atlantic

Project Report

TASK ORDER NAME: MS_NRCS_East_2018_B19
TASK ORDER NUMBER: 140G021F0262
CONTRACT NUMBER: G16PC00042
ATLANTIC PROJECT NUMBER: 19059

TABLE OF CONTENTS

SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS NGTOC task order 140G0219F0262 required Fall 2019 / Spring 2020 leaf-off LiDAR surveys to be collected over 6,245 square miles covering parts of Eastern and Central Mississippi. 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.

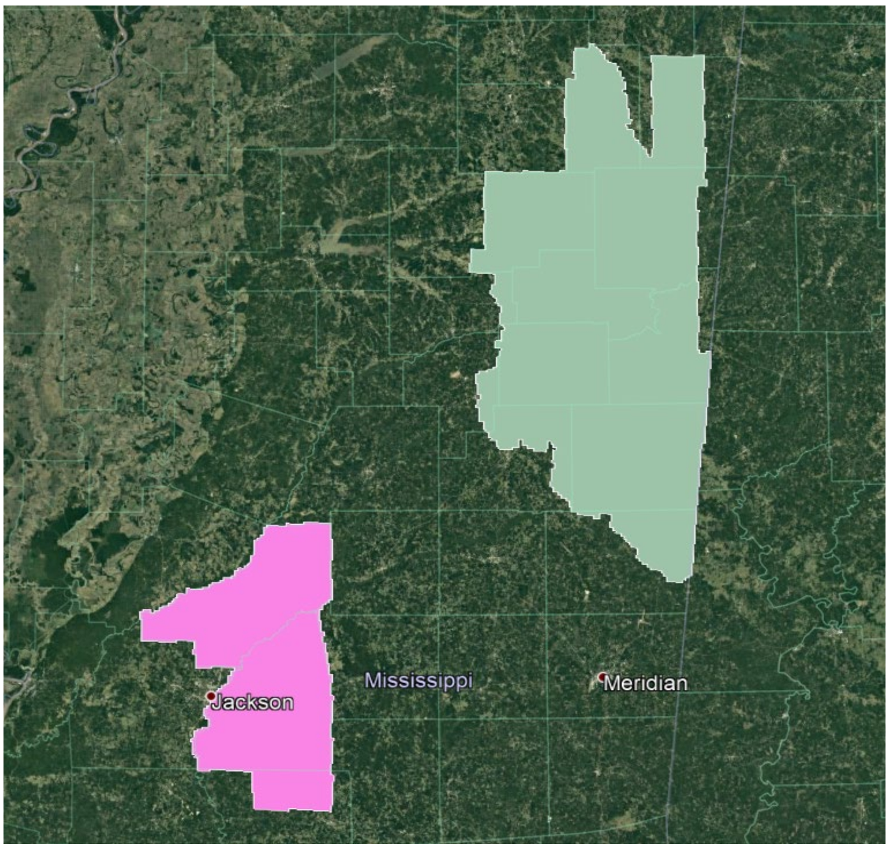

Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

1.1.2 Project Purpose

This task order is for planning, acquisition, processing, and derivative products of lidar data to be collected at an aggregate nominal pulse spacing of ≤0.71 meters, including overlap and an aggregate nominal pulse density of no less than 2 points per square meter. Lidar data and derivative products produced in compliance with this task order are based on the *"National Geospatial Program Lidar Base Specification Version 1.3"*. This project will support the 3DEP mission and the Natural Resources Conservation Service (NRCS) high resolution elevation enterprise program.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS, version 1.4, Point Record Format 6
Bare Earth Surface (Raster DEM) - Hydro	32Bit, floating point, .IMG, 1.0M cell size
Hydro Breaklines	ESRI file geodatabase (polylineZ and polygonZ feature classes)
Intensity Image	8-bit, 256 color gray scale, TIF, 1.0 M cell size
Contours	1-foot, smoothed (automated), ESRI file geodatabase
Building Footprints	Automated, ESRI file geodatabase
Delivery Diagram	ESRI shapefile
Product Metadata	XML, FGDC compliant
Flight Index	ESRI file geodatabase
Swath Data	ESRI file geodatabase
Difference Rasters	.TIF, 2.0 M cell size
Dataset Extents	ESRI shapefile
Project Report	PDF (Acquisition, Survey, Processing, QA/QC)
Tile Scheme	UTM Tiling Scheme, 1500M x 1500M
Tile Naming	US National Grid Conventions
Spatial Reference System	Universal Transverse Mercator Zone 15/16 (as appropriate), Meters; NAVD88, Meters, latest Geoid model, EPSG code 6344/6345

