Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 7B

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SECTION I: PROJECT OVERVIEW & PURPOSE

1. Aerial LiDAR Project

a. Project Overview

The State of Kansas Contract 00000000000000000000039891 required Leaf-off 2018 QL 2 LiDAR surveys to be collected over 54,663 square miles covering part or all of 86 counties in Kansas in support of the Kansas Department of Agriculture and Kansas Data Access and Support Center. 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 1.2. Project Block 7B encompasses part or all of 6 counties in Kansas and covers approximately 1936 square miles.

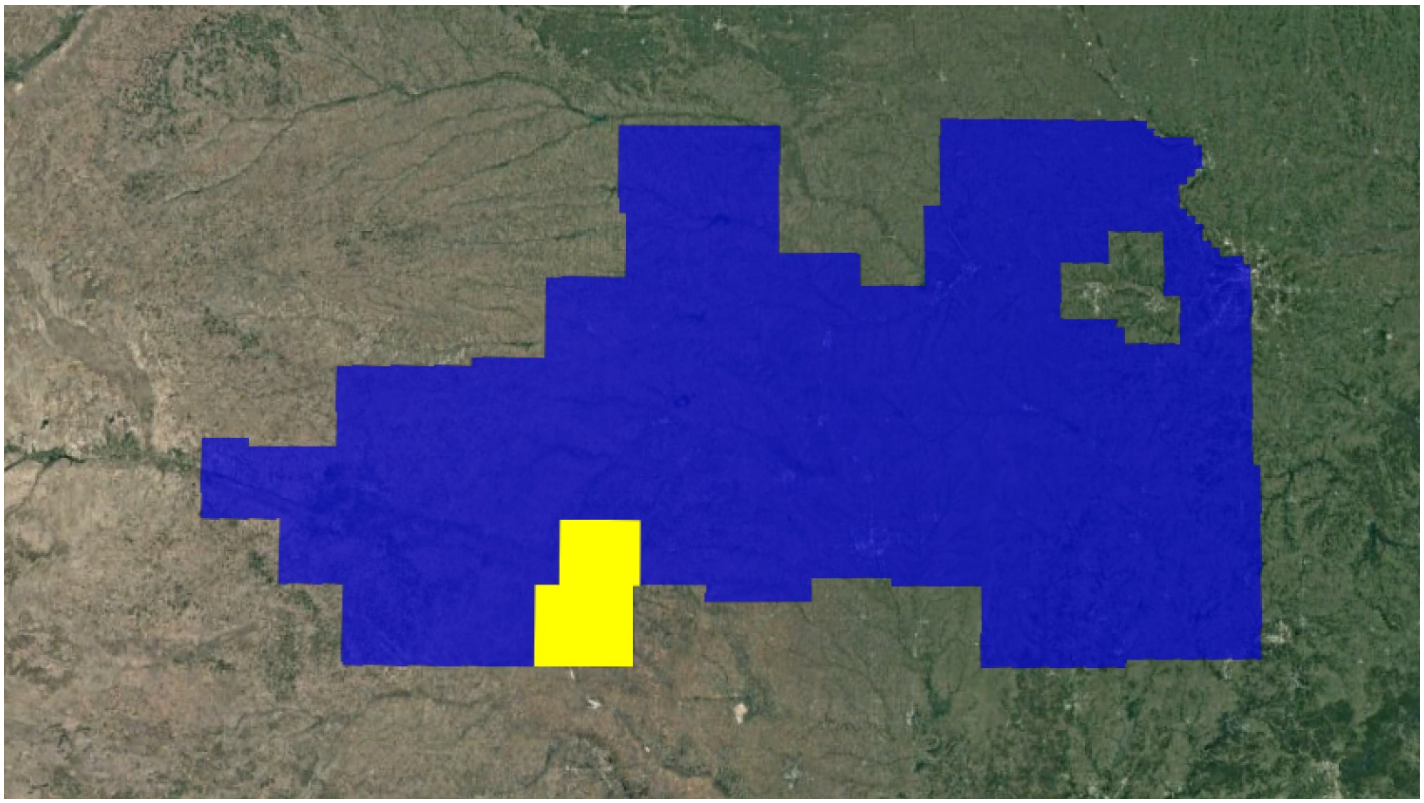


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

b. Project Purpose

The State of Kansas, on behalf of the Kansas Department of Agriculture and Kansas Data Access and Support Center, has contracted with Atlantic for professional services related to the development of Light Detection and Ranging (LiDAR). Additional partners include the USDA Natural Resource Conservation Service, the U.S. Geological Survey, the Kansas GIS Policy Board, the Kansas Department of Transportation and the Kansas Water Office. These LiDAR elevation data will be used for conservation planning, design, research, floodplain mapping, wetlands identification, dam safety assessments, hydrologic modeling, and subsidence monitoring.

c. Client Contact Information

Client Contact Information	
Name of Contact	Tara Lanzrath, CFM
Organization	Kansas Department of Agriculture
Position	Floodplain Mapping Coordinator
Telephone	785-296-2513
E-Mail Address	Tara.Lanzrath@ks.gov
Mailing Address	6531 SE Forbes Ave., Suite B
City	Topeka
State or Province	Kansas
Postal Code	66619

Table 1: Aerial LiDAR Client Contact Information

d. Contract Deliverables

Item	Specification/Format
Metadata	FGDC compliant, xml format
Project Report	.pdf format
Raw Point Cloud	Swaths, LAS 1.4
Classified Point Cloud	LAS 1.4
