Project Report

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

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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 3B encompasses part or all of 8 counties in Eastern Kansas and covers approximately 2497 square miles.

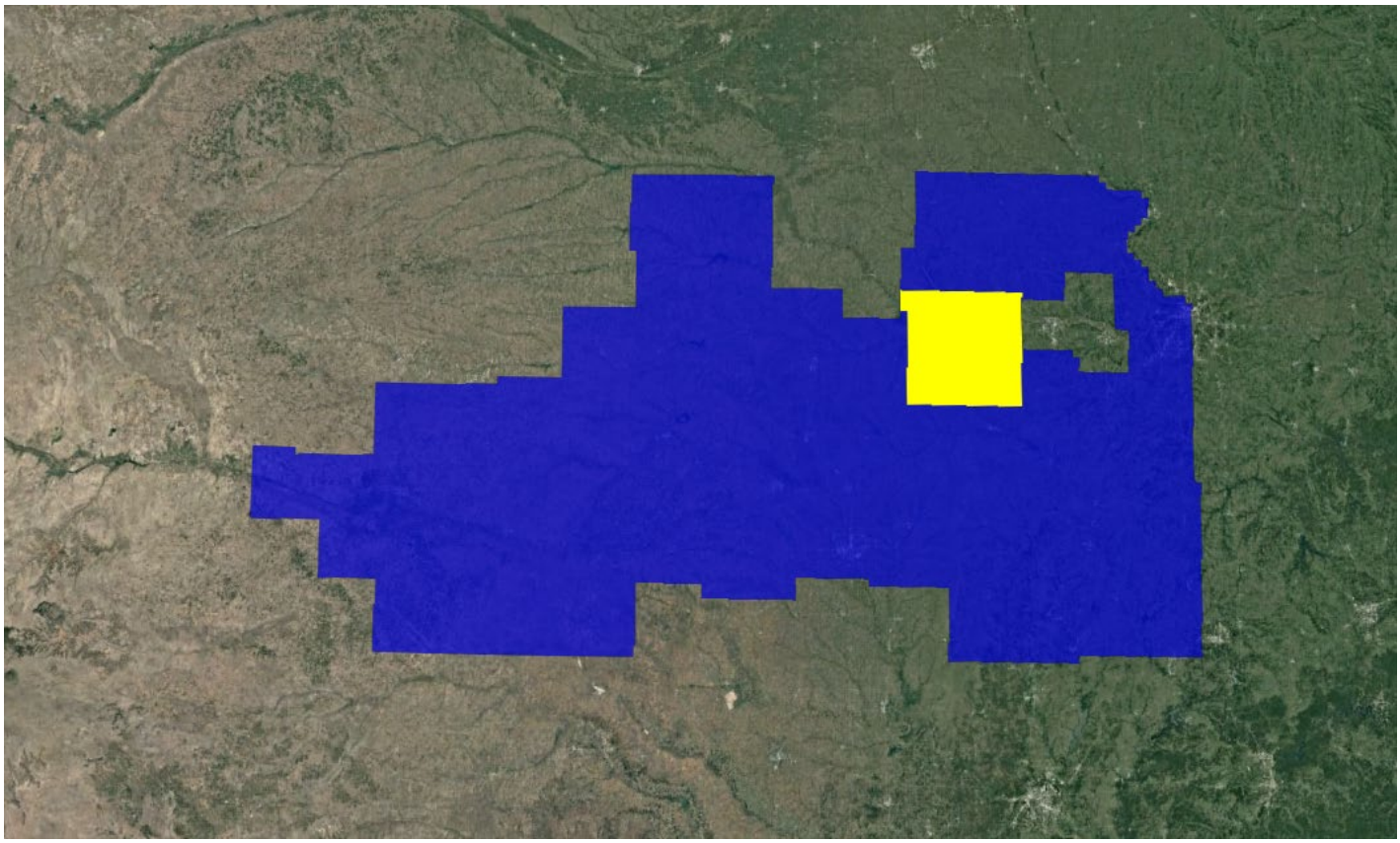


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 145 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 24 flight missions conducted between February 26, 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

