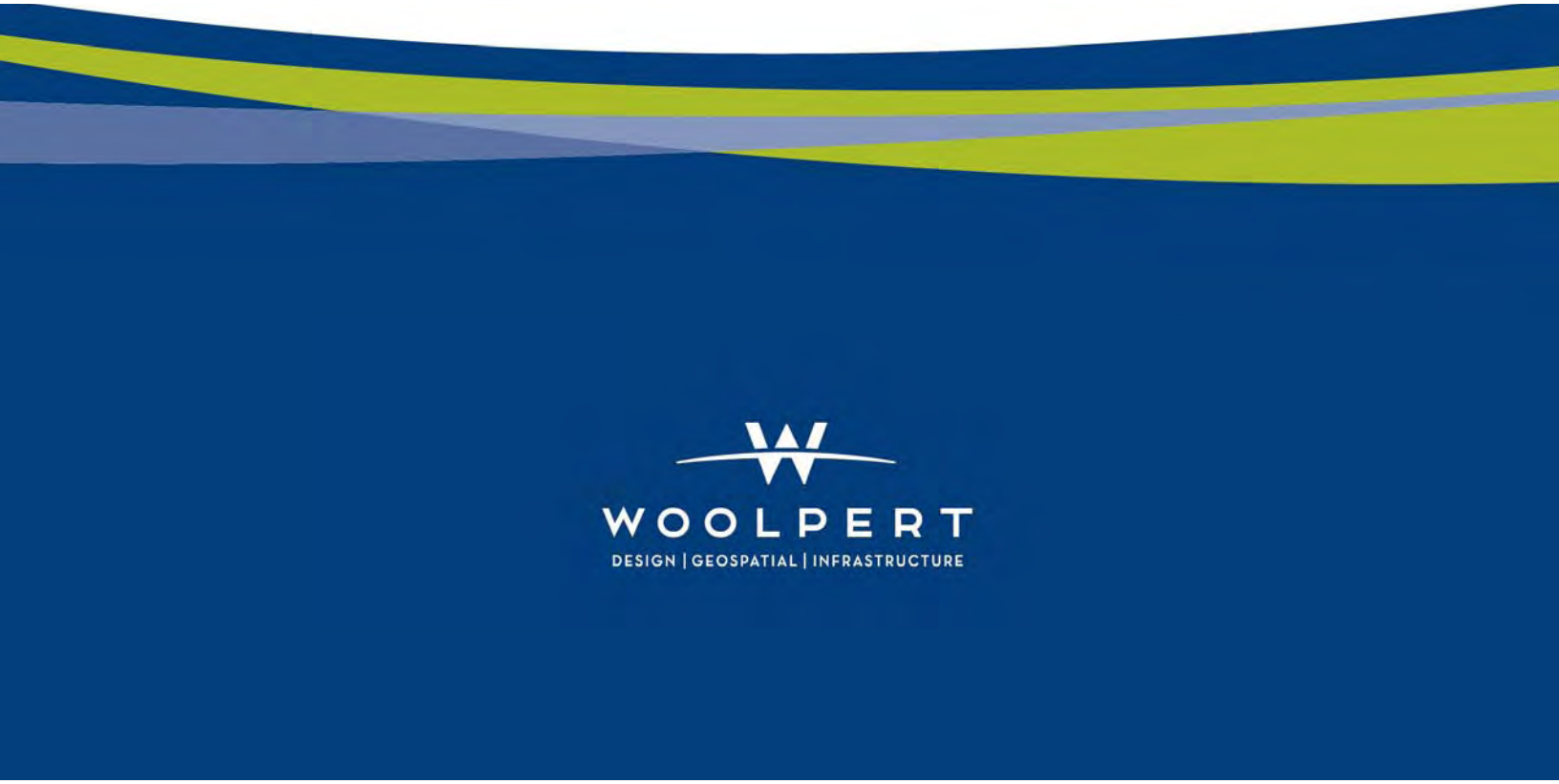
AIRBORNE LIDAR REPORT

NRCS TUPELO, MS 1M NPS LIDAR

Woolpert Project Number:72207
August 2012



AIRBORNE LIDAR TASK ORDER REPORT

NRCS TUPELO, MS 1M NPS LIDAR

WOOLPERT PROJECT #72207

For:

