Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 3A

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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 3A encompasses part or all of 10 counties in Kansas and covers approximately 2,424 square miles.

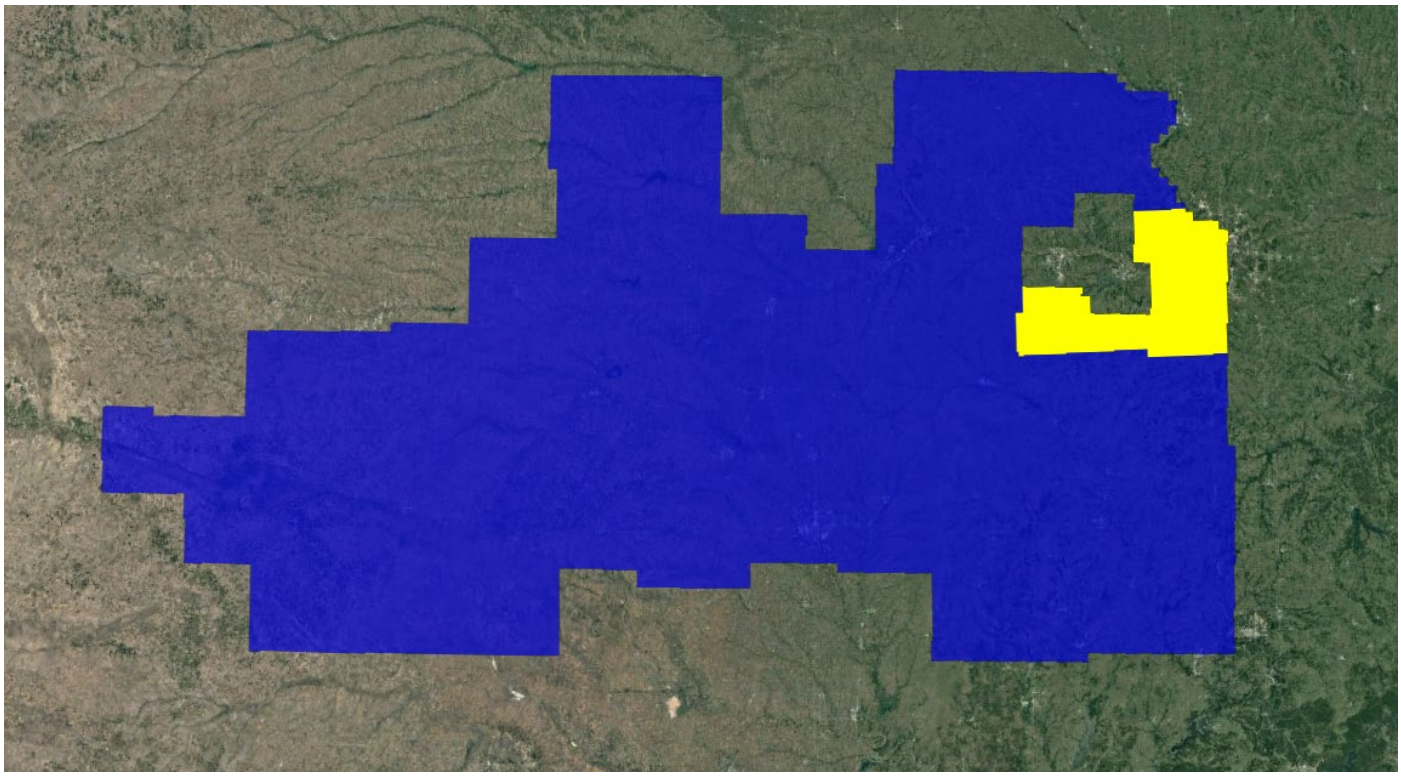


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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
Line Spacing (m)	1,171

Parameter	Specification
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 128 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 33 flight missions conducted between January 17, 2018 and March 22, 2019. 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.

