



Project Report

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TASK ORDER NUMBER: 140G0219F0277

CONTRACT NUMBER: G16PC00042

ATLANTIC PROJECT NUMBER: 19064

BLOCK NUMBER: Block 1

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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS task order 140G0219F0277 required Winter 2019/Spring 2020 LiDAR surveys to be collected over 20,320 square miles covering part or all of 60 counties in Georgia and 6 counties in Alabama in support of the USGS 3DEP Program. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of ≤ 0.71 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.3. The Block 01 area encompasses approximately 2,583 square miles.

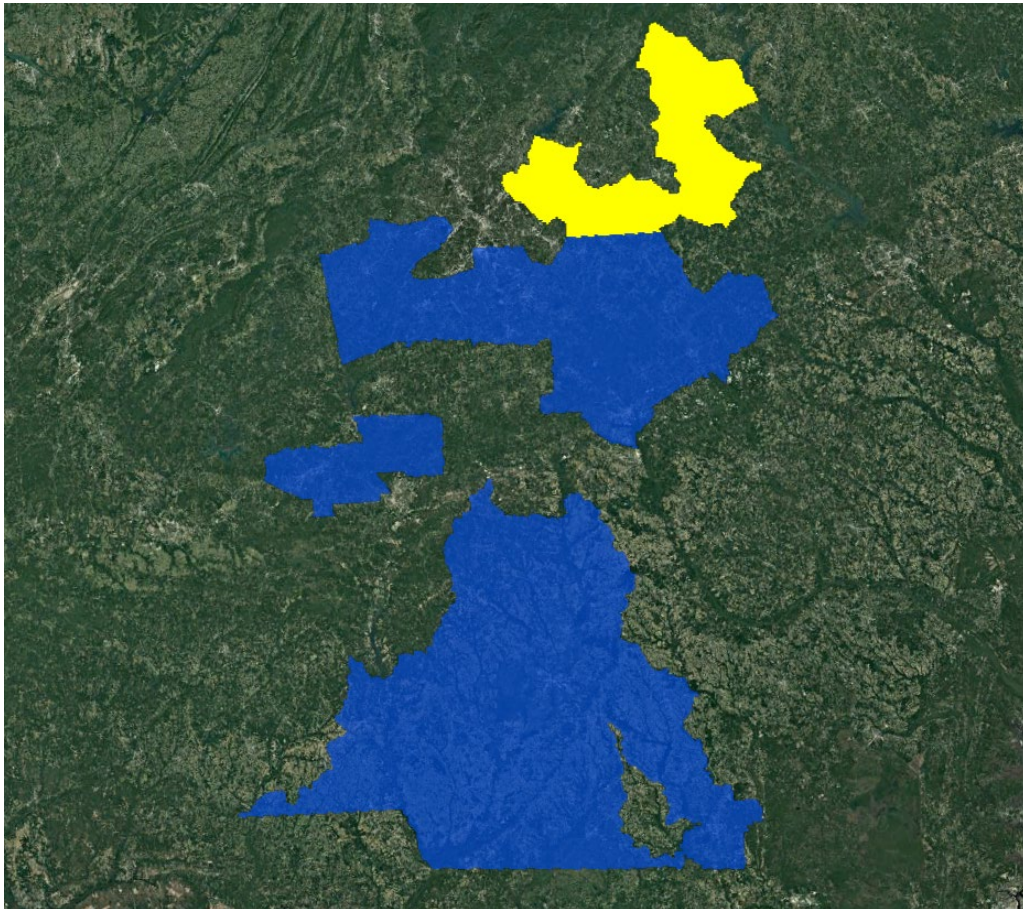


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) in Yellow and Associated Areas of Interest (AOIs) in Blue

1.1.2 Project Purpose

Aerial lidar was collected to support the mapping efforts of individual counties in the State of Georgia and Alabama and the USGS 3DEP program.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS v.14, tiled delivery
Bare Earth Surface	Raster DEM, 1m cell size, hydro flattened, GeoTIFF format
Breaklines	Hydro breaklines to BPA limit, .gdb format
Intensity Imagery	1m cell size, 8-bit, 256 gray scale, GeoTIFF format
Delivery Diagram	.gdb format
Metadata	Per product, FGDC compliant, .xml format
Project Report	Field work procedures, QC procedures and results, overall accuracy, .pdf format

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 PACDV (N750DV) outfitted with an Optech Galaxy Prime LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy Prime
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 PDU: 0.42 x 0.33 x 0.10 m, 6.5 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 Prime
Nominal Pulse Spacing (m)	0.64

Parameter	Specification
Nominal Pulse Density (pls/m ²)	2.44
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	150
Pass Heading (°)	W-E
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	60
Pulse Rate of Scanner (kHz)	350
Line Spacing (m)	1325.48
Pulse Width of Scanner (m)	1664
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	6
Beam Divergence (mrad)	0.25
Nominal Swath Width (m)	1657
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 144 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 10 flight missions conducted between January 8, 2020 and January 28, 2020. 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.

