Project Report

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TASK ORDER NUMBER: 140G0219F0272
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SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

USGS task order 140G0219F0272 required summer 2019 LiDAR surveys to be collected over 833 square miles covering part or all of Grand Canyon National Park in Arizona in support of the National Park Service. Aerial LiDAR data for this task order was planned, acquired, processed, and produced at an aggregate nominal pulse spacing (ANPS) of ≤ 0.35 meters and in compliance with USGS National Geospatial Program LiDAR Base Specification version 2021 Revision A.   Option AOI for this deliverable covers approximately 319 square miles.

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

1.1.2 Project Purpose

This project will support the National Park Service's goal of acquiring high quality elevation data in Grand Canyon National Park for use in dam safety assessments, engineering design and design reviews, conservation planning, research, delivery, floodplain mapping, habitat analysis and modeling, fire effects and fuel modeling, and hydrologic modeling utilizing lidar technology, as well as the USGS's National Cooperative Geologic Mapping Program's (NCGMP) goal of producing seamless multi-scales geological maps of the region, and the 3DEP mission.

1.1.3 Contract Deliverables

Item	Specification/Format
Classified Point Cloud	LAS v1.4
Hydro Flattened Bare Earth DEM	0.5m cell size, TIF format
Non- **Hydro Flattened Bare Earth DEM**	0.5m cell size, TIF format
First Return Surface DSM	0.5m cell size, TIF format
Breaklines	Esri Geodatabase
Intensity Imagery	0.5m cell size, TIF format
Control	Esri .shp
Metadata	Xml, .shp, and TIF format
Project Report	PDF format

Table 1: Aerial LiDAR Contract Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a PACVX (N750VX) outfitted with an Optech Galaxy Prime LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	Galaxy Prime
Manufacturer	Optech
Performance Envelope	150 – 4700 m AGL, nominal
Absolute Horizontal Accuracy	1/10,000 x altitude
Absolute Elevation Accuracy	< 0.03 – 0.20 m RMSE from 150 – 4700 m AGL
Topographic Laser	1064-nm near-infrared
Laser Classification	Class IV
Pulse Repetition Frequency (Effective)	Programmable, 50 – 1000 kHz
Beam Divergence	0.25 mrad (1/e)
Laser Range Precision	< 0.008 m
Minimum Target Separation Distance	< 0.7 m (discrete)
Range Capture	Up to 8 range measurements, including last
Intensity Capture	Up to 8 intensity measurements, including last (12-bit)
Scan Angle (Fov)	10 – 60°
Swath Width	10 – 115% of altitude AGL
Scan Frequency	0 – 120 Hz advertised (0 – 240 scan lines/sec)
Scan Product	2000 maximum
Roll Compensation	±5° minimum
Data Storage	Internal solid-state drive (SSD)
Power Requirements	28 V; 300 W
Dimensions and Weight	Sensor: 0.34 x 0.34 x 0.25 m, 27 kg PDU: 0.42 x 0.33 x 0.10 m, 6.5 kg
Operation Temperature	0 to +35°C

Table 2: System Specifications – Galaxy Prime

2.1.2 Sensor Acquisition Information

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

Parameter	Specification
System	Optech Galaxy Prime
Nominal Pulse Spacing (m)	0.35
Nominal Pulse Density (pls/m²)	8
Nominal Flight Height (AGL meters)	3730
Nominal Flight Speed (kts)	140
Pass Heading (°)	Variable
Sensor Scan Angle (°)	30
Scan Frequency (Hz)	80
Pulse Rate of Scanner (kHz)	400
Pulse Width of Scanner (m)	910.9
Sensor Operated with Multiple Pulses	5
Nominal Swath Width (m)	910
Nominal Swath Overlap (%)	56

Table 3: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 149 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 4 flight missions conducted between September 29, 2019 and October 5, 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.

