AIRBORNE LIDAR TASK ORDER REPORT

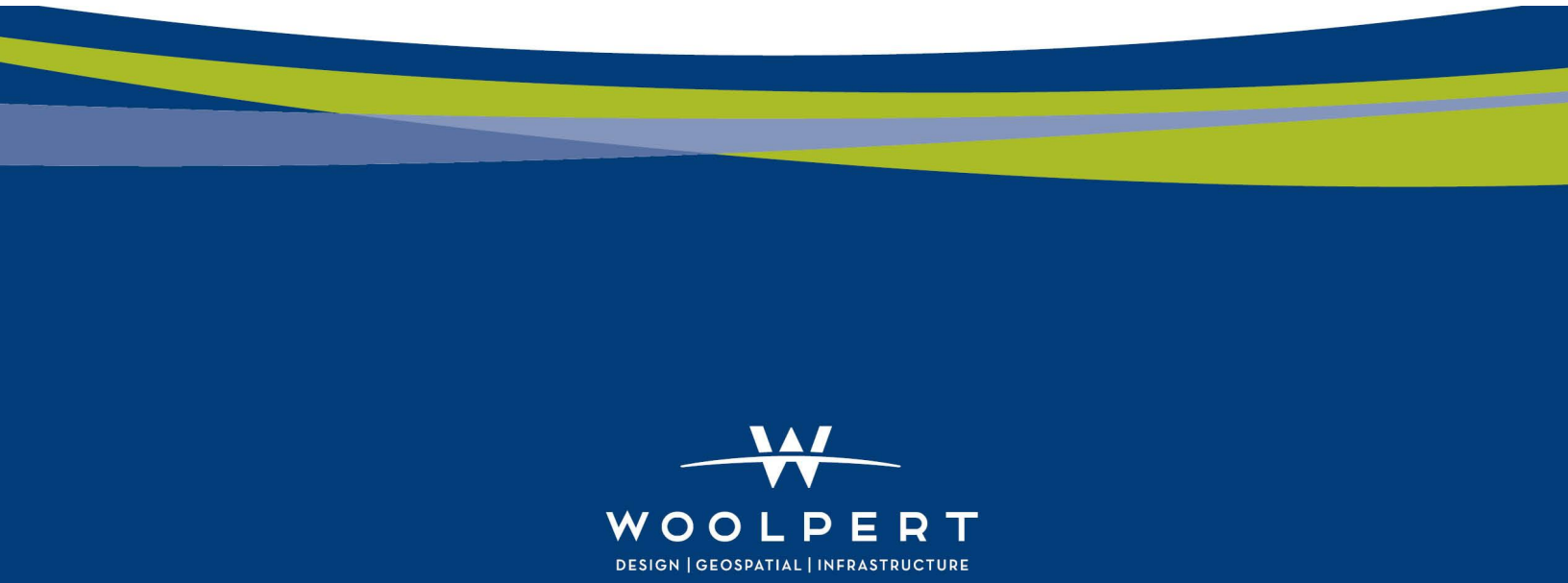
HORRY COUNTY ELEVATION DATA AND IMAGERY

NATIONAL OCEANIC AND ATMOSPHERIC ASSOCIATION (NOAA)

CONTRACT NUMBER: EA133C11CQ0010

Woolpert Project Number: 74038
January 2015

WOOLPERT
DESIGN | GEOSPATIAL | INFRASTRUCTURE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PROJECT REPORT

NOAA HORRY COUNTY ELEVATION DATA AND IMAGERY LIDAR PROCESSING

WOOLPERT PROJECT #74038

For:

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Summary of Contents

List of Figures

List of Tables

SECTION 1: OVERVIEW

PROJECT NAME: HORRY COUNTY ELEVATION DATA AND IMAGERY

WOOLPERT PROJECT #74038

This report contains a comprehensive outline of the Horry County Elevation Data and Imagery Lidar Processing task order for the National Oceanic and Atmospheric Administration (NOAA). This task is issued under Contract Number EA133C11CQ0010. This task order requires lidar data to be acquired across Horry County, South Carolina. The total area of the Horry County AOI is approximately 1092 square miles. The lidar collection was a collaborative effort between two data acquisition firms. While Woolpert was responsible for collection of the majority of the county, the coastal portion of the data was collected by Quantum Geospatial The lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.7 meters. The coastal portion of the data acquisition was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.3 meters. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The Woolpert collected data was collected using a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) lidar sensor installed in a Cessna 404 Titan fixed-wing aircraft. The ALS70 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:

Post Spacing (Minimum):	2.3 ft / 0.7m
AGL (Above Ground Level) average flying height:	6,500 ft / 1,981 m
MSL (Mean Sea Level) average flying height:	6,500 ft/ 1,981 m
Average Ground Speed:	150 knots / 173 mph
Field of View (full):	40 degrees
Pulse Rate:	272 kHz
Scan Rate:	42.6 Hz
Side Lap (Average):	28.7%

