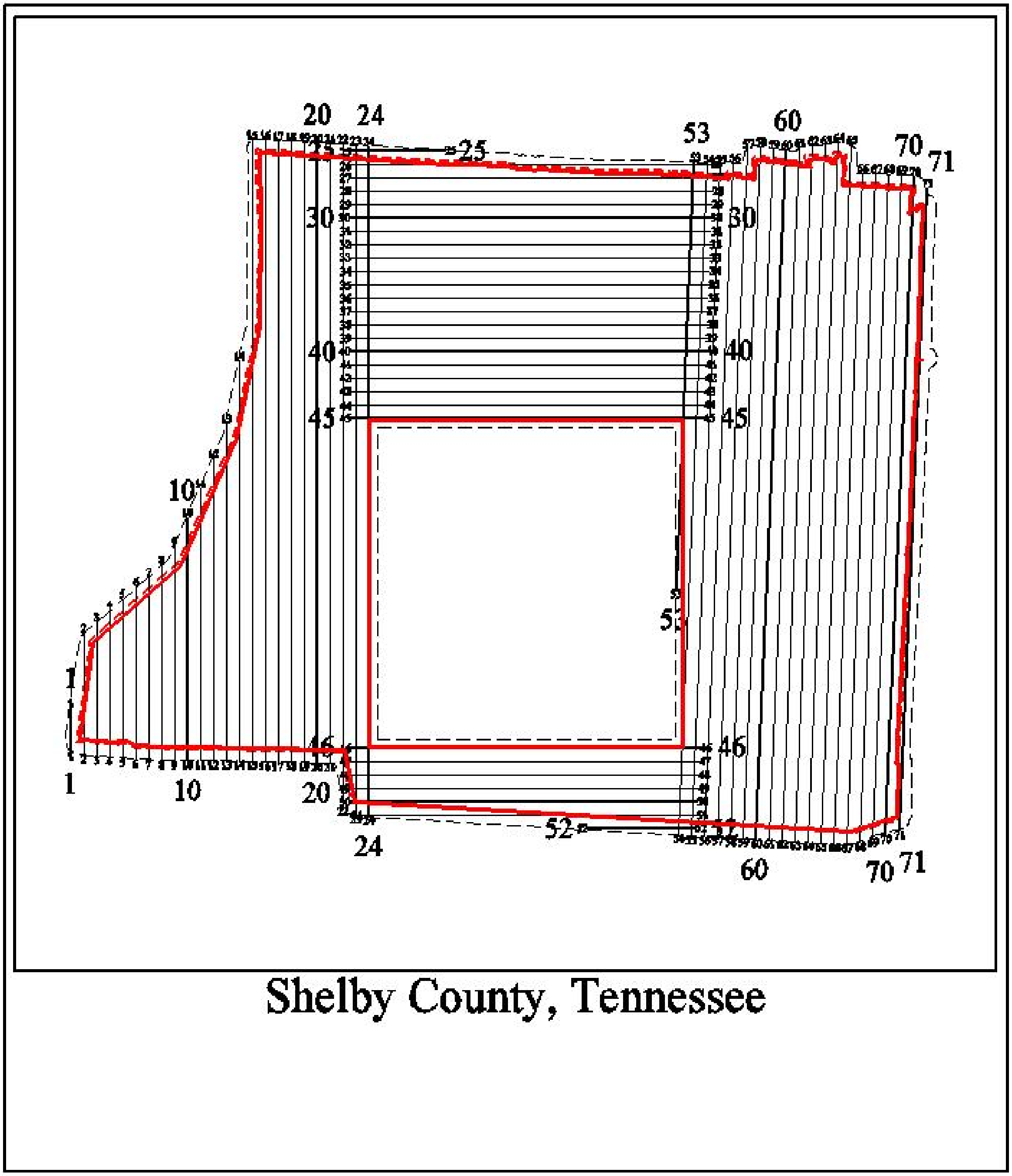


Figure 1.2 Task Order and LiDAR Flight Layout Shelby AOI



SECTION 2: ACQUISITION

The LiDAR data was acquired with a Leica ALS50-II 150 kHz Multiple Pulses in Air (MPiA) LiDAR sensor system, on board a Cessna 404. The ALS50-II LiDAR system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The system software is operated on an OC50 Operation Controller aboard the aircraft.