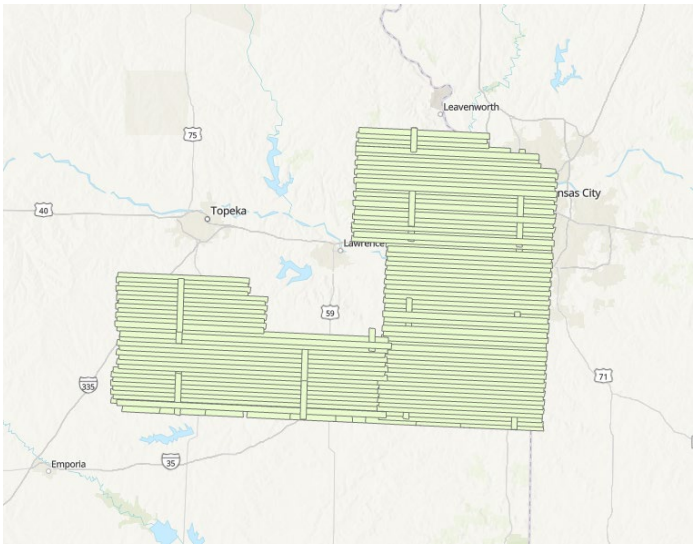


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Twenty-one (21) 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
KSBU	CORS	KSBU	38°11'44.87410"	95°44'17.05409"	291.002
KSBR	CORS	KSBR	39°06'56.69775"	94°55'43.07246"	251.885
KSCP	CORS	KSCP	38°58'16.54513"	97°01'11.91663"	320.534
KSEM	CORS	KSEM	38°24'14.59433"	96°10'42.29040"	342.398
KSHW	CORS	KSHW	39°51'04.21656"	95°33'34.79184"	324.675
KSLW	CORS	KSLW	38°57'44.03113"	95°14'33.23170"	307.758
KSMH	CORS	KSMH	39°10'44.46527"	96°34'25.38309"	290.839

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
KSOG	CORS	KSOG	38°38'14.33261"	95°49'49.98335"	307.469
KSOL	CORS	KSOL	38°50'41.94256"	94°48'52.79826"	290.344
KSPO	CORS	KSPO	38°34'22.72509"	94°52'41.82750"	257.793
KSTK	CORS	KSTK	39°05'22.98812"	95°42'09.76288"	248.526
KSU1	CORS	KSU1	39°06'02.70007"	96°36'34.13585"	325.564
NEPC	CORS	NEPC	40°06'41.82190"	96°09'33.15230"	338.801
MOBT	CORS	MOBT	38°15'26.96689"	94°23'36.09387"	229.343
MOHV	CORS	MOHV	38°36'33.11180"	94°19'12.92367"	241.525
MOPL	CORS	MOPL	39°23'04.09584"	94°47'00.08368"	211.99
MORS	CORS	MORS	39°10'44.02751"	94°36'45.19383"	211.388
MOSB	CORS	MOSB	38°49'48.71034	94°32'04.48758"	301.135
MOSV	CORS	MOSV	39°57'15.17155"	94°50'51.35862"	319.87
MOWE	CORS	MOWE	39°25'19.79323"	94°53'44.65335"	241.667
ZKC1	CORS	ZKC1	38°52'48.57351"	94°47'27.00464"	305.466

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 77 ground survey points were collected in support of this project, including 14 LiDAR Control Points (LCP), 37 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
LCP129	330918.5340	4335813.7400	286.1630
LCP150	309512.8670	4280443.6330	276.7080
LCP152	310815.6180	4330387.8550	322.3940
LCP163	257951.9870	4286626.8430	309.3410
LCP164	278324.7690	4292485.0000	343.2400
LCP52	350211.9760	4284116.1070	320.9240
LCP53	355058.9140	4282442.9690	324.9350
LCP54	345365.8190	4276298.9300	273.1980
LCP59	323416.2970	4294573.8070	315.8480
LCP60	288977.4590	4287598.5770	326.9150
LCP62	332965.5560	4275859.4200	312.4440
LCP65	316966.4560	4330507.8340	327.3430
LCP66	321339.3050	4336329.1460	279.0150
LCP93	322307.5240	4345161.2700	280.0750