Bare Earth DEM	ERDAS .IMG format, Hydroflattened
First Return DSM	ERDAS .IMG format
Hydro Polygon Breaklines	.gdb format
Intensity Imagery	ERDAS .IMG format

Table 2: Aerial LiDAR Contract Deliverables

SECTION II: FIELD OPERATIONS

1. Aerial LiDAR Project – Aerial Acquisition

a. Aircraft & Sensor Information

Atlantic operated a Cessna (N732JE) outfitted with a Leica ALS70-HP LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
Platform	Fixed-Wing
Scan Pattern	Sine, Triangle, Raster
Maximum Scan Rate (Hz)	Sine: 200 Triangle: 158 Raster: 120
Field of View (°)	0 – 75 (Full Angle, User Adjustable)
Maximum Pulse Rate (kHz)	500
Maximum Flying Height (m AGL)	3500
Number of Returns	Unlimited
Number of Intensity Measurements	3 (First, Second, Third)
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV
Storage Media	Removable 500 GB SSD
Storage Capacity (Hours @ Max Pulse Rate)	6
Size (cm)	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
Weight (kg)	Scanner: 43 Control Electronics: 45
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table3: System Specifications – ALS70-HP

b. Sensor Acquisition Information

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

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.71
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2000
Nominal Flight Speed (kts)	130
Pass Heading (°)	0
Sensor Scan Angle (°)	45
Scan Frequency (Hz)	33.9
Pulse Rate of Scanner (kHz)	256,400

Parameter	Specification
Line Spacing (m)	1,171
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	.35
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	2
Beam Divergence (mrad)	.15
Nominal Swath Width (m)	1,740
Nominal Swath Overlap (%)	20
Scan Pattern	TRIANGLE

Table 4: Aerial LiDAR Sensor Acquisition Parameters

c. Flight Plan Execution

Atlantic acquired 69 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 11 flight missions conducted between April 29, 2018 and July 5, 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.