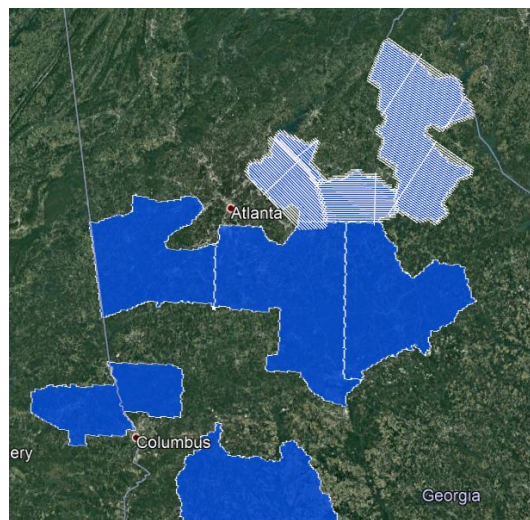


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Twenty (20) Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
ALCN	CORS	ALCN	N34°09'46.97942"	W85°39'31.04965"	164.904
ALHC	CORS	ALHC	N33°31'25.44554"	W85°38'05.50167"	256.548
ALLA	CORS	ALLA	N32°55'02.66210"	W85°24'01.80638"	237.158
FRKN	CORS	FRKN	N35°11'30.71115"	W83°23'41.77453"	619.541
GAAE	CORS	GAAE	N33°25'38.07518"	W82°04'04.06894"	124.363
GAAY	CORS	GAAY	N31°39'40.91991"	W84°16'29.65336"	55.889
GACA	CORS	GACA	N33°31'31.57947"	W85°06'27.80629"	287.242
GACC	CORS	GACC	N33°32'44.73033"	W82°08'01.72587"	98.476
GANO	CORS	GANO	N33°55'57.28318"	W84°08'59.31401"	282.933
GARS	CORS	GARS	N34°17'09.38895"	W83°06'36.12230"	252.863
GAWA	CORS	GAWA	N33°52'21.24009"	W83°25'31.59118"	198.64
GAWI	CORS	GAWI	N33°59'31.13926"	W83°43'06.14457"	278.291
NCMU	CORS	NCMU	N35°04'06.80197"	W83°57'59.38966"	474.779
NCRB	CORS	NCRB	N35°19'15.71699"	W83°47'48.71771"	605.321
NCSY	CORS	NCSY	N35°20'52.43245"	W83°12'23.41648"	643.773
P779	CORS	P779	N35°12'06.98938"	W82°52'20.93017"	878.734
P804	CORS	P804	N32°57'47.83548"	W84°13'32.72158"	216.363
P806	CORS	P806	N32°57'47.92284"	W84°13'33.05704"	215.865
SCGP	CORS	SCGP	N34°56'15.71362"	W82°13'57.29496"	278.011
ZTL4	CORS	ZTL4	N33°22'46.87805"	W84°17'48.21668"	260.682

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 105 ground survey points were collected in support of this project, including 24 LiDAR Control Points (LCP), 52 Non-vegetated Vertical Accuracy (NVA) and 29 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:

ID	Easting	Northing	Elevation
LCP01	1163340.692	1343198.926	225.363
LCP02	1181590.158	1346850.918	240.903
LCP03	1150779.863	1329481.046	252.662
LCP04	1173397.513	1330326.421	274.419
LCP05	1167144.409	1315820.335	230.534
LCP06	1156317.383	1318210.404	244.714
LCP07	1174867.071	1309184.671	223.566
LCP08	1155200.932	1300594.836	262.632
LCP09	1173061.867	1304490.53	228.178
LCP10	1194618.037	1292259.034	193.461
LCP11	1178954.785	1281904.361	225.024
LCP12	1183739.364	1274280.019	200.11
LCP13	1158552.105	1273835.068	217.114
LCP14	1139451.155	1280456.603	256.522
LCP15	1136198.554	1264902.481	242.493
LCP16	1114757.619	1274865.254	288.46