Table 6: LiDAR Control Point Coordinates

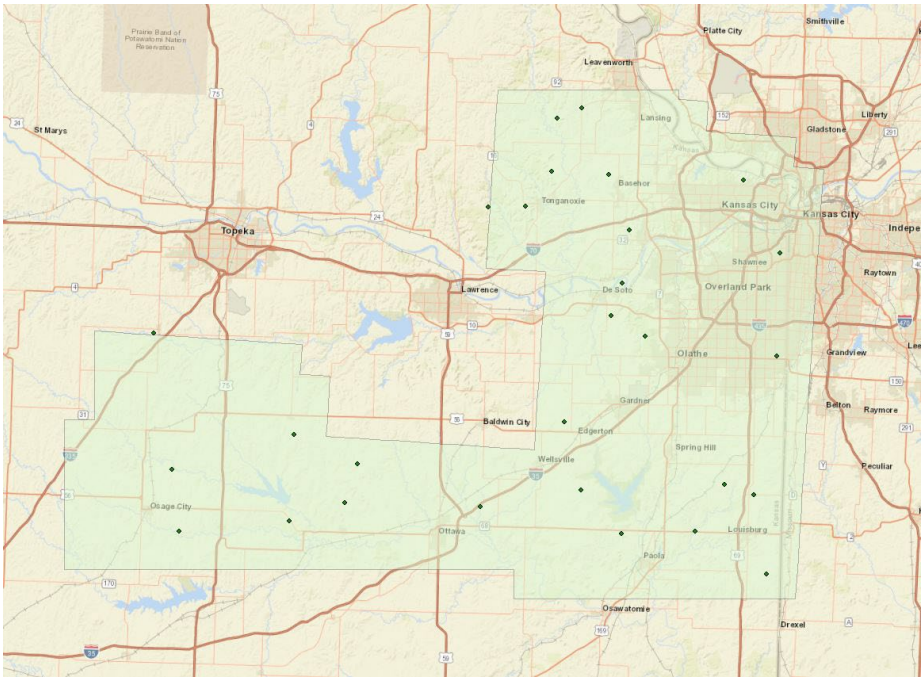


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
LCP_NVA148	357161.127	4269183.262	336.399
LCP_NVA149	331331.3750	4312328.6910	286.7550
LCP_NVA155	353409.7590	4334900.1920	288.8960
LCP_NVA61	286804.9360	4281001.8020	329.3100
LCP_NVA67	334337.0090	4326586.9880	242.2350
NVA1000	254932.7530	4309301.4250	316.9760
NVA1001	326238.8670	4283196.7330	316.1240
NVA1002	326439.91	4346909.577	299.052
NVA109	313857.3570	4275494.3940	300.8250
NVA110	274753.6920	4285311.8600	313.9990
NVA111	257887.7220	4286604.0640	309.1660
NVA114	279468.5450	4302181.9070	336.1410
NVA118	311535.2940	4336543.1530	329.6070
NVA119	331904.4460	4341621.0700	291.7950
NVA120	356432.5040	4329569.6310	261.1010
NVA122	331393.0270	4312331.8510	283.0960
NVA124	325212.1490	4288027.4210	308.4810
NVA125	357177.923	4269158.152	336.902
NVA152	266565.7110	4300083.9200	344.9900