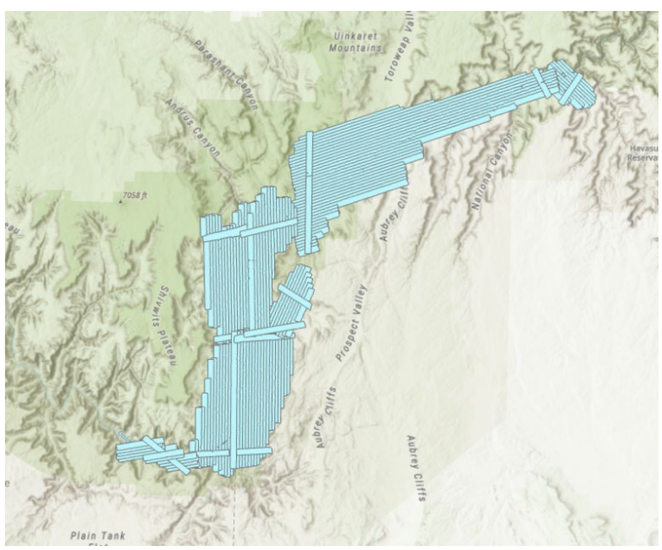

Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Fifteen (15) 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
AZDS	CORS	AZDS	N35°31'59.27673"	W114°21'33.24548"	870.669
AZFL	CORS	AZFL	N35°10'38.31362"	W111°39'25.34305"	2087.948
AZGV	CORS	AZGV	N35°15'15.74205"	W114°15'15.36563"	867.562
FERN	CORS	FERN	N35°20'30.73573"	W112°27'17.06033"	1767.848
GCES	CORS	GCES	N36°02'52.81007"	W112°07'44.95889"	2110.961
KGMN	CORS	KGMN	N35°13'51.77904"	W114°00'08.47282"	1015.642
NVLM	CORS	NVLM	N36°04'10.76768"	W114°48'47.55034"	362.043
NVWS	CORS	NVWS	N36°43'29.99460"	W114°42'55.81937"	513.78
P004	CORS	P004	N34°47'03.77117"	W112°09'07.13788"	1791.754
P006	CORS	P006	N36°09'15.07142"	W114°27'24.89044"	365.219
P008	CORS	P008	N36°08'34.15223"	W111°07'48.17867"	1522.032
P009	CORS	P009	N38°28'47.74599"	W112°13'21.78120"	1761.433
P010	CORS	P010	N34°40'02.13983"	W113°43'52.84087"	1399.033
P011	CORS	P011	N36°08'59.37697"	W109°31'09.22712"	1728.482
SGU1	CORS	SGU1	N37°06'47.49346"	W113°34'13.07877"	894.816

Table 4: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 45 ground survey points were collected in support of this project, including 12 LiDAR Control Points (LCP), 23 Non-vegetated Vertical Accuracy (NVA) and 10 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 and 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
LCP101	287452.1514	3962644.111	587.236
LCP102	289330.9533	3977022.837	437.863
LCP103	287926.1737	3991569.931	477.652
LCP104	298056.5506	3995402.949	1083.709
LCP105	305327.4958	4007093.261	1404.619
LCP106	299786.9221	3998838.45	1079.513
LCP107	315312.1436	4008968.281	516.979
LCP108	291431.9597	3971625.577	473.746
LCP109	288103.279	3962654.355	415.027
LCP110	296933.1425	3982795.905	1212.373
LCP111	304705.483	4002728.83	1345.164
LCP552	315154.5212	4009716.231	1377.231