ID	Easting	Northing	Elevation
LCP17	1106211.132	1293654.99	339.055
LCP18	1100094.725	1286518.934	344.608
LCP19	1093809.589	1275888.625	271.055
LCP20	1094049.347	1263972.719	262.836
LCP23	1144780.664	1254147.14	224.806
LCP83	1125066.689	1265660.622	257.667
LCP84	1179593.169	1333480.167	279.253
LCP85	1100675.803	1266733.084	296.357

Table 5: LiDAR Control Point Coordinates

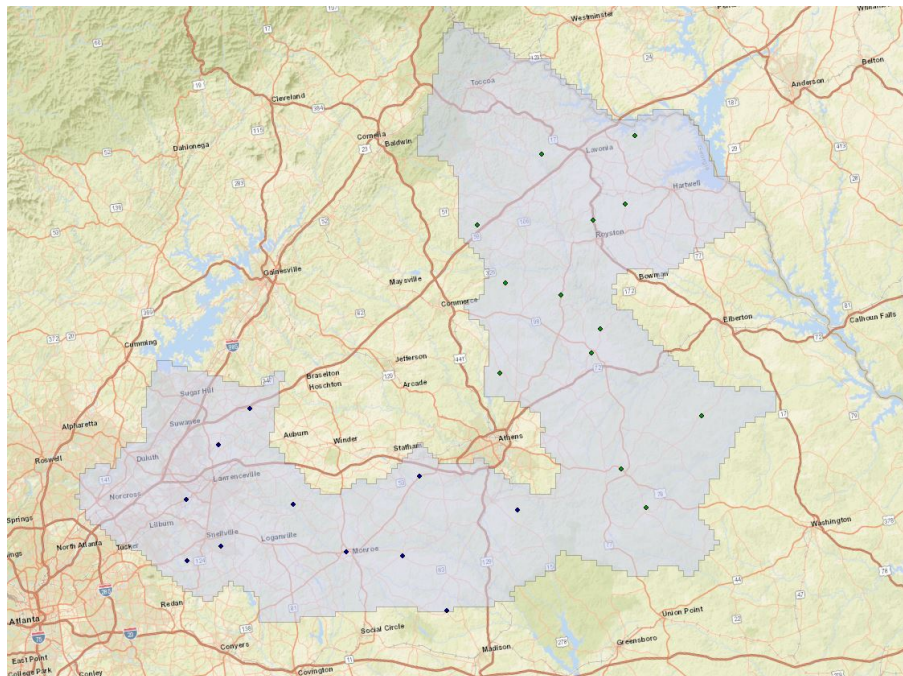


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE01	1150410.682	1358837.238	297.373
BE02	1159035.725	1346429.052	260.788
BE03	1176419.986	1341141.848	259.485
BE04	1192180.842	1330711.655	229.197
BE05	1167298.612	1326504.085	184.893

ID	Easting	Northing	Elevation
BE06	1159173.597	1311977.072	249.362
BE07	1162800.227	1300111.272	236.089
BE08	1179784.627	1303855.761	196.916
BE09	1198685.872	1292190.836	170.793
BE10	1188184.532	1279268.894	175.446
BE11	1173937.621	1272770.74	226.252
BE12	1152055.459	1274008.353	238.575
BE13	1117079.507	1267897.449	287.938
BE14	1099635.754	1282224.158	321.243
BE15	1091457.89	1298107.101	303.445
BE16	1079957.788	1274811.238	291.111
BE17	1096438.598	1261841.907	276.465
BE18	1139041.446	1255100.407	236.039
OT01	1146196.446	1347628.548	262.742
OT02	1169141.735	1346231.863	254.281
OT03	1184562.315	1334356.606	250.311
OT04	1170045.345	1312057.321	208.506
OT05	1190414.576	1289760.927	195.883
OT06	1180777.879	1269842.052	225.785
OT07	1158691.625	1268567.74	199.745
OT08	1135130.549	1274373.19	241.156
OT09	1108379.939	1274761.391	302.154
OT10	1102848.033	1293916.052	360.354
OT11	1114441.238	1255877.722	279.955
OT12	1129117.788	1259329.212	264.211
OT13	1151175.129	1256878.236	189.45
OT34	1092713.951	1270808.26	287.257
OT43	1174973.047	1287476.575	213.513
OT44	1154698.945	1333891.069	244.07
OT46	1084659.835	1282816.431	332.464
OT47	1141194.659	1266261.947	217.334
UR01	1158251.245	1355986.41	283.994
UR02	1188215.185	1346727.271	246.871
UR03	1167048.762	1339772.019	232.153
UR04	1159940.839	1324126.178	231.678
UR05	1177730.685	1324593.916	246.133