The ALS50-II 150 kHz Multiple Pulses in Air (MPiA) LiDAR System has the following specifications:

Table 2.1 ALS50-II LiDAR System Specifications

Specification	
Operating Altitude	200 - 6,000 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 90 Hz (variable based on scan angle)
Maximum Pulse Rate	150 kHz
Range Resolution	Better than 1 cm
Elevation Accuracy	8 – 24 cm single shot (one standard deviation)
Horizontal Accuracy	7 – 64 cm (one standard deviation)
Number of Returns per Pulse	4 (first, second, third, last)
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

The LiDAR data was acquired with a Leica ALS60 200 kHz Multiple Pulses in Air (MPiA) LiDAR sensor system, on board a Cessna 404. The ALS60 LiDAR system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The system software is operated on an OC50 Operation Controller aboard the aircraft.

The ALS60 200 kHz Multiple Pulses in Air (MPiA) LiDAR System has the following specifications:

Table 2.2 ALS60 LiDAR System Specifications

Specification	
Operating Altitude	200 - 6,000 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 100 Hz (variable based on scan angle)
Maximum Pulse Rate	200 kHz
Range Resolution	Better than 1 cm
Elevation Accuracy	8 – 24 cm single shot (one standard deviation)
Horizontal Accuracy	7 – 64 cm (one standard deviation)
Number of Returns per Pulse	4 (first, second, third, last)
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

Prior to mobilizing to the task order site, Woolpert flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station at the Olive Branch Airport (OLV) for the airborne GPS support. Coordinates 34 58 52.36296 (N), 089 47 19.17002 (W), Elipsoid Height 94.196 meters

The LiDAR data was collected in one (5) missions

An initial quality control process was performed immediately on the LiDAR data to review the data coverage, airborne GPS data, and trajectory solution. Any gaps found in the LiDAR data were relayed to the flight crew, and the area was re-flown.

Table 2.3 Airborne LiDAR Acquisition Flight Summary

Airborne LiDAR Acquisition Flight Summary			
Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down	Mission Time (Local = EDT) Wheels Up/ Wheels Down
Dec 01, 2011 – S/N 77	1-27 Memphis Acquisition	19:33 - 00:25	07:33 PM - 12:25 AM
Jan 23, 2011 – S/N 77	1-26	19:27 - 02:24	07:27 PM - 2:24 AM
Jan 23, 2011 – S/N 6157	27-71	19:10 - 02:18	07:10 PM - 2:18 AM
Jan 24, 2011 – S/N 6157	34, 53-54	15:40 - 19:33	03:40 PM - 7:33 PM
Jan 24, 2011 – S/N 77	46-52	15:48 - 17:17	03:48 PM - 5:17 PM

SECTION 3: LIDAR DATA PROCESSING

APPLICATIONS AND WORK FLOW OVERVIEW

1. Resolved kinematic corrections for three subsystems: inertial measurement unit (IMU), sensor orientation information and airborne GPS data. Developed a blending post-processed aircraft position with attitude data using Kalman filtering technology or the smoothed best estimate trajectory (SBET).
   Software: POSPac Software v. 5.3, IPAS Pro v.1.35.

2. Calculated laser point position by associating the SBET position to each laser point return time, scan angle, intensity, etc. Created raw laser point cloud data for the entire survey in .LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift.
   Software: ALS Post Processing Software v.2.70, Proprietary Software, TerraMatch v. 11.07.

3. Imported processed .LAS point cloud data into the task order tiles. Resulting data were classified as ground and non-ground points with additional filters created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the LiDAR data was then adjusted to reduce the vertical bias when compared to the survey ground control.
   Software: TerraScan v.11.011.

4. The .LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts and small undulations from the ground class.
   Software: TerraScan v.11.011.

5. All water bodies greater than two acres and all rivers with a nominal 100 foot width or larger were hydro-flattened using Woolpert's proprietary software.
   Software: TerraScan v.11.011, ArcMap 9.3.1, Qcoherent LP360, Proprietary Software.

6. All tiled .LAS files were also provided as intensity images
   Software: QT Modeler v7.1.1

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)-INERTIAL MEASUREMENT UNIT (IMU) TRAJECTORY PROCESSING

EQUIPMENT

Flight navigation during the LiDAR data acquisition mission is performed using IGI CCNS (Computer Controlled Navigation System). The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

The aircraft are all configured with a NovAtel Millennium 12-channel, L1/L2 dual frequency Global Navigation Satellite System (GNSS) receivers collecting at 2 Hz.

All Woolpert aerial sensors are equipped with a Litton LN200 series Inertial Measurement Unit (IMU) operating at 200 Hz.

