Project Report

TASK ORDER NAME: 2018 Kansas QL2 LiDAR
CONTRACT ID: 00000000000000000000039891
EVENT ID: EVT0003259
ATLANTIC PROJECT NUMBER: 18006
PROJECT BLOCK NUMBER: Block 4A

TABLE OF CONTENTS

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 4A encompasses part or all of 8 counties in Kansas and covers approximately 2,347 square miles.

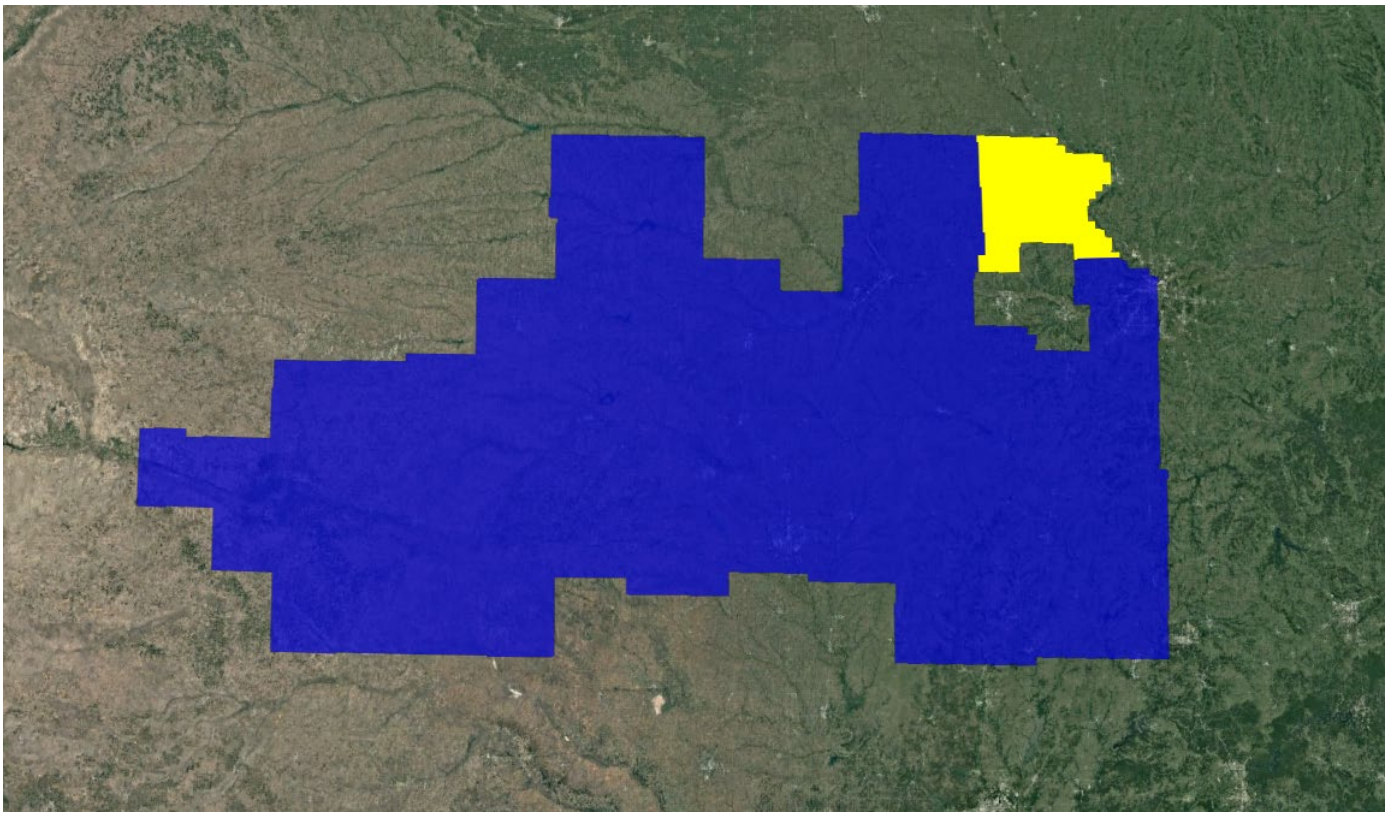


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

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 153 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 12 flight missions conducted between March 1, 2018 and April 23, 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.