ID	Easting	Northing	Elevation
UR06	1192681.927	1336173.323	220.521
UR07	1158592.633	1305493.002	264.941
UR08	1175178.174	1296015.916	216.109
UR09	1187216.901	1295871.452	199.924
UR10	1175390.232	1276670.555	243.483
UR11	1187358.414	1269656.754	193.67
UR12	1149458.977	1268458.946	219.849
UR13	1130677.326	1268662.219	255.26
UR14	1099489.399	1273157.53	308.237
UR15	1092622.367	1286880.691	333.289
UR16	1105510.668	1282267.623	295.133

Table 6: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

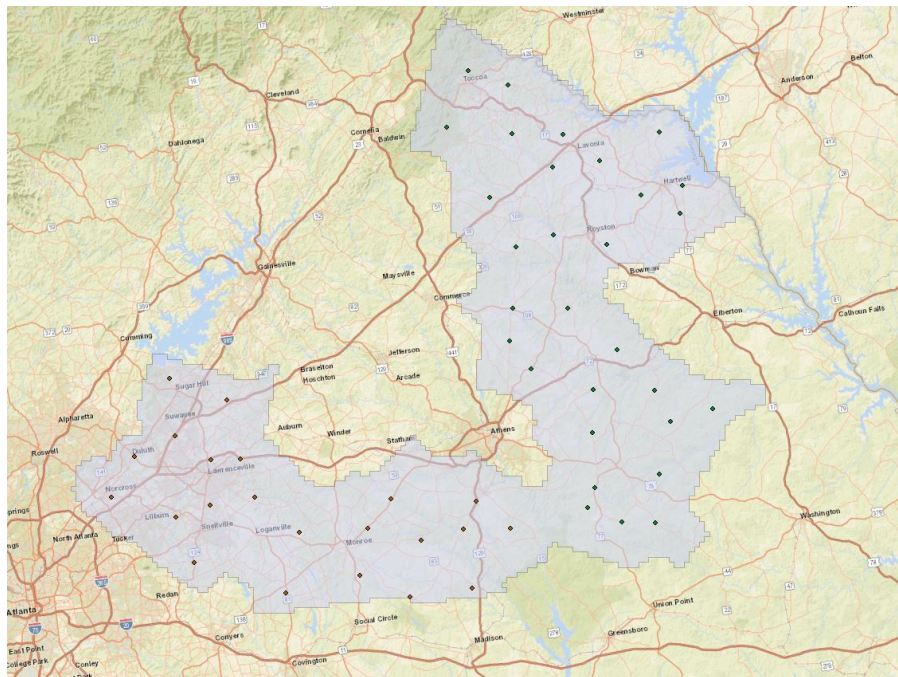


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR01	1163365.459	1350353.674	282.855
BR02	1159614.361	1337806.845	232

ID	Easting	Northing	Elevation
BR03	1187224.229	1325876.753	226.935
BR04	1173200.674	1319773.516	243.787
BR05	1168374.099	1305238.768	221.629
BR06	1178321.99	1292744.784	166.609
BR07	1179530.004	1278991.748	193.496
BR08	1144734.058	1260764.148	218.421
BR09	1121284.311	1260964.683	251.397
BR10	1084206.097	1271625.851	295.768
HG01	1162471.543	1330503.717	203.442
HG02	1198489.272	1331453.864	210.691
HG03	1163232.665	1310295.095	242.917
HG04	1167888.578	1290388.752	234.008
HG05	1190650.415	1285238.436	181.227
HG06	1153778.59	1264814.664	231.319
HG07	1127258.921	1270933.002	278.415
HG08	1095578.235	1292888.201	327.407
HG09	1111823.743	1262322.275	275.872
TR01	1153430.275	1351756.729	281.68
TR02	1153270.578	1342694.761	269.349
TR03	1183661.554	1340631.992	254.357
TR04	1172907.405	1333600.957	283.344
TR05	1162575.769	1319248.351	214.647
TR06	1181455.027	1286145.848	218.956
TR07	1167020.921	1272992.628	176.304
TR08	1145082.631	1275880.846	245.829
TR09	1106203.002	1265555.78	278.044
TR10	1089489.012	1278798.963	285.233