A base-station unit was mobilized for each acquisition mission, and was operated by a member of the Woolpert survey crew. Each base-station setup consisted of one Trimble 4000 – 5000 series dual frequency receiver, one Trimble Compact L1/L2 dual frequency antenna, one 2-meter fixed-height tripod, and essential battery power and cabling. Ground planes were used on the base-station antennas. Data was collected at 1 or 2 Hz.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station at the Olive Branch Airport (OLV) for the airborne GPS support. The GNSS base station operated during the LiDAR acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station	Latitude	Longitude	Ellipsoid Height (L1 Phase Center)
Name	(DMS)	(DMS)	(Meters)
Pin @ OLV	N 34° 58' 52.36"	W 89° 47' 19.17"	94.196

DATA PROCESSING

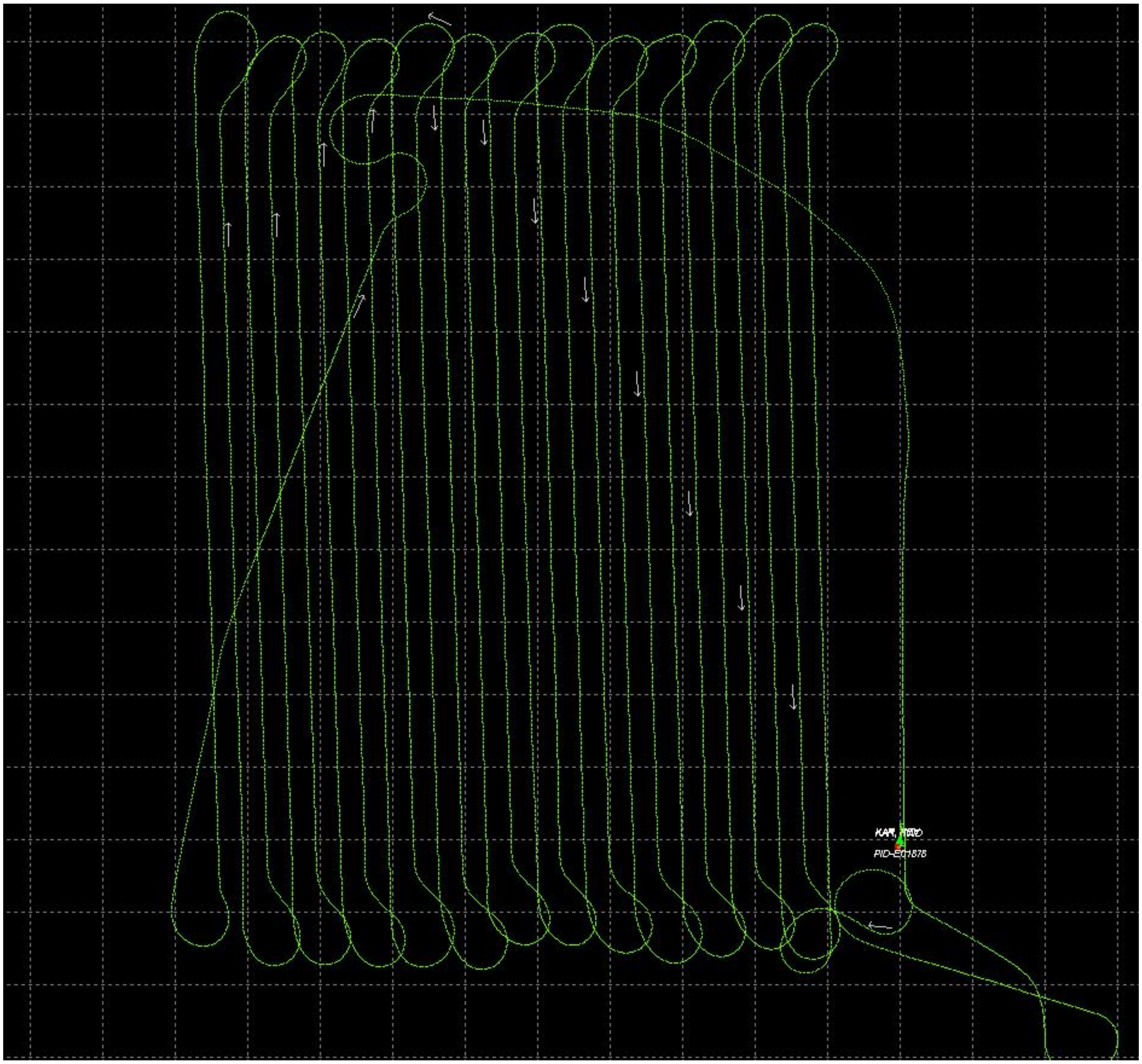
All airborne GNSS and IMU data was post-processed and quality controlled using Applanix 5.3 MMS software. GNSS data was processed at a 1 and 2 Hz data capture rate and the IMU data was processed at 200 Hz.