Table 1: Aerial LiDAR Contract Deliverables – Lots 6, 7a, 7b, and 8 Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a PAC 750 (N750VX) 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)	.65
Nominal Pulse Density (pls/m²)	2.32
Nominal Flight Height (AGL meters)	2118
Nominal Flight Speed (kts)	130
Pass Heading (°)	Cardinal
Sensor Scan Angle (°)	40
Scan Frequency (Hz)	51
Pulse Rate of Scanner (kHz)	250
Line Spacing (m)	1100
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	4
Beam Divergence (mrad)	.25
Nominal Swath Width (m)	1439
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 65 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 5 flight missions conducted between January 9, 2020 and January 14, 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.

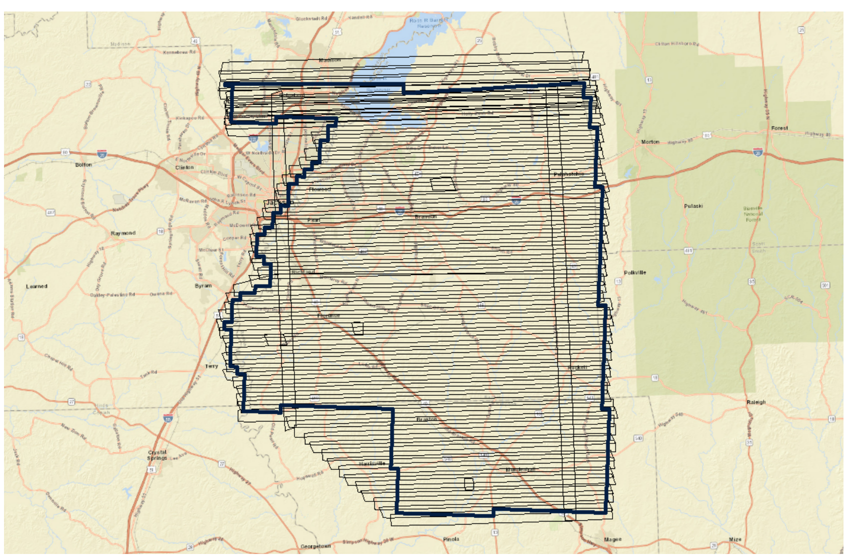

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Twenty-Eight (28) 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
1ULM	CORS	1ULM	N32°31'44.52047"	W92°04'33.26902"	15.946
AL23	CORS	AL23	N34°08'54.86892"	W87°57'13.05382"	141.234
AL81	CORS	AL81	N32°34'32.56556"	W88°10'54.32820"	21.105
ALBE	CORS	ALBE	N34°28'31.51982"	W87°51'52.39823"	226.449
ALBU	CORS	ALBU	N32°04'53.91593"	W88°13'59.36284"	16.852
ALFA	CORS	ALFA	N33°41'06.76668"	W87°49'45.54065"	89.166
ARMO	CORS	ARMO	N33°35'40.41810"	W91°48'47.53184"	52.647
MSBN	CORS	MSBN	N31°36'30.35371"	W90°24'34.01893"	125.979
MSBV	CORS	MSBV	N34°39'56.48359"	W88°33'51.51693"	128.612
MSCR	CORS	MSCR	N34°54'23.34342"	W88°32'52.90301"	110.472
MSCT	CORS	MSCT	N32°43'06.65966"	W89°34'17.24910"	85.588
MSEU	CORS	MSEU	N33°32'53.20694"	W89°10'56.99356"	94.83
MSEV	CORS	MSEV	N31°35'42.10104"	W89°12'13.30620"	52.399
MSFL	CORS	MSFL	N34°16'36.56328"	W88°24'55.00177"	75.943
MSGN	CORS	MSGN	N33°20'19.32472"	W91°02'27.47208"	16.295
MSGR	CORS	MSGR	N33°45'50.45050"	W89°49'15.94723"	54.237
MSHS	CORS	MSHS	N34°44'36.31948"	W89°27'12.73029"	153.283
MSJK	CORS	MSJK	N32°19'37.40112"	W90°10'52.80969"	86.498
MSLV	CORS	MSLV	N33°06'27.74211"	W89°04'26.82775"	140.23
MSME	CORS	MSME	N32°22'03.04229"	W88°43'56.81048"	101.878
MSOX	CORS	MSOX	N34°21'50.95182"	W89°31'56.54986"	141.876
MSPE	CORS	MSPE	N33°47'52.35270"	W88°39'30.14101"	75.323
MSPN	CORS	MSPN	N34°14'36.58661"	W89°01'00.68057"	118.394
MSSB	CORS	MSSB	N32°49'46.39663"	W88°29'13.95548"	50.529
MSST	CORS	MSST	N33°27'14.19501"	W88°47'39.13821"	100.103
MSYZ	CORS	MSYZ	N32°50'46.89732"	W90°24'43.10002"	23.04
SIHS	CORS	SIHS	N31°50'36.17712"	W91°39'19.59495"	5.736
TALL	CORS	TALL	N32°24'01.21579"	W91°10'58.84562"	6.074