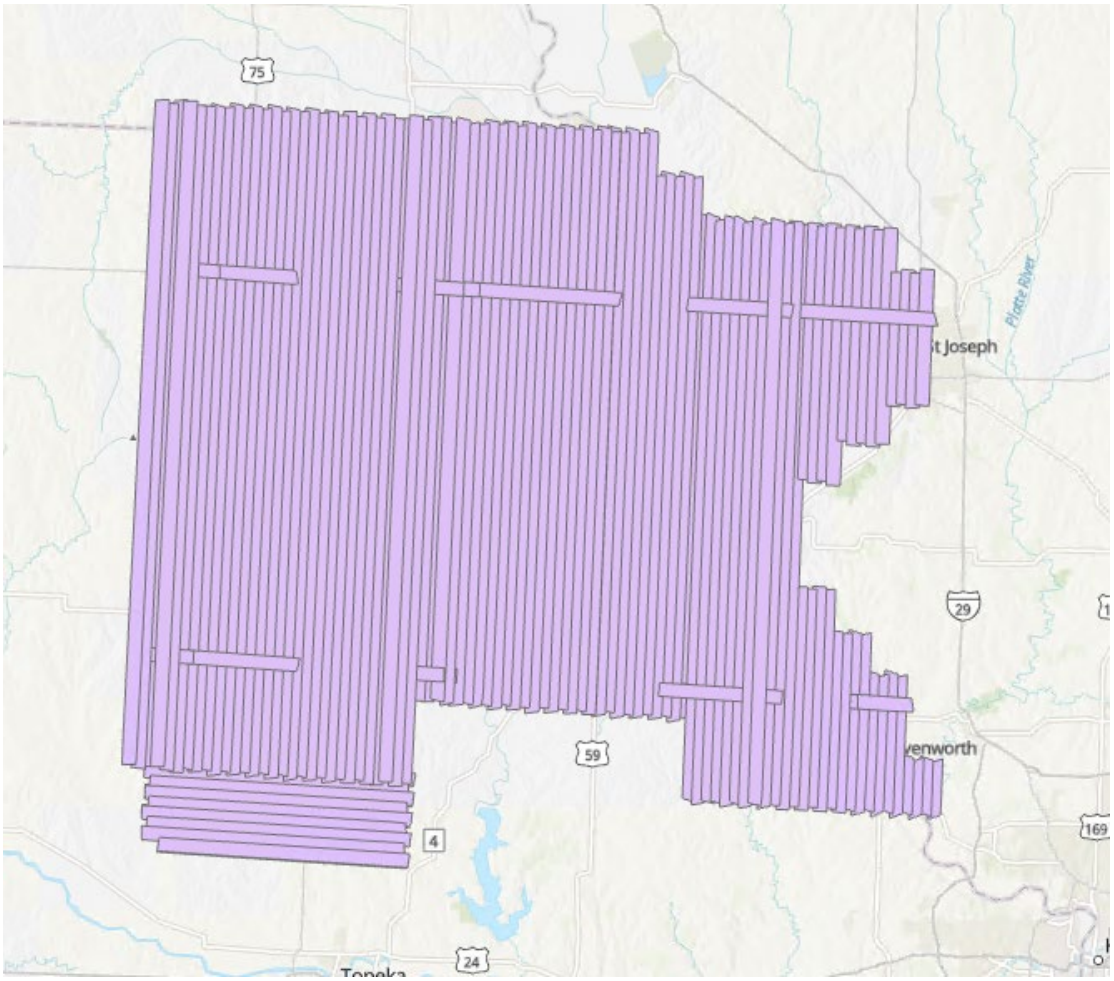


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

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
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