ID	Easting	Northing	Elevation
NVA184	316871.665	4347713.345	316.286
NVA185	266565.7100	4300083.9190	344.9910
NVA186	248000.002	4282098.367	341.195
NVA189	340647.7650	4287484.1930	326.7650
NVA195	348065.5620	4332546.8490	279.6530
NVA206	332521.479	4266936.641	287.369
NVA248	289741.417	4279678.333	311.166
NVA250	321040.1110	4315636.0970	242.7120
NVA253	338409.0980	4339206.2550	258.4000
NVA261	254558.7190	4293231.5590	323.3800
NVA262	274919.4200	4307772.6430	289.2750
NVA39	322291.403	4345188.994	278.067
NVA40	321358.2390	4336310.2270	279.1040
NVA42	288989.4130	4287598.1540	326.5360
NVA46	326452.877	4346794.393	294.781
NVA47	326230.5510	4283237.0820	317.6910
NVA48	345350.9010	4276304.4600	273.0770
NVA49	355035.1190	4282491.4170	324.0270

Table 7: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

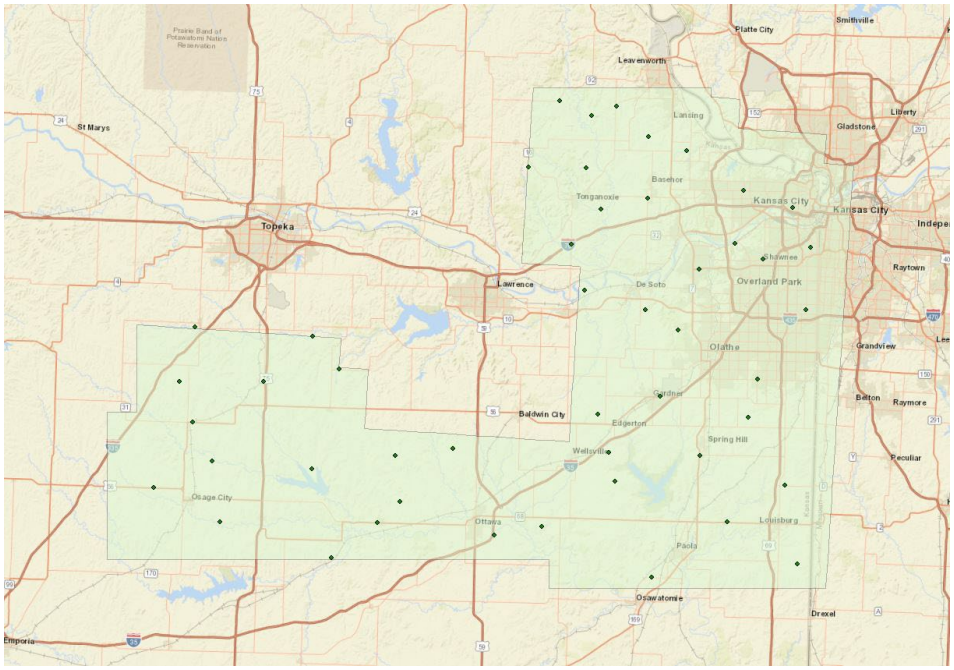


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA01	332959.5520	4275800.1450	309.1630
VVA122	339229.994	4269915.983	259.72
VVA126	353398.2110	4334872.0400	289.1890
VVA168	358622.4650	4312321.8200	290.8800
VVA169	333934.6610	4297513.2600	322.1570
VVA170	313845.3370	4275487.5760	301.0430
VVA171	318844.6410	4323437.6740	263.7650
VVA182	252229.6950	4300072.7240	361.3970
VVA183	279441.3760	4302175.0770	335.3990
VVA29	286824.4490	4281010.9980	329.4010
VVA30	277573.996	4278043.121	322.87
VVA31	332959.5520	4275800.1460	309.1640
VVA34	358911.2480	4305492.8310	308.4000
VVA35	330946.0830	4335817.5830	285.3080
VVA67	289715.973	4279650.408	310.292
VVA68	254542.2790	4293247.9170	324.0600
VVA69	278375.8830	4292500.6780	343.0060
VVA70	321038.4190	4315671.9180	242.7900
VVA72	338465.5980	4339179.7460	258.5590
VVA73	334339.2930	4326564.0860	242.8240