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 64 ground survey points were collected in support of this project, including 9 LiDAR Control Points (LCP), 32 Non-vegetated Vertical Accuracy (NVA) and 23 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
LCP069	581541.082	1048700.761	118.020	LCP
LCP070	568532.184	1044626.016	132.164	LCP
LCP071	583535.554	1038759.291	148.301	LCP
LCP072	586220.884	1020327.431	103.886	LCP
LCP073	575529.730	1026204.761	117.161	LCP
LCP074	567638.590	1012482.509	114.037	LCP
LCP075	582997.636	1006563.796	161.402	LCP
LCP076	545821.954	1026858.873	115.680	LCP
LCP083	557695.246	1021508.810	113.270	LCP
BE040	545817.072	1026863.040	115.693	NVA
BE056	581535.496	1048702.928	117.811	NVA
BE057	568523.459	1044626.060	131.817	NVA
BE058	583543.773	1038762.043	148.237	NVA
BE059	575532.088	1026211.453	116.809	NVA
BE060	586227.582	1020327.406	103.515	NVA
BE061	582984.492	1006556.636	160.704	NVA
BE062	567630.146	1012484.227	114.108	NVA
BE063	585012.302	1034144.688	135.051	NVA
OT047	559443.884	1048817.351	111.361	NVA
OT051	542283.782	1055211.087	118.608	NVA
OT053	548020.646	1032856.736	88.938	NVA

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
OT054	543457.154	1015339.380	78.534	NVA
OT059	550961.458	1018175.344	92.225	NVA
OT060	579845.474	1043332.208	115.473	NVA
OT061	585012.611	1034134.764	134.903	NVA
OT062	582622.381	1021815.748	105.697	NVA
OT063	566202.627	1033417.684	122.677	NVA
OT064	575438.392	1019572.157	104.123	NVA
OT065	564869.474	1006503.116	124.738	NVA
OT072	570048.421	1037157.852	132.958	NVA
OT073	569713.592	1017743.360	112.395	NVA
UR053	557695.510	1021501.157	113.444	NVA
UR054	564337.963	1028185.013	107.663	NVA
UR056	548206.071	1053514.732	94.406	NVA
UR068	563540.324	1050564.261	105.392	NVA
UR069	555927.382	1047390.109	97.327	NVA
UR070	550561.704	1040379.228	84.246	NVA
UR071	557487.612	1041004.387	110.815	NVA
UR072	563473.466	1040036.051	138.256	NVA
UR073	574382.454	1041778.113	114.201	NVA
UR074	580157.419	1043489.270	115.022	NVA
BR045	578259.885	1055007.373	112.865	VVA
BR046	584181.546	1047598.118	121.420	VVA
BR047	577194.221	1038194.511	143.942	VVA
BR048	581793.687	1033777.614	148.873	VVA
BR049	579274.397	1017464.807	107.265	VVA
BR050	555238.041	1030403.360	133.374	VVA
BR051	569706.144	1017723.200	112.460	VVA
HG049	573096.917	1051206.672	98.773	VVA
HG050	575255.437	1044831.074	110.017	VVA
HG051	543654.137	1024866.956	89.594	VVA
HG052	582246.028	1026083.588	119.855	VVA
HG053	586833.107	1011803.698	160.934	VVA
HG054	569179.515	1002587.652	109.133	VVA
HG055	560701.830	1024574.347	112.053	VVA
HG058	566371.666	1022380.868	116.207	VVA
TR048	582827.904	1052837.399	136.825	VVA
TR049	568424.878	1048494.527	100.319	VVA
TR050	570029.617	1037151.873	133.007	VVA
TR051	545755.063	1020575.288	80.667	VVA
TR052	581571.707	1015761.521	113.652	VVA
TR053	577568.811	1006900.219	118.704	VVA
TR054	566365.011	1022353.012	116.676	VVA
TR059	568546.136	1044619.322	131.884	VVA

