Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 06

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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 06 encompasses part or all of 10 counties in Kansas and covers approximately 2,668 square miles.

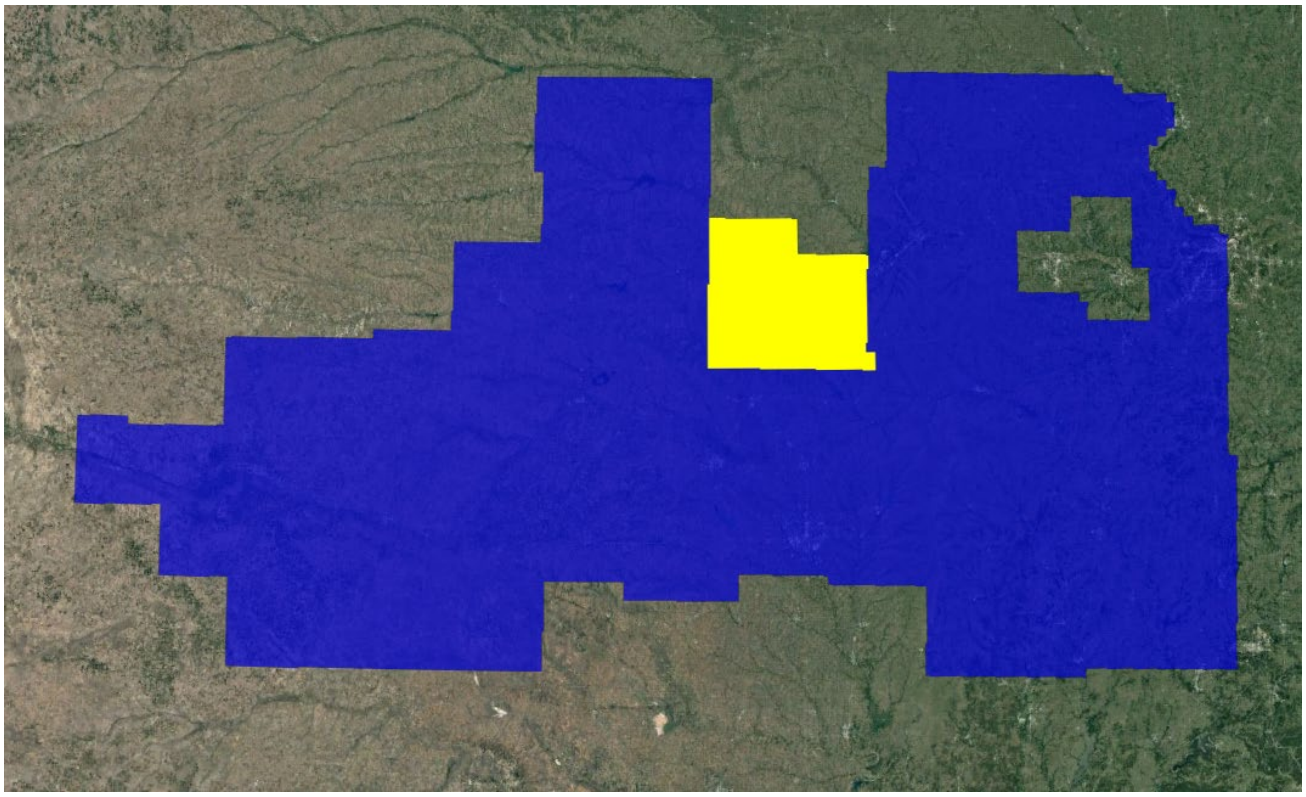


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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
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 89 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 10 flight missions conducted between March 5, 2018 and November 20, 2018. 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.