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

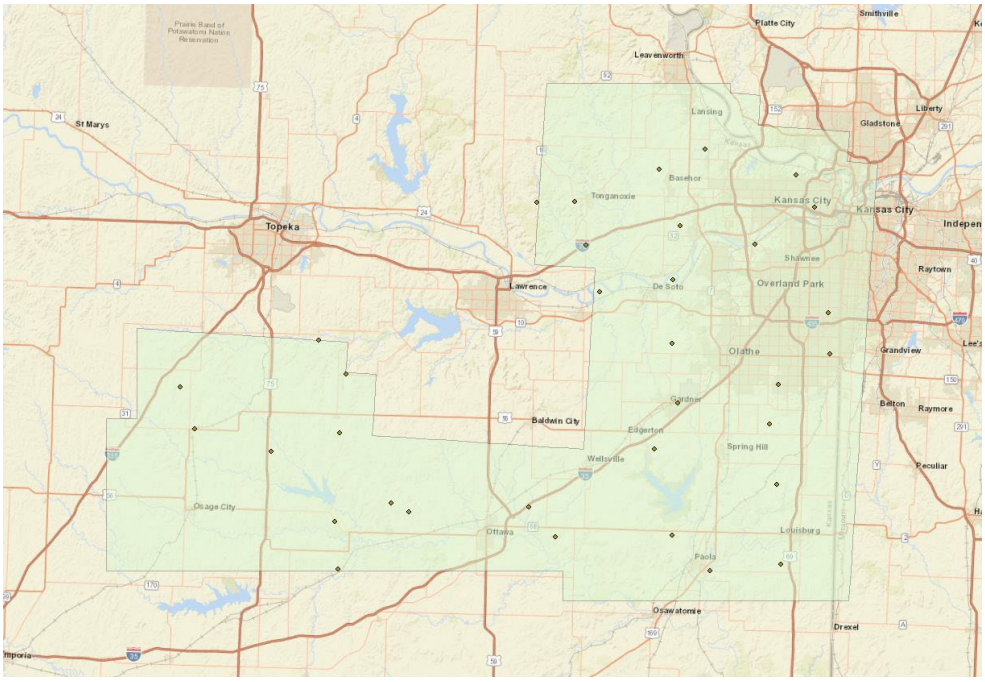


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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 2011 (HARN)
Coordinate System: UTM, 15N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	20,237,837,702
Nominal Pulse Spacing (M)	0.5955
Nominal Pulse Density (PLS/M^2)	2.8203
Total Points (Aggregate)	20,754,779,934
Aggregate Pulse Spacing (M)	0.5832
Aggregate Pulse Density (PLS/M^2)	2.9401

Table 9: 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 10: 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 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).

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)	37	0.0965	0.1892	0.1704
NVA (DEM)	37	0.0931	0.1825	0.0931
VVA (Point Cloud)	20	0.1985	0.3890	0.2967
VVA (DEM)	20	0.1822	0.3572	0.2444

