LiDAR Project Report

G15PD00518, BAA AL 3 County

QL2 LiDAR

Prepared For:

United States Geological Survey

Prepared By:

Digital Aerial Solutions, LLC

CONTRACT: #G10PC00093
CONTRACTOR: DIGITAL AERIAL SOLUTIONS
TASK ORDER: # G15PD00518

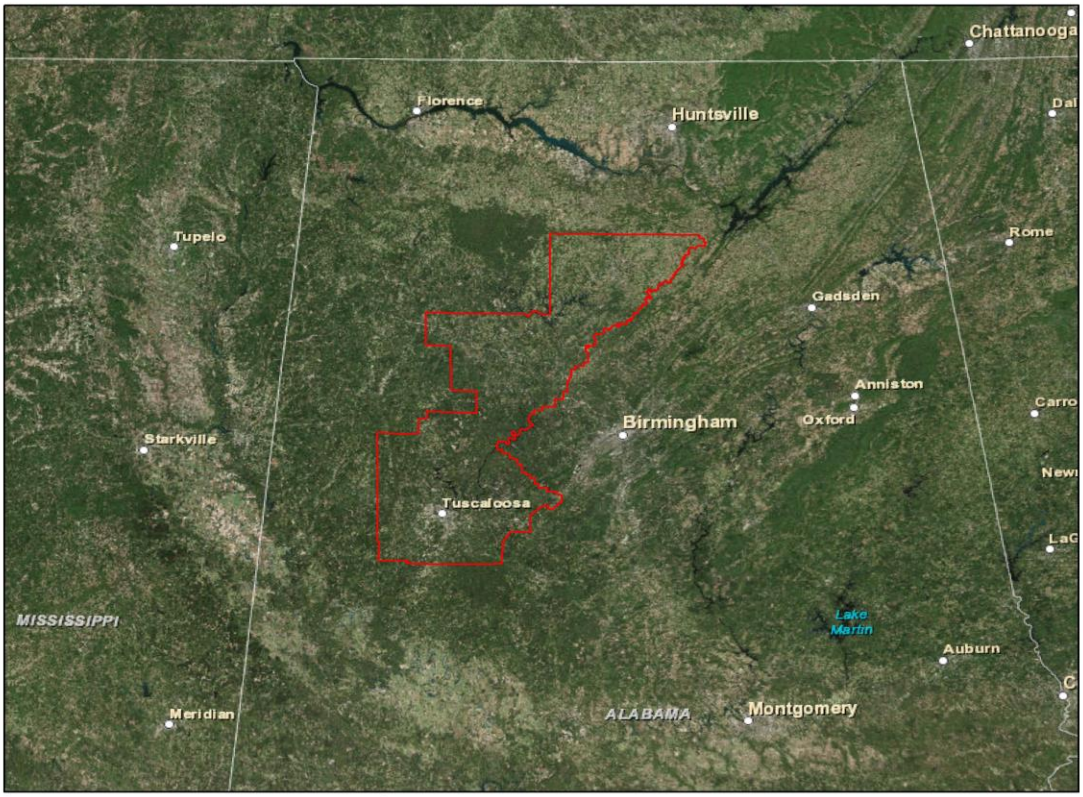
Project Report
LiDAR Collection, Processing, and QA/QC

G15PD00518, BAA AL 3 County
QL2 LiDAR

Prepared For:
US Geological Survey
1400 Independence Road
Rolla, MO 65401
Phone: (573) 308-3587

Prepared By:
Digital Aerial Solutions, LLC
8409 Laurel Fair Circle, Suite 100
Tampa, FL 33610
Phone: (813) 628-0788

BAA AL 3 County QL 2 Lidar



Date: 3/10/2015

Legend

0 20 40 80 Miles

BAA_AL_TriCounty_AOI

Coordinate System: NAD 1983 2011 StatePlane Alabama West FIPS 0102
Projection: Transverse Mercator
Datum: NAD 1983 2011
False Easting: 600,000.0000
False Northing: 0.0000
Central Meridian: -87.5000
Scale Factor: 0.9999
Latitude Of Origin: 30.0000
Units: Meter

