WOOLPERT

NOAA OCM Tift and Cook Counties GA Lidar

NOAA/Charleston, SC

July 2016

Table of Contents

List of Figures

List of Tables

Section 1: Overview

Project Name: NOAA OCM Tift and Cook Counties GA Lidar

Project: # 75271

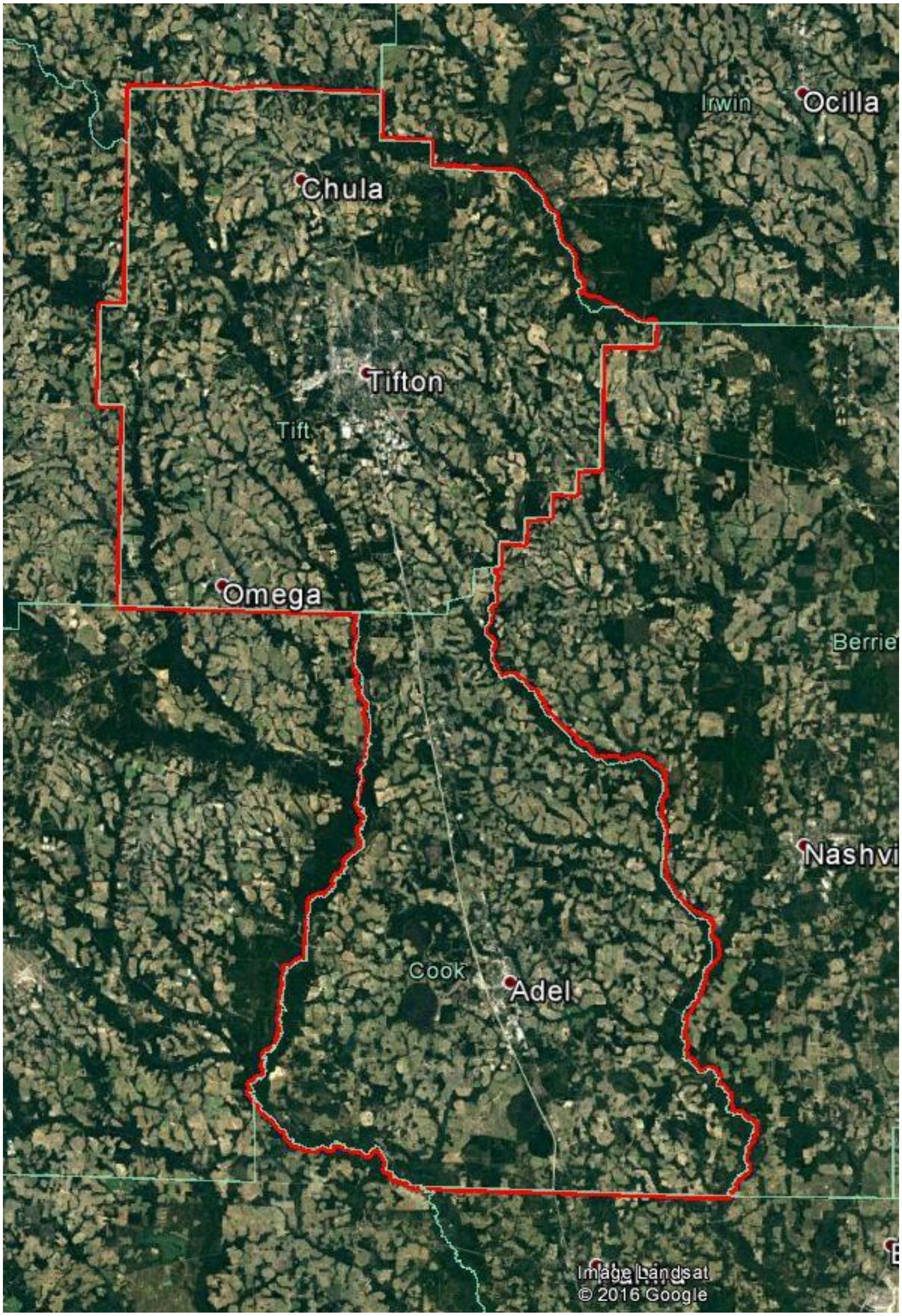
This report contains a comprehensive outline of the NOAA OCM Lidar for Tift and Cook Counties, GA Lidar task order. This task is issued under NOAA Contract Number: EA133C-11-CQ-0010 and Requisition/Reference Number: NCNA0000-15-00801. This task order requires lidar data to be acquired over Tift and Cook Counties, Georgia. The total area of the Tift and Cook Counties, Georgia Lidar AOI is approximately 515 square miles. The lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.7meter. 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 ALS80 HP 1000 kHz Multiple Pulses in Air (MPiA) lidar systems on board a Woolpert aircraft. The ALS80 sensor collects up to four returns per pulse, as well as 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:

Table 1.1: ALS80 Specifications	
Post Spacing	2.3ft / 0.7 m
AGL (Above Ground Level) average flying height	6,500 ft / 1,981 m
MSL (Mean Sea Level) average flying height	6,650 ft / 2,027 m
Average Ground Speed:	150 knots / 173 mph
Field of View (full)	40 degrees
Pulse Rate	272 kHz
Scan Rate	51.0 Hz
Side Lap	25%

The lidar data was processed and projected in State Plane Georgia West, North American Datum of 1983 (2011) in units of survey feet. The vertical datum used for the task order was referenced to NAVD 1988, GEOID12B, in units of survey feet.