Table 5: LiDAR Control/Check Point Coordinates

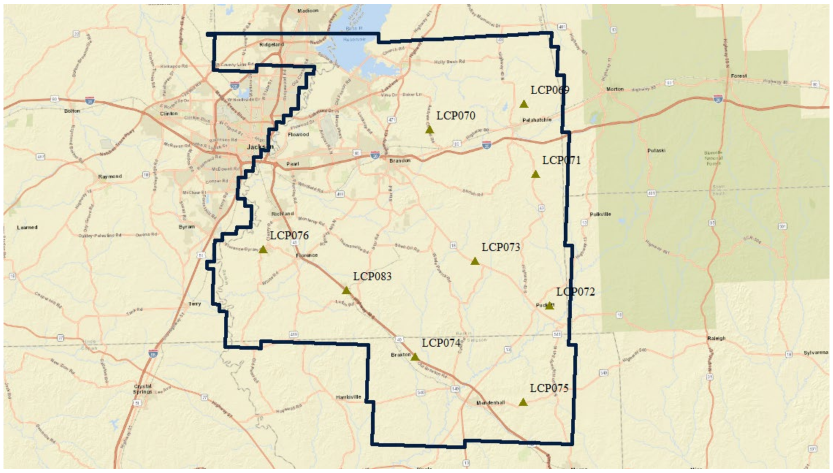

Figure 3: LiDAR Control Point Distribution

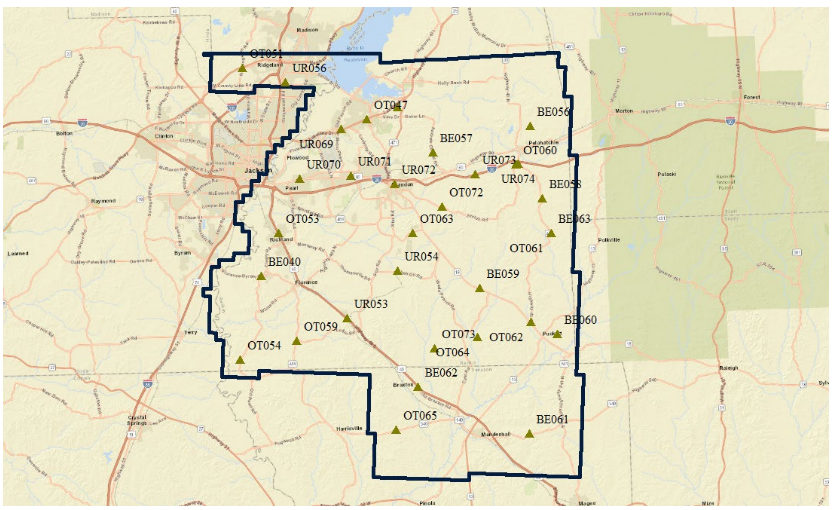

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

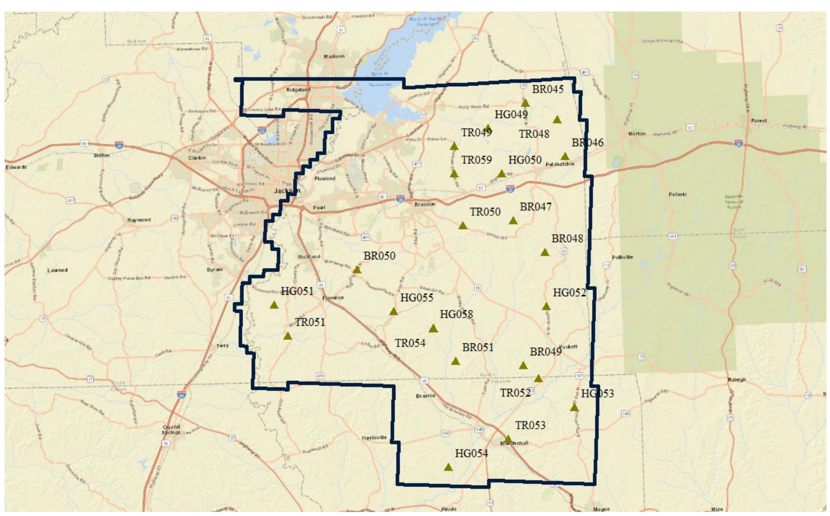

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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	UTM 16 NORTH
Coordinate System	NAD83 2011
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6345
Units of Reference	METERS

Table 6: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	6,322,833,209
Nominal Pulse Spacing (M)	0.5374
Nominal Pulse Density (PLS/M^2)	3.4621
Total Points (Aggregate)	6,322,833,209
Aggregate Pulse Spacing (M)	0.5084
Aggregate Pulse Density (PLS/M^2)	3.8686

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	Unclassified
2	Ground
6	Building
7	Low Point (“Low Noise”)
9	Water
17	Bridge Deck
18	Low Point (“High Noise”)
20	Breakline Proximity

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 1.0-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .img 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 GeoTIFF format.

