Project Report

TASK ORDER NAME: GA_SW GEORGIA 22 COUNTY LIDAR_2017_B17
TASK ORDER NUMBER: G17PD00242
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 17017
BLOCK NUMBER: GAE

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS NGTOC task order G17PD00242 required Spring 2017 LiDAR surveys to be collected over 7,931 square miles covering part or all of 22 counties in SW Georgia. These counties are Baker, Bleckley, Crawford, Crisp, Decatur, Dodge, Dooly, Early, Houston, Macon, Meriwether, Miller, Muscogee, Peach, Pulaski, Seminole, Telfair, Terrell, Troup, Turner, Twiggs, and Wilcox. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of 0.7 meters. These data were produced using class 10 for points classified as ignored ground. This is in keeping with the USGS Lidar Base Specification 1.2. The remaining point cloud processing methods are consistent with Lidar Base Specification 2021 rev A. This report is for the GAE block which covers approximately 949 square miles.

Isolated gaps in GPS data were identified in several missions covering this project. As both, the IMU data and pulse data, were present across these gaps, using the fixed positions of the GPS on either end, the aircraft velocity across the gaps, and the IMU data, LiDAR calibration staff were able to reach an effective solution to address the GPS voids. Because these gaps were not uniform in size or correction, this extended the iterative LiDAR calibration efforts on this project. Subsequent rigorous data checking confirmed adequate results to meet the required accuracy specs. The USGS QA Team reviewed affected data (blocks) for this project and found no QA/QC discrepancies to report regarding those gaps.

In three missions 123_20190317_1, 123_20190318_1, and 123_20190318_2 there were symptoms of skunk striping present in the collected data. These artifacts are manifested by low noise points at nadir and are believed to have been caused by exhaust from the aircraft during collection. Atlantic isolated the points affected by channel and by intensity and classed them out to noise and flagged them as withheld. We were able to maintain the integrity of the surface and still meet density requirements to meet spec.