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SECTION 1: OVERVIEW

PROJECT NAME: NRCS TUPELO, MS 1M NPS LIDAR

WOOLPERT PROJECT #72207

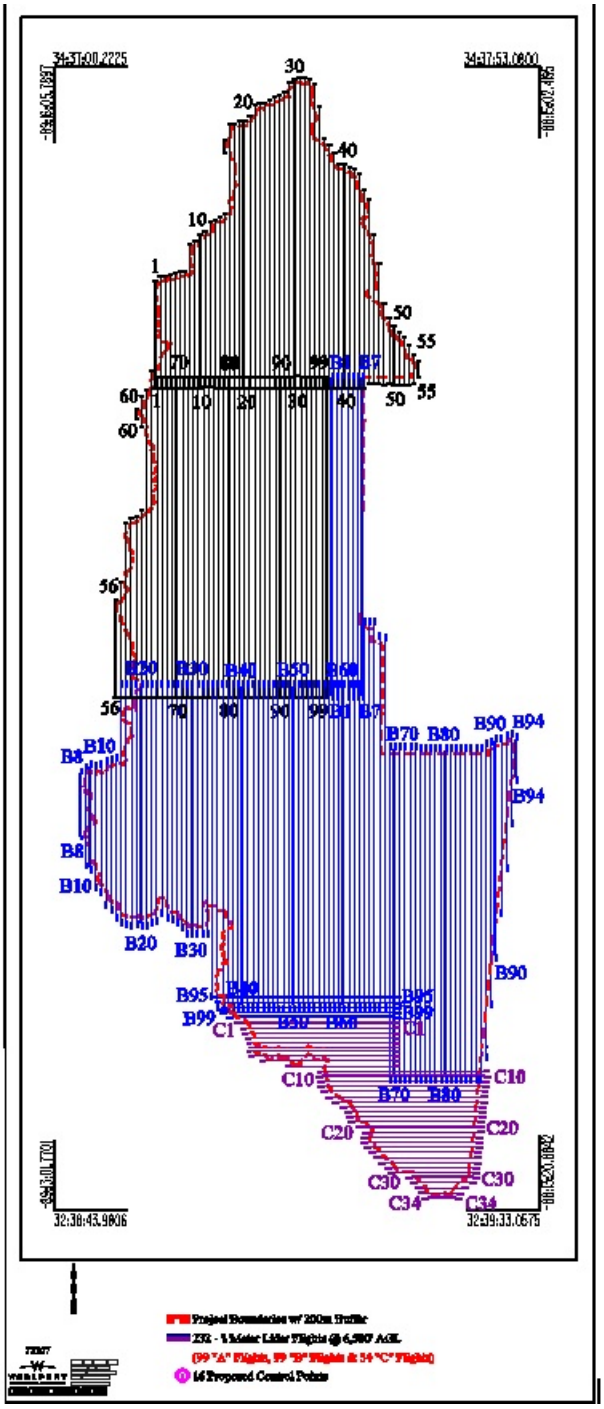
This report contains a comprehensive outline of the airborne LiDAR data acquisition consisting of a 3,697 square mile area near Tupelo, Mississippi, for the United States Geological Survey (USGS). The LiDAR was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 1 meter. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using a Leica ALS60 200 kHz Multiple Pulses in Air (MPiA) LiDAR sensor system installed in a shock isolator sled mount. The sensors collect up to four returns (echoes) 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 m
AGL (Above Ground Level) average flying height:	6,500 ft / 1,987 m
MSL (Mean Sea Level) average flying height:	Varies
Average Ground Speed:	130 knots / 150 mph
Field of View (full):	40 degrees
Pulse Rate:	115.6 kHz
Scan Rate:	41.8 Hz
Side Lap (Minimum):	25%

LiDAR data was processed and projected in UTM, Zone 16, 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.

Figure 1.1 Task Order and LiDAR Flight Layout – Tupelo



SECTION 2: ACQUISITION

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 systems, developed by Leica Geosystems of Heerbrugg, Switzerland, include 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 2.1 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 Lemons Municipal Airport (TUP) for the airborne GPS support on days 38, 39, 40 and 42. Coordinates: 34°15'52.51374"N , 88°46'01.69681"W, Elipsoid Height 79.000 meters.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station at Golden Triangle Regional Airport (GTR) for the airborne GPS support on days 43, 46, 48, 55, 56, 57, 60, 63, 64 and 65. Coordinates: 33°27'12.89565' (N), 88°35'17.09679" (W), Elipsoid Height 51.732 meters.

The LiDAR data was collected in (14) 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 2.2 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
Feb 07, 2012 – S/N 6157	38-55	19:35 – 22:45	01:35 PM – 04:43 PM
Feb 08, 2012 – S/N 6157	1, 60, 62	14:50 – 15:32	08:50 AM – 09:32 AM
Feb 09, 2012 – S/N 6157	20-37	23:37 – 04:52	05:37 PM – 10:52 PM
Feb 11, 2012 – S/N 6157	2-19	21:50 – 01:26	03:50 PM – 07:26 PM
Feb 12, 2012 – S/N 6157	89-99, b1-b7	18:52 – 00:37	12:52 PM – 06:37 PM
Feb 15, 2012 – S/N 6157	83-88, b89-b94	18:59 – 22:24	12:59 PM – 04:24 PM
Feb 17, 2012 – S/N 6157	56-82	15:28 – 22:43	09:28 AM – 04:43 PM
Feb 24, 2012 – S/N 6157	B59-B65	00:00 -04:57	06:00 PM – 10:57 PM
Feb 25, 2012 – S/N 6157	B39-B58	14:42- 21:32	08:42 AM –03:32 PM
Feb 26, 2012 – S/N 6157	B95-B99, C1-C34	15:05 – 21:52	09:05 AM – 03:52 PM
Mar 1, 2012 – S/N 6157	B8-B19	16:49 – 19:48	10:49 AM – 01:48 PM
Mar 3, 2012 – S/N 6157	B19-B43, B87, B88	15:26 – 21:07	09:26 AM – 03:07 PM

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
Mar 4, 2012 – S/N 6157	B31-B38, B86. B87	14:37 – 18:09	08:37 AM – 12:09 PM
Mar 5, 2012 – S/N 6157	B67-B86	14:21 – 21:31	08:21 AM – 03:31 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. 12.01.

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.12.005.

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.12.005.

5. All water bodies greater than two acres and all rivers with a nominal 100 foot width or larger were hydro-flattened using stereo compilation methods.
   Software: Summit Evolution v6.4, Microstation v8**,** TerraScan v.12.005.