The Coastal collected data was collected using a Leica ALS50 Multiple Pulses in Air (MPiA) lidar sensor installed in a Cessna 208B fixed-wing aircraft. The ALS50 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 collection occurred on two dates: January 22, 2014 and January 26, 2014. The absolute accuracy of the coastal data set was tested by Quantum Geospatial prior to delivery to Woolpert for inclusion to the overall Horry County dataset yielding a result of 2.9 cm RMSEz. The coastal data set was assessed for data coverage, GPS and IMU quality, collection density, and calibration quality by Woolpert prior to merging with the Woolpert collected data for the remainder of the county. Final project accuracy statistical analysis was performed on the merged county and coastal dataset. The aerial lidar was collected at the following sensor specifications:

Post Spacing (Minimum):	0.98 ft / 0.3m
AGL (Above Ground Level) average flying height:	1,968 ft / 600 m
MSL (Mean Sea Level) average flying height:	1,968 ft / 600 m
Average Ground Speed:	110 knots / 127 mph
Field of View (full):	40 degrees

Pulse Rate:	130 kHz
Scan Rate:	42.9 Hz
Side Lap (Average):	50%

The lidar data was processed and projected in State Plane South Carolina FIPS 3900, North American Datum of 1983 (2011) in units of International Feet. The vertical datum used for the task order was referenced to NAVD 1988, GEOID12A, in units of International Feet.

Figure 1.1 Woolpert Collection Lidar Task Order AOI

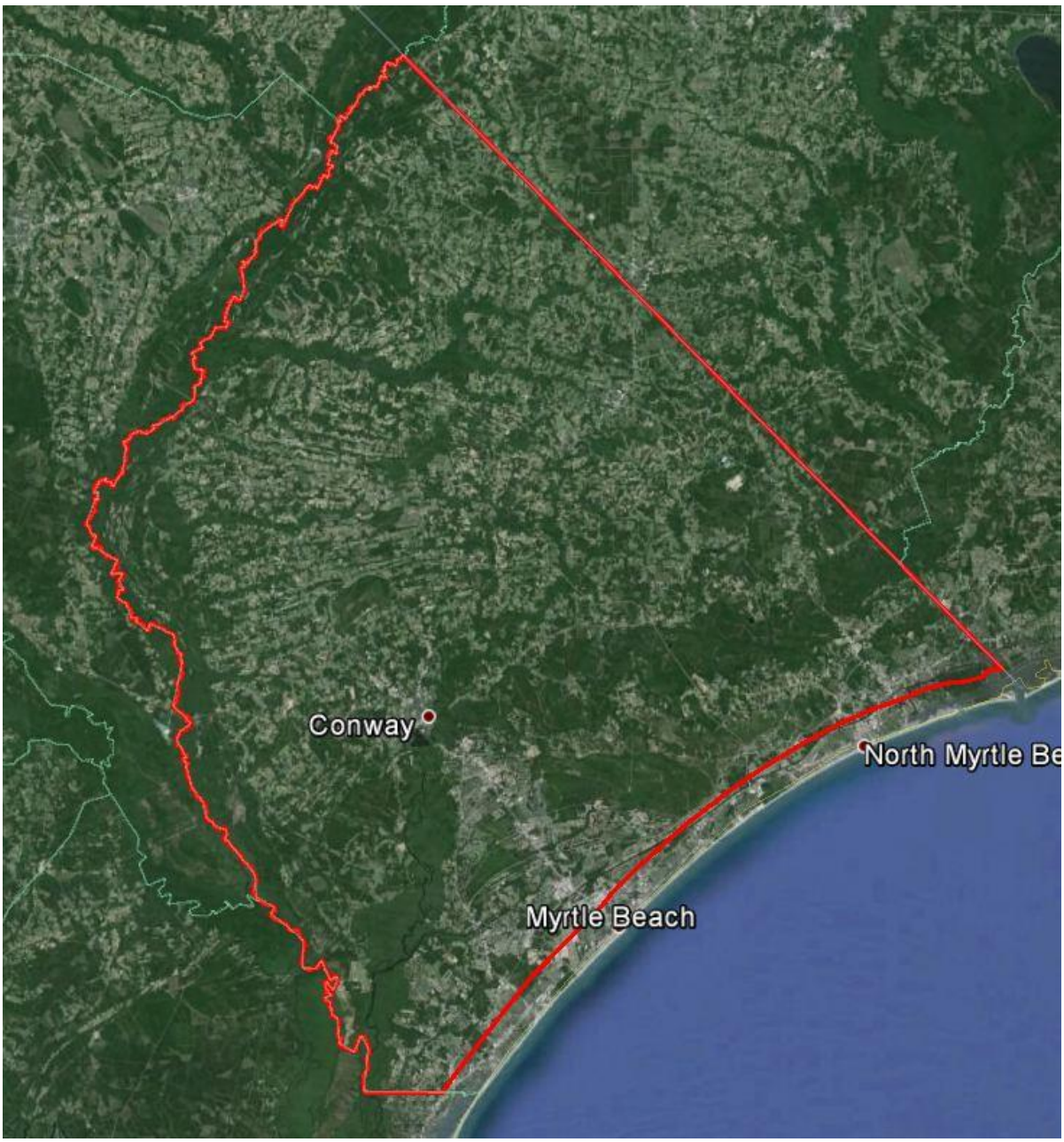
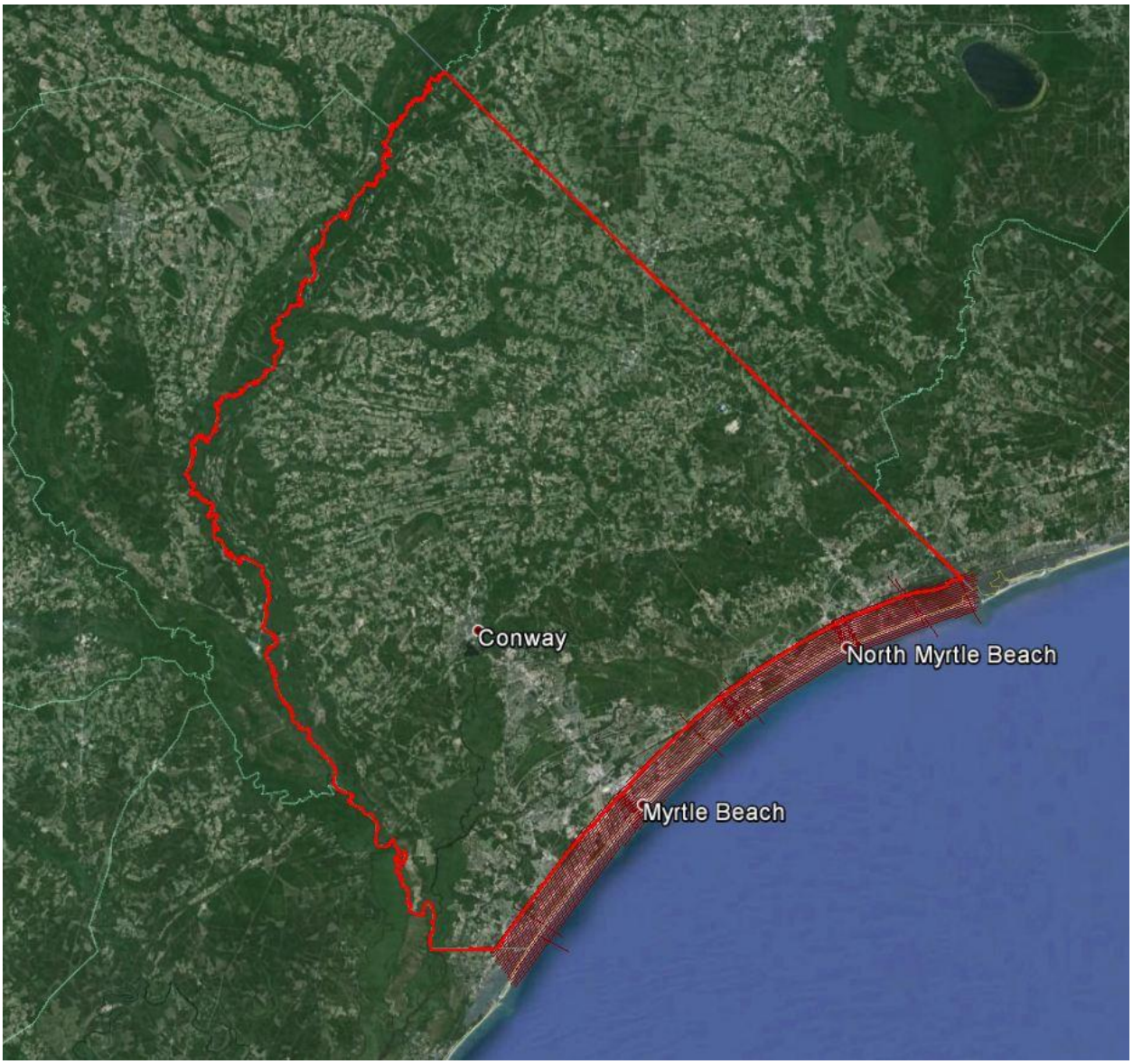