Table 12: NVA/VVA Accuracies

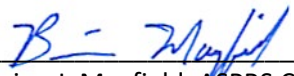
SECTION V: CERTIFICATION STATEMENTS

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)	Report Point Type
LCP_NVA106	277547.5230	4278050.3340	322.2010	322.2260	0.0250	NVA
LCP_NVA148	357161.1270	4269183.2620	336.3990	336.4970	0.0980	NVA
LCP_NVA149	331331.3750	4312328.6910	286.7550	286.6540	-0.1010	NVA
LCP_NVA155	353409.7590	4334900.1920	288.8960	288.9390	0.0430	NVA
LCP_NVA37	259198.5550	4276307.6990	324.1390	324.2180	0.0790	NVA
LCP_NVA61	286804.9360	4281001.8020	329.3100	329.3960	0.0860	NVA
LCP_NVA67	334337.0090	4326586.9880	242.2350	242.4260	0.1910	NVA
NVA01	259192.6750	4276300.7350	323.9870	323.9940	0.0070	NVA
NVA109	313857.3570	4275494.3940	300.8250	300.8010	-0.0240	NVA
NVA110	274753.6920	4285311.8600	313.9990	313.9260	-0.0730	NVA
NVA111	257887.7220	4286604.0640	309.1660	309.1360	-0.0300	NVA
NVA114	279468.5450	4302181.9070	336.1410	336.2870	0.1460	NVA
NVA118	311535.2940	4336543.1530	329.6070	329.6830	0.0760	NVA
NVA119	331904.4460	4341621.0700	291.7950	291.8070	0.0120	NVA
NVA120	356432.5040	4329569.6310	261.1010	261.2450	0.1440	NVA
NVA122	331393.0270	4312331.8510	283.0960	283.1490	0.0530	NVA
NVA124	325212.1490	4288027.4210	308.4810	308.6610	0.1800	NVA
NVA125	357177.9230	4269158.1520	336.9020	337.0500	0.1480	NVA
NVA152	266565.7110	4300083.9200	344.9900	345.0610	0.0710	NVA
NVA184	316871.6650	4347713.3450	316.2860	316.1490	-0.1370	NVA
NVA185	266565.7100	4300083.9190	344.9910	345.0610	0.0700	NVA
NVA186	248000.0020	4282098.3670	341.1950	341.2140	0.0190	NVA
NVA187	285964.2630	4276209.7340	289.5510	289.5410	-0.0100	NVA
NVA188	305791.3560	4274087.5040	282.5440	282.5590	0.0150	NVA
NVA189	340647.7650	4287484.1930	326.7650	326.8340	0.0690	NVA
NVA191	333917.8340	4297530.6180	321.7160	321.9110	0.1950	NVA
NVA195	348065.5620	4332546.8490	279.6530	279.7390	0.0860	NVA
NVA206	332521.4790	4266936.6410	287.3690	287.5330	0.1640	NVA
NVA248	289741.4170	4279678.3330	311.1660	311.1230	-0.0430	NVA
NVA250	321040.1110	4315636.0970	242.7120	242.7820	0.0700	NVA
NVA253	338409.0980	4339206.2550	258.4000	258.5680	0.1680	NVA
NVA261	254558.7190	4293231.5590	323.3800	323.5440	0.1640	NVA
NVA262	274919.4200	4307772.6430	289.2750	289.4140	0.1390	NVA
NVA39	322291.4030	4345188.9940	278.0670	278.0790	0.0120	NVA
NVA40	321358.2390	4336310.2270	279.1040	279.1800	0.0760	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
NVA42	288989.4130	4287598.1540	326.5360	326.5840	0.0480	NVA
NVA46	326452.8770	4346794.3930	294.7810	294.7630	-0.0180	NVA
NVA47	326230.5510	4283237.0820	317.6910	317.6630	-0.0280	NVA
NVA48	345350.9010	4276304.4600	273.0770	273.0520	-0.0250	NVA
NVA49	355035.1190	4282491.4170	324.0270	324.0270	0.0000	NVA
VVA01	332959.5520	4275800.1450	309.1630	309.3770	0.2140	VVA
VVA126	353398.2110	4334872.0400	289.1890	289.1390	-0.0500	VVA
VVA168	358622.4650	4312321.8200	290.8800	290.6150	-0.2650	VVA
VVA169	333934.6610	4297513.2600	322.1570	322.4850	0.3280	VVA
VVA170	313845.3370	4275487.5760	301.0430	301.0430	0.0000	VVA
VVA171	318844.6410	4323437.6740	263.7650	264.0600	0.2950	VVA
VVA182	252229.6950	4300072.7240	361.3970	361.6500	0.2530	VVA
VVA183	279441.3760	4302175.0770	335.3990	335.4970	0.0980	VVA
VVA29	286824.4490	4281010.9980	329.4010	329.5970	0.1960	VVA
VVA30	277573.9960	4278043.1210	322.8700	323.0070	0.1370	VVA
VVA31	332959.5520	4275800.1460	309.1640	309.3770	0.2130	VVA
VVA34	358911.2480	4305492.8310	308.4000	308.2470	-0.1530	VVA
VVA35	330946.0830	4335817.5830	285.3080	285.4840	0.1760	VVA
VVA67	289715.9730	4279650.4080	310.2920	310.3700	0.0780	VVA
VVA68	254542.2790	4293247.9170	324.0600	324.2670	0.2070	VVA
VVA69	278375.8830	4292500.6780	343.0060	343.1580	0.1520	VVA
VVA70	321038.4190	4315671.9180	242.7900	243.0590	0.2690	VVA
VVA72	338465.5980	4339179.7460	258.5590	258.6830	0.1240	VVA
VVA73	334339.2930	4326564.0860	242.8240	243.1060	0.2820	VVA
VVA75	350837.2120	4271023.5020	338.5460	338.5550	0.0090	VVA