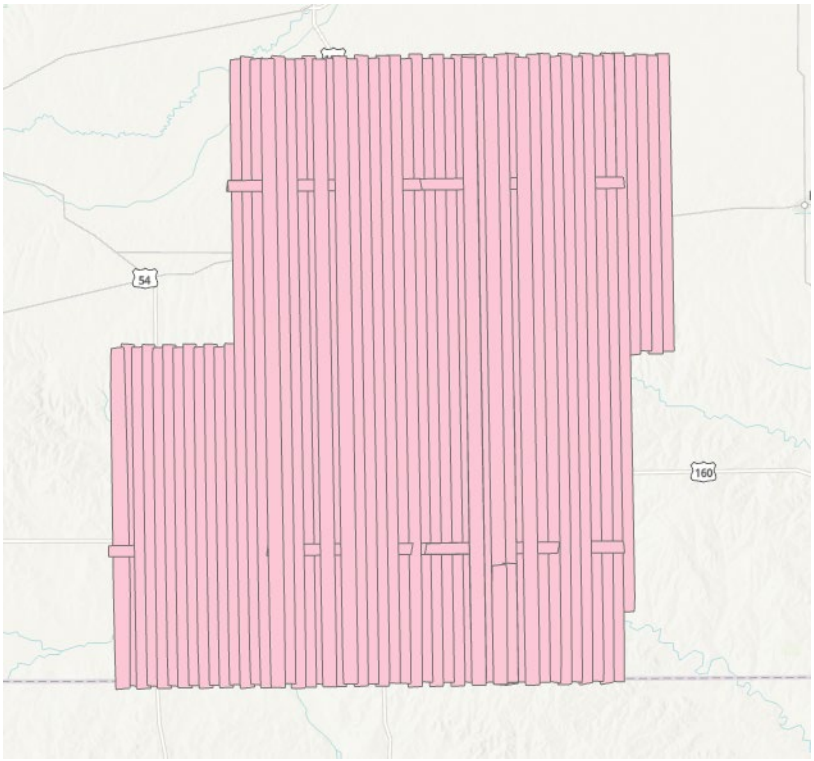


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Seventeen (17) 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
ICT3	CORS	ICT3	N37°45'09.33223"	W97°12'58.42421"	401.29
ICT4	CORS	ICT4	N37°37'08.57668"	W97°37'57.00068"	392.171
ICT5	CORS	ICT5	N37°47'12.03906"	W97°37'32.73503"	411.09
KSBK	CORS	KSBK	N37°33'03.90852"	W99°38'06.26885"	717.084
KSCW	CORS	KSCW	N37°16'24.87324"	W99°19'39.34067"	624.848
KSGB	CORS	KSGB	N38°21'16.83108"	W98°45'53.40654"	545.627
KSHU	CORS	KSHU	N38°01'52.62370"	W97°54'08.45874"	440.099
KSKG	CORS	KSKG	N37°39'01.96639”	W98°05'39.96395"	450.922
KSKY	CORS	KSKY	N37°54'40.30614"	W99°24'21.76286"	641.963
KSPR	CORS	KSPR	N37°41'26.44138"	W98°44'27.53387"	573.45
KSU1	CORS	KSU1	N39°06'02.69859"	W96°36'34.13759"	325.563
MOBT	CORS	MOBT	N38°15'26.96546"	W94°23'36.09538"	229.333
MOCA	CORS	MOCA	N37°10'39.18713"	W94°21'27.28349"	269.933
MONE	CORS	MONE	N37°51'56.74129"	W94°20'58.40977"	221.244
NERC	CORS	NERC	N40°04'32.27496"	W98°31'05.31875"	494.036
OKBF	CORS	OKBF	N36°49'40.89992"	W99°38'28.88569"	538.778
OKGM	CORS	OKGM	N36°40'28.54976"	W101°28'45.70014"	929.961

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 65 ground survey points were collected in support of this project, including 17 LiDAR Control Points (LCP), 28 Non-vegetated Vertical Accuracy (NVA) and 20 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 & 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
LCP389	444354.08	4138748.994	700.691
LCP479	450160.368	4113093.367	555.964
LCP480	457725.369	4117427.394	562.102
LCP481	485404.192	4112865.879	567.67
LCP482	473885.863	4161524.134	681.928
LCP483	462035.7	4151892.972	723.928
LCP484	460844.725	4168220.995	696.279
LCP486	497173.501	4156653.776	618.266
LCP487	490656.674	4143785.307	570.563
LCP488	479742.789	4140636.499	647.454
LCP496	476328.62	4176298.994	664.995
LCP497	493120.058	4172794.321	639.246
LCP519	440577.874	4111545.548	577.308
LCP563	447558.699	4127619.543	608.709
LCP589	447802.259	4109902.976	585.641
LCP591	493894.536	4167972.219	646.636
LCP592	496850.469	4131045.384	621.332