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 Stations at the Lemons Municipal Airport (TUP) and Golden Triangle Regional Airport (GTR) for the airborne GPS support. The GNSS base stations operated during the LiDAR acquisition missions are listed below:

Table 3.1: GNSS Base Stations

Station	Latitude	Longitude	Ellipsoid Height (L1 Phase Center)
Name	(DMS)	(DMS)	(Meters)
TUP	N 34° 15' 52.51"	W 88° 46' 01.70"	79.000
GTR	N 33° 27' 12.90"	W 88° 35' 17.10"	51.732

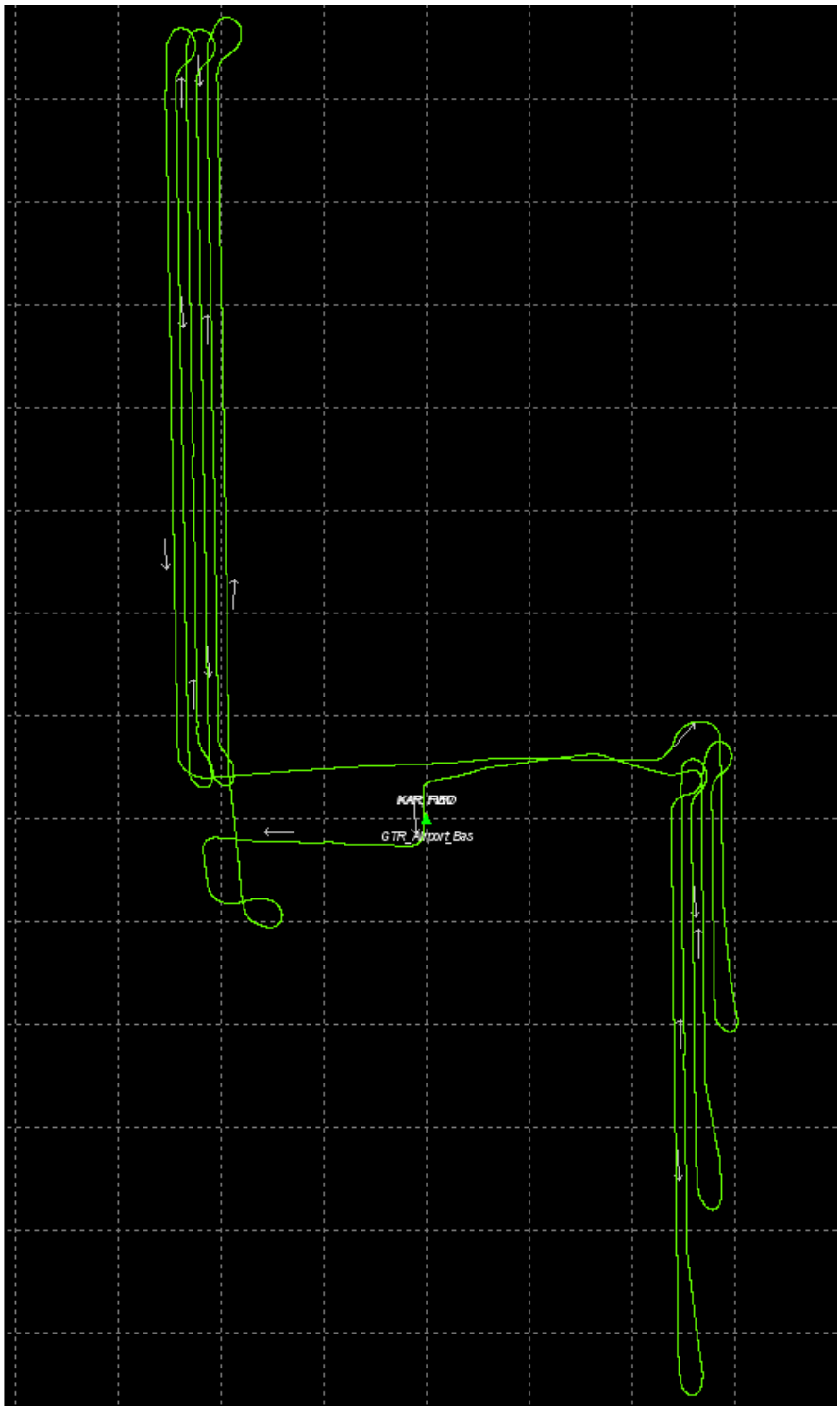
DATA PROCESSING

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.

Figure 3.1: Representative Graph from Day046: N475RC



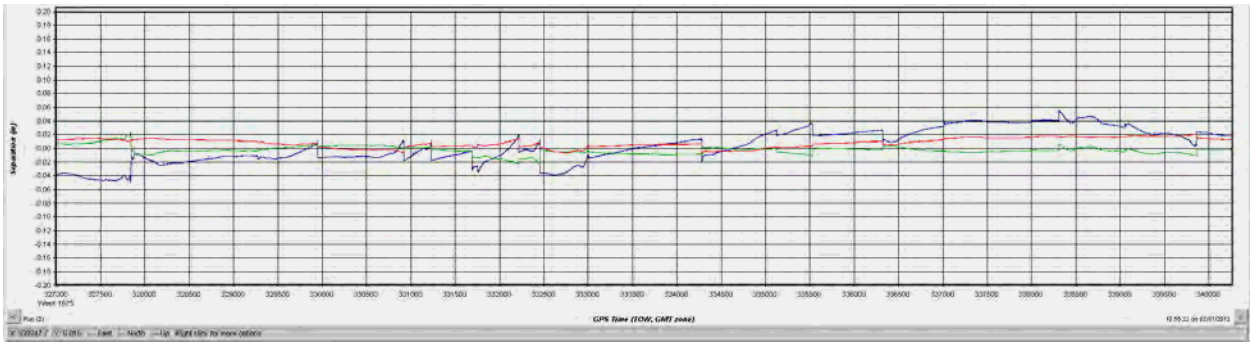
Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

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 Day046 of Combined Separation