Figure 1.1: Lidar Task Order AOI



Section 2: Acquisition

The lidar data was acquired with a Leica ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar Sensor System. The ALS80 HP 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 ALS80HP 1000 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Table 2.1: ALS80 HP Lidar System Specifications	
Operating Altitude	100 – 7,620 meters
Scan Angle	0 to 72° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	1000 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	6 - 19 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 43 cm (one standard deviation)
Number of Returns per Pulse	Unlimited
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 project 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 for the airborne GPS support.

The lidar data was collected in two (2) separate missions, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area.

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.

Figure 2.1: NOAA OCM Tift and Cook Counties GA Lidar

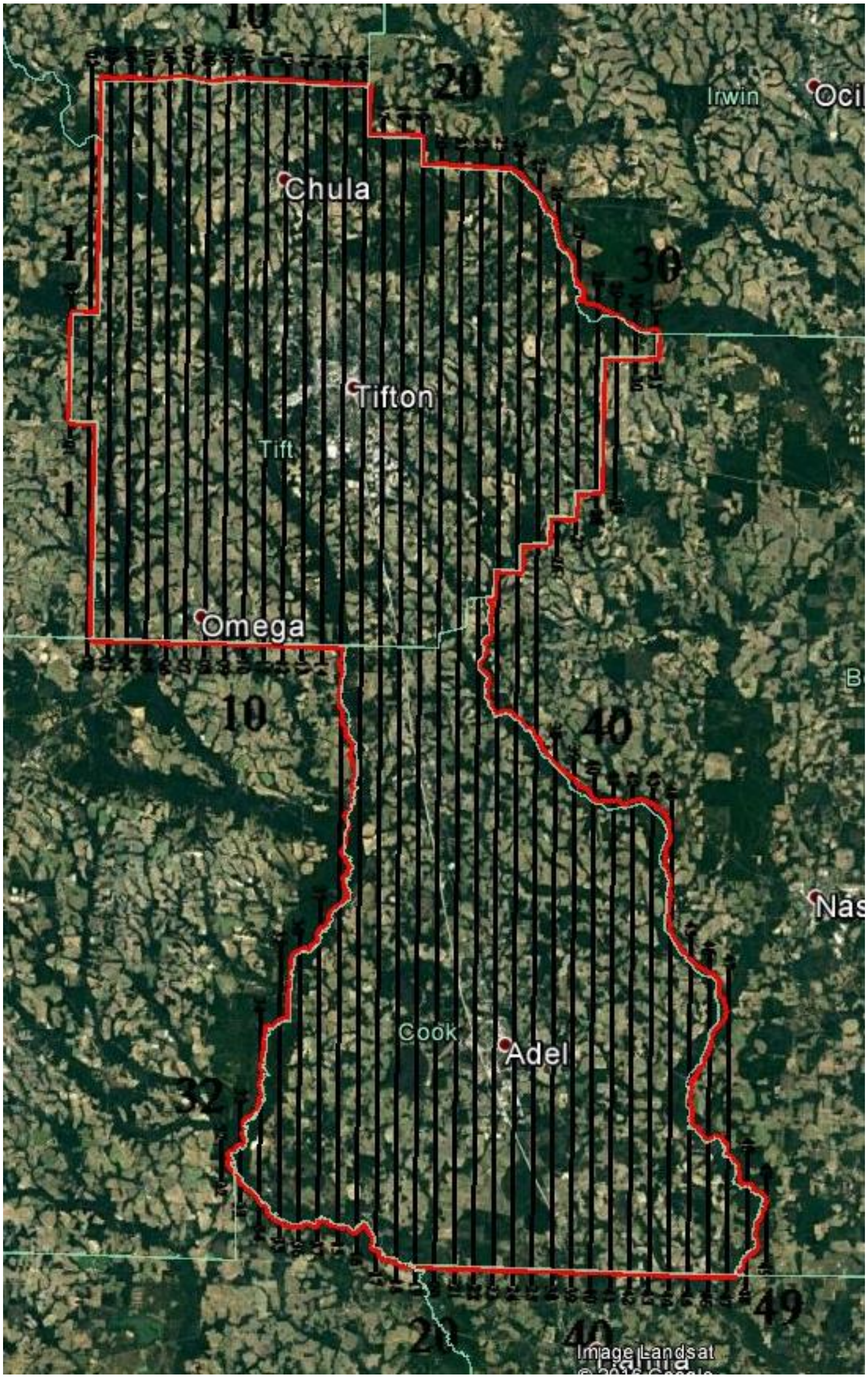


Table 2.2: Airborne Lidar Acquisition Flight Summary			
Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down	Mission Time (Local = EDT) Wheels Up/ Wheels Down
February 14, 2016 – Sensor SH8191	15-31, 38-49	14:20 – 19:55	9:20 AM – 2:55 PM
February 16, 2016 – Sensor SH8191	1-14, 32-37	16:18 – 19:18	11:18 AM - 2:18 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.2.75 build #25, Proprietary Software, TerraMatch v. 16.01.
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.16.01.
4. The LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts from the ground class.
   Software: TerraScan v.16.01.

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 acquisition team. 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.