Figure 1.2 Coastal Collection Lidar Task Order AOI



SECTION 2: WOOLPERT ACQUISITION

The Woolpert collected lidar data was acquired with a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar Sensor System, on board Woolpert Cessna aircraft. The ALS70 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.

Table 2.1: ALS70 Lidar System Specifications

The ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Specification	
Operating Altitude	200 – 3,500 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	500 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	7 - 16 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 38 cm (one standard deviation)
Number of Returns per Pulse	7 (infinite)
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 five (5) 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: Lidar Flight Layout, 2014 Horry County Task Order

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
February 22, 2014 – Sensor7177	1-24	14:05 – 21:39	09:05AM – 04:39PM
February 23, 2014 - Sensor7177_A	25-39, 54-60	13:39 – 18:58	08:39AM – 01:58PM
February 23, 2014 – Sensor7177_B	52,53, 61-63	19:15 – 20:26	02:15PM – 03:26PM
February 24, 2014 – Sensor7177	44-51	19:33 – 21:42	02:33PM – 04:42PM
February 25, 2014 – Sensor 7177	40-43	13:47 – 16:04	08:47AM – 11:04AM

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. 14.01.

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.14.011.

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.14.011.

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.

Woolpert's acquisition team was on site, operating GNSS a base station at the Myrtle Beach International Airport (KMYR).