Table 51: LiDAR Control Point Coordinates

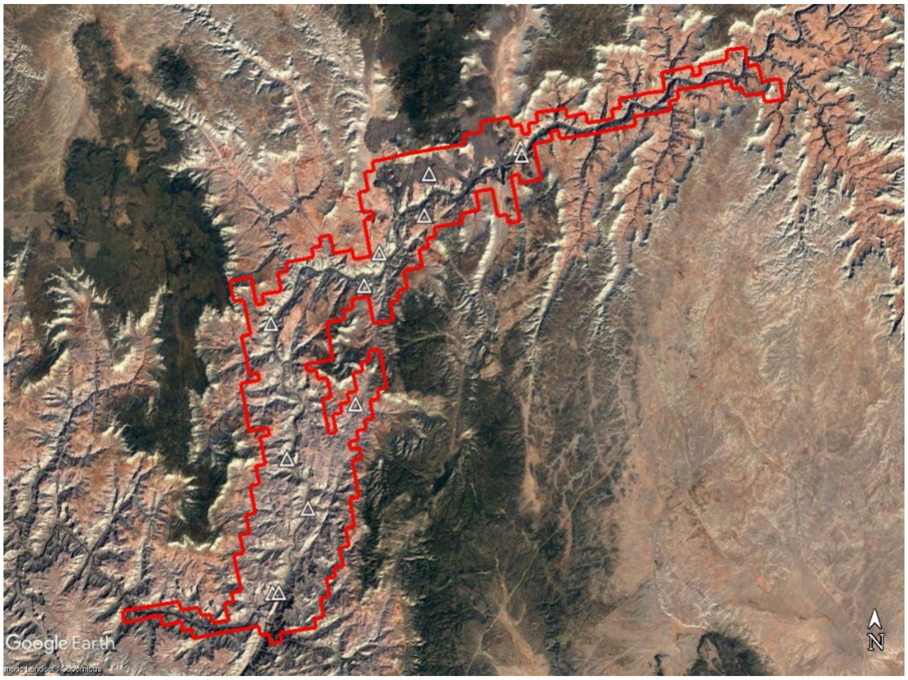

Figure 3: LiDAR Control Point Distribution

ID	Easting	Northing	Elevation
BE101	287449.5283	3962654.118	587.176
BE102	290784.2689	3969901.473	520.093
BE103	288255.7588	3988384.417	455.513
BE104	299816.699	3998835.121	1081.182
BE105	306359.3867	4005214.275	770.856
BE106	329102.3915	4014367.115	1229.409
BE107	339880.0334	4016515.617	1205.578
BE701	291016.5849	3982397.658	448.795
OT101	288087.0511	3962640.469	414.837
OT102	287935.6435	3991564.107	477.128
OT103	296958.6379	3982827.079	1212.091
OT104	293467.7849	3993990.671	1306.613
OT105	302847.6835	4005450.377	1235.038
OT106	320559.4102	4011936.846	524.927
OT107	336014.5312	4017129.132	954.094
UR101	289108.3162	3968055.098	612.462
UR102	291603.7416	3990009.284	1436.337
UR103	278859.3372	3960097.377	683.32
UR104	304723.9439	4002732.378	1345.204
UR105	313216.1295	4008414.81	769.5

ID	Easting	Northing	Elevation
UR106	326049.1221	4015611.818	1284.403
UR106B	315126.4887	4009735.027	1377.911
UR107	290870.6047	3982908.381	465.958

Table 6: Non-Vegetated Vertical Accuracy (NVA) Point Coordinates

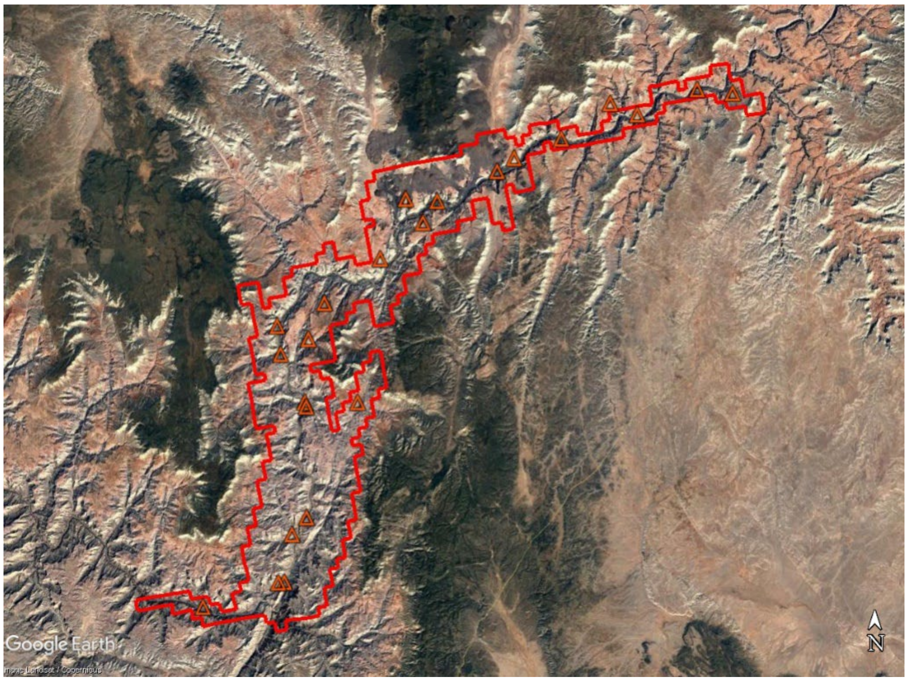

Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

ID	Easting	Northing	Elevation
BR101	288179.1608	3971206.175	900.92
BR102	298061.0233	3995405.556	1083.764
BR103	323270.834	4011756.409	527.805
HG101	289936.6741	3992105.152	1212.481
HG102	308617.2312	4006263.7	1007.737
HG103	289465.431	3966288.458	513.325
TR101	291429.2828	3971632.636	473.969
TR102	300824.7082	4004287.914	943.242
TR103	314201.4169	4004152.255	1434.872
VVA552	315129.3796	4009714.173	1378.037