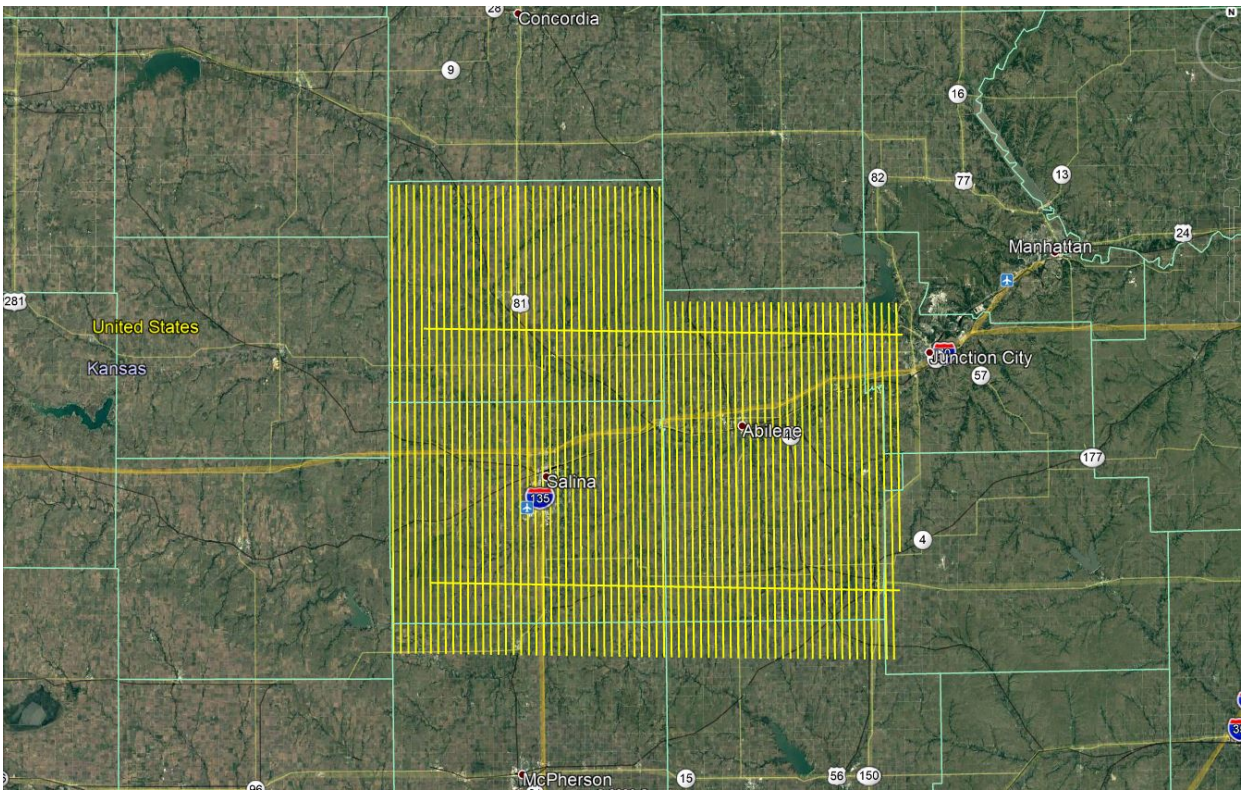


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

d. GNSS Reference Stations

Eleven (11) 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	37°45'09.33297"	97°12'58.42230	401.242m
ICT4	CORS	ICT4	37°37'08.57671"	97°37'57.00056"	392.172m
ICT5	CORS	ICT5	37°47'12.04062"	97°37'32.73360"	411.107m
KSPR	CORS	KSPR	37°41'26.44138"	98°44'27.53387"	573.45m
KSBK	CORS	KSBK	37°33'03.90852"	99°38'06.26885"	717.084m
KSCW	CORS	KSCW	37°16'24.87324"	99°19'39.34067"	624.848m
KSAY	CORS	KSAY	37°08'40.33068"	98°01'49.57453"	383.653m
KSKY	CORS	KSKY	37°54'40.30614"	99°24'21.76286"	641.963m
KSGB	CORS	KSGB	38°21'16.83108"	98°45'53.40654"	545.627m
KSHU	CORS	KSHU	38°01'52.62370"	97°54'08.45874"	440.099m
OKBF	CORS	OKBF	36°49'40.90146'	99°38'28.88423"	538.779m

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 108 ground survey points were collected in support of this project, including 29 LiDAR Control Points (LCP), 43 Non-vegetated Vertical Accuracy (NVA) and 36 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
LCP192	636656.0220	4266503.3830	407.2470
LCP194	648268.5230	4272201.4290	466.7540
LCP195	667170.0750	4275169.0660	433.0220
LCP203	636181.8180	4321114.7220	407.8640
LCP204	634386.5550	4330317.6740	390.3970
LCP205	627943.5130	4330944.5410	429.7910
LCP206	621515.4310	4332346.4510	413.8730
LCP207	625899.5670	4342157.1330	421.8640
LCP208	632599.0930	4340627.6690	438.6690
LCP211	592543.9200	4330413.8800	408.0610
LCP361	679888.6780	4303585.4550	351.3950
LCP362	669625.2010	4310774.4940	370.8670
LCP364	651958.9300	4295880.7440	375.5070
LCP366	664753.3300	4284789.9300	428.3030
LCP367	664336.2090	4295801.6210	410.7350
LCP368	638045.4440	4277834.4930	397.1530
LCP370	592940.4520	4302523.8160	443.7820
LCP372	605624.4540	4306383.3370	415.6650