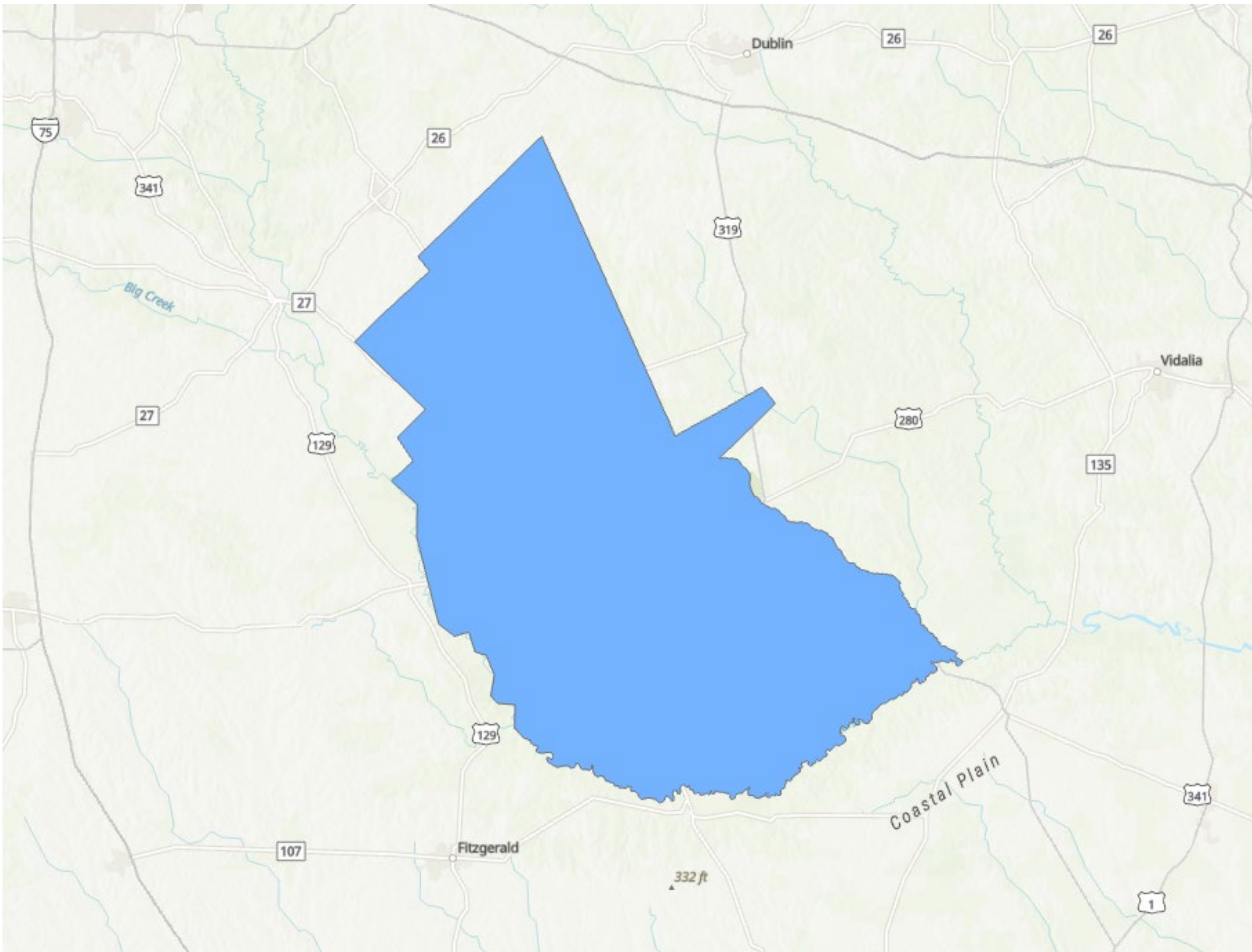

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

1.1.2 Project Purpose

The produced classified point cloud data, DEMs, and other products derived from this classified point cloud data will aid in planning and management purposes of the participating counties and participants.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified LAS Point Cloud Data	LAS, V1.4, PRF 6,7,8,9 or 10
Bare Earth Surface (Raster DEM)	GIS-compatible, 32-bit floating point raster format (GeoTIFF)
Breaklines	ESRI .gdb
Control	.shp file
Metadata	FGDC compliant, product level
Flight Index	.shp file
Project Report	pdf
Tile Index	.shp file
Intensity Image	8-bit, 256 color gray scale, GeoTIFF

Table 1: Aerial LiDAR Contract Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a Caravan (N167PM) outfitted with an Optech Galaxy T2000 LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy T2000
Manufacturer	Optech
Performance Envelope	150 – 4700 m AGL, nominal
Absolute Horizontal Accuracy	1/10,000 x altitude
Absolute Elevation Accuracy	< 0.03 – 0.20 m RMSE from 150 – 4700 m AGL
Topographic Laser	1064-nm near-infrared
Laser Classification	Class IV
Pulse Repetition Frequency (Effective)	Programmable, 50 – 1000 kHz
Beam Divergence	0.25 mrad (1/e)
Laser Range Precision	< 0.008 m
Minimum Target Separation Distance	< 0.7 m (discrete)
Range Capture	Up to 8 range measurements, including last
Intensity Capture	Up to 8 intensity measurements, including last (12-bit)
Scan Angle (Fov)	10 – 60°
Swath Width	10 – 115% of altitude AGL
Scan Frequency	0 – 120 Hz advertised (0 – 240 scan lines/sec)
Scan Product	2000 maximum
Roll Compensation	±5° minimum
Data Storage	Internal solid-state drive (SSD)
Power Requirements	28 V; 300 W
Dimensions and Weight	Sensor: 0.34 x 0.34 x 0.25 m, 27 kg
Operation Temperature	0 to +35°C