Table 5: GNSS Reference Stations

2. Aerial LiDAR Project – Ground Acquisition

a. Ground Control Survey

A total of 87 ground survey points were collected in support of this project, including 23 LiDAR Control Points (LCP), 40 Non-vegetated Vertical Accuracy (NVA) and 24 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
POINT_ID	EASTING	NORTHING	ELEVATION
LCP100	262867	4374199	334.622
LCP101	277623.3	4356148	329.698
LCP102	274983.6	4348036	328.835
LCP156	301589.3	4404732	302.742
LCP158	293470.1	4401695	319.187
LCP159	312108.4	4362334	349.462
LCP160	256475.1	4411631	386.659
LCP161	258321	4378734	366.018
LCP79	328527.1	4360312	314.936
LCP80	313328.9	4389299	277.048
LCP81	308552.8	4414613	303.896
LCP82	306827.5	4405492	291.901
LCP83	330092.2	4403227	327.57
LCP84	284273.4	4418039	328.252
LCP85	292142.4	4427555	311.215
LCP86	298123.9	4395119	349.366
LCP87	264339.8	4408088	376.24
LCP88	277291.7	4410178	358.065

ID	Easting	Northing	Elevation
LCP89	288710.6	4380916	339.997
LCP90	306215.4	4375354	319.759
LCP97	266759.3	4427911	332.165
LCP98	255008	4417327	405.845
LCP99	280642.5	4380773	295.577

Table 6: LiDAR Control Point Coordinates

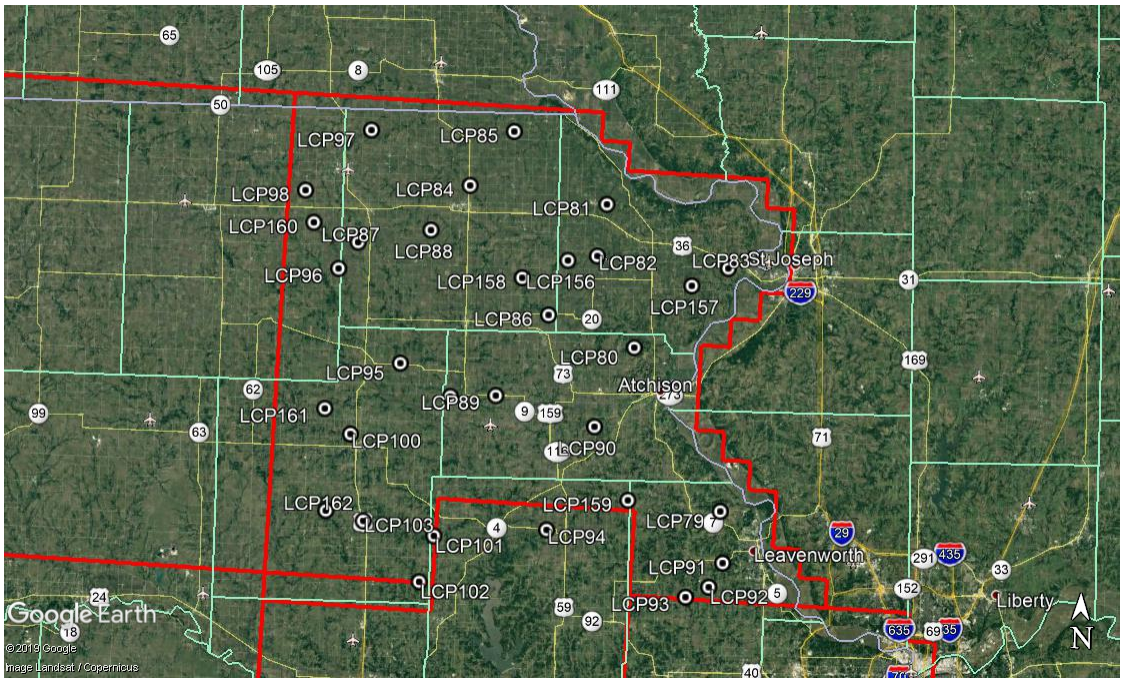


Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
NVA100	304599.2	4390100	327.912
NVA101	286282.5	4386286	334.42
NVA102	257755.4	4391427	353.194
NVA103	282249.6	4403553	343.241
NVA104	301601.6	4404702	302.4
NVA105	288706.9	4380851	337.506
NVA106	256451.7	4411609	385.838
NVA107	305267.2	4426762	258.407
NVA108	260748.1	4424366	379.453
NVA117	793082.9	4345172	290.613
NVA168	266301.5	4404035	361.364
NVA169	261905.2	4430024	346.176
NVA170	298202	4413064	341.781
NVA171	280842.5	4413779	348.788