ID	Easting	Northing	Elevation
LCP373	617750.0250	4309672.5640	375.9920
LCP374	626706.5190	4307081.0810	380.3790
LCP540	619140.9650	4281539.4840	395.6670
LCP542	661148.3240	4268770.9040	431.0200
LCP546	631356.8070	4322894.0500	381.8350
LCP548	605796.5200	4331360.8230	383.1610
LCP549	663265.5760	4307946.1670	350.6750
LCP551	676852.7870	4282148.1020	420.1210
LCP553	621666.4120	4282120.7640	390.8760
LCP635	667203.8400	4322839.7920	356.5070
LCP636	678272.5580	4314107.7790	367.0640

Table 6: LiDAR Control Point Coordinates

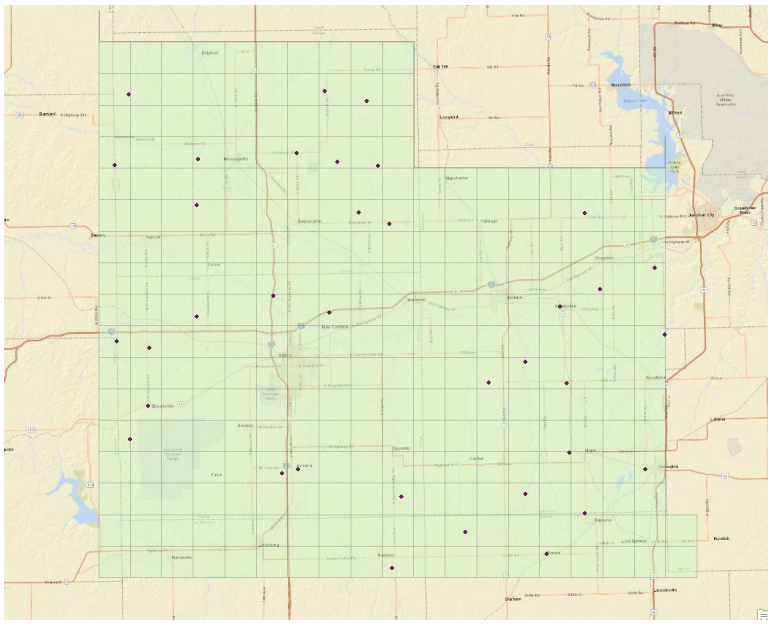


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA1005	671733.6160	4315471.1130	338.8640
NVA1030	678540.2280	4318976.7300	344.2790
NVA320	594816.7720	4341675.7640	433.1530
NVA324	664749.7240	4284792.9880	428.3560
NVA325	679888.6260	4303590.2600	351.5550
NVA326	669623.5080	4310770.3880	370.6690
NVA327	664337.7000	4295805.5380	410.8110
NVA328	638038.7450	4277831.4470	397.2510

ID	Easting	Northing	Elevation
NVA329	667134.9520	4275152.0040	432.8350
NVA330	625865.3370	4342163.1290	421.8730
NVA331	651962.3360	4295874.8620	375.6740
NVA332	621516.1710	4332402.1630	414.0010
NVA333	632582.4790	4340605.4640	438.3870
NVA518	605819.5050	4331380.0550	382.8170
NVA519	628536.1980	4271221.1680	448.1740
NVA521	634533.0680	4293941.6650	368.4470
NVA522	631505.0820	4307666.9580	388.5500
NVA523	631295.7520	4322909.1150	383.7110
NVA524	607440.7330	4301540.3360	385.8340
NVA526	661108.1420	4268757.5370	431.4040
NVA527	623647.4200	4316314.9730	390.1490
NVA528	608819.1220	4320686.5500	402.8630
NVA529	618227.3100	4338742.4970	418.2440
NVA715	596018.5750	4334172.6080	395.3370
NVA718	621382.0180	4298195.2900	374.5060
NVA719	655016.4150	4311917.3150	373.0020
NVA720	663265.7880	4307951.0380	350.5820
NVA721	676842.6040	4282151.9250	420.2350
NVA722	648294.3620	4283258.7830	399.5200
NVA723	677108.6720	4270594.2890	454.9570
NVA724	615722.8520	4270270.9760	405.5160
NVA725	621668.5270	4282125.4100	390.8760
NVA726	620849.9700	4276333.4810	397.4920
NVA727	606588.2710	4348183.9520	399.9270
NVA728	611846.4630	4331147.0190	391.9940
NVA729	650630.9320	4320821.4690	369.2840
NVA872	672017.6550	4281765.7320	403.0950
NVA873	630188.1250	4288189.3490	390.6350
NVA874	608036.3850	4295141.4230	387.3550
NVA914	619473.8360	4321904.9970	372.0210
NVA915	608506.7790	4342648.1380	395.5170
NVA950	678290.6690	4314113.2180	367.3530
NVA951	667179.6360	4322822.1550	355.3640