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

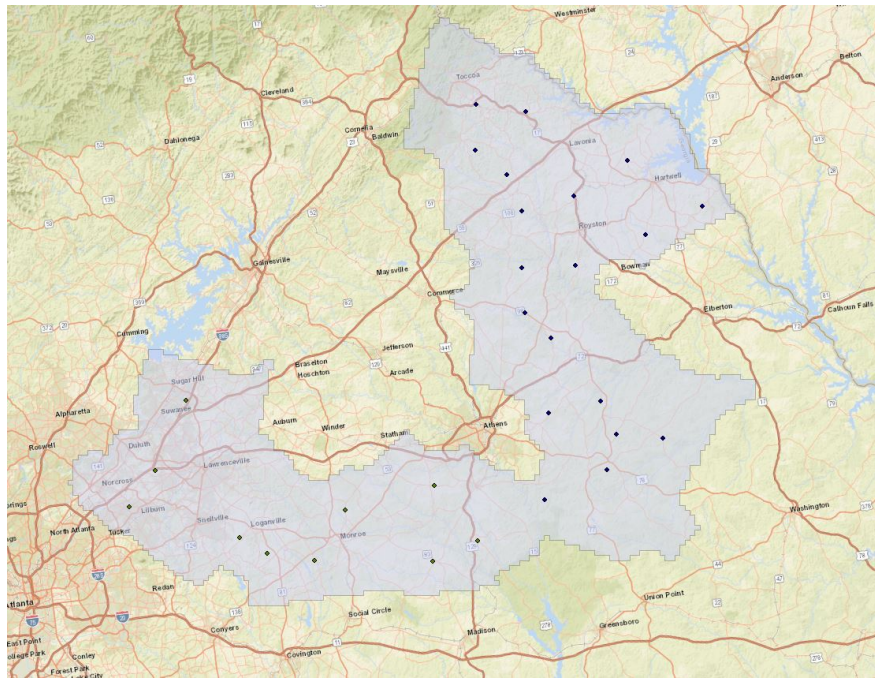


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer 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	Albers Equal Area
Coordinate System	NAD83 2011
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6350
Units of Reference	Meter

Table 8: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	28,666,893,826
Nominal Pulse Spacing (M)	0.6054
Nominal Pulse Density (PLS/M ²)	2.7283
Total Points (Aggregate)	22,974,212,187
Aggregate Pulse Spacing (M)	0.5746
Aggregate Pulse Density (PLS/M ²)	3.0288

Table 9: 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 $\leq 2\text{cm}$. 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 raster's (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 (0.5 – 5 feet)
4	Medium Vegetation (5 – 20 feet)
5	High Vegetation (>20 feet)
6	Buildings
7	Low Noise
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground (breakline proximity)
21	Snow (where reliable identifiable)
22	Temporal Exclusion (typically non-favored data in intertidal zones)

Table 10: 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 1-meter cell size. 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 1 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .tif 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 11: 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 two tables (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	52	0.0282	0.0552	0.0360
NVA (DEM)	52	0.0296	0.0580	0.0574
VVA (Point Cloud)	24	0.0596	0.1168	0.1045
VVA (DEM)	24	0.0600	0.1175	0.0226

Table 12: 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.