ID	Easting	Northing	Elevation
NVA172	306953.4	4401365	313.936
NVA173	335591.3	4401525	245.783
NVA174	284846.2	4393861	334.492
NVA177	294096.7	4377588	344.999
NVA178	316828.7	4373123	300.797
NVA179	263406	4367125	339.955
NVA181	330946.8	4356697	272.437
NVA182	265404.7	4350742	351.792
NVA23	292156.9	4427561	310.012
NVA24	255050.3	4417345	404.487
NVA25	277374.4	4410184	357.318
NVA254	307459.9	4397401	300.288
NVA255	292483.6	4408209	300.197
NVA256	295931.4	4386452	321.956
NVA257	317601.3	4367783	317.434
NVA26	306781	4405498	292.241
NVA27	330114.6	4403201	326.866
NVA28	298147.2	4395099	349.361
NVA29	313320.9	4389290	277.687
NVA30	262959.1	4374211	333.8
NVA31	324535.2	4409020	359.042
NVA32	306234.2	4375380	320.405
NVA35	328542.9	4360352	314.741
NVA38	275013.4	4348031	329.709
NVA96	312167.9	4362362	348.295
NVA99	270878.4	4368301	332.465

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

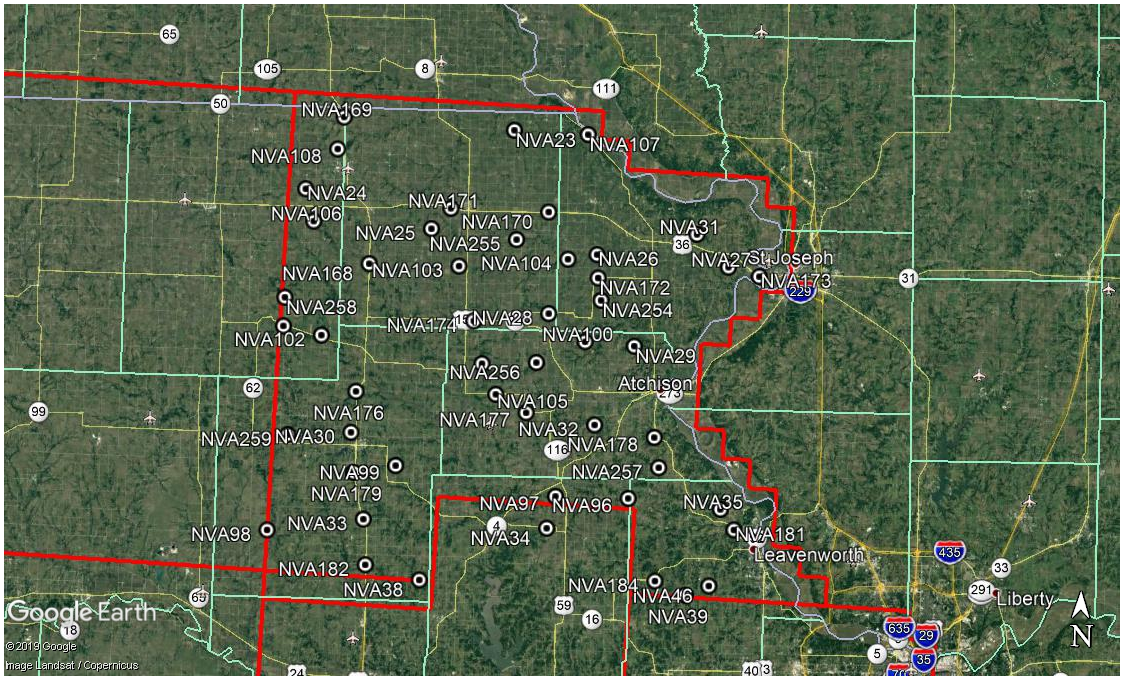


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
VVA109	258317.9	4378770	365.002
VVA110	295884.1	4386395	319.701
VVA111	264348.9	4408146	375.647
VVA114	304791.9	4421299	311.333
VVA172	282208.2	4403553	340.608
VVA175	304590.2	4390070	328.413
VVA176	335616.2	4401503	244.388