TRAJECTORY QUALITY

The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. See **Figure 3.1** for the flight trajectory.

Flight Trajectory

Figure 3.1: Representative Graph from Day33511: N404CP



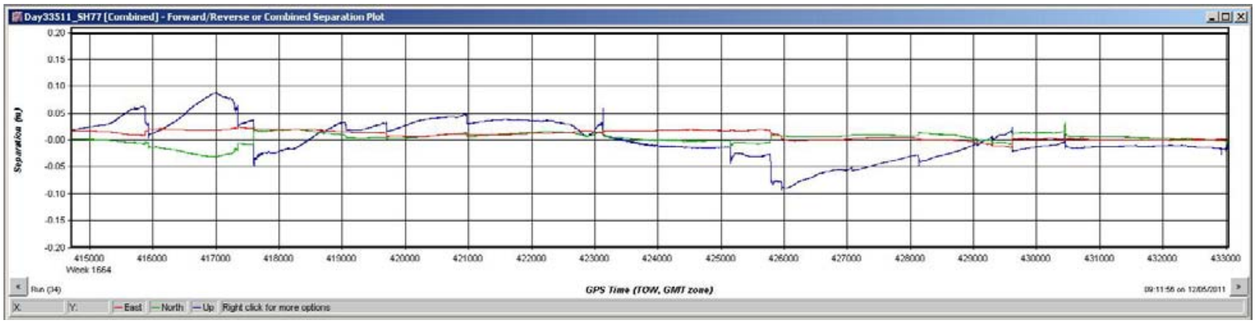
Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

Combined Separation

The Combined Separation is a measure of the difference between the forward run and the backward run solution of the trajectory. The Kalman filter is processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate reliable solution is achieved.

Woolpert's goal is to maintain a Combined Separation Difference of less than ten (10) centimeters. In most cases we achieve results below this threshold. See **Figure 3.2** for the combined separation graph.

Figure 3.2: Representative Graph from Day33511 of Combined Separation

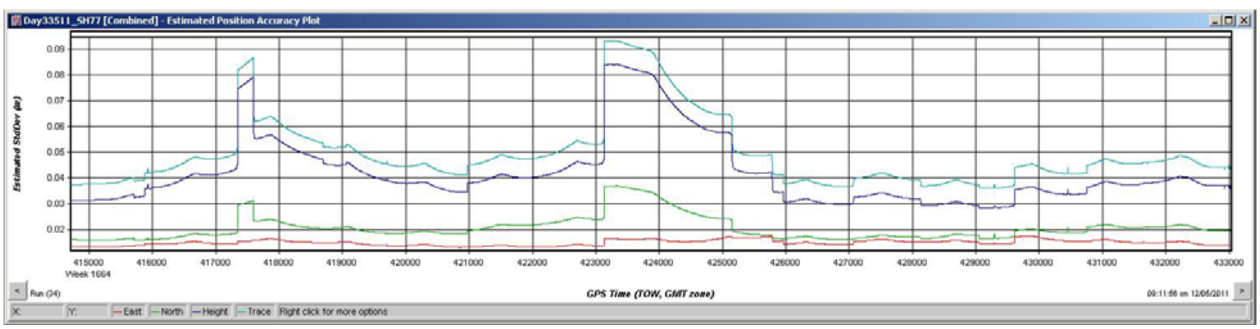


Estimated Positional Accuracy

The Estimated Positional Accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

Woolpert's goal is to maintain an Estimated Positional Accuracy of less than ten (10) centimeters, often achieving results well below this threshold.