Table of Contents

1 Introduction and Specifications 5

2 Spatial Reference System 5

3 LiDAR Acquisition 6

3.1 Survey Area 6

3.2 Acquisition Parameters 7

3.3 Acquisition Mission 8

3.4 Airborne GPS 8

4 LiDAR Processing 9

4.1 Acquisition Post-Processing 9

4.2 Geometric Calibration 9

4.3 Point Cloud Classification 10

4.4 Breakline Collection 11

4.5 DEM Generation 11

5 Quality Control 11

5.1 Point Clouds 11

5.2 Breaklines 12

5.3 Digital Elevation Models 12

Appendices 13

Appendix A. Flight Log 14

Appendix B. Vertical Accuracy Calculations 15

1 Introduction and Specifications

Digital Aerial Solutions, LLC (DAS) was tasked to collect and process a Light Detection And Ranging (LiDAR) derived elevation dataset for the G15PD00518, BAA AL 3 County QL2 LiDAR. The area encompasses approximately 2910 square miles Aerial LiDAR data was collected utilizing an ALS60 and ALS80. The ALS80 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems.
LiDAR data collected for the G15PD00518, BAA AL 3 County QL2 LiDAR survey has a nominal pulse spacing of 0.7 meters, and includes up to 4 discrete returns per pulse, along with intensity values for each return.

LiDAR datasets were post processed to generate elevation point cloud swaths for each flight line. Deliverables include the point cloud swaths, tiled point clouds classified by land cover type, breaklines to support hydro-flattening of digital elevation models (DEM)s, intensity tiles, and bare-earth DEM tiles. Point cloud deliverables are stored in the LAS version 1.4 format, point data record format 6. The tiling scheme for tiled deliverables is a 1500 meters x 1500 meter grid. Tile number is the appropriate cell number values found in the USNG index. All deliverables were generated in conformance with the *U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 1.2.*

2 Spatial Reference System

The spatial reference of the data is as follows.