Table 6: LiDAR Control Point Coordinates

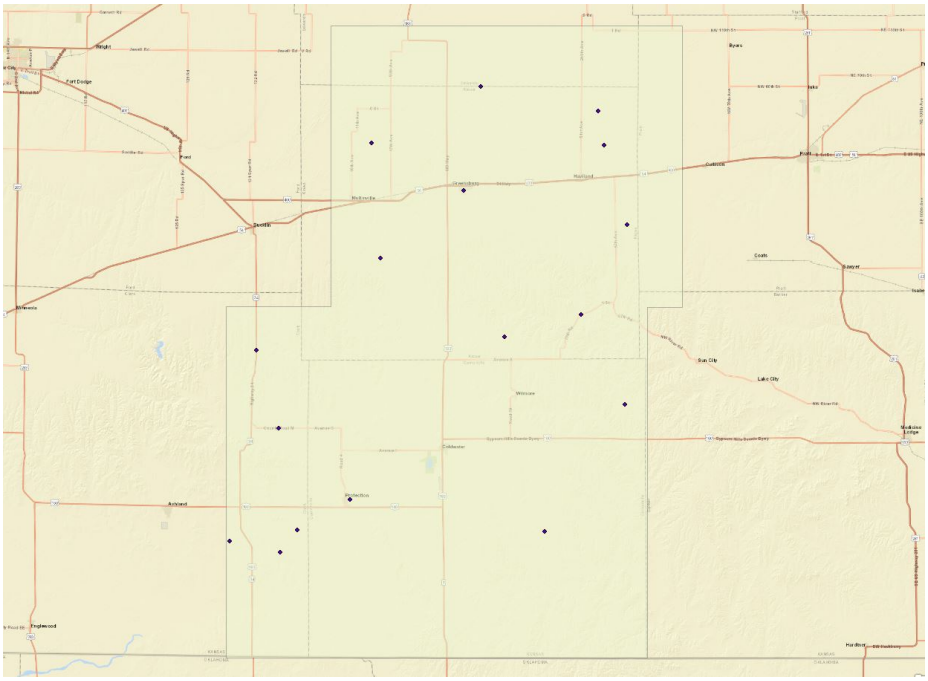


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA421	473893.4	4161541	681.912
NVA422	476314.2	4176311	664.192
NVA424	479731.1	4140649	647.57
NVA425	450146.9	4113096	555.771
NVA426	485390.9	4112870	565.541
NVA428	440573.1	4111552	577.131
NVA430	462047.1	4151890	723.194
NVA619	444577.1	4119620	596.85
NVA620	464592.7	4113125	603.145
NVA621	486991.9	4120137	629.999
NVA622	485299.7	4153174	625.32
NVA623	462043.8	4178062	684.674
NVA625	482723.9	4166082	658.055
NVA626	459685.2	4142092	664.434
NVA627	475946.6	4107100	570.896
NVA628	496855.9	4131037	621.377
NVA629	456170	4162497	707.289
NVA821	493893.5	4167983	646.577
NVA823	474846	4154281	695.727
NVA824	464697.9	4129321	649.01
NVA825	444527.2	4140498	706.523

ID	Easting	Northing	Elevation
NVA826	480100	4129353	658.013
NVA827	447553.1	4127620	608.798
NVA829	484394.7	4184993	647.528
NVA830	466781.2	4145307	695.654
NVA857	497458.1	4163094	646.647
NVA878	445041.1	4129260	622.611