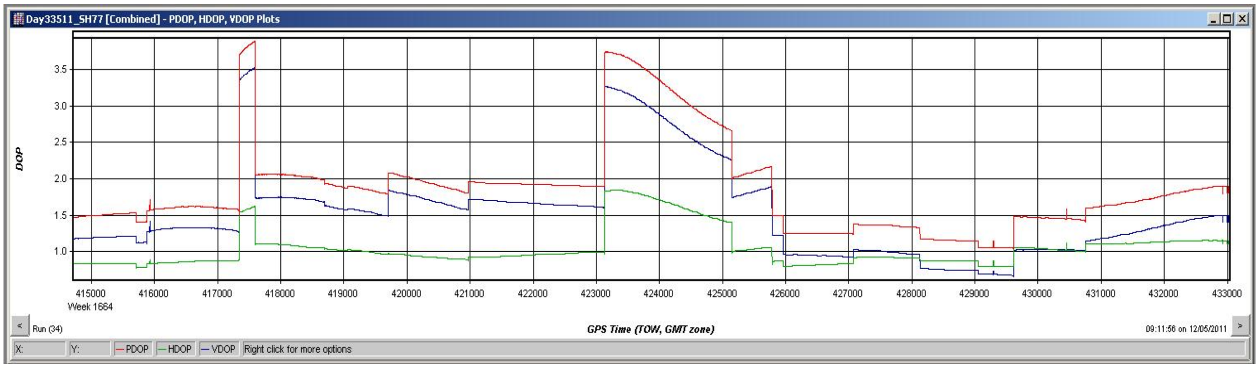
Figure 3.3: Representative Graph from Day33511 of Positional Accuracy



PDOP

Position Dilution of precision (DOP) is a measure of the quality of the GPS data being received from the satellites. Woolpert's goal is to maintain an average PDOP of 3 or less.

Figure 3.4: Representative Graph from Day33511 of PDOP



LIDAR DATA PROCESSING

When the sensor calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert LiDAR specialists included:

- Processed individual flight lines to derive a raw "Point Cloud" LAS file. Matched overlapping flight lines, generated statistics for evaluation comparisons, and made the necessary adjustments to remove any residual systematic error.

- Calibrated LAS files were imported into the task order tiles and initially filtered to create a ground and non-ground class. Then additional classes were filtered as necessary to meet client specified classes.

- Once all of the task order data was imported and classified, cross flights and survey ground control data was imported and calculated for an accuracy assessment. As a QA/QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparison among LiDAR points, ground control, and TINs. The LiDAR is adjusted accordingly to reduce any vertical bias to meet or exceed the vertical accuracy requirements.

- The LiDAR tiles were reviewed using a series of proprietary QA/QC procedures to ensure it fulfills the task order requirements. A portion of this requires a manual step to ensure anomalies have been removed from the ground class.

- The bare earth DEM surface was hydrologically flattened for waterbody features that were greater than 2 acres and rivers and streams of 100 feet and greater nominal width.

- The LiDAR LAS files for this task order have been classified into the Default (Class 1), Ground (Class 2), Noise (Class 7), Water (Class 9), and Ignored Ground (Class 10) classifications.

- FGDC Compliant metadata was developed for the task order in .xml format for the final data products.

- The horizontal datum used for the task order was referenced to UTM16N American Datum of 1983. Coordinate positions were specified in units of meters for the Shelby AOI. The vertical datum used for the task order was referenced to NAVD 1988, meters, Geoid09. The horizontal datum used for the task order was referenced to NAD83, U.S. State Plane Tennessee (FIPS4100) Survey Feet. The Horizontal datum used for the task order was referenced to NAVD88, geoid 09, Survey Feet.

SECTION 4: HYDROLOGIC FLATTENING AND FINAL QUALITY CONTROL

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

This task required the compilation of breaklines defining water bodies and rivers. The breaklines were used to perform the hydrologic flattening of water bodies, and gradient hydrologic flattening of double line streams and rivers. Lakes, reservoirs and ponds, at a minimum size of 2-acres or greater, were compiled as closed polygons. The closed water bodies were collected at a constant elevation. Rivers and streams, at a nominal minimum width of 100 feet (30.5 meters), were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation. The hydrologic flattening of the LiDAR DEM data was performed for inclusion in the National Elevation Dataset (NED). The task order area encompassed approximately 798 square miles in and near Shelby County, Tennessee with an additional minimum buffer of 200 meters as well as a 233 square mile area with an additional minimum buffer of 200 meters over Memphis, TN.

LIDAR DATA REVIEW AND PROCESSING

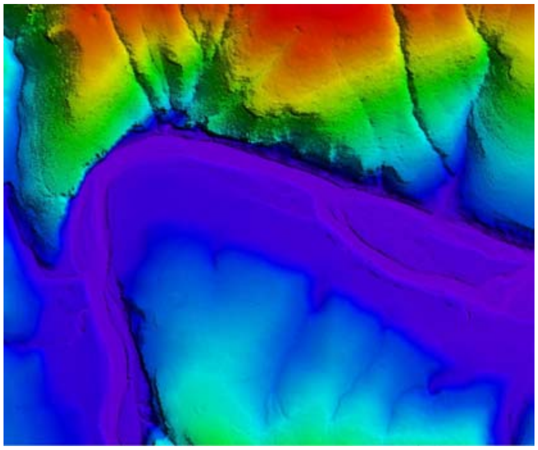
Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing LiDAR data.