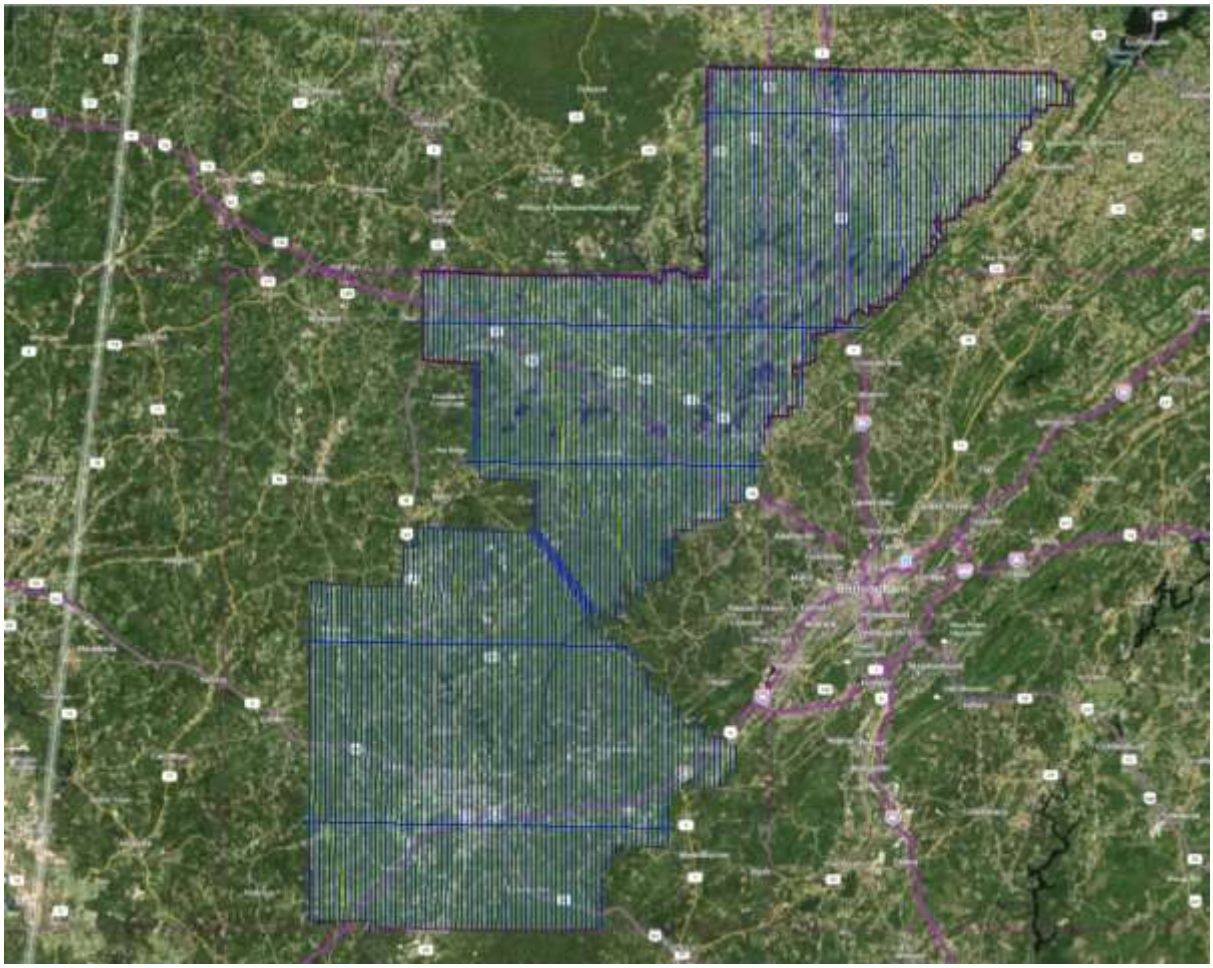
Horizontal Spatial Reference
- Datum: NAD83(2011), Meters (to 2 decimal places)
- Coordinates: State Plane, Alabama West, Meters (to 2 decimal places);

Vertical Spatial Reference
All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights
- Datum: North American Vertical Datum of 1988 (GEOID12A)

3 LiDAR Acquisition

3.1 Survey Area

The GG15PD00518, BAA AL 3 County QL2 LiDAR Lidar survey covers approximately 2910 square miles covering all of Cullman, Walker, and Tuscaloosa Counties. The flight plan consisted of 214 survey lines and 5 control lines.



3.2 Acquisition Parameters

Acquisition parameters include the sensor configuration and the flight plan characteristics, and are selected based on a number of project specific criteria. Criteria reviewed include the required accuracies for the final dataset, the land cover types within the project survey area, and the required nominal pulse spacing. Acquisition parameters selected for the GG15PD00518, BAA AL 3 County, 2ppsm Lidar project are summarized below.

Parameter	Value
Flying Height Above Ground Level	6230 feet
Nominal Sidelap	30%
Nominal Speed Over Ground	155 knots
Field of View	36°
Laser Rate	132 kHz
Scan Rate	66.2 hz
Maximum Cross Track Spacing	0.78 meters
Maximum Along Track Spacing	0.82 meters
Average Spacing	0.7 meters

3.3 Acquisition Mission

The acquisition mission for G15PD00518, BAA AL 3 County QL2 LiDAR survey was coordinated to be acquired in 2 weeks, due to weather conditions and related reflights the completion of acquisition was not until end of Janurary. Collection began on Dec. 10th 2015 and was completed on Feb 16th, 2016.