The GNSS base station operated during the Lidar acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station (Name)	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
15J_Arpt_Base	31° 08' 14.46130"	-83° 26' 58.82645"	43.595

Data Processing

All airborne GNSS and IMU data was post-processed and quality controlled using Applanix 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. 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).

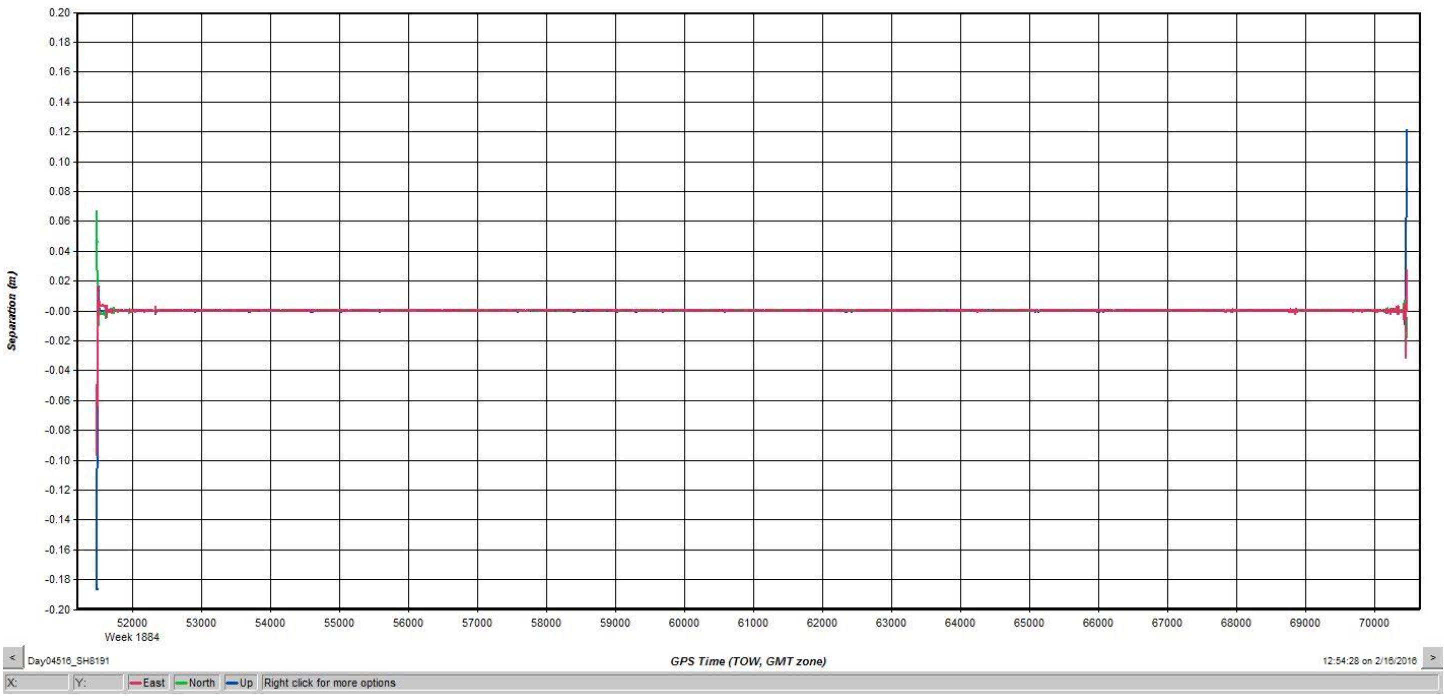
Figure 3.1: Trajectory, Day04513_SH8191

Combination 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.