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276



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
BE01	1150410.6820	1358837.2380	297.3730	297.3960	0.0230	NVA
BE02	1159035.7250	1346429.0520	260.7880	260.8040	0.0160	NVA
BE03	1176419.9860	1341141.8480	259.4850	259.4810	-0.0040	NVA
BE04	1192180.8420	1330711.6550	229.1970	229.2330	0.0360	NVA
BE05	1167298.6120	1326504.0850	184.8930	184.8990	0.0060	NVA
BE06	1159173.5970	1311977.0720	249.3620	249.3450	-0.0170	NVA
BE07	1162800.2270	1300111.2720	236.0890	236.0320	-0.0570	NVA
BE08	1179784.6270	1303855.7610	196.9160	196.8730	-0.0430	NVA
BE09	1198685.8720	1292190.8360	170.7930	170.8040	0.0110	NVA
BE10	1188184.5320	1279268.8940	175.4460	175.4690	0.0230	NVA
BE11	1173937.6210	1272770.7400	226.2520	226.2360	-0.0160	NVA
BE12	1152055.4590	1274008.3530	238.5750	238.5870	0.0120	NVA
BE13	1117079.5070	1267897.4490	287.9380	287.9550	0.0170	NVA
BE14	1099635.7540	1282224.1580	321.2430	321.2360	-0.0070	NVA
BE15	1091457.8900	1298107.1010	303.4450	303.4340	-0.0110	NVA
BE16	1079957.7880	1274811.2380	291.1110	291.1470	0.0360	NVA
BE17	1096438.5980	1261841.9070	276.4650	276.4700	0.0050	NVA
BE18	1139041.4460	1255100.4070	236.0390	236.0110	-0.0280	NVA
BR01	1163365.4590	1350353.6740	282.8550	282.9330	0.0780	VVA
BR02	1159614.3610	1337806.8450	232.0000	232.0900	0.0900	VVA
BR03	1187224.2290	1325876.7530	226.9350	227.0040	0.0690	VVA
BR04	1173200.6740	1319773.5160	243.7870	243.7770	-0.0100	VVA
BR05	1168374.0990	1305238.7680	221.6290	221.6900	0.0610	VVA
BR06	1178321.9900	1292744.7840	166.6090	166.5970	-0.0120	VVA
BR07	1179530.0040	1278991.7480	193.4960	193.4980	0.0020	VVA
BR08	1144734.0580	1260764.1480	218.4210	218.5280	0.1070	VVA
BR10	1084206.0970	1271625.8510	295.7680	295.8470	0.0790	VVA
HG01	1162471.5430	1330503.7170	203.4420	203.5120	0.0700	VVA
HG02	1198489.2720	1331453.8640	210.6910	210.7440	0.0530	VVA
HG03	1163232.6650	1310295.0950	242.9170	242.9720	0.0550	VVA
HG04	1167888.5780	1290388.7520	234.0080	234.0510	0.0430	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
HG05	1190650.4150	1285238.4360	181.2270	181.2810	0.0540	VVA
HG06	1153778.5900	1264814.6640	231.3190	231.3840	0.0650	VVA
HG07	1127258.9210	1270933.0020	278.4150	278.4650	0.0500	VVA
HG08	1095578.2350	1292888.2010	327.4070	327.4930	0.0860	VVA
HG09	1111823.7430	1262322.2750	275.8720	275.9790	0.1070	VVA
OT01	1146196.4460	1347628.5480	262.7420	262.7610	0.0190	NVA
OT02	1169141.7350	1346231.8630	254.2810	254.2840	0.0030	NVA
OT03	1184562.3150	1334356.6060	250.3110	250.3780	0.0670	NVA
OT04	1170045.3450	1312057.3210	208.5060	208.5190	0.0130	NVA
OT05	1190414.5760	1289760.9270	195.8830	195.8920	0.0090	NVA
OT06	1180777.8790	1269842.0520	225.7850	225.8010	0.0160	NVA
OT07	1158691.6250	1268567.7400	199.7450	199.7420	-0.0030	NVA
OT08	1135130.5490	1274373.1900	241.1560	241.1520	-0.0040	NVA
OT09	1108379.9390	1274761.3910	302.1540	302.1840	0.0300	NVA
OT10	1102848.0330	1293916.0520	360.3540	360.3450	-0.0090	NVA
OT11	1114441.2380	1255877.7220	279.9550	279.9410	-0.0140	NVA
OT12	1129117.7880	1259329.2120	264.2110	264.2470	0.0360	NVA
OT13	1151175.1290	1256878.2360	189.4500	189.4550	0.0050	NVA
OT34	1092713.9510	1270808.2600	287.2570	287.2350	-0.0220	NVA
OT43	1174973.0470	1287476.5750	213.5130	213.5060	-0.0070	NVA
OT44	1154698.9450	1333891.0690	244.0700	244.0670	-0.0030	NVA
OT46	1084659.8350	1282816.4310	332.4640	332.4330	-0.0310	NVA
OT47	1141194.6590	1266261.9470	217.3340	217.3430	0.0090	NVA
TR02	1153270.5780	1342694.7610	269.3490	269.4030	0.0540	VVA
TR03	1183661.5540	1340631.9920	254.3570	254.3430	-0.0140	VVA
TR05	1162575.7690	1319248.3510	214.6470	214.6380	-0.0090	VVA
TR06	1181455.0270	1286145.8480	218.9560	218.9440	-0.0120	VVA
TR07	1167020.9210	1272992.6280	176.3040	176.3120	0.0080	VVA
TR08	1145082.6310	1275880.8460	245.8290	245.8420	0.0130	VVA
UR01	1158251.2450	1355986.4100	283.9940	284.0170	0.0230	NVA
UR02	1188215.1850	1346727.2710	246.8710	246.8910	0.0200	NVA
UR03	1167048.7620	1339772.0190	232.1530	232.1670	0.0140	NVA
UR04	1159940.8390	1324126.1780	231.6780	231.6620	-0.0160	NVA
UR05	1177730.6850	1324593.9160	246.1330	246.1440	0.0110	NVA
UR06	1192681.9270	1336173.3230	220.5210	220.5120	-0.0090	NVA
UR07	1158592.6330	1305493.0020	264.9410	264.8670	-0.0740	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR08	1175178.1740	1296015.9160	216.1090	216.0700	-0.0390	NVA
UR09	1187216.9010	1295871.4520	199.9240	199.9360	0.0120	NVA
UR10	1175390.2320	1276670.5550	243.4830	243.4450	-0.0380	NVA
UR11	1187358.4140	1269656.7540	193.6700	193.5890	-0.0810	NVA
UR12	1149458.9770	1268458.9460	219.8490	219.8420	-0.0070	NVA
UR13	1130677.3260	1268662.2190	255.2600	255.2570	-0.0030	NVA
UR14	1099489.3990	1273157.5300	308.2370	308.2230	-0.0140	NVA
UR15	1092622.3670	1286880.6910	333.2890	333.3010	0.0120	NVA
UR16	1105510.6680	1282267.6230	295.1330	295.1920	0.0590	NVA