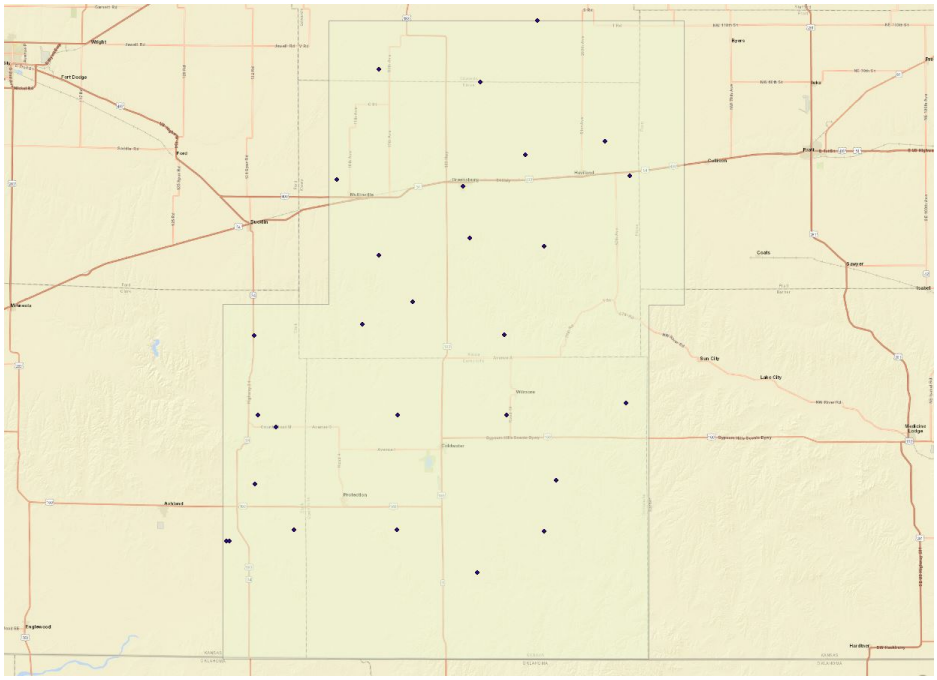


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA295	490660.318	4143800.726	569.782
VVA296	444354.054	4138766.637	700.685
VVA297	457717.961	4117430.578	562.123
VVA298	460842.124	4168209.173	696.197
VVA299	497170.13	4156664.121	618.263
VVA317	493123.276	4172805.978	638.985
VVA428	472671.201	4150216.929	679.106
VVA429	487981.51	4111670.524	564.951
VVA430	447813.95	4109922.045	585.59
VVA431	481791.072	4131977.149	612.351
VVA433	473197.045	4182774.203	666.665
VVA566	474840.972	4162211.052	678.678
VVA568	440949.617	4111575.91	579.476
VVA570	445065.403	4129261.564	623.108

ID	Easting	Northing	Elevation
VVA572	481338.558	4119679.697	609.284
VVA611	444523.977	4140519.892	706.952
VVA625	464553.586	4113112.278	603.394
VVA626	464731.34	4129297.892	649.175
VVA627	497448.718	4163107.804	646.61
VVA629	461912.559	4178131.732	684.221