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

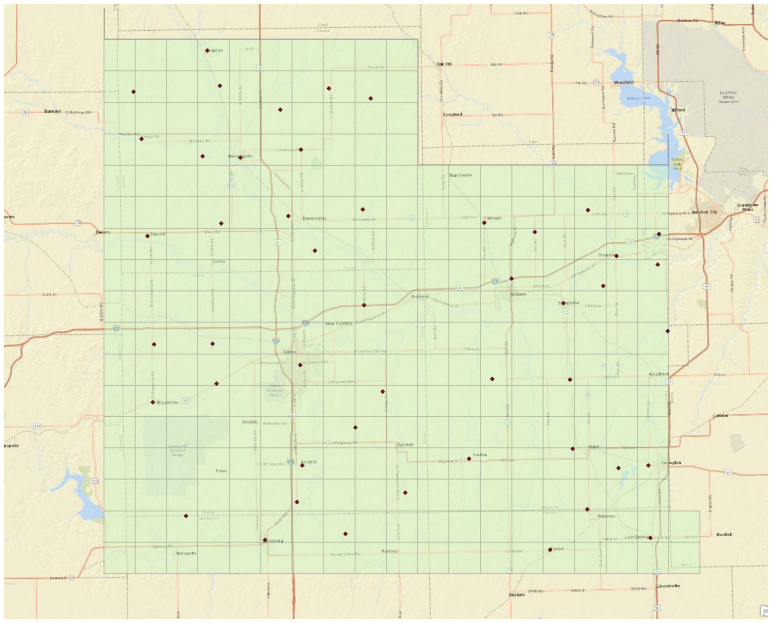


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA217	592963.6030	4302538.1990	444.5820
VVA218	592592.0400	4330421.0860	406.3490
VVA222	595009.1060	4286926.9250	459.6660
VVA223	648322.8530	4272220.2650	463.0730
VVA224	605625.3620	4324116.6720	437.3790
VVA225	657710.1830	4278219.4160	401.0170
VVA226	636155.6120	4321069.2330	406.5260
VVA228	627941.2250	4330892.1960	432.2680
VVA229	617758.4680	4309671.8530	375.9870
VVA276	636682.3620	4266498.0900	407.6680
VVA355	592819.9870	4340816.2250	431.5950
VVA356	657817.1740	4299206.0010	357.5810
VVA357	619152.0720	4281532.6760	395.7430
VVA358	636639.0940	4297140.6550	363.2850
VVA359	672030.7150	4281768.9770	402.7770
VVA360	665978.5810	4291178.5900	402.8620
VVA361	651807.7910	4308056.4570	351.4680
VVA362	630176.5230	4288188.0300	390.6030
VVA363	614825.1340	4340365.3430	396.9660
VVA398	595244.9090	4269046.7410	464.5540

ID	Easting	Northing	Elevation
VVA501	635103.0470	4343849.3610	417.3730
VVA502	619435.9450	4321898.6630	371.6790
VVA503	608513.4170	4342686.1010	395.5730
VVA504	608046.3210	4295144.5300	387.6990
VVA505	634351.1050	4330342.4520	388.3250
VVA506	652214.8990	4315326.3090	359.0810
VVA507	626697.8440	4307088.1080	380.5350
VVA605	648297.7640	4283268.3470	399.3620
VVA606	634523.8250	4293961.2180	368.4070
VVA607	631561.6680	4307666.3300	388.0630
VVA646	620842.7760	4276311.9980	396.8240
VVA647	677127.5380	4270606.1490	455.0680
VVA648	615704.8090	4270289.0880	405.5650
VVA649	623682.1180	4316298.5550	388.2050
VVA650	608839.4930	4320662.8900	402.9420
VVA707	678583.7670	4318960.4880	344.9460