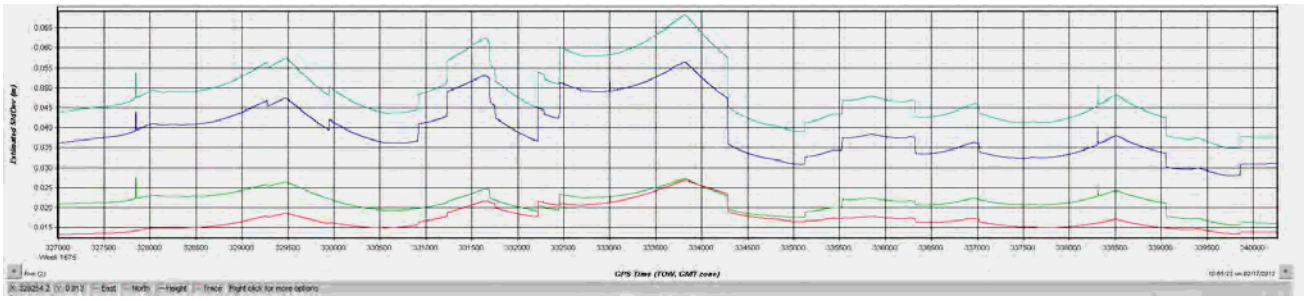


Estimated Positional Accuracy

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.

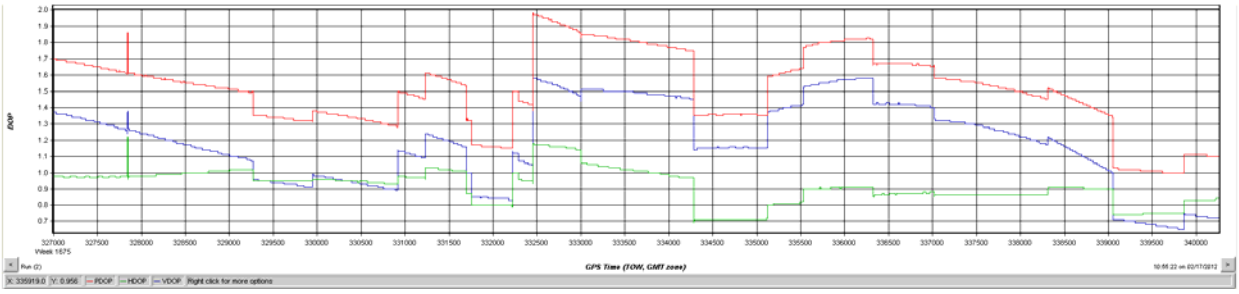
Figure 3.3: Representative Graph from Day046 of Positional Accuracy



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 Day 046 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 water body features that were greater than 2 acres and rivers and streams of 30.5 meters (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), Ignored Ground (Class 10) and Swamp (Class 11) 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 UTM 16N, North American Datum of 1983. Coordinate positions were specified in units meters for Tupelo, Mississippi. The vertical datum used for the task order was referenced to NAVD 1988, meters, Geoid09.

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 30.5 meters (100 feet), were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation.

LIDAR DATA REVIEW AND PROCESSING

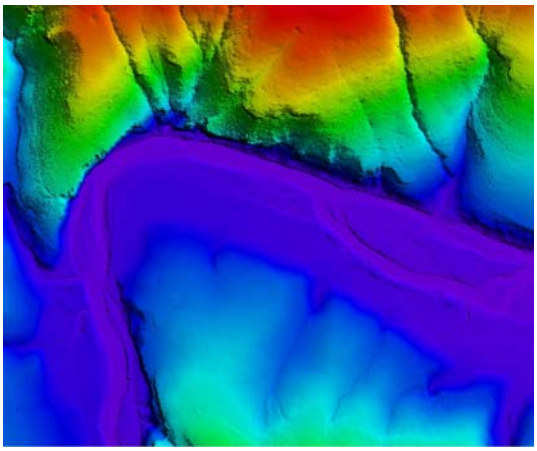
Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing LiDAR data.

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 30.5 meters (100 feet) 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 30.5 meters (100 feet), 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 1.5 meter (5 foot) 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 ERDAS .img format at a 1-meter cell size. The hydrologic breaklines compiled as part of the flattening process were provided to 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 30.5 meters (100feet) were provided as a PolylineZ file.

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 Tupelo, Mississippi

Average error	-0.006	meters
Minimum error	-0.137	meters
Maximum error	+0.220	meters
Average magnitude	0.067	meters
Root mean square	0.083	meters
Standard deviation	0.085	meters

Table 5.2: QA/QC Analysis, UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
1001	339178.46	3828059.68	151.77	151.73	-0.04
1002	359517.39	3776591.96	102.95	103.27	0.32
1003	351851	3719742.06	65.46	65.39	-0.07
1004	377102.22	3698700.59	72.64	72.56	-0.08
1005	371479.51	3642287.52	72.25	72.34	0.09
1006	365493.96	3621505.27	59.85	59.79	-0.06
1007	353934.47	3653619.22	73.82	73.76	-0.06
1008	327578.46	3653605.71	143.96	143.85	0
1009	304627.49	3671408.52	179.34	179.32	-0.02
1010	305808.94	3690945.32	108.59	108.61	0.02
1011	311686.04	3774251.31	121.25	121.18	-0.07
1012	349959.16	3773079.06	76.39	76.34	-0.05
1013	329986.88	3750847.03	104.19	104.2	0.01

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
1014	353131.89	3679228.25	87.27	87.18	-0.09
1015	325391.64	3803554.62	164.81	164.79	-0.02
1016	331897.07	3704014.58	115.04	115.15	0.11
1017	326544.36	3801960.55	129.79	129.86	0.07
1018	366480.213	3621401.447	63.107	62.97	-0.14

VERTICAL ACCURACY CONCLUSIONS

Tested 0.16 meters fundamental vertical accuracy at 95 percent confidence level in open terrain using RMSE(z) x 1.9600