Table 7: Vegetated Vertical Accuracy (VVA) Point Coordinates

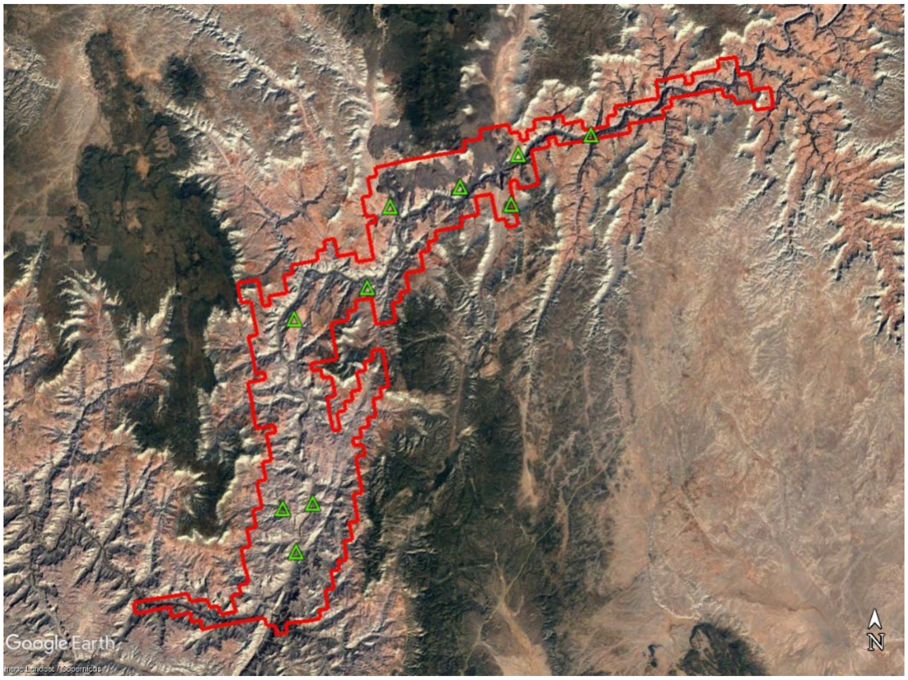

Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Optech software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Applanix PosPac 8.5 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.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD 1983 2011
Coordinate System	UTM Zone 12 North
Vertical Datum	NAVD88
Geoid Model	12B
EPSG Code	6341
Units of Reference	Meters

Table 2: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points (Nominal)	9,892,531,723
Nominal Pulse Spacing (M)	0.4181
Nominal Pulse Density (PLS/M^2)	5.7200
Total Points (Aggregate)	9,853,014,146
Aggregate Pulse Spacing (M)	0.2876
Aggregate Pulse Density (PLS/M^2)	12.0878

Table 3: LiDAR Point Cloud Statistics

3.1.4 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.

3.1.5 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.

3.1.6 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 class 9 (Water).

Code	Description
1	Unclassified
2	Ground
7	Low Point ("Low Noise")
9	Water
17	Bridge Decks
18	High Noise
20	Ignored Ground
21	Snow
22	Temporal exclusion

Table 4: LiDAR Point Classification Codes and Descriptions

3.1.7 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 GeoTIFF format.

3.1.8 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.

3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)

Two sets of bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points and using only the bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 0.5 meter. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point GeoTIFF format.

3.1.10 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 0.5 meter. DSMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point GeoTIFF format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 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 5: 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).

4.1.2 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)	21	0.0765	0.1498	0.0570
NVA (DEM)	21	0.0814	0.1596	0.1798
VVA (Point Cloud)	10	0.1038	0.2034	0.1659
VVA (DEM)	10	0.1201	0.2355	0.1520

Table 6: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 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.