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

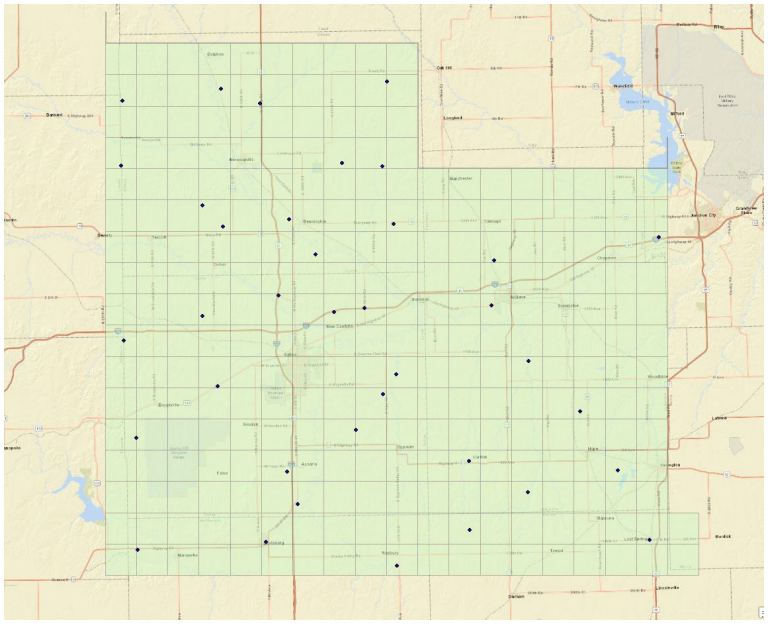


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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, 14N
Vertical Datum: NAVD88
Geoid Model: 12B
Units of Reference: Meter

c. LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	21,497,809,205
Nominal Pulse Spacing (M)	0.6678
Nominal Pulse Density (PLS/M^2)	2.2427
Total Points (Aggregate)	21,497,809,205
Aggregate Pulse Spacing (M)	0.5975
Aggregate Pulse Density (PLS/M^2)	2.8010

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)	43	0.0960	0.1882	0.1545
NVA (DEM)	42	0.0979	0.1919	0.0773
VVA (Point Cloud)	36	0.1991	0.3903	0.4003
VVA (DEM)	36	0.1996	0.3913	0.1214

Table 12: NVA/VVA Accuracies

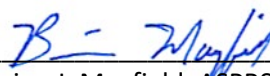
SECTION V: CERTIFICATION STATEMENTS

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
NVA1005	671733.6160	4315471.1130	338.8640	338.8530	-0.0110	NVA
NVA1030	678540.2280	4318976.7300	344.2790	344.2060	-0.0730	NVA
NVA320	594816.7720	4341675.7640	433.1530	433.3810	0.2280	NVA
NVA324	664749.7240	4284792.9880	428.3560	428.3980	0.0420	NVA
NVA325	679888.6260	4303590.2600	351.5550	351.5260	-0.0290	NVA
NVA326	669623.5080	4310770.3880	370.6690	370.7650	0.0960	NVA
NVA327	664337.7000	4295805.5380	410.8110	410.6510	-0.1600	NVA
NVA328	638038.7450	4277831.4470	397.2510	397.2530	0.0020	NVA
NVA329	667134.9520	4275152.0040	432.8350	432.7560	-0.0790	NVA
NVA330	625865.3370	4342163.1290	421.8730	421.9230	0.0500	NVA
NVA331	651962.3360	4295874.8620	375.6740	375.7960	0.1220	NVA
NVA332	621516.1710	4332402.1630	414.0010	414.0590	0.0580	NVA
NVA333	632582.4790	4340605.4640	438.3870	438.4760	0.0890	NVA
NVA518	605819.5050	4331380.0550	382.8170	382.9230	0.1060	NVA
NVA519	628536.1980	4271221.1680	448.1740	448.0750	-0.0990	NVA
NVA521	634533.0680	4293941.6650	368.4470	368.5970	0.1500	NVA
NVA522	631505.0820	4307666.9580	388.5500	388.6270	0.0770	NVA
NVA523	631295.7520	4322909.1150	383.7110	383.8660	0.1550	NVA
NVA524	607440.7330	4301540.3360	385.8340	385.9660	0.1320	NVA
NVA526	661108.1420	4268757.5370	431.4040	431.5230	0.1190	NVA
NVA527	623647.4200	4316314.9730	390.1490	390.2640	0.1150	NVA
NVA528	608819.1220	4320686.5500	402.8630	402.9310	0.0680	NVA
NVA529	618227.3100	4338742.4970	418.2440	418.3580	0.1140	NVA
NVA715	596018.5750	4334172.6080	395.3370	395.4410	0.1040	NVA
NVA718	621382.0180	4298195.2900	374.5060	374.5550	0.0490	NVA
NVA719	655016.4150	4311917.3150	373.0020	373.0920	0.0900	NVA
NVA720	663265.7880	4307951.0380	350.5820	350.5640	-0.0180	NVA
NVA721	676842.6040	4282151.9250	420.2350	420.1970	-0.0380	NVA
NVA722	648294.3620	4283258.7830	399.5200	399.6360	0.1160	NVA
NVA723	677108.6720	4270594.2890	454.9570	454.9360	-0.0210	NVA
NVA724	615722.8520	4270270.9760	405.5160	405.5130	-0.0030	NVA
NVA725	621668.5270	4282125.4100	390.8760	390.9730	0.0970	NVA
NVA726	620849.9700	4276333.4810	397.4920	397.4740	-0.0180	NVA
NVA727	606588.2710	4348183.9520	399.9270	399.9870	0.0600	NVA
NVA728	611846.4630	4331147.0190	391.9940	392.1780	0.1840	NVA