VVA177	316799.3	4373142	299.884
VVA178	257779.2	4391415	351.517
VVA179	263922.3	4381473	327.626
VVA18	266769.5	4427932	333.347
VVA180	265422.5	4350701	351.966
VVA19	308544	4414602	303.54
VVA20	284239	4418029	326.872
VVA23	280631.4	4380750	295.649
VVA24	277613.7	4356102	329.976
VVA26	770273.5	4349183	307.076
VVA58	322535.8	4357266	336.887
VVA60	297964.2	4368482	330.041
VVA61	277209.2	4371277	326.36
VVA63	293494.6	4401704	318.411
VVA64	307427.9	4397409	300.739

ID	Easting	Northing	Elevation
VVA65	272709.6	4419591	345.038
VVA66	278623.1	4427853	319.324

Table 8: Vegetated Vertical Accuracy (VVA) Point Coordinates

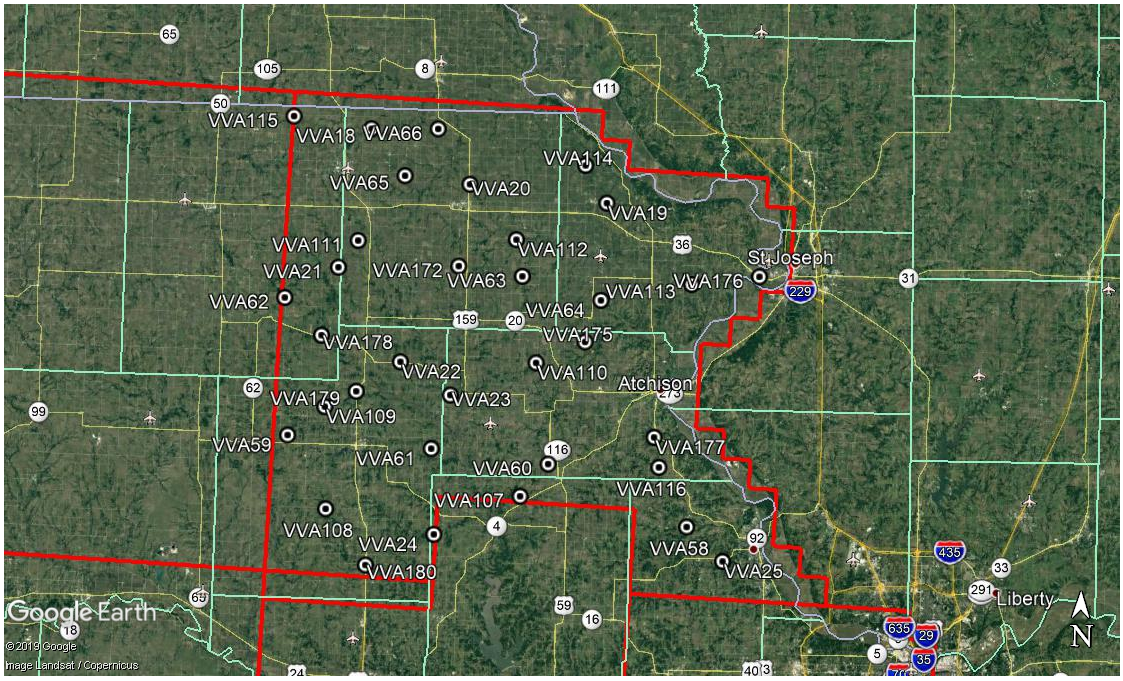


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

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(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)	21,520,592,072
Nominal Pulse Spacing (M)	0.8786
Nominal Pulse Density (PLS/M^2)	1.2955
Total Points (Aggregate)	21,617,232,904
Aggregate Pulse Spacing (M)	0.5747
Aggregate Pulse Density (PLS/M^2)	3.0280

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)	40	0.0975	0.1911	0.1122
NVA (DEM)	40	0.0938	0.1839	0.1524
VVA (Point Cloud)	24	0.1891	0.3706	0.2968
VVA (DEM)	24	0.1484	0.2909	0.2145