James C. Cannon, ASPRS Certified Photogrammetrist #R1594CP

SECTION 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE101	287449.5280	3962654.1180	587.1760	587.2160	0.0400	NVA
BE102	290784.2690	3969901.4730	520.0930	520.1500	0.0570	NVA
BE104	299816.6990	3998835.1210	1081.1820	1081.1170	-0.0650	NVA
BE105	306359.3870	4005214.2750	770.8560	770.8920	0.0360	NVA
BE106	329102.3920	4014367.1150	1229.4090	1229.4220	0.0130	NVA
BE107	339880.0330	4016515.6170	1205.5780	1205.6040	0.0260	NVA
BE701	291016.5850	3982397.6580	448.7950	448.8160	0.0210	NVA
BR101	288179.1610	3971206.1750	900.9200	901.1300	0.2100	VVA
BR102	298061.0230	3995405.5560	1083.7640	1083.7500	-0.0140	VVA
BR103	323270.8340	4011756.4090	527.8050	527.9170	0.1120	VVA
HG101	289936.6740	3992105.1520	1212.4810	1212.3510	-0.1300	VVA
HG102	308617.2310	4006263.7000	1007.7370	1007.6900	-0.0470	VVA
HG103	289465.4310	3966288.4580	513.3250	513.3660	0.0410	VVA
OT101	288087.0510	3962640.4690	414.8370	414.8710	0.0340	NVA
OT102	287935.6430	3991564.1070	477.1280	477.0340	-0.0940	NVA
OT103	296958.6380	3982827.0790	1212.0910	1211.8970	-0.1940	NVA
OT104	293467.7850	3993990.6710	1306.6130	1306.4650	-0.1480	NVA
OT105	302847.6830	4005450.3770	1235.0380	1235.0370	-0.0010	NVA
OT106	320559.4100	4011936.8460	524.9270	524.9320	0.0050	NVA
OT107	336014.5310	4017129.1320	954.0940	954.1340	0.0400	NVA
TR101	291429.2830	3971632.6360	473.9690	473.9830	0.0140	VVA
TR102	300824.7080	4004287.9140	943.2420	943.1900	-0.0520	VVA
TR103	314201.4170	4004152.2550	1434.8720	1434.7080	-0.1640	VVA
UR0104	304723.9440	4002732.3780	1345.2040	1345.1840	-0.0200	NVA
UR101	289108.3160	3968055.0980	612.4620	612.4920	0.0300	NVA
UR102	291603.7420	3990009.2840	1436.3370	1436.1610	-0.1760	NVA
UR103	278859.3370	3960097.3770	683.3200	683.3880	0.0680	NVA
UR105	313216.1300	4008414.8100	769.5000	769.5300	0.0300	NVA
UR106B	315126.4890	4009735.0270	1377.9110	1377.8810	-0.0300	NVA
UR107	290870.6050	3982908.3810	465.9580	465.9930	0.0350	NVA
VVA552	315129.3800	4009714.1730	1378.0370	1378.0220	-0.0150	VVA

Table 13: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE101	287449.528	3962654.118	587.176	587.2137	-0.0377	NVA
BE102	290784.2690	3969901.4730	520.0930	520.1625	-0.0695	NVA
BE104	299816.699	3998835.121	1081.182	1081.1222	0.0598	NVA
BE105	306359.3870	4005214.2750	770.8560	770.8922	-0.0362	NVA
BE106	329102.392	4014367.115	1229.409	1229.4157	-0.0067	NVA
BE107	339880.0330	4016515.6170	1205.5780	1205.6062	-0.0282	NVA
BE701	291016.585	3982397.658	448.795	448.8195	-0.0245	NVA
OT101	288087.0510	3962640.4690	414.8370	414.8944	-0.0574	NVA
OT102	287935.643	3991564.107	477.128	477.0324	0.0956	NVA
OT103	296958.6380	3982827.0790	1212.0910	1211.8747	0.2163	NVA
OT104	293467.785	3993990.671	1306.613	1306.4581	0.1549	NVA
OT105	302847.6830	4005450.3770	1235.0380	1235.0328	0.0052	NVA
OT106	320559.41	4011936.846	524.927	524.9272	-0.0002	NVA
OT107	336014.5310	4017129.1320	954.0940	954.1404	-0.0464	NVA
UR0104	304723.944	4002732.378	1345.204	1345.1772	0.0268	NVA
UR101	289108.3160	3968055.0980	612.4620	612.4922	-0.0302	NVA
UR102	291603.742	3990009.284	1436.337	1436.1572	0.1798	NVA
UR103	278859.3370	3960097.3770	683.3200	683.3927	-0.0727	NVA
UR105	313216.13	4008414.81	769.5	769.5231	-0.0231	NVA
UR106B	315126.4890	4009735.0270	1377.9110	1377.8868	0.0242	NVA
UR107	290870.605	3982908.381	465.958	465.9892	-0.0312	NVA
BR101	288179.1610	3971206.1750	900.9200	901.1909	-0.2709	VVA
BR102	298061.023	3995405.556	1083.764	1083.7981	-0.0341	VVA
BR103	323270.8340	4011756.4090	527.8050	527.9261	-0.1211	VVA
HG101	289936.674	3992105.152	1212.481	1212.3457	0.1353	VVA
HG102	308617.2310	4006263.7000	1007.7370	1007.6944	0.0426	VVA
HG103	289465.431	3966288.458	513.325	513.3801	-0.0551	VVA
TR101	291429.2830	3971632.6360	473.9690	473.9844	-0.0154	VVA
TR102	300824.708	4004287.914	943.242	943.1777	0.0643	VVA
TR103	314201.4170	4004152.2550	1434.8720	1434.7064	0.1656	VVA
VVA552	315129.38	4009714.173	1378.037	1378.0234	0.0136	VVA

Table 147: DEM Check Point Assessment