Figure 3.2: Combined Separation, Day04513_SH8191

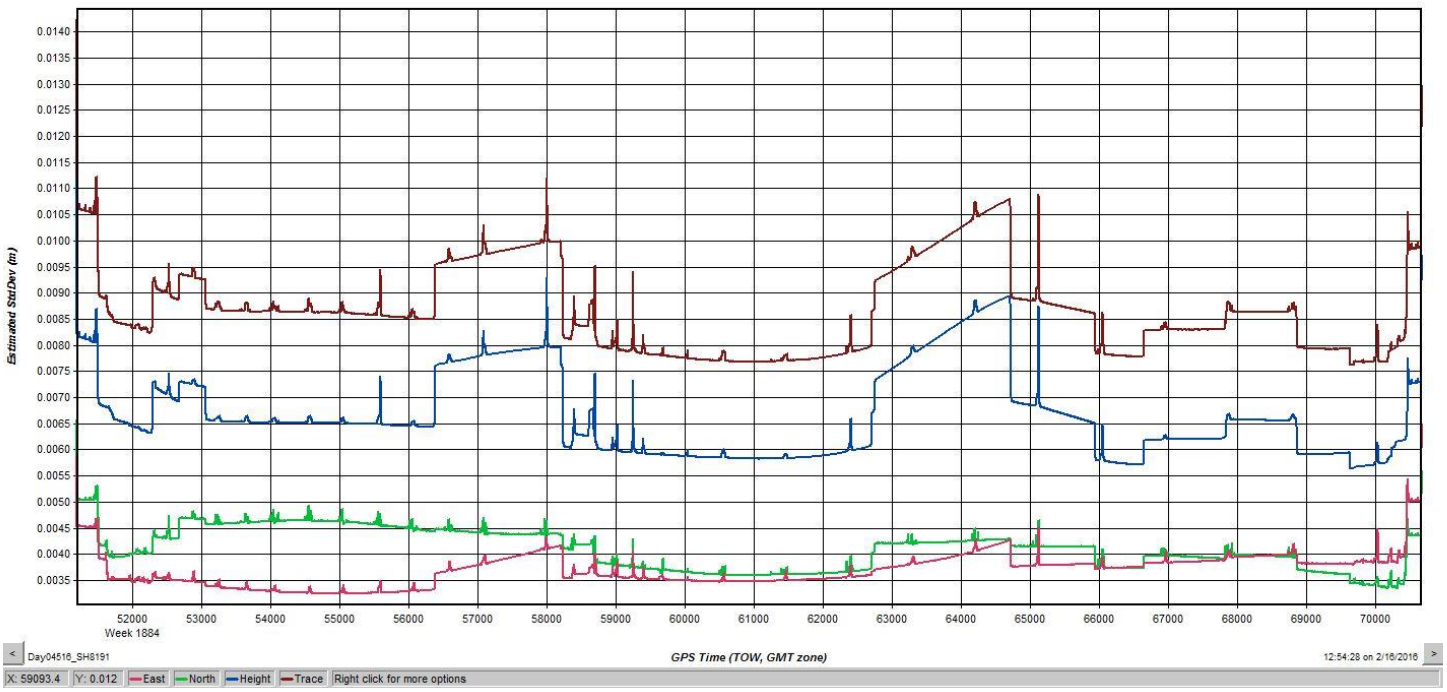


Estimated Positional Accuracy

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: Estimated Positional Accuracy, Day04513_SH8191

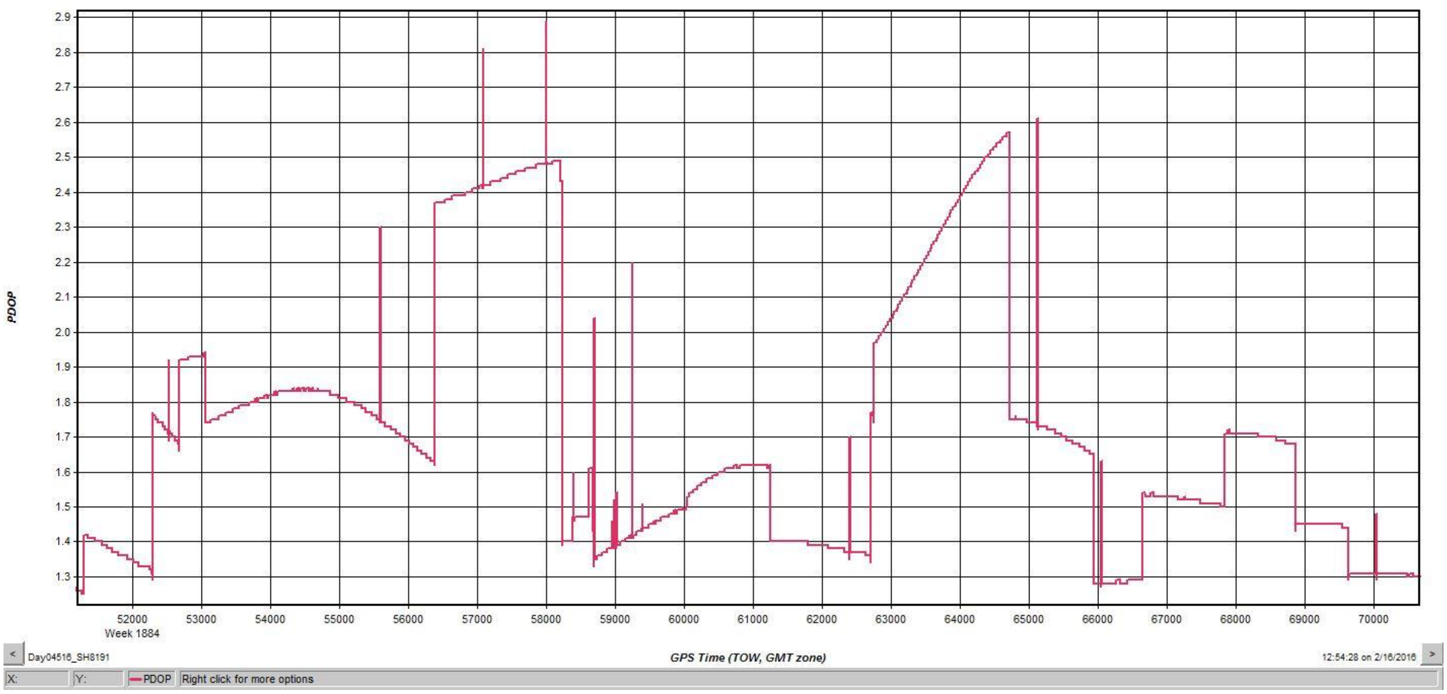


PDOP

The PDOP measures the precision of the GPS solution in regards to the geometry of the satellites acquired and used for the solution.