Table 2: System Specifications – Galaxy Prime

2.1.2 Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Optech Galaxy T2000
Nominal Pulse Spacing (m)	0.597
Nominal Pulse Density (pls/m²)	2.8
Nominal Flight Height (AGL meters)	2200
Nominal Flight Speed (kts)	150
Pass Heading (°)	Varies
Sensor Scan Angle (°)	40
Scan Frequency (Hz)	64
Pulse Rate of Scanner (kHz)	400
Line Spacing (m)	1260
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	7
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	1588
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 85 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 7 flight missions conducted between January 19, 2021 and January 30, 2021. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

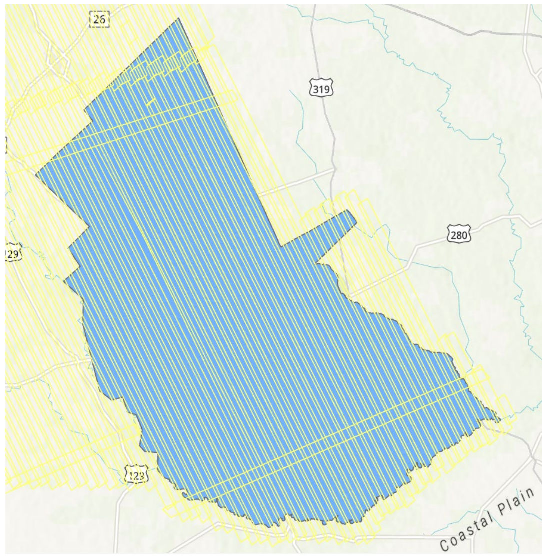

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

16 Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in the table below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

PID	Latitude (N)	Longitude (W)	Elevation
AL76	N31°52'29.95914"	W85°13'32.48414"	100.108
ALA1	N32°35'55.88599"	W85°30'14.13709"	184.083
ALDO	N31°14'22.17259"	W85°26'24.71391"	79.679
ALLA	N32°55'02.66208"	W85°24'01.80686"	237.157
FL75	N30°36'45.11304"	W83°08'48.07712"	23.029
GAAE	N33°25'38.07520"	W82°04'04.06946"	124.363
GAAY	N31°39'40.91991"	W84°16'29.65382"	55.888
GABY	N31°22'39.31820"	W84°56'06.69141"	63.547
GACC	N33°32'44.73006"	W82°08'01.72612"	98.524
GAHA	N32°11'35.73988"	W83°28'54.37969"	66.192
GAIR	N31°34'51.00271"	W83°05'51.06280"	70.682
GALU	N31°33'48.73821"	W83°50'12.23502"	107.079
GASN	N32°58'54.70716"	W82°48'33.11709"	115.806
TALH	N30°23'47.50413"	W84°21'21.06182"	-7.293
ZJX1	N30°41'55.89383"	W81°54'29.46939"	1.724
ZTL4	N33°22'46.87805"	W84°17'48.21718"	260.680

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 39 ground survey points were collected in support of this project, including 8 LiDAR Control Points (LCP), 17 Non-vegetated Vertical Accuracy (NVA) and 14 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed "busts" in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA and VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
CTRL09	351457.800	873887.560	374.103	LCP
CTRL10	336042.450	724790.770	223.845	LCP
CTRL11	339812.440	804157.160	362.169	LCP
CTRL12	404160.230	766803.540	274.983	LCP
CTRL17	425254.360	755048.500	242.698	LCP
CTRL18	403921.100	660239.540	212.039	LCP
CTRL19	498717.340	703631.570	138.313	LCP
CTRL20	378606.550	732226.690	276.273	LCP