3.1.10 Contours

Contours for this project were generated utilizing Model Key Points LiDAR point cloud data. Contours were generated at 1.0’ (foot) intervals, with 1.0’ contours designated as intermediate and every fifth contour interval as index contours. Contour data was delivered as an ESRI geodatabase.

3.1.11 Building Footprint Extractions

Building Footprints were derived from lidar points classified as buildings. Building rooftop polygons for features 400 square feet and larger were extracted from automated building classification algorithms performed on the lidar point cloud data. Omission/Commission errors will exist. Rooftop outlines may appear “generalized” or incomplete in certain areas where vegetation or other artifacts are present in the data. This product was delivered as an ESRI geodatabase (.gdb) for the entire block area.

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 Choose an item.

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 two tables (values provided in meters):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	21	0.0390	0.0765	0.0360
NVA (DEM)	21	0.0580	0.1137	0.1240
VVA (Point Cloud)	18	0.0570	0.1117	0.1035
VVA (DEM)	18	0.0470	0.0921	0.0736

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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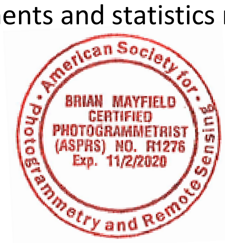
Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276



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
BE056	237827.6060	3581540.8020	117.8110	117.8160	0.0050	NVA
BE057	224421.5800	3578685.0510	131.8170	131.8370	0.0200	NVA
BE058	238929.2300	3571506.0530	148.2370	148.1910	-0.0460	NVA
BE059	229759.2860	3559794.5500	116.8090	116.8010	-0.0080	NVA
BE060	239931.0620	3552988.6420	103.5150	103.4670	-0.0480	NVA
BE061	235427.0220	3539629.9610	160.7040	160.6820	-0.0220	NVA
BE062	220595.3450	3546901.8450	114.1080	114.1070	-0.0010	NVA
BE063	239977.4540	3566795.8870	135.0510	135.0170	-0.0340	NVA
BR045	235123.7130	3588086.5840	112.8650	112.8800	0.0150	VVA
BR046	240376.6900	3580204.8320	121.4200	121.4710	0.0510	VVA
BR048	236720.7790	3566725.0830	148.8730	148.9450	0.0720	VVA
BR049	232708.0700	3550782.9140	107.2650	107.2790	0.0140	VVA
BR051	223151.3120	3551908.2480	112.4600	112.4420	-0.0180	VVA
HG049	229604.1860	3584790.5920	98.7730	98.8720	0.0990	VVA
HG050	231183.2790	3578275.6710	110.0170	110.0730	0.0560	VVA
HG052	236470.5060	3559057.2140	119.8550	119.8550	0.0000	VVA
HG053	239758.6370	3544482.8710	160.9340	160.9560	0.0220	VVA
HG054	221245.5390	3536946.9810	109.1330	109.2620	0.1290	VVA
HG058	220236.8270	3556829.0240	116.2070	116.2590	0.0520	VVA
OT060	235643.4670	3576372.2810	115.4730	115.5010	0.0280	NVA
OT061	239976.8560	3566786.0230	134.9030	134.8620	-0.0410	NVA
OT062	236457.4380	3554792.1020	105.6970	105.7330	0.0360	NVA
OT063	221073.8850	3567786.1530	122.6770	122.6610	-0.0160	NVA
OT064	229059.5700	3553220.8540	104.1230	104.1650	0.0420	NVA
OT065	217286.8190	3541220.8840	124.7380	124.7280	-0.0100	NVA
OT072	225266.9670	3571144.1030	132.9580	132.9720	0.0140	NVA
OT073	223160.6070	3551927.5610	112.3950	112.3430	-0.0520	NVA
TR048	239500.6700	3585520.0070	136.8250	136.8540	0.0290	VVA
TR049	224676.2510	3582528.0220	100.3190	100.3710	0.0520	VVA