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

Table 3.1: GNSS Base Station

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
KMYR Airport Base	33°40'27.49674"	-78°56'04.89547"	-27.711

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

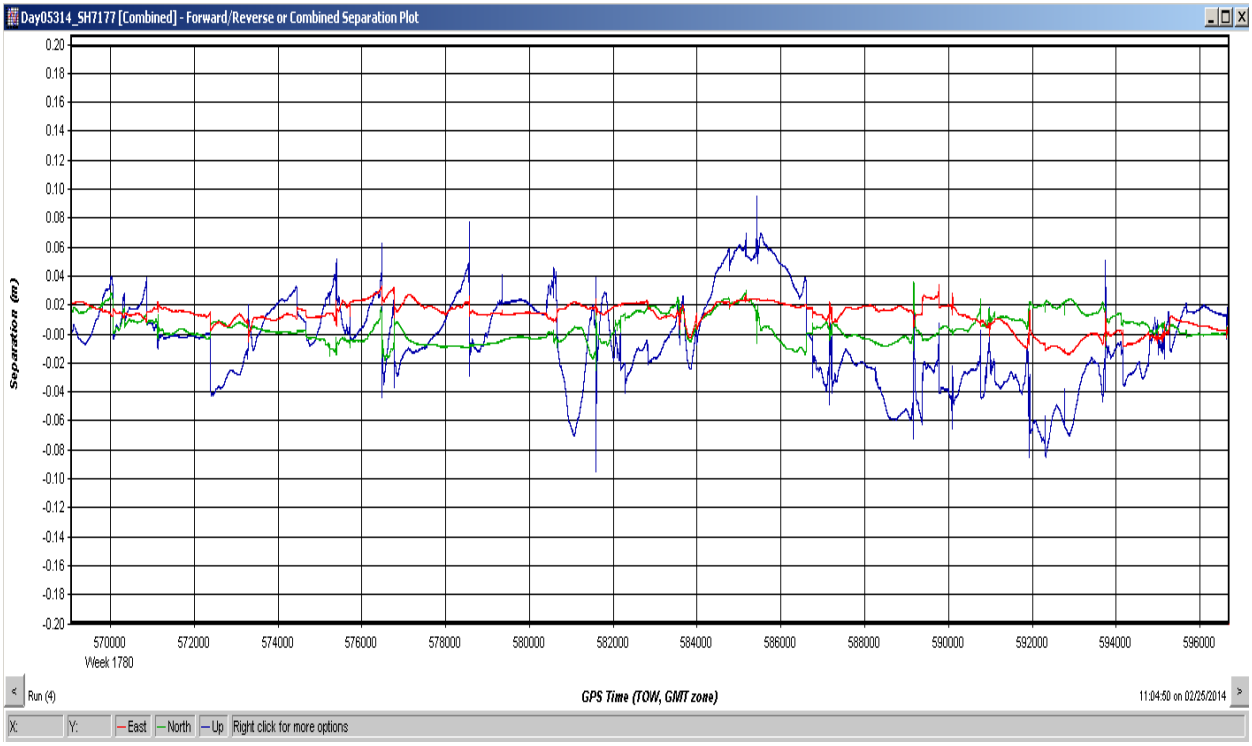
The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

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.