Table 5: LiDAR Control/Check Point Coordinates

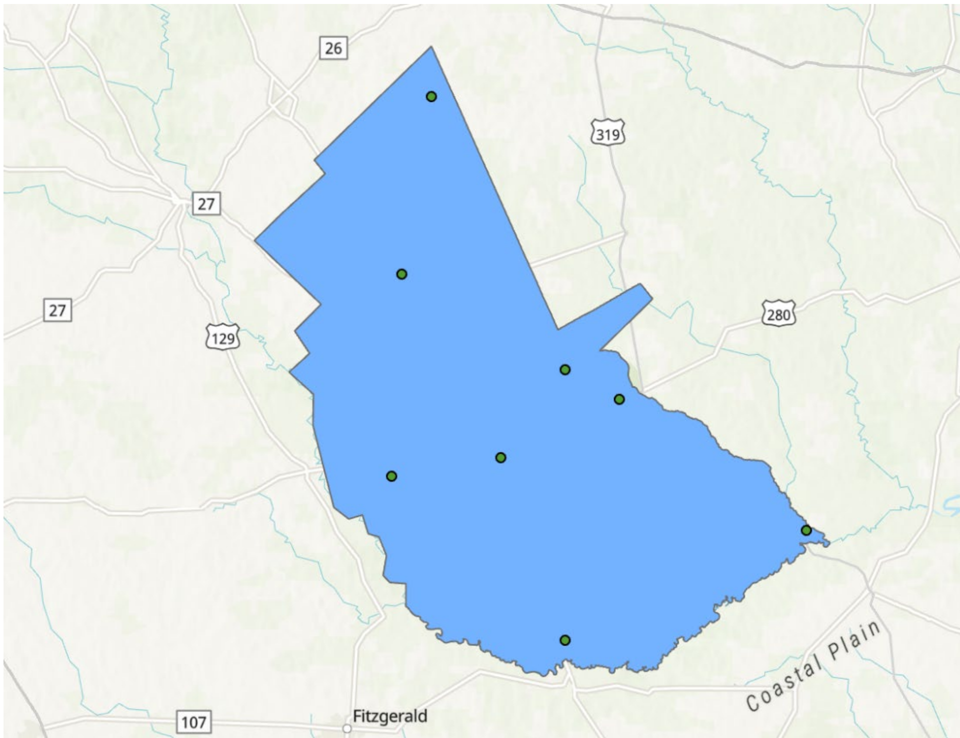

Figure 3: LiDAR Control Point Distribution

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BE07	360603.447	836128.15	358.004	NVA
BE08	405513.965	766699.54	280.36	NVA
BE09	309396.557	779762.946	246.334	NVA
BE12	366842.001	701062.755	324.27	NVA
BE13	422772.177	727706.938	214.905	NVA
BE14	424311.486	702202.293	217.457	NVA
OT07	294609.291	822843.902	311.701	NVA
OT08	349244.862	790753.959	351.576	NVA
OT09	341949.135	755657.002	267.346	NVA
OT11	454122.751	735224.704	255.179	NVA
OT12	474929.447	688411.197	152.824	NVA
OT13	378662.175	732772.739	287.468	NVA
UR07	335992.373	725196.635	242.299	NVA
UR08	339396.709	804766.974	368.827	NVA
UR11	424688.271	755304.523	248.368	NVA
UR12	498995.913	703563.194	138.364	NVA
UR13	403908.954	661098.842	197.384	NVA