1. Woolpert used the newly acquired LiDAR data to manually draw the hydrologic features in a 2D environment using the LiDAR intensity and bare earth surface. Google Earth was used as reference when necessary.

2. Woolpert utilizes an integrated software approach to combine the LiDAR data and 2D breaklines. This process “drapes” the 2D breaklines onto the 3D LiDAR surface model to assign an elevation. A monotonic process is performed to ensure the streams are consistently flowing in a gradient manner. A secondary step within the program verifies an equally matching elevation of both stream edges. The breaklines that characterize the closed water bodies are draped onto the 3D LiDAR surface and assigned a constant elevation at or just below ground elevation.

3. The lakes, reservoirs and ponds, at a minimum size of 2-acres or greater, were compiled as closed polygons. **Figure 4.1** illustrates a good example of 2-acre lakes and 100 feet (30.5 meters) nominal streams identified and defined with hydrologic breaklines. During the collection of linework, the technical staff used a program that displayed the polygon measurement area as a reference to identify lakes larger than 2-acres. The breaklines defining rivers and streams, at a nominal minimum width of 100 feet (30.5 meters), were draped with both sides of the stream maintaining an equal gradient elevation.

Figure 4.1



4. All ground points were reclassified from inside the hydrologic feature polygons to water, class nine (9).

5. All ground points were reclassified from within a 5 foot (1.5 meter) buffer along the hydrologic feature breaklines to buffered ground, class ten (10).

6. The LiDAR ground points and hydrologic feature breaklines were used to generate a new digital elevation model (DEM).

Figure 4.2

Figure 4.3

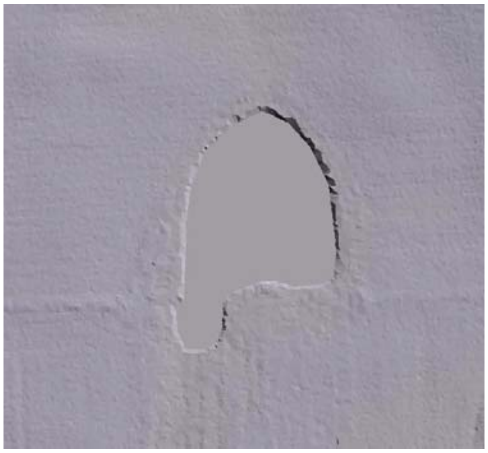


Figure 4.2 reflects a DEM generated from original LiDAR bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

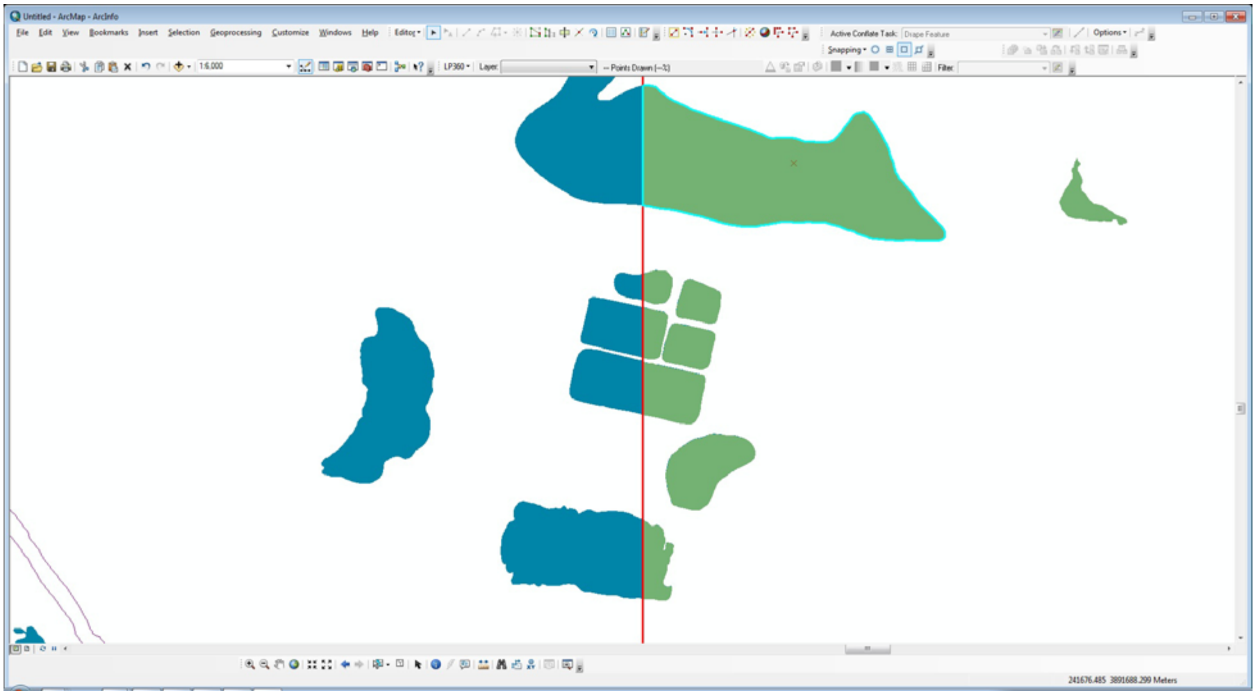
Figure 4.3 reflects a DEM generated from LiDAR with breaklines compiled to define the hydrologic features. This figure illustrates the results of adding the breaklines to hydrologically flatten the DEM data. Note the smooth appearance of the lake surface in the DEM.