Table 12: NVA/VVA Accuracies

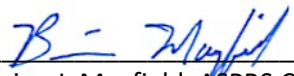
SECTION V: CERTIFICATION STATEMENTS

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
NVA100	819501.4060	4394248.5720	327.9120	328.0140	0.1020	NVA
NVA101	801468.1240	4389216.9250	334.4200	334.4030	-0.0170	NVA
NVA102	772650.6390	4392443.2480	353.1940	353.0620	-0.1320	NVA
NVA103	796287.2380	4406184.6120	343.2410	343.2440	0.0030	NVA
NVA104	815530.7370	4408628.6470	302.4000	302.4140	0.0140	NVA
NVA105	804251.2610	4383952.7980	337.5060	337.5000	-0.0060	NVA
NVA106	769998.8940	4412495.6860	385.8380	385.6760	-0.1620	NVA
NVA107	817709.0820	4430901.1000	258.4070	258.5910	0.1840	NVA
NVA108	773429.9080	4425514.8320	379.4530	379.2890	-0.1640	NVA
NVA117	793082.8750	4345172.2360	290.6130	290.4090	-0.2040	NVA
NVA168	780336.3300	4405597.1160	361.3640	361.2240	-0.1400	NVA
NVA169	774204.0720	4431239.5720	346.1760	346.0520	-0.1240	NVA
NVA170	811575.4670	4416748.9990	341.7810	341.7630	-0.0180	NVA
NVA171	794196.9790	4416297.9060	348.7880	348.7350	-0.0530	NVA
NVA172	821098.3670	4405654.9400	313.9360	314.0510	0.1150	NVA
NVA173	849689.6070	4407733.4510	245.7830	245.8330	0.0500	NVA
NVA174	799528.0210	4396683.3360	334.4920	334.5340	0.0420	NVA
NVA177	809850.1340	4381053.9190	344.9990	345.0370	0.0380	NVA
NVA178	832847.5690	4378110.5940	300.7970	300.8670	0.0700	NVA
NVA179	779909.8110	4368566.0830	339.9550	339.8020	-0.1530	NVA
NVA181	848042.4610	4362643.4960	272.4370	272.4120	-0.0250	NVA
NVA182	782992.6470	4352347.0420	351.7920	351.6980	-0.0940	NVA
NVA23	804565.6280	4430817.2080	310.0120	310.0250	0.0130	NVA
NVA24	768215.5700	4418125.6050	404.4870	404.3240	-0.1630	NVA
NVA25	790976.2710	4412476.6990	357.3180	357.2030	-0.1150	NVA
NVA254	821869.5840	4401730.8870	300.2880	300.3680	0.0800	NVA
NVA255	806191.9100	4411518.2370	300.1970	300.2790	0.0820	NVA
NVA256	811090.4510	4390026.5900	321.9560	322.0020	0.0460	NVA
NVA257	833974.8760	4372829.6850	317.4340	317.4060	-0.0280	NVA
NVA259	767781.5560	4374471.9570	379.0770	378.9470	-0.1300	NVA
NVA26	820649.1590	4409770.6720	292.2410	292.3250	0.0840	NVA
NVA27	844106.6020	4409041.1460	326.8660	326.9350	0.0690	NVA
NVA28	812724.7290	4398808.3380	349.3610	349.4030	0.0420	NVA
NVA29	828265.0730	4394022.8310	277.6870	277.7150	0.0280	NVA
NVA30	778992.3200	4375608.3340	333.8000	333.6740	-0.1260	NVA