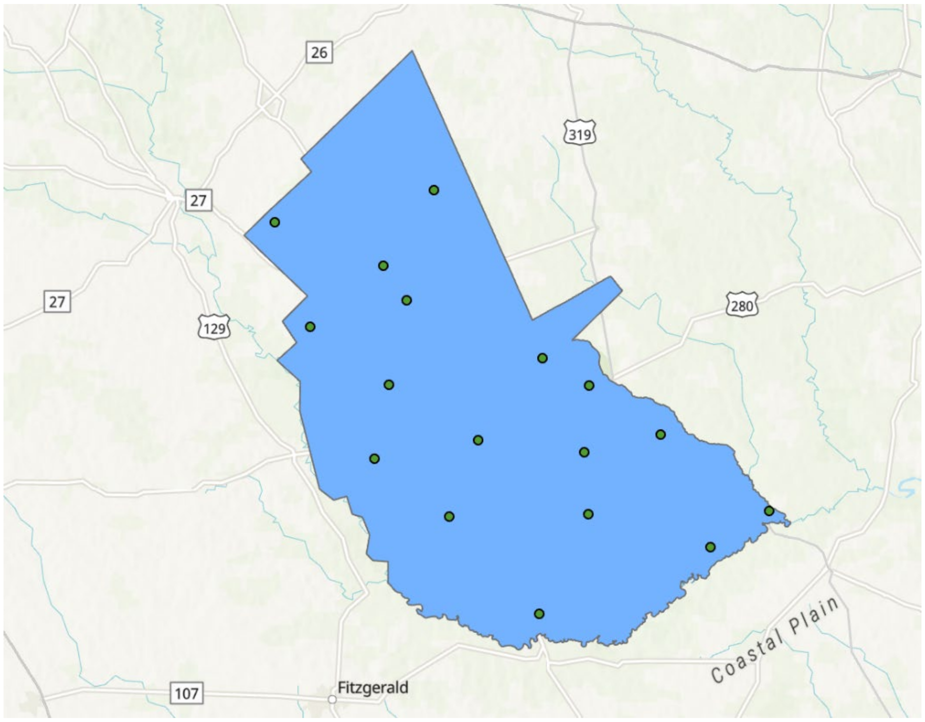

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BR05	358310.264	860275.654	384.537	VVA
BR07	374545.687	734969.45	312.618	VVA
BR09	395681.639	747430.024	290.92	VVA
BR10	398821.669	719164.884	294.952	VVA
HG04	346862.527	887785.777	328.295	VVA
HG05	315189.996	762576.045	244.093	VVA
HG06	309482.499	814459.166	295.303	VVA
HG09	423019.602	770366.437	212.906	VVA
HG10	393350.403	689844.209	216.359	VVA
TR05	332145.642	846566.785	323.386	VVA
TR06	360399.25	776216.464	311.401	VVA
TR08	424948.533	744099.426	228.32	VVA
TR09	357725.618	682851.845	203.318	VVA
TR10	437189.864	680397.698	208.5	VVA