d. GNSS Reference Stations

Twelve (12) 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	N38°11'44.87401"	W95°44'17.05409"	291.004
KSCP	CORS	KSCP	N38°58'16.54525"	W97°01'11.91593"	320.533
KSJM	CORS	KSJM	N38°04'01.27769"	W99°53'51.37825"	702.4662
KSLC	CORS	KSLC	N38°31'55.09280"	W99°18'19.68116"	608.942
KSMA	CORS	KSMA	N38°21'35.65317"	W97°00'42.65221"	381.2789
KSMH	CORS	KSMH	N39°10'44.46539"	W96°34'25.38239"	290.838
KSNC	CORS	KSNC	N38°27'11.84854"	W99°53'41.03852"	672.107
KSOG	CORS	KSOG	N38°38'14.33271"	W95°49'49.98266"	307.468
KSOL	CORS	KSOL	N38°50'41.91931"	W94°48'52.75696"	291.4203
KSU1	CORS	KSU1	N39°06'02.70006"	W96°36'34.13586"	325.564
KSWK	CORS	KSWK	N39°01'03.70265"	W99°52'05.27388"	728.846
ZKC1	CORS	ZKC1	N38°52'48.57351"	W94°47'27.00466"	305.466

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 80 ground survey points were collected in support of this project, including 20 LiDAR Control Points (LCP), 25 Non-vegetated Vertical Accuracy (NVA) and 35 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
LCP06	763697.8	4295322	362.509
LCP107	760501.6	4317130	339.304
LCP346	724051.5	4278126	376.914
LCP347	727324.3	4276591	382.333
LCP355	709125.4	4277417	426.485
LCP356	717954.7	4321457	452.924
LCP358	744405.4	4319027	385.443
LCP359	748507.5	4315976	408.296
LCP360	710495.3	4314828	442.029
LCP541	725682	4291777	450.414
LCP547	728027.5	4302362	452.146
LCP609	750822.8	4297033	408.622
LCP610	717712.9	4287583	400.461
LCP612	724968.6	4313807	359.73
LCP613	733665.5	4329784	352.596
LCP614	731137.2	4339688	298.751
LCP630	702206.9	4353623	372.663
LCP637	699282.2	4322118	345.311
LCP660	730076.2	4349890	310.031