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

SUPPLEMENTAL VERTICAL ACCURACY ASSESSMENTS

Table 5.3: QA/QC Analysis, Bare Earth and Open Terrain, UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
2000	336562.28	3822158.46	131.28	131.24	-0.04
2001	350187.31	3794751.85	95.82	95.85	0.03
2002	350123.14	3771133.93	73.22	73.2	-0.02
2003	344906.81	3750926.66	84.03	83.99	-0.04
2004	330006.77	3733067.15	107.06	107.04	-0.02
2005	347060.94	3729506.74	86.63	86.71	0.08
2006	345029.44	3697368.31	67.25	67.23	-0.02
2007	336409.36	3689313.56	83.28	83.26	-0.02
2008	306615.38	3692678.14	110.16	110.18	0.02
2500	329249.54	3814677.08	111.21	111.2	-0.01

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
2501	337170.43	3815286.94	115.8	115.8	0
2502	337234.77	3809256.55	113.8	113.81	0.01
2503	321314.56	3793576.53	119.06	118.98	-0.08
2504	332859.23	3781774.26	81.93	81.96	0.03
2505	323242.44	3780868.73	155.15	155.16	0.01
2506	312015.39	3770361.84	114.19	114.16	-0.03
2507	325822.98	3751241.37	94.56	94.63	0.07
2508	309143.29	3727829.92	91.53	91.54	0.01
2509	330888.02	3733318.69	94.89	94.8	-0.09
2510	315180.97	3677192.58	157.6	157.56	-0.04
2701	354139.85	3678387.63	78.43	78.43	0
2702	370178.95	3678674.91	69.64	69.6	-0.04
2703	363952.41	3662590.76	65.36	65.33	-0.03
2704	356511.8	3647865.81	75.03	75.02	-0.01
2705	364482.54	3632895.51	59.94	60.05	0.11

ACCURACY CONCLUSIONS

Bare Earth/Open Terrain Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.101 meters supplemental vertical accuracy at the 95th percentile in Bare Earth/Open Terrain. Tested against the DEM. Errors larger than 95th percentile include:

Point 2705, Easting 364482.54, Northing 3632895.51, Z-Error 0.11

Table 5.4: QA/QC Analysis, Brush Lands and Trees, UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
5000	337836.06	3828626.78	213.35	213.39	0.04
5001	337763.48	3822246.67	140.15	140.24	0.09
5002	351971.21	3805998.62	139.89	140.09	0.2
5003	340619.04	3805755.74	96.51	96.82	0.31
5004	344050.12	3740185.57	86.42	86.58	0.16
5005	348337.7	3708733.58	66.87	66.95	0.08
5006	351809.07	3710211.14	54.64	54.76	0.12
5007	336996.76	3725992.61	74.7	74.85	0.15
5008	363294.6	3688198.56	73	72.96	-0.04
5009	375987.93	3696686.46	75.9	76	0.1
5010	323015.66	3682939.91	84.43	84.54	0.11
5011	319709.57	3698124.2	97.72	97.65	-0.07
5012	350924.45	3782935.1	92.01	92.12	0.11
5501	319635.39	3708200.23	89.74	89.79	0.05
5502	308416.23	3722454.07	118.05	118.38	0.33
5503	321166.2	3729473.23	85.68	85.84	0.16
5504	337219.15	3722414.95	76.74	76.86	0.12
5505	315562.51	3717427.1	86.86	87.1	0.24
5506	310014.91	3738412.06	101.14	101.29	0.15
5701	337335.31	3674409.63	73.22	73.29	0.07
5702	374344.99	3661966	64.81	64.91	0.1
5703	347973.53	3649374.9	80.1	80.2	0.1
5704	328982.25	3654461.15	124.64	124.64	0
5705	353025.44	3630552.15	118.69	118.75	0.06
5706	361058.33	3628665.84	62.43	62.58	0.15

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
5707	362172.74	3621688.06	72.93	72.96	0.03
5708	365909.66	3621057.15	55.29	55.47	0.18

ACCURACY CONCLUSIONS

Brush Lands and Trees Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.322 meters supplemental vertical accuracy at the 95th percentile in Brush Lands and Trees. Tested against the DEM. Brush Lands and Trees Errors larger than 95th percentile include:

Point 5502, Easting 308416.23, Northing 3722454.07, Z-Error 0.33

Table 5.5: QA/QC Analysis, Forested and Fully Grown, UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
6500	317054.07	3692839.61	87.87	87.87	0
6501	317070.34	3692836.87	87.75	87.75	0
6502	317087.78	3692836.74	87.8	87.78	-0.02
6503	317103.97	3692836.12	87.79	87.74	-0.05
6504	317126.84	3692834.81	87.74	87.73	-0.01
6505	317142.11	3692832.84	87.8	87.79	-0.01
6506	317157.36	3692835.2	87.86	87.83	-0.03
6507	317181.65	3692829.73	87.77	87.65	-0.12
6508	317209.74	3692823.22	87.51	87.52	0.01
6509	317233.57	3692826.78	87.63	87.59	-0.04
6510	317262.42	3692825.39	87.36	87.35	-0.01
6511	317301.47	3692831.18	87.22	87.22	0
6512	344637.41	3733972.2	75.97	76.04	0.07