3.4 Airborne GPS/IMU

Airborne global positioning system (GPS) and inertial measurement unit (IMU) data was collected on the aircraft during the acquisition mission, providing sensor position and orientation information for geo-referencing the LiDAR data. Airborne GPS observations were collected at a frequency of 2Hz, and IMU observations are collected at a frequency of 200Hz.

Aircraft	Sensor	GPS Lever Arm (m)	IMU Lever Arm (m)
C421 – N112MJ	ALS80 – SN8235	x: -0.210, y: -0.060, z: -1.370	x: -0.450, y: -0.159, z: -0.169

In addition, GPS data was collected with ground base stations during the acquisition mission, providing corrections to support differential post-processing of the airborne GPS. One ground base station was setup at an NGS Benchmark (Keyport) as the base of operation. The additional ground base station were selected and place threw the project to ensure complete coverage. Ground GPS observations were collected at a frequency of 2Hz.

4 LiDAR Processing

4.1 Acquisition Post-Processing

Once the acquisition was completed, initial post-processing was performed to generate geo-referenced LiDAR elevation point clouds.

The airborne GPS dataset was differentially corrected using the ground base station GPS datasets collected by DAS in Lecia's InertialExplorer software. InertialExplorer computes the GPS dataset corrections in both forward and reverse chronological sequence, obtaining two solutions for the GPS trajectory. The differences between these two solutions were reviewed to ensure a consistent result, and agree within +/- 3cm. The forward and reverse solutions also show good fit between the two different base stations used in the post-processing.

Differentially corrected airborne GPS data was merged with the airborne IMU data in InertialExplorer software through Kalman filtering techniques. InertialExplorer applies the reference lever arms for the GPS and IMU measurement systems during processing to determine the trajectory (position and orientation) of the LiDAR sensor during the acquisition mission. Estimated lever arm values reported posteriori validate the measurements made during sensor installation in the aircraft.

Raw LiDAR data and the final sensor trajectory from InertialExplorer processed in Leica's CloudPro software to produce the LiDAR elevation point cloud swaths for each flightline, stored in LAS version 1.4 file format. Quality control of the swath point clouds was performed to validate proper function of the sensor systems, full coverage of the project AOI, and point density consistent with the planned nominal pulse spacing.

Swath point clouds were assigned a unique File Source ID within the LAS file format before further processing. Swath files for the G15PD00518, BAA AL 3 County QL2 LiDAR project were numbered in chronological order of acquisition.

4.2 Geometric Calibration

Geometric and positional accuracy of the LiDAR swath point clouds is highly dependent on accurate calibration of the various subsystems within the LiDAR sensor system. Sensor calibration parameters fall into two categories, one being those parameters proprietary to the manufacturer's sensor design, and the other being parameters common to most commercial airborne LiDAR sensors, the IMU to laser reference system alignment angles (bore-site), and mirror deformation constants (scaling).

The manufacturer specific calibration parameters are applied in Leica's Cloud Pro software for the ALS80 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-site and mirror scale parameters for the G15PD00518, BAA AL 3 County QL2 LiDAR. Within the TerraMatch software, the Tie- line workflow was used to solve for the parameters. The Tie-line workflow involves automated selection of numerous 'tie-lines', which represent a linear segment fit to the data that should have the same slope, azimuth, position and elevation, within the overlap sections of the survey lines and control lines. The tie- lines provide observations for algorithms within TerraMatch to solve for the bore-site and mirror scale parameters for the lift.

The Tie-line workflow is dependent upon well distributed tie-lines throughout the swath point clouds to effectively solve for bore-site and mirror scale parameters with the automated algorithms.

survey and control lines. Manual estimation of the bore-site and mirror scale parameters was performed using the observed tie-lines in overlap areas.