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
LCP_NVA106	277547.5230	4278050.3340	322.2010	322.1745	0.0265	NVA
LCP_NVA148	357161.1270	4269183.2620	336.3990	336.4806	-0.0816	NVA
LCP_NVA149	331331.3750	4312328.6910	286.7550	286.6510	0.1040	NVA
LCP_NVA155	353409.7590	4334900.1920	288.8960	288.9172	-0.0212	NVA
LCP_NVA37	259198.5550	4276307.6990	324.1390	324.1996	-0.0606	NVA
LCP_NVA61	286804.9360	4281001.8020	329.3100	329.3593	-0.0493	NVA
LCP_NVA67	334337.0090	4326586.9880	242.2350	242.4035	-0.1685	NVA
NVA01	259192.6750	4276300.7350	323.9870	324.0182	-0.0312	NVA
NVA109	313857.3570	4275494.3940	300.8250	300.8062	0.0188	NVA
NVA110	274753.6920	4285311.8600	313.9990	313.9065	0.0925	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA111	257887.7220	4286604.0640	309.1660	309.1285	0.0375	NVA
NVA114	279468.5450	4302181.9070	336.1410	336.2941	-0.1531	NVA
NVA118	311535.2940	4336543.1530	329.6070	329.6903	-0.0833	NVA
NVA119	331904.4460	4341621.0700	291.7950	291.7811	0.0139	NVA
NVA120	356432.5040	4329569.6310	261.1010	261.2471	-0.1461	NVA
NVA122	331393.0270	4312331.8510	283.0960	283.1589	-0.0629	NVA
NVA124	325212.1490	4288027.4210	308.4810	308.6752	-0.1942	NVA
NVA125	357177.9230	4269158.1520	336.9020	337.0481	-0.1461	NVA
NVA152	266565.7110	4300083.9200	344.9900	345.0552	-0.0652	NVA
NVA184	316871.6650	4347713.3450	316.2860	316.1532	0.1328	NVA
NVA185	266565.7100	4300083.9190	344.9910	345.0552	-0.0642	NVA
NVA186	248000.0020	4282098.3670	341.1950	341.2166	-0.0216	NVA
NVA187	285964.2630	4276209.7340	289.5510	289.5512	-0.0002	NVA
NVA188	305791.3560	4274087.5040	282.5440	282.5045	0.0395	NVA
NVA189	340647.7650	4287484.1930	326.7650	326.8535	-0.0885	NVA
NVA191	333917.8340	4297530.6180	321.7160	321.8935	-0.1775	NVA
NVA195	348065.5620	4332546.8490	279.6530	279.7427	-0.0897	NVA
NVA206	332521.4790	4266936.6410	287.3690	287.4968	-0.1278	NVA
NVA248	289741.4170	4279678.3330	311.1660	311.1258	0.0402	NVA
NVA250	321040.1110	4315636.0970	242.7120	242.7299	-0.0179	NVA
NVA253	338409.0980	4339206.2550	258.4000	258.5588	-0.1588	NVA
NVA261	254558.7190	4293231.5590	323.3800	323.5431	-0.1631	NVA
NVA262	274919.4200	4307772.6430	289.2750	289.3360	-0.0610	NVA
NVA39	322291.4030	4345188.9940	278.0670	278.1513	-0.0843	NVA
NVA40	321358.2390	4336310.2270	279.1040	279.1477	-0.0437	NVA
NVA42	288989.4130	4287598.1540	326.5360	326.5731	-0.0371	NVA
NVA46	326452.8770	4346794.3930	294.7810	294.7145	0.0665	NVA
NVA47	326230.5510	4283237.0820	317.6910	317.6674	0.0236	NVA
NVA48	345350.9010	4276304.4600	273.0770	273.0328	0.0442	NVA
NVA49	355035.1190	4282491.4170	324.0270	323.9994	0.0276	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA01	332959.5520	4275800.1450	309.1630	309.1437	0.0193	VVA