ID	Easting	Northing	Elevation
LCP664	700287.3	4337201	333.722

Table 6: LiDAR Control Point Coordinates

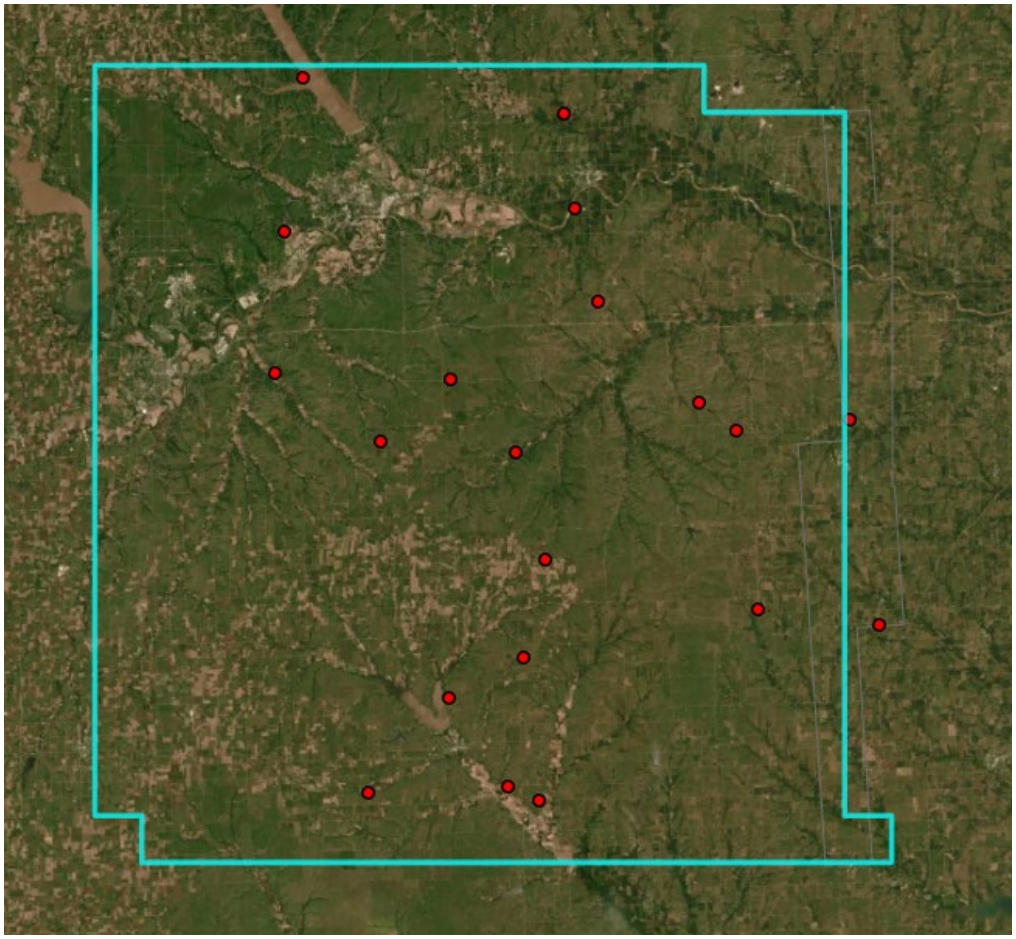


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA1006	687702.7	4322121	337.517
NVA1007	709286.5	4340247	313.571
NVA1009	752943.6	4342467	292.675
NVA1010	750902.5	4305138	432.453
NVA115	764494.3	4320279	314.535
NVA151	761860.8	4281968	346.071
NVA334	748507.6	4315983	408.659
NVA335	725686.3	4291781	450.46
NVA36	760503.2	4317145	339.861
NVA534	726081.6	4323217	392.794
NVA535	741690.5	4286591	462.196
NVA536	727334	4276588	382.132

ID	Easting	Northing	Elevation
NVA730	744091.9	4305583	400.012
NVA732	687129	4289647	429.415
NVA733	696783.7	4296338	447.846
NVA735	734811.7	4321379	323.723
NVA871	695015	4307183	415.968
NVA952	731163.9	4339698	298.727
NVA954	702210.4	4353594	371.697
NVA957	724958.2	4313824	360.381
NVA959	750844.6	4297036	408.364
NVA961	699261.1	4322098	342.649
NVA979	747543.8	4298112	414.217
NVA983	700307.1	4337198	333.101
NVA984	734888.2	4350045	313.502