Terrascan was used to add the hydrologic breakline vertices and export the lattice models. The hydrologically flattened DEM data was provided to USGS in ArcGRID 32-bit FLOAT format at a 1-meter cell size for the UTM delivery and 4-foot cell size for the State Plane delivery. The final LiDAR data was delivered in a UTM projection tiling format, based on a modular layout. The tiles were clipped to eliminate overlap between adjacent tiles. The 1500 meter x 1500 meter tile file name was derived from the National Grid naming convention. In addition a final LiDAR data set was delivered in a State Plane projection tiling format, based on a modular layout. The tiles were clipped to eliminate overlap between adjacent tiles. The 5000 foot x 5000 foot tile file name was derived from the lower left coordinates of each tile.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS as an ESRI shapefile. The breaklines defining the water bodies greater than 2-acres were provided as a PolygonZ file. The breaklines compiled for the gradient flattening of all rivers and streams at a nominal minimum width of 100-feet were provided as a PolylineZ file.

Due to the fact that the Memphis AOI and Shelby AOI data sets were collected at different times of the year, there is a higher water level in the Memphis AOI data as compared to the Shelby AOI data. The hydro flattened data for each respective AOI is representative of the water levels at the time of the LiDAR collection. This affects streams and lakes. The lakes along the Memphis AOI and Shelby AOI border are split into two polygons to best represent the elevation of the lidar data of there respective acquisition areas. **Figure 4.4** illustrates this scenario.

Figure 4.4: Example of Memphis AOI and Shelby AOI Border Lake Procedure



DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v11, by reviewing the grids and hydrologic breakline features.

Edits and corrections were addressed individually by tile. If a water body breakline needed to be adjusted to improve the flattening of the ArcGRID DEM, the area was cross referenced by tile number, corrected accordingly, a new ArcGRID DEM was regenerated and then reviewed in Global Mapper.

SECTION 5: FINAL ACCURACY ASSESSMENT

FINAL VERTICAL ACCURACY ASSESSMENT

The vertical accuracy statistics were calculated by comparison of the LiDAR bare earth points to the ground surveyed QA/QC points.

Table 5.1: Overall Vertical Accuracy Statistics Memphis AOI

Average error	-0.004	meters
Minimum error	-0.115	meters
Maximum error	+0.113	meters
Average magnitude	0.060	meters
Root mean square	0.069	meters
Standard deviation	0.071	meters

Table 5.2: QA/QC Analysis UTM16N, NAD83, Memphis AOI

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
1001	217914.821	3894744.943	66.353	66.310	-0.043
1002	227836.767	3901355.198	84.598	84.560	-0.038
1003	238666.629	3901076.428	90.879	90.990	+0.111
1004	221488.603	3893116.794	74.935	74.820	-0.115
1005	234370.537	3895854.825	76.568	76.640	+0.072
1006	238880.004	3887785.014	101.699	101.800	+0.101
1007	241341.451	3877348.867	112.067	112.180	+0.113
1008	230443.697	3879237.820	109.790	109.730	-0.060
1009	217679.141	3877490.515	71.933	71.900	-0.033
1010	219946.035	3884596.872	76.619	76.600	-0.019
1011	230173.928	3886215.710	76.870	76.810	-0.060
1012	229226.944	3891386.112	92.791	92.720	-0.071

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
1013	232464.907	3884195.800	79.920	79.920	+0.000
1014	234937.427	3879052.340	95.889	95.970	+0.081
1015	225526.629	3881233.805	92.686	92.640	-0.046
1016	226886.934	3883949.990	73.955	73.920	-0.035
1021	233198.342	3893782.374	82.754	82.730	-0.024

VERTICAL ACCURACY CONCLUSIONS

- **Data Accuracy** tested 0.135 meters vertical accuracy at 95% percent confidence level.