NVA729	650630.9320	4320821.4690	369.2840	369.3570	0.0730	NVA
NVA872	672017.6550	4281765.7320	403.0950	403.1180	0.0230	NVA
NVA873	630188.1250	4288189.3490	390.6350	390.5920	-0.0430	NVA
NVA874	608036.3850	4295141.4230	387.3550	387.4890	0.1340	NVA
NVA914	619473.8360	4321904.9970	372.0210	372.0990	0.0780	NVA
NVA915	608506.7790	4342648.1380	395.5170	395.5750	0.0580	NVA
NVA950	678290.6690	4314113.2180	367.3530	367.4550	0.1020	NVA
NVA951	667179.6360	4322822.1550	355.3640	355.3300	-0.0340	NVA
VVA217	592963.6030	4302538.1990	444.5820	444.3310	-0.2510	VVA
VVA218	592592.0400	4330421.0860	406.3490	406.3720	0.0230	VVA
VVA222	595009.1060	4286926.9250	459.6660	460.0600	0.3940	VVA
VVA223	648322.8530	4272220.2650	463.0730	463.1580	0.0850	VVA
VVA224	605625.3620	4324116.6720	437.3790	437.6780	0.2990	VVA
VVA225	657710.1830	4278219.4160	401.0170	401.4980	0.4810	VVA
VVA226	636155.6120	4321069.2330	406.5260	406.6360	0.1100	VVA
VVA228	627941.2250	4330892.1960	432.2680	432.2450	-0.0230	VVA
VVA229	617758.4680	4309671.8530	375.9870	376.1610	0.1740	VVA
VVA276	636682.3620	4266498.0900	407.6680	407.7500	0.0820	VVA
VVA355	592819.9870	4340816.2250	431.5950	431.1780	-0.4170	VVA
VVA356	657817.1740	4299206.0010	357.5810	358.0000	0.4190	VVA
VVA357	619152.0720	4281532.6760	395.7430	395.8870	0.1440	VVA
VVA358	636639.0940	4297140.6550	363.2850	363.4170	0.1320	VVA
VVA359	672030.7150	4281768.9770	402.7770	402.8400	0.0630	VVA
VVA360	665978.5810	4291178.5900	402.8620	402.7480	-0.1140	VVA
VVA361	651807.7910	4308056.4570	351.4680	351.5850	0.1170	VVA
VVA362	630176.5230	4288188.0300	390.6030	390.5410	-0.0620	VVA
VVA363	614825.1340	4340365.3430	396.9660	397.1860	0.2200	VVA
VVA398	595244.9090	4269046.7410	464.5540	464.7860	0.2320	VVA
VVA501	635103.0470	4343849.3610	417.3730	417.5680	0.1950	VVA
VVA502	619435.9450	4321898.6630	371.6790	371.7160	0.0370	VVA
VVA503	608513.4170	4342686.1010	395.5730	395.7390	0.1660	VVA
VVA504	608046.3210	4295144.5300	387.6990	387.7940	0.0950	VVA
VVA505	634351.1050	4330342.4520	388.3250	388.4680	0.1430	VVA
VVA506	652214.8990	4315326.3090	359.0810	359.1590	0.0780	VVA
VVA507	626697.8440	4307088.1080	380.5350	380.6350	0.1000	VVA
VVA605	648297.7640	4283268.3470	399.3620	399.5000	0.1380	VVA
VVA606	634523.8250	4293961.2180	368.4070	368.5520	0.1450	VVA
VVA607	631561.6680	4307666.3300	388.0630	388.2080	0.1450	VVA
VVA646	620842.7760	4276311.9980	396.8240	396.9030	0.0790	VVA
VVA647	677127.5380	4270606.1490	455.0680	455.1020	0.0340	VVA