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

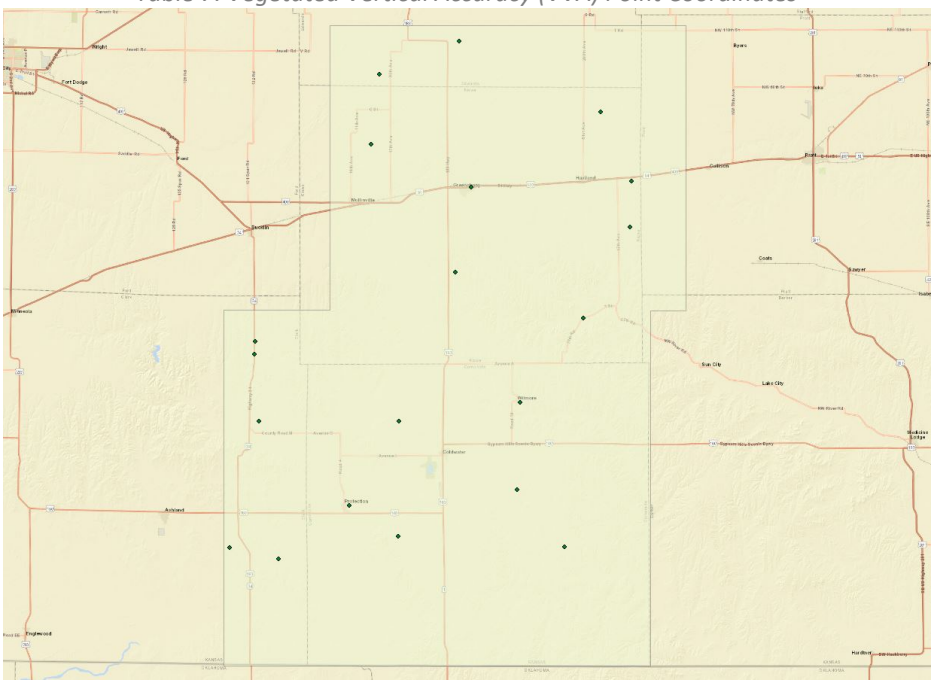


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION III: DATA PRODUCTION

3. Aerial LiDAR Project – Calibration/Classification

a. 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.

b. Coordinate Reference System

Horizontal Datum: NAD83(HARN)
Coordinate System: UTM, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points	16,188,640,196
Nominal Pulse Spacing (m)	0.689
Nominal Pulse Density (pls/m²)	2.1065
Aggregate Total Points	16,188,640,196
Aggregate Nominal Pulse Spacing (m)	0.5908
Aggregate Nominal Pulse Density (pls/m²)	2.8648

Table 8: LiDAR Point Cloud Statistics

d. 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.

e. 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.

f. 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 classes 9 (Water) and 10 (Ignored Ground).

Code	Description
1	Unclassified
2	Ground
7	Low point (noise)
9	Water
10	Ignored ground (breakline proximity)
17	Bridge
18	High point (noise)

Table 9: LiDAR Point Classification Codes and Descriptions

g. 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 0.5-meter cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in .img format.

h. 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.

i. 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 .img format.

j. Surface-Digital Elevation Model (DSM)

Surface digital elevation models (DSMs) were derived using all first return LiDAR points, excluding LiDAR points classified as high or low noise. All DSMs were created with a grid spacing of 1 meter. DSMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .img format.

SECTION IV: ACCURACY ASSESSMENT

1. Aerial LiDAR Project – Vertical Accuracy Assessment

a. 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 10: 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).

b. 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)	27	0.0717	0.1404	0.0951
NVA (DEM)	27	0.0756	0.1483	0.1208
VVA (Point Cloud)	20	0.1773	0.3474	0.2310
VVA (DEM)	20	0.1638	0.3211	0.1089

Table 11: NVA/VVA Accuracies

PointID	Easting	Northing	KnownZ	LaserZ	Description	DeltaZ
NVA426	485390.8920	4112869.9830	565.5410	560.8020	-4.7390	NVA426

Table 12: Outlier Check Points

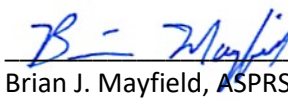
SECTION V: CERTIFICATION STATEMENTS

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 VI: CONTROL POINT ASSESSMENTS