Figure 3.1: Combined Separation, Day05314 SH7177

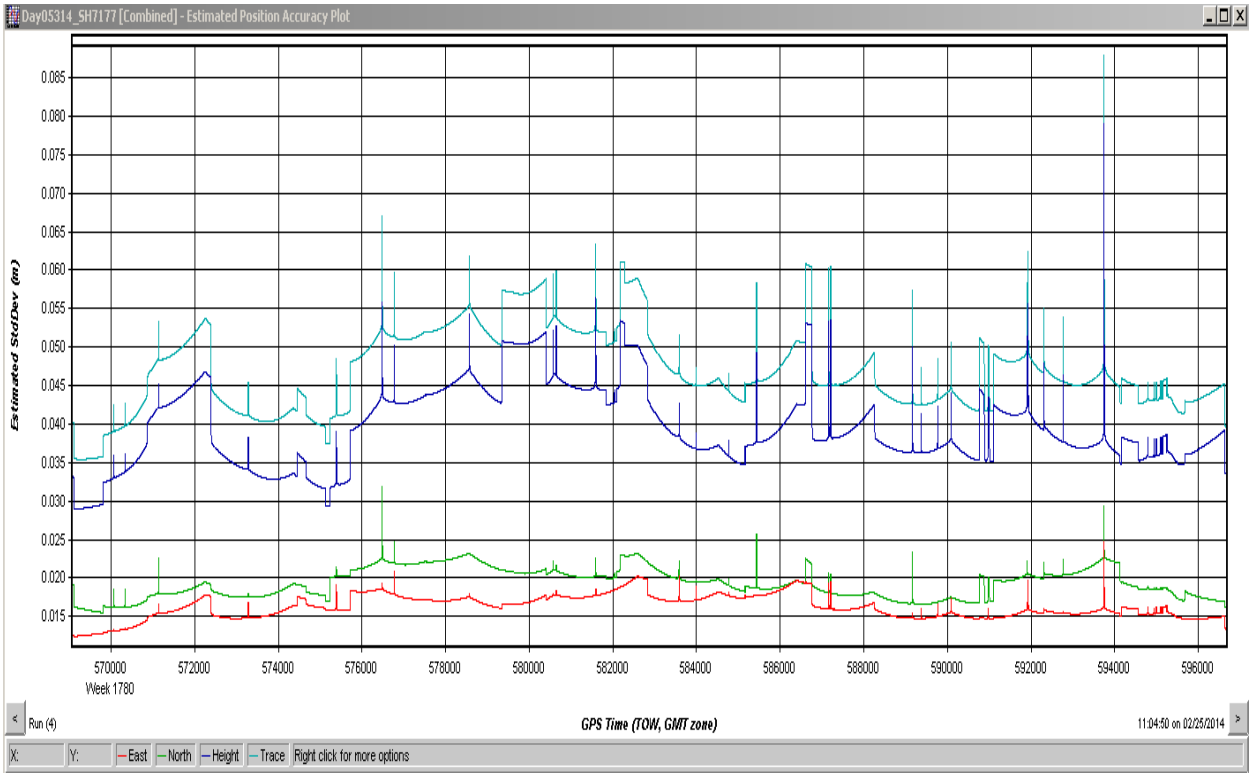


Estimated Positional Accuracy

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 3.2: Estimated Positional Accuracy, Day05314 SH7177

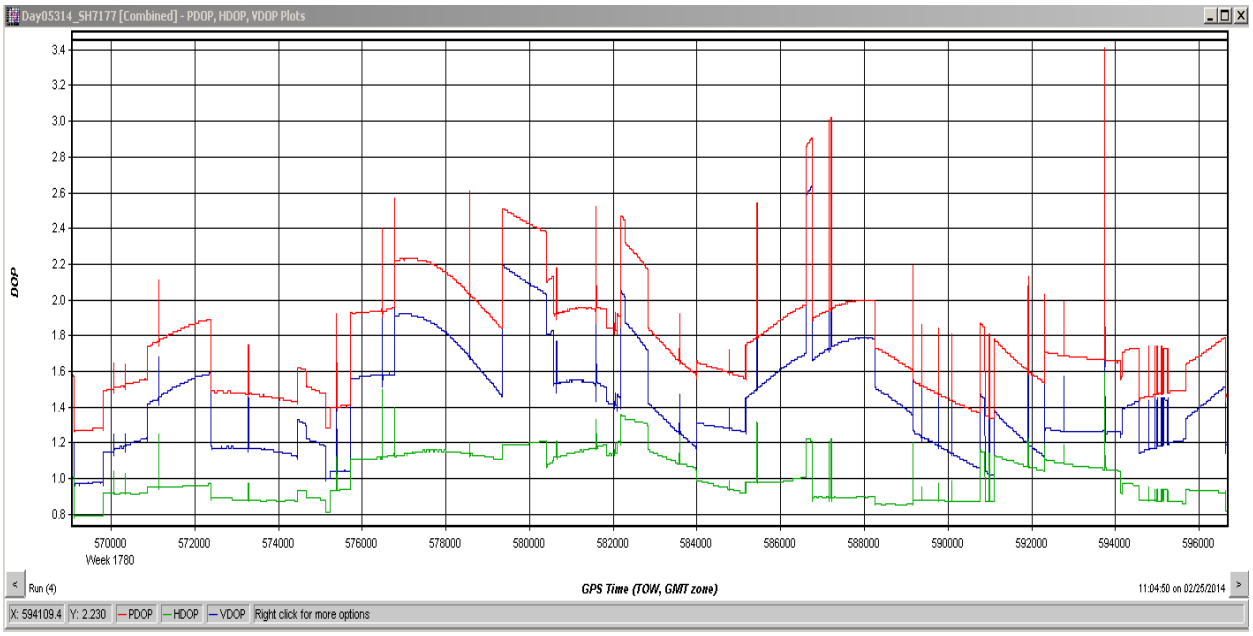


PDOP

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 3.3: PDOP, Day05314 SH7177



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 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 South Carolina North American Datum of 1983 (2011) FIPS 3900 in units of International Feet. The vertical datum used for the task order was referenced to NAVD 1988, GEOID12A. Coordinate positions were specified in units of International Feet.

SECTION 4: HYDROLOGIC FLATTENING

HYDROLOGIC FLATTENING OF LIDAR DEM DATA

Horry County Elevation Data and Imagery 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-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

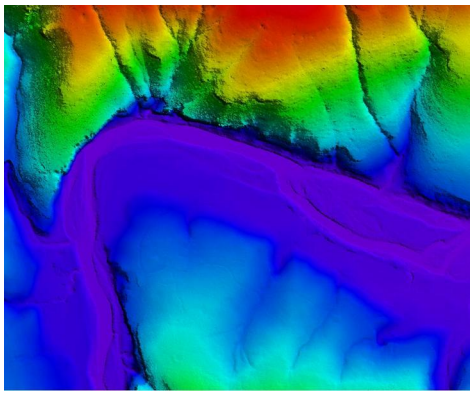
Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing lidar data.