VVA648	615704.8090	4270289.0880	405.5650	405.6340	0.0690	VVA
VVA649	623682.1180	4316298.5550	388.2050	388.5220	0.3170	VVA
VVA650	608839.4930	4320662.8900	402.9420	403.0840	0.1420	VVA
VVA707	678583.7670	4318960.4880	344.9460	344.9340	-0.0120	VVA

Table 13: Point Cloud Check Point Assessment

b. DEM Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA1005	671733.6160	4315471.1130	338.8640	338.8190	0.0450	NVA
NVA1030	678540.2280	4318976.7300	344.2790	344.2329	0.0461	NVA
NVA320	594816.7720	4341675.7640	433.1530	433.1537	-0.0007	NVA
NVA324	664749.7240	4284792.9880	428.3560	428.4269	-0.0709	NVA
NVA325	679888.6260	4303590.2600	351.5550	351.5691	-0.0141	NVA
NVA326	669623.5080	4310770.3880	370.6690	370.8145	-0.1455	NVA
NVA327	664337.7000	4295805.5380	410.8110	410.6839	0.1271	NVA
NVA328	638038.7450	4277831.4470	397.2510	397.3031	-0.0521	NVA
NVA329	667134.9520	4275152.0040	432.8350	432.7255	0.1095	NVA
NVA330	625865.3370	4342163.1290	421.8730	421.9066	-0.0336	NVA
NVA331	651962.3360	4295874.8620	375.6740	375.7443	-0.0703	NVA
NVA332	621516.1710	4332402.1630	414.0010	414.0629	-0.0619	NVA
NVA333	632582.4790	4340605.4640	438.3870	438.4905	-0.1035	NVA
NVA518	605819.5050	4331380.0550	382.8170	382.9303	-0.1133	NVA
NVA519	628536.1980	4271221.1680	448.1740	448.1090	0.0650	NVA
NVA521	634533.0680	4293941.6650	368.4470	368.6181	-0.1711	NVA
NVA522	631505.0820	4307666.9580	388.5500	388.5785	-0.0285	NVA
NVA523	631295.7520	4322909.1150	383.7110	383.8953	-0.1843	NVA
NVA524	607440.7330	4301540.3360	385.8340	386.0149	-0.1809	NVA
NVA526	661108.1420	4268757.5370	431.4040	431.4895	-0.0855	NVA
NVA527	623647.4200	4316314.9730	390.1490	390.3211	-0.1721	NVA
NVA528	608819.1220	4320686.5500	402.8630	402.9383	-0.0753	NVA
NVA529	618227.3100	4338742.4970	418.2440	418.3526	-0.1086	NVA
NVA718	621382.0180	4298195.2900	374.5060	374.5699	-0.0639	NVA
NVA719	655016.4150	4311917.3150	373.0020	373.1730	-0.1710	NVA
NVA720	663265.7880	4307951.0380	350.5820	350.5544	0.0276	NVA
NVA721	676842.6040	4282151.9250	420.2350	420.2128	0.0222	NVA
NVA722	648294.3620	4283258.7830	399.5200	399.6141	-0.0941	NVA
NVA723	677108.6720	4270594.2890	454.9570	454.8817	0.0753	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA724	615722.8520	4270270.9760	405.5160	405.5385	-0.0225	NVA
NVA725	621668.5270	4282125.4100	390.8760	390.9901	-0.1141	NVA
NVA726	620849.9700	4276333.4810	397.4920	397.4879	0.0041	NVA
NVA727	606588.2710	4348183.9520	399.9270	399.9665	-0.0395	NVA
NVA728	611846.4630	4331147.0190	391.9940	392.1895	-0.1955	NVA
NVA729	650630.9320	4320821.4690	369.2840	369.3758	-0.0918	NVA
NVA872	672017.6550	4281765.7320	403.0950	403.1029	-0.0079	NVA
NVA873	630188.1250	4288189.3490	390.6350	390.5576	0.0774	NVA