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

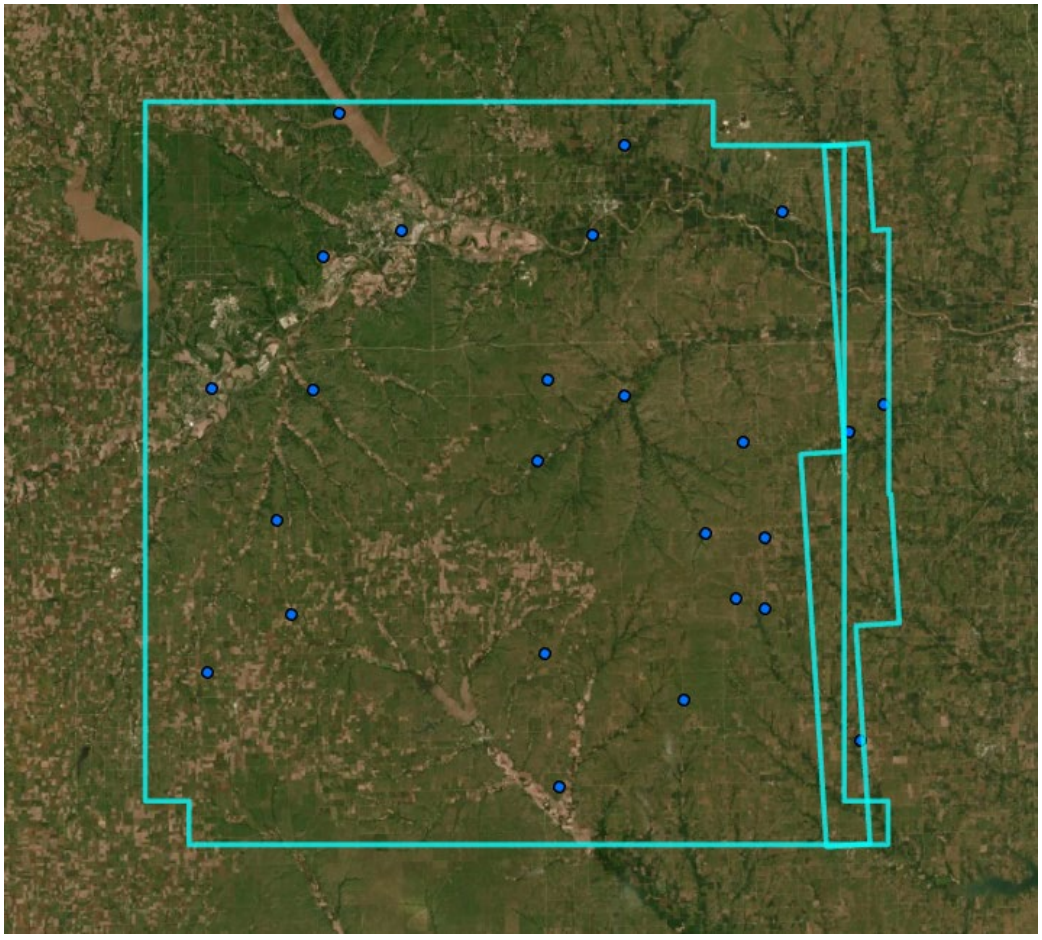


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA117	764907.2	4330356	312.02
VVA184	764519.8	4320273	313.816
VVA230	735855	4308170	383.426
VVA231	717942.9	4321442	451.99
VVA232	744403.8	4319014	385.284
VVA233	704280.7	4290907	407.175
VVA234	696290	4280662	460.588
VVA235	724025.6	4278108	375.448
VVA28	763711.9	4295347	362.619
VVA364	695022.1	4307180	416.076
VVA365	732620.3	4323966	341.127
VVA366	692880.7	4285391	452.217
VVA367	709036.6	4293852	416.153
VVA368	689753.6	4294372	430.453
VVA369	759267.2	4286094	356.8
VVA508	702571.4	4283649	461.926
VVA509	698840.7	4317269	374.827
VVA510	729062.8	4311181	382.535
VVA511	736464.2	4290420	437.755
VVA512	756583.1	4277430	345.901
VVA550	709124.3	4277425	426.133
VVA600	741700	4286582	461.584
VVA603	744071.2	4305574	399.091
VVA604	691909.5	4306786	378.379
VVA679	717523.1	4306875	434.171
VVA680	717690.7	4287589	401.134
VVA681	709674.7	4326439	403.476
VVA695	730068.5	4349905	310.15
VVA696	696654.4	4349977	402.475
VVA697	733639	4329832	352.95
VVA709	752600	4310814	393.446
VVA710	698470.7	4322961	346.293
VVA722	757195.7	4330261	293.814
VVA723	734290.5	4328363	348.545
VVA727	720749.2	4336768	308.866