Woolpert's goal is to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Figure 3.4: PDOP, Day04513_SH8191



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 project data was imported and classified, survey ground control data was imported and calculated for an accuracy assessment. As a QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparisons against the TIN and the DEM using surveyed ground control of higher accuracy. The lidar is adjusted accordingly 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 lidar LAS files are classified into the Default (Class 1), Ground (Class 2), Noise (Class 7), Water (Class 9), Ignored Ground (Class 10), Overlap default (Class 17), and Overlap Ground (Class 18) 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 State Plane Georgia West, North American Datum of 1983 (2011). The vertical datum used for the task order was referenced to NAVD 1988, US Survey Feet, GEOID12B. Coordinate positions were specified in units of US Survey Feet.

Section 4: Hydrologic Flattening

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

NOAA OCM Tift and Cook Counties, GA Lidar processing task order 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-acre 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 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. Open Source imagery 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-acre or greater and streams at a minimum size of 30 meters (100 feet) nominal width, were compiled to meet task order requirements. Figure 4.1 illustrates an example of 30 meters (100 feet) nominal streams identified and defined with hydrologic breaklines. The breaklines defining rivers and streams, at a nominal minimum width of 30 meters (100 feet), were draped with both sides of the stream maintaining an equal gradient elevation.

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 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 4.1: Example Hydrologic Breaklines

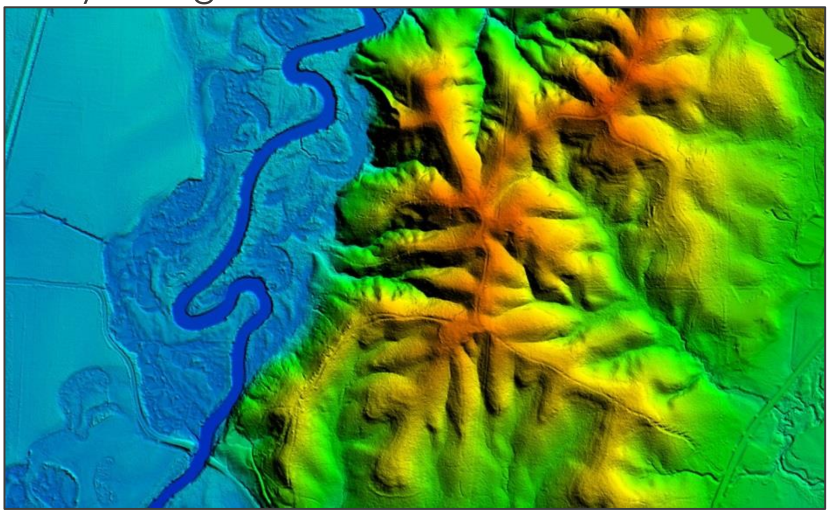


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

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.

Figure 4.2

Figure 4.3

Terrascan was used to add the hydrologic breakline vertices and export the lattice models. The hydrologically flattened DEM data was provided to NOAA in ESRI grid format.

The hydrologic breaklines compiled as part of the flattening process were provided to NOAA as an ESRI Geodatabase. The breaklines defining the water bodies greater than 2-acre and for the gradient flattening of all rivers and streams at a nominal minimum width of 30 meters (100 feet) were provided as a Polygon-Z feature class.

DATA QA/QC

Initial QA/QC for this task order was performed in Global Mapper v15, by reviewing the grids and hydrologic breakline features. Additionally, ESRI software and proprietary methods were used to review the overall connectivity of the hydrologic breaklines.

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

Section 5: ACCURACY ASSESSMENT

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,		
Average error	0.137	feet
Minimum error	-0.005	feet
Maximum error	0.456	feet
Average magnitude	0.137	feet
Root mean square	0.168	feet
Standard deviation	0.099	feet

Table 5.2: Raw Swath Quality Check Point Analysis FVA

Point ID	Easting (feet)	Northing (feet)	TIN Elevation (feet)	Dz (feet)
1001	2459991.006	538910.803	328.170	0.054
1002	2471613.547	572755.438	325.670	0.111
1003	2483552.119	523073.843	299.930	-0.005
1004	2524878.971	520250.024	314.650	0.143
1005	2502048.945	528497.207	348.190	0.062
1006	2553553.178	534835.127	290.190	0.107
1007	2462357.885	506435.603	292.290	0.109
1008	2496910.102	493945.707	235.640	0.456
1009	2512517.512	500449.348	320.170	0.082
1010	2538930.366	534332.152	324.850	0.345
1011	2514262.540	557136.182	314.700	0.217
1012	2487771.100	389239.854	179.500	0.148
1013	2515920.882	408001.908	239.550	0.143
1014	2527985.304	413795.841	238.980	0.134
1015	2554497.565	420687.296	224.170	0.148
1016	2561097.054	394775.512	204.670	0.054
1017	2514409.056	470510.319	295.570	0.132
1018	2534701.907	447994.568	253.820	0.215
1019	2527613.346	375570.515	234.950	0.139
1020	2508384.518	399393.236	218.190	0.102
1021	2568656.510	385191.803	228.920	0.039
1022	2513814.154	420601.624	243.140	0.085
1023	2538775.977	516688.960	329.720	0.126

VERTICAL ACCURACY CONCLUSIONS

Raw LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.329 feet fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all points.

LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.319 feet fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using ground points.