TR050	225247.5880	3571139.8870	133.0070	133.0030	-0.0040	VVA
TR052	234852.6640	3548885.3510	113.6520	113.7150	0.0630	VVA
TR053	230036.8930	3540462.5540	118.7040	118.6740	-0.0300	VVA
TR054	220227.6240	3556802.0100	116.6760	116.7620	0.0860	VVA
TR059	224443.6790	3578676.3100	131.8840	131.8480	-0.0360	VVA
UR054	218729.2230	3562768.0990	107.6630	107.5660	-0.0970	NVA
UR068	219972.2530	3585023.5910	105.3920	105.3480	-0.0440	NVA
UR072	218944.1950	3574594.6890	138.2560	138.1870	-0.0690	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
UR073	230029.8310	3575329.3470	114.2010	114.2050	0.0040	NVA
UR074	235970.2620	3576499.5300	115.0220	114.9990	-0.0230	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)	Report Point Type
BE056	237827.6060	3581540.8020	117.8110	117.8140	-0.0030	NVA
BE057	224421.5800	3578685.0510	131.8170	131.8100	0.0070	NVA
BE058	238929.2300	3571506.0530	148.2370	148.2030	0.0340	NVA
BE059	229759.2860	3559794.5500	116.8090	116.7960	0.0130	NVA
BE060	239931.0620	3552988.6420	103.5150	103.3830	0.1320	NVA
BE061	235427.0220	3539629.9610	160.7040	160.6800	0.0240	NVA
BE062	220595.3450	3546901.8450	114.1080	114.0680	0.0400	NVA
BE063	239977.4540	3566795.8870	135.0510	134.9270	0.1240	NVA
OT060	235643.4670	3576372.2810	115.4730	115.4610	0.0120	NVA
OT061	239976.8560	3566786.0230	134.9030	134.8740	0.0290	NVA
OT062	236457.4380	3554792.1020	105.6970	105.7150	-0.0180	NVA
OT063	221073.8850	3567786.1530	122.6770	122.6580	0.0190	NVA
OT064	229059.5700	3553220.8540	104.1230	104.1420	-0.0190	NVA
OT065	217286.8190	3541220.8840	124.7380	124.7220	0.0160	NVA
OT072	225266.9670	3571144.1030	132.9580	132.8760	0.0820	NVA
OT073	223160.6070	3551927.5610	112.3950	112.3270	0.0680	NVA
UR054	218729.2230	3562768.0990	107.6630	107.5710	0.0920	NVA
UR068	219972.2530	3585023.5910	105.3920	105.3250	0.0670	NVA
UR072	218944.1950	3574594.6890	138.2560	138.1730	0.0830	NVA
UR073	230029.8310	3575329.3470	114.2010	114.1860	0.0150	NVA
UR074	235970.2620	3576499.5300	115.0220	114.9970	0.0250	NVA
BR045	235123.7130	3588086.5840	112.8650	112.8410	0.0240	VVA
BR046	240376.6900	3580204.8320	121.4200	121.4490	-0.0290	VVA
BR048	236720.7790	3566725.0830	148.8730	148.8950	-0.0220	VVA
BR049	232708.0700	3550782.9140	107.2650	107.2290	0.0360	VVA
BR051	223151.3120	3551908.2480	112.4600	112.3880	0.0720	VVA
HG049	229604.1860	3584790.5920	98.7730	98.8040	-0.0310	VVA
HG050	231183.2790	3578275.6710	110.0170	110.0790	-0.0620	VVA
HG052	236470.5060	3559057.2140	119.8550	119.8580	-0.0030	VVA
HG053	239758.6370	3544482.8710	160.9340	160.9480	-0.0140	VVA
HG054	221245.5390	3536946.9810	109.1330	109.2120	-0.0790	VVA
HG058	220236.8270	3556829.0240	116.2070	116.2300	-0.0230	VVA
TR048	239500.6700	3585520.0070	136.8250	136.8160	0.0090	VVA
TR049	224676.2510	3582528.0220	100.3190	100.3810	-0.0620	VVA
TR050	225247.5880	3571139.8870	133.0070	132.9800	0.0270	VVA
TR052	234852.6640	3548885.3510	113.6520	113.7140	-0.0620	VVA
TR053	230036.8930	3540462.5540	118.7040	118.6210	0.0830	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
TR054	220227.6240	3556802.0100	116.6760	116.6450	0.0310	VVA
TR059	224443.6790	3578676.3100	131.8840	131.8270	0.0570	VVA

Table 12: DEM Check Point Assessment