NVA31	838143.4230	4414478.2870	359.0420	359.1510	0.1090	NVA
NVA32	822116.8040	4379658.9020	320.4050	320.4830	0.0780	NVA
NVA35	845398.0940	4366135.1380	314.7410	314.8530	0.1120	NVA
NVA38	792763.4340	4350278.0760	329.7090	329.6370	-0.0720	NVA
NVA96	828909.2360	4367053.0970	348.2950	348.2900	-0.0050	NVA
NVA99	787289.9200	4370236.5870	332.4650	332.3850	-0.0800	NVA
VVA109	774056.5510	4379848.8090	365.0020	364.9190	-0.0830	VVA
VVA110	811046.9870	4389967.0920	319.7010	319.8680	0.1670	VVA
VVA111	778112.1470	4409569.1000	375.6470	375.3850	-0.2620	VVA
VVA114	817601.9750	4425415.0840	311.3330	311.5960	0.2630	VVA
VVA172	796245.9620	4406181.8760	340.6080	340.7440	0.1360	VVA
VVA175	819494.4450	4394218.0560	328.4130	328.6890	0.2760	VVA
VVA176	849715.9580	4407713.8560	244.3880	244.4870	0.0990	VVA
VVA177	832816.9280	4378127.8200	299.8840	300.0070	0.1230	VVA
VVA178	772675.2040	4392432.1740	351.5170	351.4260	-0.0910	VVA
VVA179	779469.6540	4382919.8600	327.6260	327.4130	-0.2130	VVA
VVA18	779199.3250	4429479.0390	333.3470	333.2430	-0.1040	VVA
VVA180	783013.1150	4352307.6100	351.9660	351.9570	-0.0090	VVA
VVA19	821798.6730	4418979.5000	303.5400	303.9810	0.4410	VVA
VVA20	797302.0870	4420768.7240	326.8720	326.9030	0.0310	VVA
VVA23	796196.1000	4383313.2600	295.6490	295.9470	0.2980	VVA
VVA24	794823.8890	4358506.8120	329.9760	330.1080	0.1320	VVA
VVA26	770273.5320	4349183.2790	307.0760	307.3660	0.2900	VVA
VVA58	839603.0870	4362653.1760	336.8870	337.0940	0.2070	VVA
VVA60	814318.3380	4372219.3770	330.0410	330.0740	0.0330	VVA
VVA61	793411.1810	4373628.7760	326.3600	326.2220	-0.1380	VVA
VVA63	807637.2900	4405091.5520	318.4110	318.5350	0.1240	VVA
VVA64	821837.0790	4401736.7150	300.7390	300.8880	0.1490	VVA
VVA65	785688.7380	4421553.0600	345.0380	344.9180	-0.1200	VVA
VVA66	791035.7370	4430197.2300	319.3240	319.2960	-0.0280	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
NVA100	819501.4060	4394248.5720	327.9120	327.9860	-0.0740	NVA
NVA101	801468.1240	4389216.9250	334.4200	334.3770	0.0430	NVA
NVA102	772650.6390	4392443.2480	353.1940	353.0490	0.1450	NVA
NVA103	796287.2380	4406184.6120	343.2410	343.2590	-0.0180	NVA
NVA104	815530.7370	4408628.6470	302.4000	302.3710	0.0290	NVA
NVA105	804251.2610	4383952.7980	337.5060	337.4580	0.0480	NVA
NVA106	769998.8940	4412495.6860	385.8380	385.7350	0.1030	NVA
NVA107	817709.0820	4430901.1000	258.4070	258.5880	-0.1810	NVA
NVA108	773429.9080	4425514.8320	379.4530	379.3330	0.1200	NVA
NVA117	793082.8750	4345172.2360	290.6130	290.4790	0.1340	NVA
NVA168	780336.3300	4405597.1160	361.3640	361.2510	0.1130	NVA
NVA169	774204.0720	4431239.5720	346.1760	346.0130	0.1630	NVA
NVA170	811575.4670	4416748.9990	341.7810	341.7490	0.0320	NVA
NVA171	794196.9790	4416297.9060	348.7880	348.7660	0.0220	NVA
NVA172	821098.3670	4405654.9400	313.9360	314.0480	-0.1120	NVA
NVA173	849689.6070	4407733.4510	245.7830	245.8140	-0.0310	NVA
NVA174	799528.0210	4396683.3360	334.4920	334.5440	-0.0520	NVA
NVA177	809850.1340	4381053.9190	344.9990	345.0550	-0.0560	NVA