The final step of geometric calibration is to determine elevation (z) offset corrections to be applied to the swath point clouds. Z values calculated during the course of the acquisition mission can vary at the centimeter level as the GPS satellite constellation observed in the survey area changes with satellites moving through their orbits over the course of the mission. Baseline length from the ground base station GPS to the airborne GPS can also impact the z values calculated for the swath point clouds. Z offset corrections are calculated in two steps; a relative step, where individual lines are corrected one to another using the adjusted tie-lines from the bore-site and mirror scale calculation step; and an absolute step, where groups of lines are leveled to project ground control.

For the G15PD00518, BAA AL 3 County QL2 LiDAR project, the control lines were used to determine relative z offset corrections in areas of discernible ground. The base station operated by DAS in the survey area provided for minimal baseline lengths, resulting in generally good z agreement between the survey lines and control lines.

The final geometrically calibrated swath point clouds were compared to the bare-earth profile survey data. The data fit the profile surveys within the vertical accuracy tolerance specified for the project. Full documentation of the vertical accuracy checks maybe found in section 5.1.

4.3 Point Cloud Classification

Georeference information was applied to the swath point could LAS files. Geometrically calibrated swath point clouds were cut into USNG index, 1500 meter x 1500 meter LAS 1.4 format tiles for point cloud classification and derived product creation.

Tiled point cloud data was processed in Terrasolid's Terrascan software to assign initial classification values. The Terrascan software provides a number of routines to algorithmically detect and assign points to their appropriate class. Points left unclassified by the algorithmic routine remain as Class 1 – Processed, but unclassified. Automated classification routines assigned points to one of the following classes:

Class 1 – Processed, but unclassified
Class 2 – Bare-earth ground
Class 7 – Low Noise (low, manually identified, if necessary)
Class 9 — Water
Class 10 — Ignored Ground (Breakline Proximity)
Class 17 — Bridge Decks
Class 18 – High Noise (high, manually identified, if necessary)

Automated classification results were reviewed for each tiled point cloud, and manual edits made where necessary to correct for misclassified points. Points remaining in Class 1 after the automated classification routines were run were left in Class 1. Points falling outside of a 100 meter buffer of the project AOI polygon were excluded from the tiled point clouds.

4.4 Breakline Collection

Manual breakline collection was performed to support the hydro-flattening requirements of the project's DEM deliverables. Breaklines were collected directly from the classified point clouds and from triangulated irregular network (TIN) surface models built from the classified point clouds, in Terrasolids's Terrascan and Terramodeler software. Breakline features were collected as design file elements in Bentley's Microstation software. Breaklines were converted to ESRI 3D shapefile format for the breakline deliverable, and tiled to USNG index.

The data collected for the G15PD00518, BAA AL 3 County QL2 LiDAR survey maintained significant point density in the water, limiting the usefulness of point density as guiding factor in breakline placement.

Points classified as Class 2 – Bare-earth ground, falling within a one meter buffer of the collected breaklines, were reassigned to Class 10 – Ignored Ground. These points are excluded from the surface model during DEM generation to preserve the hydro-flattening characteristics of the breaklines.

4.5 DEM Generation

The final classified point clouds and collected breaklines were reviewed for completeness and conformance to the task order scope of work. Within the Terramodeler software, points in Class 2 – Bare-earth ground and the breaklines were combined to generate TIN elevation models for each tile, from which the bare-earth DEM tiles were interpolated and exported as 32 bit raster IMG format.

5 Quality Control

5.1 Point Clouds

Accuracy and completeness of the LiDAR point clouds directly impacts the quality of all other derived LiDAR derived products. Ensuring a quality LiDAR dataset begins with proper mission planning and execution. Ground GPS base stations are located such that GPS baselines between the ground and airborne receivers do not exceed 30km. For the G15PD00518, BAA AL 3 County QL2 LiDAR project, two base stations were run to meet this requirement, one at the field operations airport and one within the survey area. Static alignment is performed both before take-off and after landing to allow for GPS integer ambiguity resolution. Sensor operators carefully monitor the LiDAR unit and its various subsystems during the acquisition mission to ensure proper function. Airborne GPS positional dilution of precision (PDOP) estimates are monitored to ensure they remain less than 3.The optical system is monitored to ensure there are no ranging errors encountered during the flight lines.