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

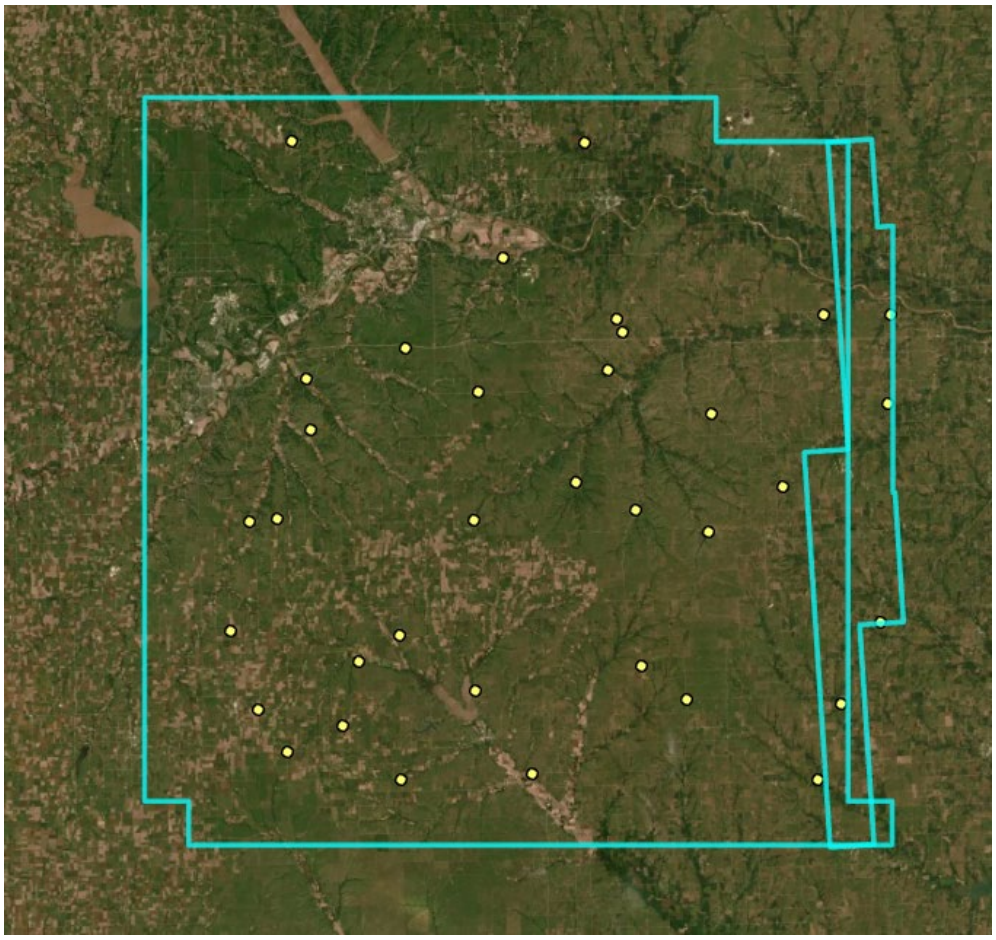


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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(ITRF96)
Coordinate System: UTM, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	20,361,248,684
Nominal Pulse Spacing (M)	0.6589
Nominal Pulse Density (PLS/M^2)	2.3032
Total Points (Aggregate)	20,460,927,405
Aggregate Pulse Spacing (M)	0.5720
Aggregate Pulse Density (PLS/M^2)	3.0560

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)	25	0.0931	0.1824	0.0680
NVA (DEM)	25	0.0994	0.1949	0.1543
VVA (Point Cloud)	35	0.1716	0.3363	0.2318
VVA (DEM)	35	0.1675	0.3283	0.2848