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. 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-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. 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 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**

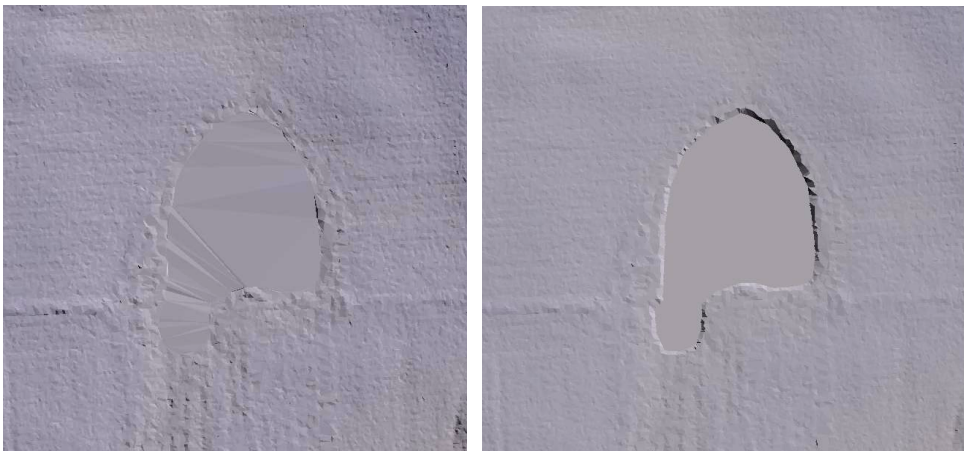


Figure 4.2 reflects a DEM generated from original lidar bare earth point data prior to the hydrologic flattening process. Note the "tinning" across the lake surface.

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 in ERDAS .IMG format at a 1-meter cell size.

The hydrologic breaklines compiled as part of the flattening process were provided as an ESRI Geodatabase. 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 (100 feet) were provided as a PolylineZ file.

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: FINAL ACCURACY ASSESSMENT

FINAL VERTICAL ACCURACY ASSESSMENT

The vertical accuracy statistics were calculated by comparison of the lidar points to the ground surveyed quality check points.

Table 5.1: Overall Vertical Accuracy Statistics

Average error	0.005	Intl ft
Minimum error	-0.520	Intl ft
Maximum error	0.290	Intl ft
Root mean square	0.203	Intl ft
Standard deviation	0.208	Intl ft

Table 5.2: Raw Swath Quality Check Point Analysis, FVA, State Plane South Carolina, NAD83(2011), NAVD88 GEOID12A, Horry County Elevation Data and Imagery

Point ID	Easting (Intl feet)	Northing (Intl feet)	TIN Elevation (Intl feet)	Dz (Intl feet)
2000	2645666.079	850739.951	85.5	-0.015
2001	2638622.728	815020.833	96.06	0.177
2002	2615718.76	796790.937	106.21	0.26
2003	2592895.522	757262.305	28.87	0.165
2004	2585390.995	708042.436	15.98	0.069
2005	2566040.278	673915.858	18.5	0.081
2006	2724622.672	752214.101	48.7	-0.52
2007	2705709.457	730901.443	10.83	0.04
2008	2669387.201	714396.345	9.57	0.054
2009	2638370.602	692328.262	19.36	-0.175
2010	2609564.398	654318.392	24.15	-0.055
2011	2605227.711	652275.565	32.38	0.29
2012	2593594.83	887882.167	102	-0.244

Point ID	Easting (Intl feet)	Northing (Intl feet)	TIN Elevation (Intl feet)	Dz (Intl feet)
2013	2571326.211	875083.709	60.77	-0.304
2014	2589335.13	837970.499	80.82	-0.256
2015	2574291.094	830296.478	71.31	-0.102
2016	2560941.327	815815.752	62.05	-0.082
2017	2544518.34	792531.582	102.62	0.035
2018	2538736.84	775877.549	73.76	0.242
2019	2539410.455	734503.038	47.78	0.252
2020	2551428.486	704813.048	20.9	0.113
2030	2644435.268	826462.077	98.8	0.089

VERTICAL ACCURACY CONCLUSIONS

Raw LAS Swath Fundamental Vertical Accuracy (FVA) Tested 0.397 ft (4.764 inches) fundamental vertical accuracy at 95 percent confidence level, derived according to NSSDA, in open terrain in open using (RMSEz) 0.203 x 1.9600, tested against the TIN against all points.

Approved By:			
Title	Name	Signature	Date
Associate Lidar Specialist Certified Photogrammetrist #1281	Qian Xiao		January 2015

SECTION 6: WOOLPERT FLIGHT LOGS

FLIGHT LOGS

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

Woolpert

Leica LIDAR	Date of Flight	Day of Year	Project #	Phase #	Project Name
	2/22/2014	53	74038	1	74038 Horry County Lidar

Operator	Aircraft	Local Start Time	GMT Start Time	Base
BURKE	N7079F	9:05:00	14:05:00	WOOLPERT PIN

Pilot	Sensor Type	Local End Time	GMT	Plot
RADER	ALS-7177	16:39:00	21:39:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
303/12	10	Clr 12k	high cirrus	12	3	30.16	N/A	Departing	KMYR
								Arriving	KMYR