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
6513	344662.2	3733983.94	76.03	76.16	0.13
6514	344687.15	3733988.73	76.15	76.2	0.05
6515	344718.23	3733992.39	76.34	76.37	0.03
6516	344749.01	3733994.02	76.34	76.41	0.07
6517	344771.75	3734000.02	76.55	76.6	0.05
6518	344801.05	3734001.13	76.6	76.68	0.08
6519	344832.54	3733994.28	76.78	76.84	0.06
6520	344859.19	3733993.06	76.93	76.93	0
6521	344891	3733985.44	77.11	77.14	0.03
6522	325983.08	3788845.09	96.43	96.41	-0.02
6523	325954.51	3788848.33	96.27	96.36	0.09
6524	325930.2	3788860.28	96.37	96.43	0.06
6525	325905.77	3788872.18	96.48	96.44	-0.04
6526	325880.61	3788884.23	96.33	96.45	0.12
6527	325849.91	3788895.84	96.47	96.5	0.03
6528	325825.3	3788909.29	96.52	96.52	0
6529	325799.47	3788924.23	96.63	96.66	0.03
6530	325773.95	3788937.18	96.69	96.72	0.03
6531	325749.11	3788946.69	96.78	96.88	0.1
6701	365404.93	3628373.32	56.31	56.44	0.13
6702	365422.52	3628336	56.75	56.85	0.1
6703	365423.63	3628295.99	57.16	57.27	0.11
6704	365416.86	3628270.28	56.34	56.4	0.06
6705	365429.13	3628242.4	56.11	56.21	0.1
6711	365427.7	3628389.56	57.08	57.12	0.04
6712	365458.89	3628365.65	57.12	57.16	0.04

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
6713	365487.57	3628342.95	57.92	57.86	-0.06
6714	365513.64	3628320.79	58.44	58.42	-0.02
6715	365540.8	3628298.2	58.83	58.85	0.02
6716	365567.93	3628276.09	58.98	59.02	0.04

ACCURACY CONCLUSIONS

Forested and Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.128 meters supplemental vertical accuracy at the 95th percentile in Forested and Fully Grown. Tested against the DEM. Forested and Fully Grown Errors larger than 95th percentile include:

Point 6513, Easting 344662.2, Northing 3733983.94Z-Error 0.13
Point 6701, Easting 365404.93, Northing 3628373.32, Z-Error 0.13

Table 5.6: QA/QC Analysis, Tall Weeds and Crops. UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
4000	356467.56	3778030.87	99.35	99.54	0.19
4001	349126.97	3763218.15	96.86	96.9	0.04
4001_Alternate	349124.73	3763210.03	96.71	96.73	0.02
4002	340950.97	3754334.26	98.21	98.26	0.05
4002_Alternate	340950.6	3754334.54	98.12	98.25	0.13
4003	342503.49	3740955.86	73.52	73.55	0.03
4004	316041.11	3750024.61	94.37	94.44	0.07
4005	339779.92	3719990.19	58.04	58.32	0.28
4006	342557.08	3692989.33	99.55	99.66	0.11
4007	319122.53	3688339.25	97.51	97.5	-0.01
4500	330719.62	3817745.05	133.27	133.27	0

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
4501	326976.15	3807236.46	142.76	142.77	0.01
4502	326700.67	3774631.17	156.18	156.39	0.21
4503	326657.71	3767037.66	101.85	102.08	0.23
4504	329120.08	3753291.08	106.12	106.19	0.07
4505	310256.38	3734607.42	98.62	98.72	0.1
4506	340229.97	3719916.79	56.87	57.06	0.19
4507	342658.97	3710740.12	74.62	74.79	0.17
4508	309407.8	3682286.75	99.59	99.78	0.19
4509	310104.26	3686910.6	132.49	132.6	0.11
4510	300433.26	3687333.43	177.63	177.69	0.06
4511	327827.64	3739624.95	71.65	71.73	0.08
4512	320518.31	3762325.44	119.59	119.79	0.2
4701	339114.21	3662935.72	73.22	73.42	0.2
4702	349950.83	3638536.51	76.92	76.97	0.05

ACCURACY CONCLUSIONS

Tall Weeds/Crops Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.265 meters supplemental vertical accuracy at the 95th percentile in Tall Weeds/Crops. Tested against the DEM. Tall Weeds/Crops Errors larger than 95th percentile include:

Point 4005, Easting 339779.92, Northing 3719990.19, Z-Error 0.28

Table 5.7: QA/QC Analysis, Urban, UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
3000	344848.93	3806141.4	107.47	107.47	0
3001	350076.57	3710668.69	59.75	59.72	-0.03
3002	347129.21	3717718.41	63.31	63.37	0.06
3003	351764.85	3716494.72	55.04	55.01	-0.03
3004	348936.76	3719845.69	68.95	68.96	0.01
3005	347183.65	3698451.84	69.44	69.38	-0.06
3006	332027.39	3702660.86	113.12	113.15	0.03
3007	332583.78	3702207.04	112.18	112.16	-0.02
3008	332055.68	3703635.96	115.99	116	0.01
3009	378541.25	3700879.13	96.4	96.35	-0.05
3010	308803.08	3691323.65	102.75	102.78	0.03
3500	330699.26	3803579.66	110.1	110.13	0.03
3501	335653.98	3792742.21	102.29	102.27	-0.02
3502	340832.46	3784844.07	91.51	91.6	0.09
3503	326980.27	3786617.15	101.41	101.44	0.03
3504	314051.51	3768070.05	118.23	118.24	0.01
3504_Alternate	314053.17	3768067.77	118.21	118.25	0.04
3505	337479.31	3763870.42	103.01	102.99	-0.02
3506	339891.24	3763719.8	98.42	98.46	0.04
3507	319322.25	3717646.13	85.15	85.16	0.01
3508	309739.21	3739728.9	103.61	103.42	-0.19
3701	354638.26	3666064.97	68.7	68.66	-0.04
3702	354170.77	3650353.51	64.36	64.31	-0.05

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
3703	352701.27	3650156.94	67.91	67.9	-0.01
3704	361336.18	3633490.15	67.58	67.63	0.05

ACCURACY CONCLUSIONS

Urban Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.081 meters supplemental vertical accuracy at the 95th percentile in Urban. Tested against the DEM. Urban Errors larger than 95th percentile include:

Point 3502, Easting 340832.46, Northing 3784844.07, Z-Error 0.09
Point 3508, Easting 309739.21, Northing 3739728.9, Z-Error -0.19