NVA874	608036.3850	4295141.4230	387.3550	387.4462	-0.0912	NVA
NVA914	619473.8360	4321904.9970	372.0210	372.0660	-0.0450	NVA
NVA915	608506.7790	4342648.1380	395.5170	395.5771	-0.0601	NVA
NVA950	678290.6690	4314113.2180	367.3530	367.4907	-0.1377	NVA
NVA951	667179.6360	4322822.1550	355.3640	355.3133	0.0507	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA217	592963.6030	4302538.1990	444.5820	444.3475	0.2345	VVA
VVA218	592592.0400	4330421.0860	406.3490	406.3408	0.0082	VVA
VVA222	595009.1060	4286926.9250	459.6660	460.0639	-0.3979	VVA
VVA223	648322.8530	4272220.2650	463.0730	463.1671	-0.0941	VVA
VVA224	605625.3620	4324116.6720	437.3790	437.6571	-0.2781	VVA
VVA225	657710.1830	4278219.4160	401.0170	401.5722	-0.5552	VVA
VVA226	636155.6120	4321069.2330	406.5260	406.6636	-0.1376	VVA
VVA228	627941.2250	4330892.1960	432.2680	432.2829	-0.0149	VVA
VVA229	617758.4680	4309671.8530	375.9870	376.1519	-0.1649	VVA
VVA276	636682.3620	4266498.0900	407.6680	407.6258	0.0422	VVA
VVA355	592819.9870	4340816.2250	431.5950	431.3109	0.2841	VVA
VVA356	657817.1740	4299206.0010	357.5810	357.9489	-0.3679	VVA
VVA357	619152.0720	4281532.6760	395.7430	395.8520	-0.1090	VVA
VVA358	636639.0940	4297140.6550	363.2850	363.4743	-0.1893	VVA
VVA359	672030.7150	4281768.9770	402.7770	402.8654	-0.0884	VVA
VVA360	665978.5810	4291178.5900	402.8620	402.7783	0.0837	VVA
VVA361	651807.7910	4308056.4570	351.4680	351.6441	-0.1761	VVA
VVA362	630176.5230	4288188.0300	390.6030	390.5765	0.0265	VVA
VVA363	614825.1340	4340365.3430	396.9660	397.1129	-0.1469	VVA
VVA398	595244.9090	4269046.7410	464.5540	464.6874	-0.1334	VVA
VVA501	635103.0470	4343849.3610	417.3730	417.5507	-0.1777	VVA
VVA502	619435.9450	4321898.6630	371.6790	371.7841	-0.1051	VVA
VVA503	608513.4170	4342686.1010	395.5730	395.6767	-0.1037	VVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA504	608046.3210	4295144.5300	387.6990	387.7455	-0.0465	VVA
VVA505	634351.1050	4330342.4520	388.3250	388.4566	-0.1316	VVA
VVA506	652214.8990	4315326.3090	359.0810	359.2089	-0.1279	VVA
VVA507	626697.8440	4307088.1080	380.5350	380.7123	-0.1773	VVA
VVA605	648297.7640	4283268.3470	399.3620	399.5084	-0.1464	VVA
VVA606	634523.8250	4293961.2180	368.4070	368.5773	-0.1703	VVA
VVA607	631561.6680	4307666.3300	388.0630	388.2515	-0.1885	VVA
VVA646	620842.7760	4276311.9980	396.8240	397.2001	-0.3761	VVA
VVA647	677127.5380	4270606.1490	455.0680	455.0441	0.0239	VVA
VVA648	615704.8090	4270289.0880	405.5650	405.6742	-0.1092	VVA
VVA649	623682.1180	4316298.5550	388.2050	388.4341	-0.2291	VVA
VVA650	608839.4930	4320662.8900	402.9420	403.0605	-0.1185	VVA
VVA707	678583.7670	4318960.4880	344.9460	344.9035	0.0425	VVA

Table 14: Digital Elevation Model (DEM) Check Point Assessment