1. Aerial LiDAR Project

a. Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)
NVA421	473893.4140	4161541.1540	681.9120	681.8880	-0.0240
NVA422	476314.2110	4176311.0730	664.1920	664.1280	-0.0640
NVA424	479731.1220	4140649.1060	647.5700	647.5280	-0.0420
NVA425	450146.8890	4113096.4950	555.7710	555.8010	0.0300
NVA428	440573.1160	4111552.3930	577.1310	577.1100	-0.0210
NVA430	462047.0500	4151889.9480	723.1940	723.2870	0.0930
NVA619	444577.1020	4119619.6250	596.8500	596.8470	-0.0030
NVA620	464592.7380	4113124.6440	603.1450	603.0150	-0.1300
NVA621	486991.9130	4120137.3850	629.9990	629.9670	-0.0320
NVA622	485299.6640	4153174.4100	625.3200	625.3350	0.0150
NVA623	462043.8160	4178062.3130	684.6740	684.7700	0.0960
NVA625	482723.8770	4166081.9130	658.0550	658.0320	-0.0230
NVA626	459685.2360	4142091.5980	664.4340	664.6200	0.1860
NVA627	475946.5660	4107099.8410	570.8960	570.9170	0.0210
NVA628	496855.8680	4131036.6380	621.3770	621.2670	-0.1100
NVA629	456169.9550	4162496.5100	707.2890	707.2490	-0.0400
NVA821	493893.5490	4167983.1520	646.5770	646.6580	0.0810
NVA823	474845.9840	4154281.2690	695.7270	695.6290	-0.0980
NVA824	464697.9360	4129320.9150	649.0100	648.9620	-0.0480
NVA825	444527.1740	4140497.9900	706.5230	706.5120	-0.0110
NVA826	480099.9850	4129352.8750	658.0130	658.0040	-0.0090
NVA827	447553.1110	4127619.6700	608.7980	608.7290	-0.0690
NVA829	484394.7220	4184992.8890	647.5280	647.5570	0.0290
NVA830	466781.1530	4145307.3040	695.6540	695.6720	0.0180
NVA857	497458.0600	4163094.0690	646.6470	646.5270	-0.1200
NVA878	445041.0880	4129259.8860	622.6110	622.5300	-0.0810
NVA890	440963.4010	4111556.9120	581.0100	581.0070	-0.0030
VVA295	490660.3180	4143800.7260	569.7820	569.7010	-0.0810
VVA296	444354.0540	4138766.6370	700.6850	700.6750	-0.0100
VVA297	457717.9610	4117430.5780	562.1230	562.3480	0.2250
VVA298	460842.1240	4168209.1730	696.1970	696.5410	0.3440
VVA299	497170.1300	4156664.1210	618.2630	618.1380	-0.1250
VVA317	493123.2760	4172805.9780	638.9850	639.0560	0.0710
VVA428	472671.2010	4150216.9290	679.1060	679.2730	0.1670
VVA429	487981.5100	4111670.5240	564.9510	564.9890	0.0380

VVA430	447813.9500	4109922.0450	585.5900	585.6290	0.0390
VVA431	481791.0720	4131977.1490	612.3510	612.3510	0.0000
VVA433	473197.0450	4182774.2030	666.6650	666.6320	-0.0330
VVA566	474840.9720	4162211.0520	678.6780	679.2830	-0.6050
VVA568	440949.6170	4111575.9100	579.4760	579.4290	-0.0470
VVA570	445065.4030	4129261.5640	623.1080	623.1240	0.0160
VVA572	481338.5580	4119679.6970	609.2840	609.2150	-0.0690
VVA611	444523.9770	4140519.8920	706.9520	706.9990	0.0470
VVA625	464553.5860	4113112.2780	603.3940	603.4550	0.0610
VVA626	464731.3400	4129297.8920	649.1750	649.1110	-0.0640
VVA627	497448.7180	4163107.8040	646.6100	646.7130	0.1030
VVA629	461912.5590	4178131.7320	684.2210	684.3000	0.0790