Table 13: 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)	Report Point Type
BE01	1150410.6820	1358837.2380	297.3730	297.3940	-0.0210	NVA
BE02	1159035.7250	1346429.0520	260.7880	260.7982	-0.0102	NVA
BE03	1176419.9860	1341141.8480	259.4850	259.4765	0.0085	NVA
BE04	1192180.8420	1330711.6550	229.1970	229.2364	-0.0394	NVA
BE05	1167298.6120	1326504.0850	184.8930	184.8899	0.0031	NVA
BE06	1159173.5970	1311977.0720	249.3620	249.3474	0.0146	NVA
BE07	1162800.2270	1300111.2720	236.0890	236.0310	0.0580	NVA
BE08	1179784.6270	1303855.7610	196.9160	196.8590	0.0570	NVA
BE09	1198685.8720	1292190.8360	170.7930	170.7831	0.0099	NVA
BE10	1188184.5320	1279268.8940	175.4460	175.4703	-0.0243	NVA
BE11	1173937.6210	1272770.7400	226.2520	226.2320	0.0200	NVA
BE12	1152055.4590	1274008.3530	238.5750	238.5846	-0.0096	NVA
BE13	1117079.5070	1267897.4490	287.9380	287.9510	-0.0130	NVA
BE14	1099635.7540	1282224.1580	321.2430	321.2403	0.0027	NVA
BE15	1091457.8900	1298107.1010	303.4450	303.4202	0.0248	NVA
BE16	1079957.7880	1274811.2380	291.1110	291.1462	-0.0352	NVA
BE17	1096438.5980	1261841.9070	276.4650	276.4698	-0.0048	NVA
BE18	1139041.4460	1255100.4070	236.0390	236.0030	0.0360	NVA
OT01	1146196.4460	1347628.5480	262.7420	262.7769	-0.0349	NVA
OT02	1169141.7350	1346231.8630	254.2810	254.2959	-0.0149	NVA
OT03	1184562.3150	1334356.6060	250.3110	250.3895	-0.0785	NVA
OT04	1170045.3450	1312057.3210	208.5060	208.5161	-0.0101	NVA
OT05	1190414.5760	1289760.9270	195.8830	195.8959	-0.0129	NVA
OT06	1180777.8790	1269842.0520	225.7850	225.7958	-0.0108	NVA



Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
OT07	1158691.6250	1268567.7400	199.7450	199.7373	0.0077	NVA
OT08	1135130.5490	1274373.1900	241.1560	241.1587	-0.0027	NVA
OT09	1108379.9390	1274761.3910	302.1540	302.1885	-0.0345	NVA
OT10	1102848.0330	1293916.0520	360.3540	360.3428	0.0112	NVA
OT11	1114441.2380	1255877.7220	279.9550	279.9347	0.0203	NVA
OT12	1129117.7880	1259329.2120	264.2110	264.2458	-0.0348	NVA
OT13	1151175.1290	1256878.2360	189.4500	189.4585	-0.0085	NVA
OT34	1092713.9510	1270808.2600	287.2570	287.2368	0.0202	NVA
OT43	1174973.0470	1287476.5750	213.5130	213.5081	0.0049	NVA
OT44	1154698.9450	1333891.0690	244.0700	244.0649	0.0051	NVA
OT46	1084659.8350	1282816.4310	332.4640	332.4335	0.0305	NVA
OT47	1141194.6590	1266261.9470	217.3340	217.3419	-0.0079	NVA
UR01	1158251.2450	1355986.4100	283.9940	284.0203	-0.0263	NVA
UR02	1188215.1850	1346727.2710	246.8710	246.8664	0.0046	NVA
UR03	1167048.7620	1339772.0190	232.1530	232.1497	0.0033	NVA
UR04	1159940.8390	1324126.1780	231.6780	231.6663	0.0117	NVA
UR05	1177730.6850	1324593.9160	246.1330	246.1418	-0.0088	NVA
UR06	1192681.9270	1336173.3230	220.5210	220.5097	0.0113	NVA
UR07	1158592.6330	1305493.0020	264.9410	264.8721	0.0689	NVA
UR08	1175178.1740	1296015.9160	216.1090	216.0745	0.0345	NVA
UR09	1187216.9010	1295871.4520	199.9240	199.9461	-0.0221	NVA
UR10	1175390.2320	1276670.5550	243.4830	243.4459	0.0371	NVA
UR11	1187358.4140	1269656.7540	193.6700	193.5840	0.0860	NVA
UR12	1149458.9770	1268458.9460	219.8490	219.8446	0.0044	NVA
UR13	1130677.3260	1268662.2190	255.2600	255.2627	-0.0027	NVA
UR14	1099489.3990	1273157.5300	308.2370	308.2171	0.0199	NVA
UR15	1092622.3670	1286880.6910	333.2890	333.3037	-0.0147	NVA
UR16	1105510.6680	1282267.6230	295.1330	295.1842	-0.0512	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR01	1163365.4590	1350353.6740	282.8550	282.9400	-0.0850	VVA
BR02	1159614.3610	1337806.8450	232.0000	232.0866	-0.0866	VVA
BR03	1187224.2290	1325876.7530	226.9350	227.0019	-0.0669	VVA
BR04	1173200.6740	1319773.5160	243.7870	243.7845	0.0025	VVA
BR05	1168374.0990	1305238.7680	221.6290	221.6984	-0.0694	VVA
BR06	1178321.9900	1292744.7840	166.6090	166.5808	0.0282	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR07	1179530.0040	1278991.7480	193.4960	193.5078	-0.0118	VVA
BR08	1144734.0580	1260764.1480	218.4210	218.5395	-0.1185	VVA
BR10	1084206.0970	1271625.8510	295.7680	295.8465	-0.0785	VVA
HG01	1162471.5430	1330503.7170	203.4420	203.5470	-0.1050	VVA
HG02	1198489.2720	1331453.8640	210.6910	210.7491	-0.0581	VVA
HG03	1163232.6650	1310295.0950	242.9170	242.9701	-0.0531	VVA
HG04	1167888.5780	1290388.7520	234.0080	234.0599	-0.0519	VVA
HG05	1190650.4150	1285238.4360	181.2270	181.2896	-0.0626	VVA
HG06	1153778.5900	1264814.6640	231.3190	231.3651	-0.0461	VVA
HG07	1127258.9210	1270933.0020	278.4150	278.4827	-0.0677	VVA
HG08	1095578.2350	1292888.2010	327.4070	327.4451	-0.0381	VVA
HG09	1111823.7430	1262322.2750	275.8720	275.9562	-0.0842	VVA
TR02	1153270.5780	1342694.7610	269.3490	269.3850	-0.0360	VVA
TR03	1183661.5540	1340631.9920	254.3570	254.3471	0.0099	VVA
TR05	1162575.7690	1319248.3510	214.6470	214.6405	0.0065	VVA
TR06	1181455.0270	1286145.8480	218.9560	218.9311	0.0249	VVA
TR07	1167020.9210	1272992.6280	176.3040	176.3097	-0.0057	VVA
TR08	1145082.6310	1275880.8460	245.8290	245.8282	0.0008	VVA

Table 14: DEM Check Point Assessment