Table 12: NVA/VVA Accuracies

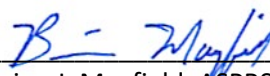
SECTION V: CERTIFICATION STATEMENTS

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
NVA1006	687702.7040	4322120.6660	337.5170	337.3890	-0.1280	NVA
NVA1007	709286.5090	4340246.8770	313.5710	313.6270	0.0560	NVA
NVA1009	752943.6220	4342466.9830	292.6750	292.7340	0.0590	NVA
NVA1010	750902.4860	4305137.6630	432.4530	432.3550	-0.0980	NVA
NVA115	764494.3450	4320278.9850	314.5350	314.4520	-0.0830	NVA
NVA151	761860.8160	4281968.2290	346.0710	345.9280	-0.1430	NVA
NVA334	748507.5970	4315983.1430	408.6590	408.5730	-0.0860	NVA
NVA335	725686.3140	4291780.6500	450.4600	450.3740	-0.0860	NVA
NVA36	760503.1670	4317145.0240	339.8610	339.8690	0.0080	NVA
NVA534	726081.5530	4323216.8640	392.7940	392.6860	-0.1080	NVA
NVA535	741690.5160	4286590.8620	462.1960	462.1820	-0.0140	NVA
NVA536	727333.9910	4276587.9140	382.1320	382.1580	0.0260	NVA
NVA730	744091.8610	4305583.0530	400.0120	399.9480	-0.0640	NVA
NVA732	687128.9930	4289646.7780	429.4150	429.2690	-0.1460	NVA
NVA733	696783.7450	4296338.0660	447.8460	447.6950	-0.1510	NVA
NVA735	734811.6750	4321378.7140	323.7230	323.6380	-0.0850	NVA
NVA871	695014.9760	4307183.1840	415.9680	415.8420	-0.1260	NVA
NVA952	731163.9100	4339697.8330	298.7270	298.7830	0.0560	NVA
NVA954	702210.3630	4353594.2880	371.6970	371.7610	0.0640	NVA
NVA957	724958.1620	4313824.1590	360.3810	360.2310	-0.1500	NVA
NVA959	750844.5890	4297036.1200	408.3640	408.2860	-0.0780	NVA
NVA961	699261.1090	4322097.6300	342.6490	342.5760	-0.0730	NVA
NVA979	747543.7560	4298111.9160	414.2170	414.1450	-0.0720	NVA
NVA983	700307.0600	4337198.1510	333.1010	333.1700	0.0690	NVA
NVA984	734888.2120	4350045.4300	313.5020	313.5850	0.0830	NVA
VVA117	764907.1690	4330355.8620	312.0200	312.4360	0.4160	VVA
VVA184	764519.8480	4320272.9320	313.8160	313.7000	-0.1160	VVA
VVA230	735855.0250	4308170.2870	383.4260	383.3990	-0.0270	VVA
VVA231	717942.9380	4321442.3330	451.9900	451.9710	-0.0190	VVA
VVA232	744403.7810	4319014.1720	385.2840	385.3330	0.0490	VVA
VVA233	704280.7080	4290907.0560	407.1750	407.0850	-0.0900	VVA
VVA234	696290.0300	4280662.0240	460.5880	460.5260	-0.0620	VVA
VVA235	724025.6470	4278108.2700	375.4480	375.4160	-0.0320	VVA
VVA28	763711.8730	4295346.6000	362.6190	362.7180	0.0990	VVA
VVA364	695022.1280	4307179.6540	416.0760	416.0640	-0.0120	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
VVA365	732620.3080	4323966.3650	341.1270	340.9860	-0.1410	VVA
VVA366	692880.6740	4285391.2210	452.2170	452.0360	-0.1810	VVA
VVA367	709036.5940	4293851.7720	416.1530	416.0280	-0.1250	VVA
VVA368	689753.5540	4294372.2010	430.4530	430.3380	-0.1150	VVA
VVA369	759267.1830	4286094.3620	356.8000	356.7090	-0.0910	VVA
VVA508	702571.3920	4283648.8640	461.9260	461.5690	-0.3570	VVA
VVA509	698840.7480	4317269.0990	374.8270	374.8450	0.0180	VVA
VVA510	729062.8170	4311181.1770	382.5350	382.2060	-0.3290	VVA
VVA511	736464.2200	4290419.5020	437.7550	437.4900	-0.2650	VVA
VVA512	756583.1060	4277429.8500	345.9010	345.7200	-0.1810	VVA
VVA550	709124.2900	4277425.3440	426.1330	426.1850	0.0520	VVA
VVA600	741700.0230	4286582.3850	461.5840	461.7020	0.1180	VVA
VVA603	744071.1890	4305574.4010	399.0910	399.1280	0.0370	VVA
VVA604	691909.4930	4306786.4550	378.3790	378.1460	-0.2330	VVA
VVA679	717523.0600	4306875.0460	434.1710	434.1890	0.0180	VVA
VVA680	717690.6820	4287589.2250	401.1340	401.0430	-0.0910	VVA
VVA681	709674.6740	4326438.9170	403.4760	403.3220	-0.1540	VVA
VVA695	730068.4520	4349904.6960	310.1500	310.3530	0.2030	VVA
VVA696	696654.4190	4349976.7510	402.4750	402.6800	0.2050	VVA
VVA697	733639.0350	4329832.1090	352.9500	353.0110	0.0610	VVA
VVA709	752599.9640	4310813.9350	393.4460	393.3190	-0.1270	VVA
VVA710	698470.7120	4322961.4540	346.2930	346.2680	-0.0250	VVA
VVA722	757195.7080	4330261.4180	293.8140	294.0920	0.2780	VVA
VVA723	734290.4570	4328363.4990	348.5450	348.3040	-0.2410	VVA
VVA727	720749.1860	4336767.8660	308.8660	309.0780	0.2120	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
NVA1006	687702.704	4322120.666	337.517	337.4021	0.1149	NVA
NVA1007	709286.509	4340246.877	313.571	313.5767	-0.0057	NVA
NVA1009	752943.622	4342466.983	292.675	292.7323	-0.0573	NVA
NVA1010	750902.486	4305137.663	432.453	432.3767	0.0763	NVA
NVA115	764494.345	4320278.985	314.535	314.4440	0.0910	NVA
NVA151	761860.816	4281968.229	346.071	345.9227	0.1483	NVA
NVA334	748507.597	4315983.143	408.659	408.5501	0.1089	NVA
NVA335	725686.314	4291780.65	450.46	450.3733	0.0867	NVA
NVA36	760503.167	4317145.024	339.861	339.8360	0.0250	NVA
NVA534	726081.553	4323216.864	392.794	392.6125	0.1815	NVA