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (Mhz)	Laser Power %	Fixed Gain	Mode			Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	HDOP	GS	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At: 7:04:00
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns Before Mission Yes X No
1	325	14:40:39	14:55:39		16	1.4	147	
2	145	14:58:01	15:13:35		15	1.4	148	
3	325	15:15:51	15:31:24		15	1.5	147	
4	145	15:33:29	15:48:45		18	1.1	149	
5	325	15:51:03	16:06:14		17	1.1	146	
6	145	16:08:37	16:23:51		16	1.2	151	
7	325	16:26:21	16:41:05		15	1.4	149	
8	145	16:43:32	16:58:56		15	1.5	153	
9	325	17:00:31	17:15:10		15	1.2	152	FCMS In-Flight evaluation list 0.1 nmi data gap
10	145	17:17:21	17:32:04		14	1.3	151	
11	325	17:34:13	17:48:38		14	1.3	155	
12	145	17:50:49	18:04:59		15	1.2	154	
13	325	18:07:03	18:20:55		15	1.2	153	
14	145	18:22:58	18:36:26		15	1.2	153	
15	325	18:42:27	18:51:53		17	1.1	153	
16	145	18:54:03	19:07:24		14	1.4	151	
17	325	19:09:26	19:22:41		15	1.4	150	
18	145	19:25:00	19:38:14		14	1.5	153	
19	325	19:40:13	19:53:20		14	1.4	152	
20	145	19:55:21	20:08:42		15	1.1	151	
21	325	20:10:37	20:24:04		13	1.3	152	
22	145	20:26:14	20:39:30		13	1.2	152	
23	325	20:41:22	20:54:29		14	1.1	151	
24	145	20:56:22	21:09:27		14	1.2	154	
9	325	21:13:38	21:19:01		14	1.2	154	Re-Fly data gap FCMS list line complete

↑ Times entered are Zulu / GMT ↑		Page	1	Verify 5-Turns After Mission	Yes	X	No	

Additional Comments:	Drive #
High clouds too thick for AdS	0114

Woolpert

Leica LIDAR					
	2/23/2014	54	74038	1	74038 Horry County Lidar
BURKE	N7079F	3045.5	8:39:00	13:39:00	WOOLPERT PIN
RADER	AL5-7177	3050.7	13:58:00	18:58:00	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fog/Cloud		
Calm	10	CLR 12K	High Cirrus	7	5	30.11	Haze	Departing	KMYR
								Arriving	KMYR

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	GS	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At: 8:06:00
		↑ Times entered are Zulu / GMT ↑						Verify 5-Turns Before Mission End X No
25	325	14:05:29	14:18:54		17	146	1.1	
26	145	14:21:10	14:33:53		18	143	1.2	
27	325	14:36:07	14:48:56		16	148	1.2	
28	145	14:51:07	15:03:38		15	151	1.4	
29	325	15:05:59	15:18:46		15	147	1.4	
30	145	15:20:55	15:33:20		18	153	1.2	
31	325	15:35:33	15:48:08		17	149	1.1	
32	145	15:50:15	16:02:24		15	152	1.2	
33	325	16:04:20	16:16:24		16	147	1.1	
34	145	16:18:45	16:30:25		14	150	1.7	
35	325	16:32:29	16:44:10		14	149	1.4	
36	145	16:46:33	16:58:24		14	150	1.4	
37	325	17:00:13	17:12:12		15	147	1.3	
38	145	17:18:29	17:26:19		15	151	1.3	
39	325	17:28:12	17:40:20		15	151	1.3	
54	145	17:46:41	17:54:55		16	153	1.1	Relocate to clean up MOA area
55	325	17:57:04	18:05:05		16	150	1.1	
56	145	18:06:40	18:14:05		16	151	1.1	
57	325	18:16:16	18:23:29		15	148	1.1	
58	145	18:26:20	18:33:20		16	150	1.1	
59	325	18:35:26	18:40:38		17	148	1.1	
60	145	18:43:16	18:47:09		14	150	1.3	
61	325	18:49:31	18:52:30		14	151	1.3	No TDC msg in FCMS however FCMS stopped displaying range data See notes below:
001		18:55:30	18:56:23					Manual start to review ranges
Flew over Base 18:58 shut down system restart								

↑ Times entered are Zulu / GMT ↑		Page	1	Verify 5-Turns After Mission	Yes	X	No	

Additional Comments:

Checked Trac Gui SC60 yellow indicator message displayed "TDC data fetch timeout error due to no mem switch signal on I/O AUX 1 connection on TDC"

Drive #: 00097

Woolpert

Leica LIDAR	Mission Date	Day of Year	Project #	Flight #	Project Name
	2/23/2014	54	74038	1	74038 Horry County Lidar

Operator	Aircraft	Aircraft Start	Local Start Time	Zulu Start Time	Base
BURKE	N7079F	3050.7	14:15:40	19:15:40	WOOLPERT PIN
Pilot	**Sensor Type**	**Aircraft Stop**	**Local Stop Time**	**Zulu Stop Time**	**PIC**
RADER	ALS-7177	3052.0	15:26:45	20:26:45	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Haze/Fire/Cloud		
170/8	10	15l Bkn	Overcast	15	5	30.02		Departing	KMYR
								Arriving	KMYR