VVA126	353398.2110	4334872.0400	289.1890	289.1601	0.0289	VVA
VVA168	358622.4650	4312321.8200	290.8800	290.6423	0.2377	VVA
VVA169	333934.6610	4297513.2600	322.1570	322.3641	-0.2071	VVA
VVA170	313845.3370	4275487.5760	301.0430	301.0275	0.0155	VVA
VVA171	318844.6410	4323437.6740	263.7650	264.0644	-0.2994	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA182	252229.6950	4300072.7240	361.3970	361.6830	-0.2860	VVA
VVA183	279441.3760	4302175.0770	335.3990	335.5174	-0.1184	VVA
VVA29	286824.4490	4281010.9980	329.4010	329.3705	0.0305	VVA
VVA30	277573.9960	4278043.1210	322.8700	322.9493	-0.0793	VVA
VVA31	332959.5520	4275800.1460	309.1640	309.1437	0.0203	VVA
VVA34	358911.2480	4305492.8310	308.4000	308.0272	0.3728	VVA
VVA35	330946.0830	4335817.5830	285.3080	285.4336	-0.1256	VVA
VVA67	289715.9730	4279650.4080	310.2920	310.3562	-0.0642	VVA
VVA68	254542.2790	4293247.9170	324.0600	324.2917	-0.2317	VVA
VVA69	278375.8830	4292500.6780	343.0060	343.1518	-0.1458	VVA
VVA70	321038.4190	4315671.9180	242.7900	242.9664	-0.1764	VVA
VVA72	338465.5980	4339179.7460	258.5590	258.6853	-0.1263	VVA
VVA73	334339.2930	4326564.0860	242.8240	243.1225	-0.2985	VVA
VVA75	350837.2120	4271023.5020	338.5460	338.5654	-0.0194	VVA

Table 14: DEM Check Point Assessment

SECTION VII: ADDENDUM

7.1 Low Confidence Polygons

Low confidence polygons have been delivered with this dataset. These polygons represent areas where heavy vegetation or inundated areas greatly diminish penetration of the lidar pulse, resulting in a bare earth surface that is potentially less accurate due to the lack of lidar returns from the ground beneath the vegetation or surface water. Low confidence polygons delineate areas where conformance to VVA standards may not be met. The low confidence polygons created for this dataset were delineated according to the criteria and assumptions outlined in the ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014). Low confidence areas are identified using a ground density raster. All areas with a Nominal Ground Point Density less than the threshold of 0.5 pts/m^2 are identified as low confidence cells in the ground density raster. The low confidence cells are exported to polygons and aggregated into larger shapes. Areas of expected low density in the ground, such as water or where buildings/structures have been removed, are deleted from the aggregated low confidence polygons. The size of all polygons is then calculated and polygons below the minimum size threshold of 5 acres are removed from the final low confidence polygon dataset.