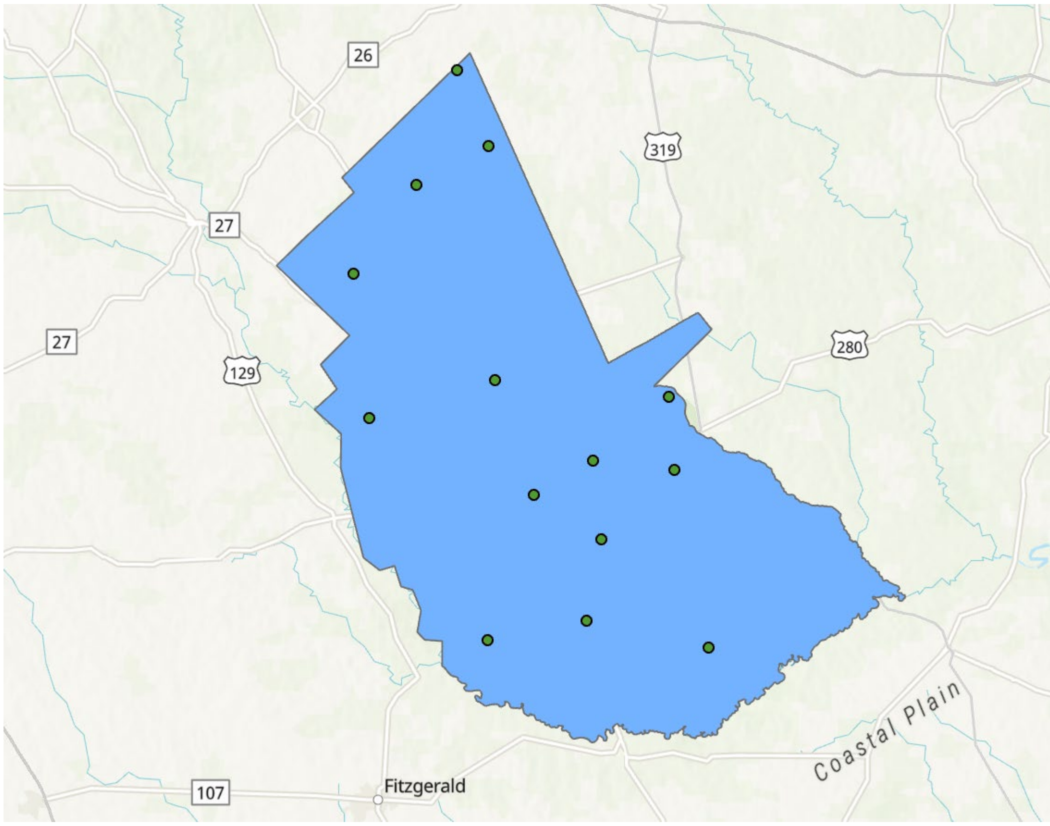

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Optech software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Applanix PosPac 8.5 is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD83 (2011)
Coordinate System	SPCS, GA East
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6445
Units of Reference	Feet (US Survey)

Table 6: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	19,124,398,355
Nominal Pulse Spacing (M)	0.6873
Nominal Pulse Density (PLS/M^2)	2.1171
Total Points (Aggregate)	19,130,288,726
Aggregate Pulse Spacing (FT)	1.3142
Aggregate Pulse Density (PLS/FT^2)	0.5790

Table 7: LiDAR Point Cloud Statistics

3.1.4 Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer.

3.1.5 LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤2cm. A final analysis of the calibrated lidar is preformed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity rasters (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

3.1.6 LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for class 9 (Water).

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
7	Low Point (“Low Noise”)
9	Water
10	Ignored ground (Breakline Proximity)
17	Bridge Decks
18	High Noise

Table 8: LiDAR Point Classification Codes and Descriptions

3.1.7 LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 2.5-feet cell size. The points flagged as withheld have been excluded from the processing of these images, and the valid points left in class 1 were included in the processing of these images as well. Intensity images were cut to match the tile index and its corresponding tile names and delivered in GeoTIFF format.

3.1.8 Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 2.5 feet. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point GeoTIFF format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 9: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

4.1.2 Results

An overall statistical assessment of the check points can be found in the following table (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	17	0.1295	0.2538	0.2282
NVA (DEM)	17	0.1397	0.2737	0.2251
VVA (Point Cloud)	14	0.4107	0.8050	0.6379
VVA (DEM)	14	0.3793	0.7434	0.2880

Table 10: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 Aerial LiDAR Project

This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.

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Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

American Society for Photogrammetry and Remote Sensing
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SECTION 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE07	360603.4470	836128.1500	358.0040	358.1100	0.1060	NVA
BE08	405513.9650	766699.5400	280.3600	280.5400	0.1800	NVA
BE09	309396.5570	779762.9460	246.3340	246.3100	-0.0240	NVA
BE12	366842.0010	701062.7550	324.2700	324.4900	0.2200	NVA
BE13	422772.1770	727706.9380	214.9050	214.9400	0.0350	NVA
BE14	424311.4860	702202.2930	217.4570	217.5600	0.1030	NVA
BR05	358310.2640	860275.6540	384.5370	384.6700	0.1330	VVA
BR07	374545.6870	734969.4500	312.6180	312.9200	0.3020	VVA
BR09	395681.6390	747430.0240	290.9200	291.0300	0.1100	VVA
BR10	398821.6690	719164.8840	294.9520	295.6100	0.6580	VVA
HG04	346862.5270	887785.7770	328.2950	328.3400	0.0450	VVA
HG05	315189.9960	762576.0450	244.0930	244.4800	0.3870	VVA
HG06	309482.4990	814459.1660	295.3030	295.9300	0.6270	VVA
HG09	423019.6020	770366.4370	212.9060	213.0700	0.1640	VVA
HG10	393350.4030	689844.2090	216.3590	216.9300	0.5710	VVA
OT07	294609.2910	822843.9020	311.7010	311.5200	-0.1810	NVA
OT08	349244.8620	790753.9590	351.5760	351.7500	0.1740	NVA
OT09	341949.1350	755657.0020	267.3460	267.4500	0.1040	NVA
OT11	454122.7510	735224.7040	255.1790	255.4400	0.2610	NVA
OT12	474929.4470	688411.1970	152.8240	152.9400	0.1160	NVA
OT13	378662.1750	732772.7390	287.4680	287.3700	-0.0980	NVA
TR05	332145.6420	846566.7850	323.3860	323.6400	0.2540	VVA
TR06	360399.2500	776216.4640	311.4010	311.4400	0.0390	VVA
TR08	424948.5330	744099.4260	228.3200	228.8400	0.5200	VVA
TR09	357725.6180	682851.8450	203.3180	202.6000	-0.7180	VVA
TR10	437189.8640	680397.6980	208.5000	208.7400	0.2400	VVA
UR07	335992.3730	725196.6350	242.2990	242.3000	0.0010	NVA
UR08	339396.7090	804766.9740	368.8270	368.8800	0.0530	NVA
UR11	424688.2710	755304.5230	248.3680	248.4400	0.0720	NVA
UR12	498995.9130	703563.1940	138.3640	138.4500	0.0860	NVA
UR13	403908.9540	661098.8420	197.3840	197.3700	-0.0140	NVA