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT

Table 5.8: QA/QC Analysis, Consolidated Vertical Accuracy (CVA), UTM 16N, NAD83, Tupelo, Mississippi

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
2000	336562.28	3822158.46	131.28	131.24	-0.04
2001	350187.31	3794751.85	95.82	95.85	0.03
2002	350123.14	3771133.93	73.22	73.2	-0.02
2003	344906.81	3750926.66	84.03	83.99	-0.04
2004	330006.77	3733067.15	107.06	107.04	-0.02
2005	347060.94	3729506.74	86.63	86.71	0.08
2006	345029.44	3697368.31	67.25	67.23	-0.02
2007	336409.36	3689313.56	83.28	83.26	-0.02
2008	306615.38	3692678.14	110.16	110.18	0.02
2500	329249.54	3814677.08	111.21	111.2	-0.01

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
2501	337170.43	3815286.94	115.8	115.8	0
2502	337234.77	3809256.55	113.8	113.81	0.01
2503	321314.56	3793576.53	119.06	118.98	-0.08
2504	332859.23	3781774.26	81.93	81.96	0.03
2505	323242.44	3780868.73	155.15	155.16	0.01
2506	312015.39	3770361.84	114.19	114.16	-0.03
2507	325822.98	3751241.37	94.56	94.63	0.07
2508	309143.29	3727829.92	91.53	91.54	0.01
2509	330888.02	3733318.69	94.89	94.8	-0.09
2510	315180.97	3677192.58	157.6	157.56	-0.04
2701	354139.85	3678387.63	78.43	78.43	0
2702	370178.95	3678674.91	69.64	69.6	-0.04
2703	363952.41	3662590.76	65.36	65.33	-0.03
2704	356511.8	3647865.81	75.03	75.02	-0.01
2705	364482.54	3632895.51	59.94	60.05	0.11
3000	344848.93	3806141.4	107.47	107.47	0
3001	350076.57	3710668.69	59.75	59.72	-0.03
3002	347129.21	3717718.41	63.31	63.37	0.06
3003	351764.85	3716494.72	55.04	55.01	-0.03
3004	348936.76	3719845.69	68.95	68.96	0.01
3005	347183.65	3698451.84	69.44	69.38	-0.06
3006	332027.39	3702660.86	113.12	113.15	0.03
3007	332583.78	3702207.04	112.18	112.16	-0.02
3008	332055.68	3703635.96	115.99	116	0.01
3009	378541.25	3700879.13	96.4	96.35	-0.05
3010	308803.08	3691323.65	102.75	102.78	0.03

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
3500	330699.26	3803579.66	110.1	110.13	0.03
3501	335653.98	3792742.21	102.29	102.27	-0.02
3502	340832.46	3784844.07	91.51	91.6	0.09
3503	326980.27	3786617.15	101.41	101.44	0.03
3504	314051.51	3768070.05	118.23	118.24	0.01
3504_Alt	314053.17	3768067.77	118.21	118.25	0.04
3505	337479.31	3763870.42	103.01	102.99	-0.02
3506	339891.24	3763719.8	98.42	98.46	0.04
3507	319322.25	3717646.13	85.15	85.16	0.01
3508	309739.21	3739728.9	103.61	103.42	-0.19
3701	354638.26	3666064.97	68.7	68.66	-0.04
3702	354170.77	3650353.51	64.36	64.31	-0.05
3703	352701.27	3650156.94	67.91	67.9	-0.01
3704	361336.18	3633490.15	67.58	67.63	0.05
4000	356467.56	3778030.87	99.35	99.54	0.19
4001	349126.97	3763218.15	96.86	96.9	0.04
4001_Alt	349124.73	3763210.03	96.71	96.73	0.02
4002	340950.97	3754334.26	98.21	98.26	0.05
4002_Alt	340950.6	3754334.54	98.12	98.25	0.13
4003	342503.49	3740955.86	73.52	73.55	0.03
4004	316041.11	3750024.61	94.37	94.44	0.07
4005	339779.92	3719990.19	58.04	58.32	0.28
4006	342557.08	3692989.33	99.55	99.66	0.11
4007	319122.53	3688339.25	97.51	97.5	-0.01
4500	330719.62	3817745.05	133.27	133.27	0
4501	326976.15	3807236.46	142.76	142.77	0.01

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
4502	326700.67	3774631.17	156.18	156.39	0.21
4503	326657.71	3767037.66	101.85	102.08	0.23
4504	329120.08	3753291.08	106.12	106.19	0.07
4505	310256.38	3734607.42	98.62	98.72	0.1
4506	340229.97	3719916.79	56.87	57.06	0.19
4507	342658.97	3710740.12	74.62	74.79	0.17
4508	309407.8	3682286.75	99.59	99.78	0.19
4509	310104.26	3686910.6	132.49	132.6	0.11
4510	300433.26	3687333.43	177.63	177.69	0.06
4511	327827.64	3739624.95	71.65	71.73	0.08
4512	320518.31	3762325.44	119.59	119.79	0.2
4701	339114.21	3662935.72	73.22	73.42	0.2
4702	349950.83	3638536.51	76.92	76.97	0.05
5000	337836.06	3828626.78	213.35	213.39	0.04
5001	337763.48	3822246.67	140.15	140.24	0.09
5002	351971.21	3805998.62	139.89	140.09	0.2
5003	340619.04	3805755.74	96.51	96.82	0.31
5004	344050.12	3740185.57	86.42	86.58	0.16
5005	348337.7	3708733.58	66.87	66.95	0.08
5006	351809.07	3710211.14	54.64	54.76	0.12
5007	336996.76	3725992.61	74.7	74.85	0.15
5008	363294.6	3688198.56	73	72.96	-0.04
5009	375987.93	3696686.46	75.9	76	0.1
5010	323015.66	3682939.91	84.43	84.54	0.11
5011	319709.57	3698124.2	97.72	97.65	-0.07
5012	350924.45	3782935.1	92.01	92.12	0.11