Table 13: Point Cloud Check Point Assessment

b. Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA421	473894.1550	4161540.4330	681.9120	681.8700	0.0420	NVA
NVA422	476314.9510	4176310.3490	664.1920	664.0940	0.0980	NVA
NVA424	479731.8620	4140648.3880	647.5700	647.5140	0.0560	NVA
NVA425	450147.6340	4113095.7810	555.7710	555.8080	-0.0370	NVA
NVA428	440573.8630	4111551.6790	577.1310	577.0720	0.0590	NVA
NVA430	462047.7930	4151889.2280	723.1940	723.2760	-0.0820	NVA
NVA619	444577.8480	4119618.9100	596.8500	596.8410	0.0090	NVA
NVA620	464593.4810	4113123.9310	603.1450	603.0230	0.1220	NVA
NVA621	486992.6520	4120136.6710	629.9990	629.9620	0.0370	NVA
NVA622	485300.4030	4153173.6900	625.3200	625.2990	0.0210	NVA
NVA623	462044.5580	4178061.5890	684.6740	684.7610	-0.0870	NVA
NVA625	482724.6160	4166081.1910	658.0550	658.0200	0.0350	NVA
NVA626	459685.9790	4142090.8800	664.4340	664.6200	-0.1860	NVA
NVA627	475947.3070	4107099.1290	570.8960	570.9260	-0.0300	NVA
NVA628	496856.6050	4131035.9220	621.3770	621.2310	0.1460	NVA
NVA629	456170.6990	4162495.7880	707.2890	707.2700	0.0190	NVA
NVA821	493894.2860	4167982.4300	646.5770	646.5600	0.0170	NVA
NVA823	474846.7250	4154280.5490	695.7270	695.6320	0.0950	NVA
NVA824	464698.6790	4129320.1990	649.0100	648.9600	0.0500	NVA
NVA825	444527.9200	4140497.2720	706.5230	706.4800	0.0430	NVA
NVA826	480100.7250	4129352.1590	658.0130	657.9850	0.0280	NVA
NVA827	447553.8570	4127618.9540	608.7980	608.7270	0.0710	NVA
NVA829	484395.4600	4184992.1640	647.5280	647.4510	0.0770	NVA

NVA830	466781.8950	4145306.5850	695.6540	695.6670	-0.0130	NVA
NVA857	497458.7970	4163093.3480	646.6470	646.5290	0.1180	NVA
NVA878	445041.8340	4129259.1700	622.6110	622.5340	0.0770	NVA
NVA890	440964.1480	4111556.1980	581.0100	580.9950	0.0150	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA295	490661.0560	4143800.0080	569.7820	569.6760	0.1060	VVA
VVA296	444354.8000	4138765.9190	700.6850	700.6950	-0.0100	VVA
VVA297	457718.7050	4117429.8640	562.1230	562.2060	-0.0830	VVA
VVA298	460842.8670	4168208.4500	696.1970	696.4790	-0.2820	VVA
VVA299	497170.8670	4156663.4010	618.2630	618.0980	0.1650	VVA
VVA317	493124.0130	4172805.2550	638.9850	639.0490	-0.0640	VVA
VVA428	472671.9420	4150216.2100	679.1060	679.2170	-0.1110	VVA
VVA429	487982.2490	4111669.8110	564.9510	564.9220	0.0290	VVA
VVA430	447814.6960	4109921.3320	585.5900	585.6420	-0.0520	VVA
VVA431	481791.8120	4131976.4330	612.3510	612.3580	-0.0070	VVA
VVA433	473197.7850	4182773.4780	666.6650	666.6310	0.0340	VVA
VVA566	474841.7120	4162210.3310	678.6780	679.2830	-0.6050	VVA
VVA568	440950.3640	4111575.1960	579.4760	579.4300	0.0460	VVA
VVA570	445066.1490	4129260.8480	623.1080	623.1240	-0.0160	VVA
VVA572	481339.2980	4119678.9830	609.2840	609.2200	0.0640	VVA
VVA611	444524.7230	4140519.1740	706.9520	706.9650	-0.0130	VVA
VVA625	464554.3290	4113111.5650	603.3940	603.4450	-0.0510	VVA
VVA626	464732.0830	4129297.1760	649.1750	649.1170	0.0580	VVA
VVA627	497449.4550	4163107.0830	646.6100	646.6350	-0.0250	VVA
VVA629	461913.3010	4178131.0080	684.2210	684.3270	-0.1060	VVA

Table 14: DEM Check Point Assessment