NVA178	832847.5690	4378110.5940	300.7970	300.8590	-0.0620	NVA
NVA179	779909.8110	4368566.0830	339.9550	339.7960	0.1590	NVA
NVA181	848042.4610	4362643.4960	272.4370	272.4100	0.0270	NVA
NVA182	782992.6470	4352347.0420	351.7920	351.7150	0.0770	NVA
NVA23	804565.6280	4430817.2080	310.0120	310.0990	-0.0870	NVA
NVA24	768215.5700	4418125.6050	404.4870	404.3350	0.1520	NVA
NVA25	790976.2710	4412476.6990	357.3180	357.2110	0.1070	NVA
NVA254	821869.5840	4401730.8870	300.2880	300.4250	-0.1370	NVA
NVA255	806191.9100	4411518.2370	300.1970	300.3030	-0.1060	NVA
NVA256	811090.4510	4390026.5900	321.9560	321.9870	-0.0310	NVA
NVA257	833974.8760	4372829.6850	317.4340	317.4390	-0.0050	NVA
NVA26	820649.1590	4409770.6720	292.2410	292.3430	-0.1020	NVA
NVA27	844106.6020	4409041.1460	326.8660	326.9440	-0.0780	NVA
NVA28	812724.7290	4398808.3380	349.3610	349.4000	-0.0390	NVA
NVA29	828265.0730	4394022.8310	277.6870	277.7480	-0.0610	NVA
NVA30	778992.3200	4375608.3340	333.8000	333.6880	0.1120	NVA
NVA31	838143.4230	4414478.2870	359.0420	359.1620	-0.1200	NVA
NVA32	822116.8040	4379658.9020	320.4050	320.5150	-0.1100	NVA
NVA35	845398.0940	4366135.1380	314.7410	314.7720	-0.0310	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
NVA38	792763.4340	4350278.0760	329.7090	329.6810	0.0280	NVA
NVA96	828909.2360	4367053.0970	348.2950	348.3390	-0.0440	NVA
NVA99	787289.9200	4370236.5870	332.4650	332.3600	0.1050	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
VVA109	774056.5510	4379848.8090	365.0020	364.7960	0.2060	VVA
VVA110	811046.9870	4389967.0920	319.7010	319.8120	-0.1110	VVA
VVA111	778112.1470	4409569.1000	375.6470	375.3880	0.2590	VVA
VVA114	817601.9750	4425415.0840	311.3330	311.5060	-0.1730	VVA
VVA172	796245.9620	4406181.8760	340.6080	340.6820	-0.0740	VVA
VVA175	819494.4450	4394218.0560	328.4130	328.5840	-0.1710	VVA
VVA176	849715.9580	4407713.8560	244.3880	244.5160	-0.1280	VVA
VVA177	832816.9280	4378127.8200	299.8840	300.0100	-0.1260	VVA
VVA178	772675.2040	4392432.1740	351.5170	351.4410	0.0760	VVA
VVA179	779469.6540	4382919.8600	327.6260	327.4100	0.2160	VVA
VVA18	779199.3250	4429479.0390	333.3470	333.1850	0.1620	VVA
VVA180	783013.1150	4352307.6100	351.9660	351.9280	0.0380	VVA
VVA19	821798.6730	4418979.5000	303.5400	303.7380	-0.1980	VVA
VVA20	797302.0870	4420768.7240	326.8720	327.0180	-0.1460	VVA
VVA23	796196.1000	4383313.2600	295.6490	295.8310	-0.1820	VVA
VVA24	794823.8890	4358506.8120	329.9760	330.0400	-0.0640	VVA
VVA26	770273.5320	4349183.2790	307.0760	307.2390	-0.1630	VVA
VVA58	839603.0870	4362653.1760	336.8870	337.0620	-0.1750	VVA
VVA60	814318.3380	4372219.3770	330.0410	330.1840	-0.1430	VVA
VVA61	793411.1810	4373628.7760	326.3600	326.2580	0.1020	VVA
VVA63	807637.2900	4405091.5520	318.4110	318.4620	-0.0510	VVA
VVA64	821837.0790	4401736.7150	300.7390	300.9330	-0.1940	VVA
VVA65	785688.7380	4421553.0600	345.0380	344.9830	0.0550	VVA
VVA66	791035.7370	4430197.2300	319.3240	319.2950	0.0290	VVA

Table 14: DEM Check Point Assessment