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
5501	319635.39	3708200.23	89.74	89.79	0.05
5502	308416.23	3722454.07	118.05	118.38	0.33
5503	321166.2	3729473.23	85.68	85.84	0.16
5504	337219.15	3722414.95	76.74	76.86	0.12
5505	315562.51	3717427.1	86.86	87.1	0.24
5506	310014.91	3738412.06	101.14	101.29	0.15
5701	337335.31	3674409.63	73.22	73.29	0.07
5702	374344.99	3661966	64.81	64.91	0.1
5703	347973.53	3649374.9	80.1	80.2	0.1
5704	328982.25	3654461.15	124.64	124.64	0
5705	353025.44	3630552.15	118.69	118.75	0.06
5706	361058.33	3628665.84	62.43	62.58	0.15
5707	362172.74	3621688.06	72.93	72.96	0.03
5708	365909.66	3621057.15	55.29	55.47	0.18
6500	317054.07	3692839.61	87.87	87.87	0
6501	317070.34	3692836.87	87.75	87.75	0
6502	317087.78	3692836.74	87.8	87.78	-0.02
6503	317103.97	3692836.12	87.79	87.74	-0.05
6504	317126.84	3692834.81	87.74	87.73	-0.01
6505	317142.11	3692832.84	87.8	87.79	-0.01
6506	317157.36	3692835.2	87.86	87.83	-0.03
6507	317181.65	3692829.73	87.77	87.65	-0.12
6508	317209.74	3692823.22	87.51	87.52	0.01
6509	317233.57	3692826.78	87.63	87.59	-0.04
6510	317262.42	3692825.39	87.36	87.35	-0.01
6511	317301.47	3692831.18	87.22	87.22	0

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
6512	344637.41	3733972.2	75.97	76.04	0.07
6513	344662.2	3733983.94	76.03	76.16	0.13
6514	344687.15	3733988.73	76.15	76.2	0.05
6515	344718.23	3733992.39	76.34	76.37	0.03
6516	344749.01	3733994.02	76.34	76.41	0.07
6517	344771.75	3734000.02	76.55	76.6	0.05
6518	344801.05	3734001.13	76.6	76.68	0.08
6519	344832.54	3733994.28	76.78	76.84	0.06
6520	344859.19	3733993.06	76.93	76.93	0
6521	344891	3733985.44	77.11	77.14	0.03
6522	325983.08	3788845.09	96.43	96.41	-0.02
6523	325954.51	3788848.33	96.27	96.36	0.09
6524	325930.2	3788860.28	96.37	96.43	0.06
6525	325905.77	3788872.18	96.48	96.44	-0.04
6526	325880.61	3788884.23	96.33	96.45	0.12
6527	325849.91	3788895.84	96.47	96.5	0.03
6528	325825.3	3788909.29	96.52	96.52	0
6529	325799.47	3788924.23	96.63	96.66	0.03
6530	325773.95	3788937.18	96.69	96.72	0.03
6531	325749.11	3788946.69	96.78	96.88	0.1
6701	365404.93	3628373.32	56.31	56.44	0.13
6702	365422.52	3628336	56.75	56.85	0.1
6703	365423.63	3628295.99	57.16	57.27	0.11
6704	365416.86	3628270.28	56.34	56.4	0.06
6705	365429.13	3628242.4	56.11	56.21	0.1
6711	365427.7	3628389.56	57.08	57.12	0.04

Point ID	Easting (UTM meters)	Northing (UTM meters)	Elevation (meters)	Laser Elevation (meters)	Dz (meters)
6712	365458.89	3628365.65	57.12	57.16	0.04
6713	365487.57	3628342.95	57.92	57.86	-0.06
6714	365513.64	3628320.79	58.44	58.42	-0.02
6715	365540.8	3628298.2	58.83	58.85	0.02
6716	365567.93	3628276.09	58.98	59.02	0.04

ACCURACY CONCLUSIONS

Consolidated Vertical Accuracy (CVA) Tested 0.200 meters consolidated vertical accuracy at the 95th percentile level, derived according to ASPRS Guidelines for Vertical Accuracy Reporting for LiDAR Data. Tested against the DEM. Based on the 95th percentile error in all land cover categories combined. Errors larger than 95th percentile include:

Point 4005, Easting 339779.92, Northing 3719990.19, Z-Error 0.28
Point 4502, Easting 326700.67, Northing 3774631.17, Z-Error 0.21
Point 4503, Easting 326657.71, Northing 3767037.66, Z-Error 0.23
Point 4512, Easting 320518.31, Northing 3762325.44, Z-Error 0.2
Point 4701, Easting 339114.21, Northing 3662935.72, Z-Error 0.2
Point 5002, Easting 351971.21, Northing 3805998.62, Z-Error 0.2
Point 5003, Easting 340619.04, Northing 3805755.74, Z-Error 0.31
Point 5502, Easting 308416.23, Northing 3722454.07, Z-Error 0.33
Point 5505, Easting 308416.23, Northing 3722454.07, Z-Error 0.24

Approved By:			
Title	Name	Signature	Date
Associate LiDAR Specialist Certified Photogrammetrist #1281	Qian Xiao		Aug 27, 2012

SECTION 6: FINAL DELIVERABLES

FINAL DELIVERABLES

The final LiDAR deliverables are listed below.

- 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 Polygon z and Polyline z shapefiles
- Hydrologically flattened bare earth 1-meter DEM in ERDAS .img format
- 8-bit Intensity Geotiff 1-meter pixel size
- Tile Layout and data extent provided as ESRI shapefile
- Control points provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- LiDAR processing report in pdf format
- Survey report in pdf format