NVA535	741690.516	4286590.862	462.196	462.1455	0.0505	NVA
NVA536	727333.991	4276587.914	382.132	382.1304	0.0016	NVA
NVA730	744091.861	4305583.053	400.012	399.9448	0.0672	NVA
NVA732	687128.993	4289646.778	429.415	429.2618	0.1532	NVA
NVA733	696783.745	4296338.066	447.846	447.6914	0.1546	NVA
NVA735	734811.675	4321378.714	323.723	323.5946	0.1284	NVA
NVA871	695014.976	4307183.184	415.968	415.8271	0.1409	NVA
NVA952	731163.91	4339697.833	298.727	298.7836	-0.0566	NVA
NVA954	702210.363	4353594.288	371.697	371.7549	-0.0579	NVA
NVA957	724958.162	4313824.159	360.381	360.2439	0.1371	NVA
NVA959	750844.589	4297036.12	408.364	408.2732	0.0908	NVA
NVA961	699261.109	4322097.63	342.649	342.5791	0.0699	NVA
NVA979	747543.756	4298111.916	414.217	414.1562	0.0608	NVA
NVA983	700307.06	4337198.151	333.101	333.1689	-0.0679	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA184	764519.8480	4320272.9320	313.8160	313.5390	-0.2770	VVA
VVA230	735855.0250	4308170.2870	383.4260	383.3185	-0.1075	VVA
VVA231	717942.9380	4321442.3330	451.9900	451.9660	-0.0240	VVA
VVA232	744403.7810	4319014.1720	385.2840	385.1479	-0.1361	VVA
VVA233	704280.7080	4290907.0560	407.1750	407.0329	-0.1421	VVA
VVA234	696290.0300	4280662.0240	460.5880	460.5976	0.0096	VVA
VVA235	724025.6470	4278108.2700	375.4480	375.3595	-0.0885	VVA
VVA28	763711.8730	4295346.6000	362.6190	362.5363	-0.0827	VVA
VVA364	695022.1280	4307179.6540	416.0760	415.9577	-0.1183	VVA
VVA365	732620.3080	4323966.3650	341.1270	340.9577	-0.1693	VVA
VVA366	692880.6740	4285391.2210	452.2170	452.0143	-0.2027	VVA
VVA367	709036.5940	4293851.7720	416.1530	416.0186	-0.1344	VVA
VVA368	689753.5540	4294372.2010	430.4530	430.2987	-0.1543	VVA
VVA369	759267.1830	4286094.3620	356.8000	356.6150	-0.1850	VVA
VVA508	702571.3920	4283648.8640	461.9260	461.6186	-0.3074	VVA
VVA509	698840.7480	4317269.0990	374.8270	374.7617	-0.0653	VVA
VVA510	729062.8170	4311181.1770	382.5350	382.2286	-0.3064	VVA
VVA511	736464.2200	4290419.5020	437.7550	437.6379	-0.1171	VVA
VVA512	756583.1060	4277429.8500	345.9010	345.7919	-0.1091	VVA
VVA550	709124.2900	4277425.3440	426.1330	426.1865	0.0535	VVA
VVA600	741700.0230	4286582.3850	461.5840	461.5111	-0.0729	VVA
VVA603	744071.1890	4305574.4010	399.0910	399.0173	-0.0737	VVA
VVA604	691909.4930	4306786.4550	378.3790	378.2245	-0.1545	VVA

VVA679	717523.0600	4306875.0460	434.1710	434.1051	-0.0659	VVA
VVA680	717690.6820	4287589.2250	401.1340	400.8879	-0.2461	VVA
VVA681	709674.6740	4326438.9170	403.4760	403.1427	-0.3333	VVA
VVA695	730068.4520	4349904.6960	310.1500	310.2606	0.1106	VVA
VVA696	696654.4190	4349976.7510	402.4750	402.6389	0.1639	VVA
VVA697	733639.0350	4329832.1090	352.9500	353.1917	0.2417	VVA
VVA709	752599.9640	4310813.9350	393.4460	393.2753	-0.1707	VVA
VVA710	698470.7120	4322961.4540	346.2930	345.9947	-0.2983	VVA
VVA722	757195.7080	4330261.4180	293.8140	294.1764	0.3624	VVA
VVA723	734290.4570	4328363.4990	348.5450	348.7405	0.1955	VVA
VVA727	720749.1860	4336767.8660	308.8660	309.1702	0.3042	VVA

Table 14: DEM Check Point Assessment