Table 11: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Point Type
BE07	360603.4470	836128.1500	358.0040	358.1201	-0.1161	NVA
BE08	405513.9650	766699.5400	280.3600	280.5413	-0.1813	NVA
BE09	309396.5570	779762.9460	246.3340	246.1089	0.2251	NVA
BE12	366842.0010	701062.7550	324.2700	324.4980	-0.2280	NVA
BE13	422772.1770	727706.9380	214.9050	214.9967	-0.0917	NVA
BE14	424311.4860	702202.2930	217.4570	217.5394	-0.0824	NVA
OT07	294609.2910	822843.9020	311.7010	311.6142	0.0868	NVA
OT08	349244.8620	790753.9590	351.5760	351.7487	-0.1727	NVA
OT09	341949.1350	755657.0020	267.3460	267.4672	-0.1212	NVA
OT11	454122.7510	735224.7040	255.1790	255.3117	-0.1327	NVA
OT12	474929.4470	688411.1970	152.8240	152.8642	-0.0402	NVA
OT13	378662.1750	732772.7390	287.4680	287.3031	0.1649	NVA
UR07	335992.3730	725196.6350	242.2990	242.2900	0.0090	NVA
UR08	339396.7090	804766.9740	368.8270	368.7598	0.0672	NVA
UR11	424688.2710	755304.5230	248.3680	248.4744	-0.1064	NVA
UR12	498995.9130	703563.1940	138.3640	138.4121	-0.0481	NVA
UR13	403908.9540	661098.8420	197.3840	197.1588	0.2252	NVA
BR05	358310.2640	860275.6540	384.5370	384.6325	-0.0955	VVA
BR07	374545.6870	734969.4500	312.6180	312.8642	-0.2462	VVA
BR09	395681.6390	747430.0240	290.9200	291.0335	-0.1135	VVA
BR10	398821.6690	719164.8840	294.9520	295.5184	-0.5664	VVA
HG04	346862.5270	887785.7770	328.2950	328.2448	0.0502	VVA
HG05	315189.9960	762576.0450	244.0930	244.6325	-0.5395	VVA
HG06	309482.4990	814459.1660	295.3030	295.7349	-0.4319	VVA
HG09	423019.6020	770366.4370	212.9060	212.9560	-0.0500	VVA
HG10	393350.4030	689844.2090	216.3590	216.9226	-0.5636	VVA
TR05	332145.6420	846566.7850	323.3860	323.6286	-0.2426	VVA
TR06	360399.2500	776216.4640	311.4010	311.4370	-0.0360	VVA
TR08	424948.5330	744099.4260	228.3200	228.7631	-0.4431	VVA
TR09	357725.6180	682851.8450	203.3180	202.5886	0.7294	VVA
TR10	437189.8640	680397.6980	208.5000	208.6483	-0.1483	VVA

Table 12: DEM Check Point Assessment