Based on the analysis of the LiDAR data, the accuracy of the data meets the task order requirements.

Approved By:			
Title	Name	Signature	Date
Associate LiDAR Specialist Certified Photogrammetrist #1281	Qian Xiao		April 3, 2012

Table 5.3: Overall Vertical Accuracy Statistics Shelby AOI

Average error	-0.028	meters
Minimum error	-0.103	meters
Maximum error	+0.089	meters
Average magnitude	0.045	meters
Root mean square	0.054	meters
Standard deviation	0.047	meters

Table 5.4: QA/QC Analysis UTM16N, NAD83, Shelby AOI

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
1001	210605.986	3919740.701	68.591	68.600	+0.009
1002	232007.014	3919891.396	91.951	91.910	-0.041
1003	256661.625	3918705.014	119.771	119.700	-0.071
1004	251192.309	3899165.993	112.435	112.450	+0.015
1005	255266.476	3872500.216	109.610	109.560	-0.050
1006	217319.716	3873604.804	85.684	85.640	-0.044
1007	196766.253	3881167.905	72.632	72.560	-0.072
1008	207518.793	3895965.021	64.351	64.440	+0.089
1009	223696.743	3906455.315	74.097	74.100	+0.003
1010	253756.335	3882269.139	105.401	105.330	-0.071
1011	238438.408	3914634.701	84.189	84.120	-0.069
1012	216200.049	3911134.189	68.598	68.580	-0.018
1013	244933.823	3890595.939	81.317	81.300	-0.017
1014	248542.122	3908482.224	77.997	78.040	+0.043
1015	212506.285	3918026.540	68.660	68.630	-0.030
1016	215385.787	3914683.975	68.280	68.260	-0.020
1017	214202.689	3901765.186	67.580	67.550	-0.030
1018	215396.980	3885207.968	73.297	73.200	-0.097
1030	257035.505	3911918.348	81.562	81.530	-0.032
1031	244128.366	3904899.440	94.806	94.820	+0.014
1035	215423.053	3885202.274	73.593	73.490	-0.103

VERTICAL ACCURACY CONCLUSIONS

- **Data Accuracy** tested 0.105 meters vertical accuracy at 95% percent confidence level.

Based on the analysis of the LiDAR data, the accuracy of the data meets the task order requirements.

Approved By:			
Title	Name	Signature	Date
Associate LiDAR Specialist Certified Photogrammetrist #1281	Qian Xiao		June 18, 2012

SECTION 6: FINAL DELIVERABLES

FINAL DELIVERABLES

The final deliverables are listed below. The final LiDAR data was delivered in a UTM projection tiling format, based on a modular layout. The tiles were clipped to eliminate overlap between adjacent tiles. The 1500 meter x 1500 meter tile file name was derived from the National Grid naming convention. In addition a final LiDAR data set was delivered in a State Plane projection tiling format, based on a modular layout. The tiles were clipped to eliminate overlap between adjacent tiles. The 5000 foot x 5000 foot tile file name was derived from the lower left coordinates of each tile.

- LAS v1.2 classified point cloud.
- LAS v1.2 raw unclassified point cloud flight line strips no greater than 2GB. Long swaths greater than 2GB will be split into segments).
- Hydrologically flattened bare earth 1-meter DEM in IMG format.
- Breaklines compiled as part of the hydrologic flattening process were provided as ESRI PolygonZ and PolylineZ shapefiles.
- 8-bit intensity images matching LAS data extent
- Feature Extraction Data in ESRI Shapefile format
- Tile Layout and data extent provided as ESRI shapefile.
- Control points provided as ESRI shapefile.
- FGDC compliant metadata by file in XML format.
- LiDAR processing report in pdf format
- Survey report in pdf format
- The task order data was delivered on external USB 2.0 hard drives.

The DEMs produced under this task order met the following specifications:

- The water body hydrologic flattening was completed using the methodology described in this report and Woolpert's original proposal in response to the task order.
- The DEMs were edge joined with minimal data overlap to avoid data gaps.
- The hydrologically flattened bare earth data was delivered in IMG format at a 1-meter posting for the UTM Shelby AOI and at a 4-foot posting for the State Plane Shelby County delivery.