Bare-Earth DEM Fundamental Vertical Accuracy (FVA) tested 0.346 feet fundamental vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

SUPPLEMENTAL VERTICAL ACCURACY ASSESSMENTS

Table 5.3: Tall Grass Land Cover Quality Check Point Analysis SVA

Point ID	Easting (feet)	Northing (feet)	DEM Elevation (feet)	Dz (feet)
2001	2460010.089	538866.891	327.861	-0.429
2002	2471709.432	572237.795	323.901	-0.587
2003	2483622.724	522924.204	303.791	-0.056
2004	2524891.221	520338.094	314.221	-0.127
2005	2502819.050	527057.671	338.851	-0.085
2006	2553556.744	534807.084	289.451	-0.145
2007	2463001.961	506751.231	280.811	-0.462
2008	2496969.249	493876.800	237.360	-0.183
2009	2512575.009	500432.718	321.151	-0.397
2010	2538679.797	534427.311	323.311	-0.340
2011	2510991.349	558166.850	320.941	-0.075
2012	2486706.417	389770.928	175.170	0.030
2013	2516295.628	410223.370	236.960	-0.259
2014	2554517.331	420615.610	224.640	-0.341
2015	2561215.619	394527.069	212.120	-0.107
2016	2514812.345	470511.476	293.831	-0.079
2017	2534679.638	447933.010	252.811	-0.167
2018	2520660.332	380488.754	231.990	-0.129
2019	2508403.756	399174.029	220.090	-0.313
2020	2568539.554	385469.988	226.080	-0.225
2021	2513736.946	420701.142	240.130	-0.462
2022	2551460.686	412183.697	243.250	-0.175
2023	2454699.101	531075.463	337.761	-0.369

VERTICAL ACCURACY CONCLUSIONS

Tall Grass Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.562 feet supplemental vertical accuracy at the 95th percentile in the Tall Grass supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Tall Grass Errors at the 95th percentile include:
Point 2002, Easting 2471709.432, Northing 572237.795, Z-Error 0.587 feet

Table 5.4: Forested/Fully Grown Land Cover Quality Check Point Analysis SVA

Point ID	Easting (feet)	Northing (feet)	DEM Elevation (feet)	Dz (feet)
3001	2459792.697	539008.734	335.351	-0.285
3002	2471559.199	572709.810	317.271	-0.171
3003	2483580.998	523121.094	299.351	0.539
3004	2524886.813	520217.849	314.251	-0.231
3005	2502886.299	527084.309	339.931	-0.216
3006	2553613.612	534898.651	288.741	-0.232
3007	2462430.783	506218.749	291.341	-0.079
3008	2496883.191	493912.057	237.070	-0.174
3009	2512450.330	500485.851	321.971	-0.218
3010	2538918.072	534227.472	324.521	-0.399
3011	2514343.562	557133.758	319.251	-0.070
3012	2487744.411	389247.058	179.230	0.052
3013	2516135.552	407920.164	236.270	-0.175
3014	2527954.631	413634.760	239.910	-0.612
3015	2554425.198	420673.596	224.520	-0.121
3016	2561186.390	394708.269	207.500	-0.055
3017	2514482.120	470498.377	294.631	-0.092
3018	2534735.125	447953.448	252.651	-0.468
3019	2527552.367	375625.157	235.970	-0.182
3020	2508329.952	399267.931	216.150	-0.339
3021	2568665.854	385123.889	227.970	-0.173
3022	2513722.415	420687.499	240.570	-0.492
3023	2538757.600	516713.722	329.541	-0.268

VERTICAL ACCURACY CONCLUSIONS

Forested/Fully Grown Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.597 feet supplemental vertical accuracy at the 95th percentile in the Forested/Fully Grown supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Forested/Fully Grown Errors at the 95th percentile include:
Point 3014, Easting 2527954.631, Northing 413634.760, Z-Error 0.612 feet

Table 5.5: Swamp Land Cover Quality Check Point Analysis SVA

Point ID	Easting (feet)	Northing (feet)	DEM Elevation (feet)	Dz (feet)
4002	2472112.188	572697.391	323.621	0.430
4004	2513962.829	556644.502	297.351	-0.535
4005	2525222.075	520050.755	304.521	-0.008

4006	2463458.314	484517.841	246.540	-0.140
4007	2463220.486	506882.876	276.031	-0.244
4007	2553525.257	534725.013	286.861	-0.399
4009	2497068.881	494090.052	235.400	-0.396
4010	2512496.570	500879.434	312.161	-0.579
4011	2538978.858	534340.864	321.901	-0.249
4012	2487712.039	389154.445	178.420	-0.226
4013	2515094.458	407975.418	233.710	-0.227
4014	2513424.133	420862.242	238.490	-0.006
4015	2528203.137	407956.673	231.550	-0.104
4016	2554550.084	421317.626	205.490	-0.184
4017	2560933.006	395093.514	192.910	-0.723
4018	2515896.962	470014.448	295.851	-0.076
4019	2534146.159	448638.958	254.211	-0.316
4020	2527378.240	375521.697	228.940	-0.762
4021	2510020.861	400964.557	225.440	-0.422
4022	2560174.041	397953.775	191.070	-0.285
4023	2497055.109	494404.131	234.590	-0.625