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	6	Single		A	180
				Gain - Fine/Down	12	Multi	X	B	170

Air Speed		AGL		MSL		Waveform Used			Waveform Mode		Pre-Trigger Dist.	
150	Kts	6500	Ft		Ft	SW	HW	X	@	NS		Ft

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	GS	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At: 8:06:00
		↑ Times entered are Zulu / GMT ↑						Verify S-Turns Before Mission Yes X No
61	326	19:27:46	19:30:48		14	154	1.4	Re-Fly due to error on M1 20140223
62	144	19:33:00	19:34:09		14	148	1.4	
63	326	19:37:01	19:38:14		14	150	1.4	
53	326	19:43:10	19:51:36		15	153	1.3	
56	144	19:53:47	19:55:28		15	154	1.2	FCMS in-flight evaluation list 0.31 nmi data gap WPTS 1-10 re-flown letting FCMS auto select area
52	144	20:03:31	20:13:10		15	148	1.2	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission Yes X No

Additional Comments:	Drive #
	00097

Woolpert

Leica LIDAR	2/24/2014	SS	74038	1	74038 Horry County Lidar
BURRIS	ACID796	3056.9	14:33:00	19:33:00	WOOLPERT PIN
RADER	AES-7177	3058.0	16:42:30	21:42:30	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Rain/Fog/Clouds	Departing	KMYR
350/8	10	CLR	0	18	2	30.01		Arriving	KMYR

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Odd/EVEN	0	Single		A	180
				Gain - Nine/Done	12	Multi	X	B	170

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SVs	GS	PDOP	Line Notes/Comments	
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At:	8:38:00
↑ Times entered are Zulu / GMT ↑								Verify E-Turns Before Mission:	Yes X No
001	180	16:29:30	16:32:25		15	145	1.6	Test after re-boot due to TDC error	
51	324	19:38:34	19:49:13		16	140	1.2		
50	144	19:52:28	20:02:59		15	159	1.3		
49	324	20:05:20	20:16:48		14	141	1.3		
48	144	20:19:15	20:30:13		15	158	1.2		
47	324	20:32:51	20:44:32		15	146	1.1		
46	144	20:47:11	20:58:28		15	152	1.2		
45	324	21:00:39	21:12:50		15	142	1.2		
44	144	21:15:18	21:26:56		15	156	1.2		
↑ Times entered are Zulu / GMT ↑				Page		1		Verify E-Turns After Mission:	Yes X No

Additional Comments:

Drive #

Booted system on ground drive 00097 let it run while working ADS mission TDC error listed in FCMS shut down changed drive rebooted at 16:24 airborne initialization at 19:33 no TDC errors on second drive 114

00114

Woolpert

Leica LIDAR	Date (mm/dd/yyyy)	Day of Year	Project #	Flight #	Project Name
	2/25/2014	56	74038	1	74038 Horry County Lidar

Pilot	Aircraft	Aircraft Hobbs	Takeoff Time	Landing Time	Pilot
BURNS	N70796	3058.0	8:47:41	12:47:41	WOOLPERT PIN
Sensor Operator	Sensor Type	Sensor S/N	Power On Time	Off	Op
RADER	AES-7177	3060.2	11:04:30	16:04:30	

Wind Dir/Speed	Visibility	Ceiling	Cloud Cover %	Temp	Dew Point	Pressure	Rain/Fog/Cloud		
Calm	10	CLR 12k	0	7	5	30.04		Departing	KMYR
								Arriving	KMYR

Scan Angle (FOV)	Scan Frequency (Hz)	Pulse Rate (kHz)	Laser Power %	Fixed Gain		Mode		Threshold Values	
40	42.3	272	100	Gain - Course/Up	8	Single		A	320
				Gain - Fine/Down	12	Multi	X	B	370

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

Line #	Dir.	Line Start Time	Line End Time	Time On Line	SV's	GS	PDOP	Line Notes/Comments
Test	n/a			n/a	n/a	n/a	n/a	GPS Began Logging At: 8:58:00
↑ Times entered are Zulu / GMT ↑								Verify S-Turns Before Mission: Yes X No
43	325	14:13:08	14:25:44		19	144	1.1	
42	144	14:28:10	14:40:00		19	152	1	
41	325	14:42:24	14:54:58		16	142	1.3	
40	144	14:57:25	15:09:09		16	1155	1.4	
↑ Times entered are Zulu / GMT ↑				Page		1		Verify S-Turns After Mission: Yes X No

Additional Comments:

Lidar collect complete pending QC no errors during flight

Office #

0097

SECTION 7: FINAL DELIVERABLES

FINAL DELIVERABLES

The final lidar deliverables are listed below.

- LAS v1.2 classified point cloud
- Hydrologically flattened Polygon z and Polyline z breaklines as ESRI Geodatabase
- Hydrologically flattened bare earth 4 ft pixel DEM in ERDAS .IMG format
- Flightline Vectors as ESRI Geodatabase
- Tile layout and data extent provided as ESRI Geodatabase
- Control/QC points provided as ESRI Geodatabase
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in pdf format