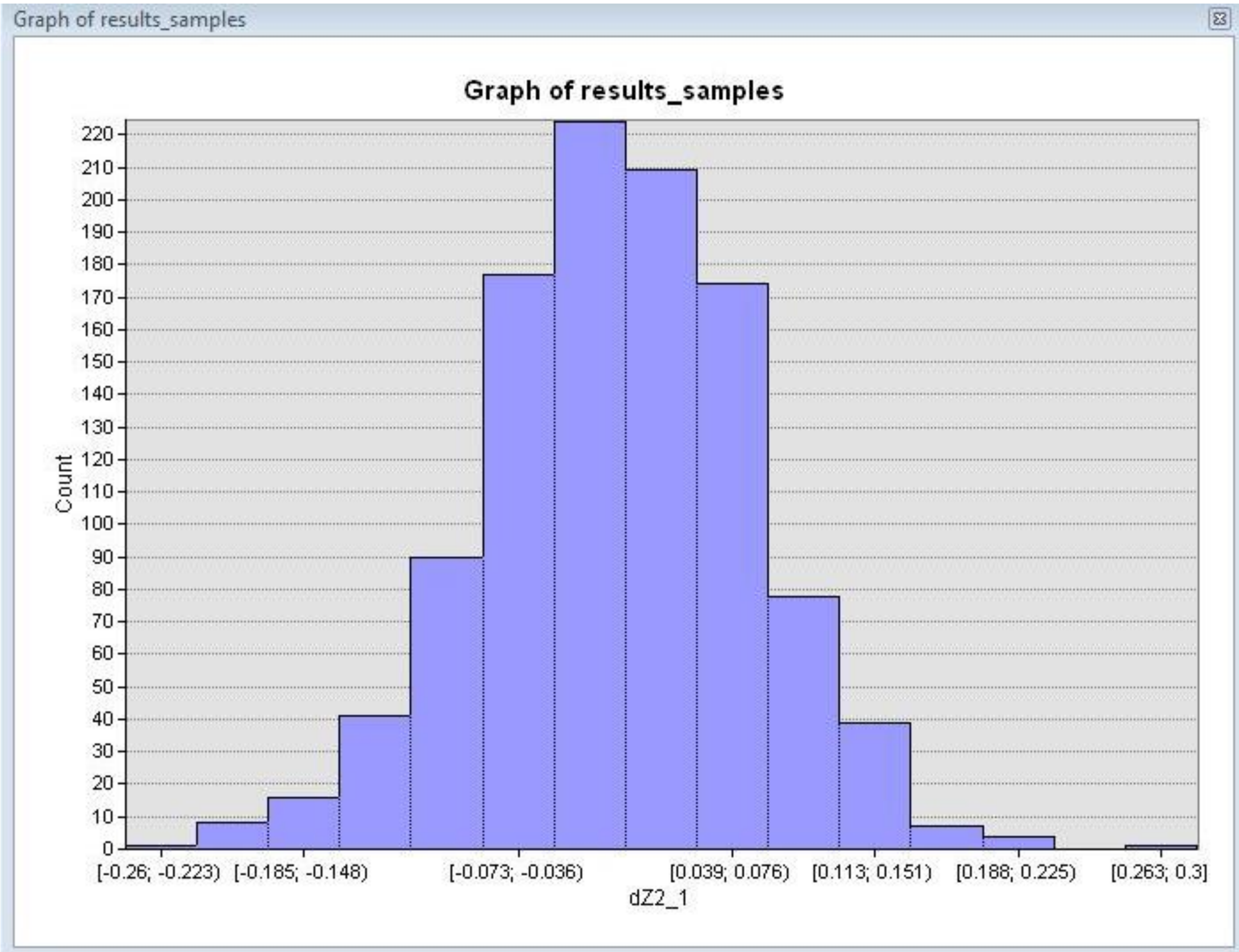
VERTICAL ACCURACY CONCLUSIONS

Swamp Land Cover Classification Supplemental Vertical Accuracy (SVA) Tested 0.758 feet supplemental vertical accuracy at the 95th percentile in the Swamp supplemental class reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. Swamp Errors at the 95th percentile include:
Point 4020, Easting 2527378.240, Northing 375521.697, Z-Error 0.762 feet

CONSOLIDATED VERTICAL ACCURACY ASSESSMENT AND CONCLUSION

Consolidated Vertical Accuracy (CVA) Tested 0.598 feet consolidated vertical accuracy at the 95th percentile level; reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. CVA is based on the 95th percentile error in all land cover categories combined.
Point 3014, Easting 2527954.631, Northing 413634.760, Z-Error 0.612 feet
Point 4017, Easting 2560933.006, Northing 395093.514, Z-Error 0.723 feet
Point 4020, Easting 2527378.240, Northing 375521.697, Z-Error 0.762 feet
Point 4023, Easting 2497055.109, Northing 494404.131, Z-Error 0.625 feet

Figure 5.1: LIDAR Relative Accuracy Histogram



RELATIVE ACCURACY ASSESSMENT AND CONCLUSION

Relative accuracy also known as “between swath accuracy” was tested through a series of well distributed flight line overlap locations. The relative accuracy for the NOAA OCM Tift and Cook Counties GA Lidar task order tested at 0.070 feet RMSDz.

Approved by:	Name	Signature	Date
Associate Member, Lidar Specialist Certified Photogrammetrist #1381	Qian Xiao	[signature]	July 2016

Section 6: Flight Logs

Flight logs for the project are shown on the following pages:

Woolpert

Leica LIDAR

MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
2/14/2016	45	75271		tift-cook

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SMITH	N404CP	5297.6	9:20:00	14:20:00	

Pilot	Sensor Type	HOBBS END	Local End Time	Zulu End Time	PID
ALBERS	OTHER	5303.1	2:55:00	19:55:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud	Departing	15j
								Arriving	15j

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode			
40	51	545	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	x	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode		Pre-Trigger Dist.
150	Kts	6500	Ft	6650	Ft	Yes		No		@	NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	
		⇩ Times entered are Zulu / GMT ⇩						Verify S-Turns Before Mission	Yes x No
49	s	14:32:00	14:33:00		19	0.6	1.1		
48	n	14:36:00	14:37:00		19	0.6	1.1		
47	s	14:42:00	14:46:00		19	0.6	1.1		
46	n	14:48:00	14:52:00		19	0.6	1.1		
45	s	14:55:00	14:59:00		16	0.6	1.3		
44	n	15:02:00	15:07:00		17	0.6	1.3		
43	s	15:10:00	15:16:00		16	0.6	1.5		
42	n	15:18:00	15:24:00		16	0.6	1.5		
41	s	15:27:00	15:33:00		17	0.6	1.3		
40	n	15:36:00	15:41:00		17	0.6	1.3		
39	s	15:44:00	15:50:00		18	0.6	1.2		
38	n	15:52:00	15:58:00		20	0.6	1.1		
26	n	16:00:00	16:04:00		21	0.6	1.1		
27	s	16:08:00	16:11:00		20	0.6	1.1		
28	n	16:14:00	16:16:00		20	0.6	1.1		
29	s	16:19:00	16:21:00		20	0.6	1.1		
30	n	16:25:00	16:26:00		20	0.6	1.1		
31	s	16:28:00	16:29:00		19	0.6	1.2		
25	s	16:35:00	16:48:00		18	0.6	1.2		
24	n	16:50:00	17:02:00		19	0.6	1.1		
23	s	17:05:00	18:58:00		19	0.6	1.1		
22	n	17:21:00	17:33:00		20	0.6	1		
21	s	17:36:00	17:48:00		21	0.6	0.9		
20	n	17:51:00	18:03:00		17	0.6	1.3		
19	s	18:07:00	18:19:00		17	0.6	1.2		
18	n	18:21:00	18:34:00		17	0.6	1.1		
17	s	18:37:00	18:49:00		17	0.6	1.1		
16	n	18:52:00	19:05:00		17	0.6	1.1		
15	s	19:08:00	19:21:00		15	0.6	1.3		
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission	Yes x No

Additional Comments: | Drive #

** als warning -sow is not being updated error-sc has not recieved proper recovery message(tm1b) from ins/gnss module

Woolpert

Leica LIDAR	MM/DD/YEAR	Day of Year	Project #	Phase #	Project Name
	2/16/2016	47	75271		tift-cook

Operator	Aircraft	HOBBS Start	Local Start Time	ZULU Start Time	Base
SMITH	N404CP	5303.3	11:18:00	16:18:00	
Pilot	**Sensor Type**	**HOBBS END**	**Local End Time**	**Zulu End Time**	**PID**
ALBERS	OTHER	5306.3	2:18:00	19:18:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
								Departing	15j
								Arriving	15j

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode			
40	51	545	100	Gain - Course/Up		Single		A	
				Gain - Fine/Down		Multi	x	B	

Air Speed		AGL		MSL		Waveform Used				Waveform Mode	Pre-Trigger Dist.
150	Kts	6500	Ft	6650	Ft	Yes		No		@ NS	Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:
		⇩ Times entered are Zulu / GMT ⇩						Verify S-Turns Before Mission Yes X No
37	n	16:29:00	16:32:00		18	0.7	1.2	
36	s	16:36:00	16:39:00		18	0.7	1.2	
35	n	16:43:00	16:45:00		18	0.7	1.2	
34	s	16:48:00	16:50:00		19	0.7	1.2	
33	n	16:53:00	16:54:00		18	0.7	1.3	
32	s	16:56:00	16:57:00		18	0.7	1.3	
14	n	17:05:00	17:11:00		18	0.7	1.3	
13	s	17:14:00	17:20:00		18	0.7	1.1	
12	n	17:23:00	17:29:00		18	0.7	1.1	
11	s	17:31:00	17:38:00		18	0.7	1.1	
10	n	17:40:00	17:47:00		16	0.7	1.4	
9	s	17:50:00	17:56:00		15	0.7	1.4	
8	n	17:59:00	18:05:00		16	0.7	1.2	
7	s	18:08:00	18:15:00		16	0.7	1.2	
6	n	18:17:00	18:24:00		16	0.7	1.1	
5	s	18:27:00	18:33:00		16	0.7	1.1	
4	n	18:36:00	18:42:00		16	0.7	1.1	
3	s	18:45:00	18:52:00		17	0.7	1	
2	n	18:55:00	19:01:00		16	0.7	1.2	
1	s	19:04:00	19:06:00		15	0.7	1.3	
⇧ Times entered are Zulu / GMT ⇧				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments:	Drive #

Section 7: Final Deliverables

The final lidar deliverables are listed below.

- LAS v1.2 classified point cloud
- Digital Elevation Model in ESRI Grid Format
- Tile layout and data extent provided in ESRI .GDB
- Control Points provided in ESRI .GDB
- Flightline vectors provided in ESRI .GDB
- Breaklines used in hydrologic flattening provided in ESRI .GDB
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in pdf format