During acquisition post-processing estimates of the trajectory data accuracy are reviewed to ensure they will support the required accuracies of the point cloud data. The trajectory accuracy is a function of the differentially corrected GPS data and the IMU data.

The raw swath point clouds generated from CloudPro are reviewed as another check for proper sensor function. The point clouds are reviewed for full coverage of the AOI, required point density and nominal pulse spacing, clustering, proper intensity values, full swath coverage within the planned field of view, and planned survey line overlap.

Geometric calibration quality control validates that the positional accuracy requirements of the project are met, and includes relative accuracy assessments for intra-swath (within) and inter-swath (between) accuracy, along with absolute accuracy assessments against project ground control.

Relative vertical accuracy assessments are normally made using the tie-lines generated in the Terramatch software, as these lines provide positional observations throughout the extent of individual swaths, and between neighboring swaths.

There is not a systematic method of testing when testing horizontal accuracy in LiDAR. The estimated Horizontal accuracy at one sigma based on the flying height for the project, is between 10cm and 20cm according to manufacturer specifications.

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the G15PD00518, BAA AL 3 County QL2 LiDAR, ground check point data consisted of the ground GPS base station, and real-time kinematic (RTK) GPS techniques.

Check point locations were collected at 1 – second intervals during the RTK survey. Points collected during the static pre-initialization and post-initialization were removed from the assessment so as not to bias the assessment.

Local TIN models of the elevation points are built around each ground check points. The tin model elevation is sampled at the horizontal position of the ground check point. The TIN model elevation and ground check point survey elevation values were used to calculate the fundamental vertical accuracy (FVA) of the swath point clouds. The NVA of the TIN tested RMSEz 0.084 meters and 0.166 meters at the 95% confidence level in open terrain. NVA of the DEM tested at an RMSEz of 0.087 meters and 0.171 meters at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B.

FVA of TIN

$RMSE_Z$ =	0.084	meters
NSSDA=	0.166	meters

FVA of DEM

$RMSE_Z$ =	0.087	meters
NSSDA=	0.171	meters

The tiled point cloud products were reviewed for full coverage of the AOI and proper classification. As part of the QC process, TINs are built in the Terramodeler software for each tile using the ground class and the hydro-flattening breaklines. The TINs are reviewed for non-ground features, and edited where necessary to remove any remaining non-ground features. Points were also reviewed for absolute elevation, and points falling below the selected orthometric elevation for water were removed from the ground class.

5.2 Breaklines

The final breaklines in ESRI 3D shapefile format were reviewed for topological consistency and correct elevation. Breaklines features are continuous and do not have overlaps or dangles.

5.3 Digital Elevation Models

Digital elevation models (DEMs) were reviewed for conformance with the SOW and the Base Mapping Specification version 1.2 guidelines. DEM files were loaded in the Global Mapper software and inspected visually for edge matching between tiles, void areas within the project AOI, and proper coding of the NODATA values. DEM file naming was verified for consistency with the USNG index.

Appendix A. Flight Logs

DAS Digital Aerial Solutions

3UID-2 ✓ 20160119_023040

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235							Sensor Operator/s	
									-		Bertin Evina-Ze	
Date/Julian:	01-18-2016		Disk Drive MM70			TAR AIRSPD (KNTS)				Base PID:	Pilot/s	
Hobbs End	3005.5		3-808654C			155					Mike Millard	
Hobbs ST	3004.2		LIFT			TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:
Flight Time	0.0	4-3	A			6100-6,900		AL_3Counties_PALS80		1.500	421C 13RF	JFX (Jasper, AL)

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A						6400		74	287				
	1	10		03:03	03:10		180	157	741	19	1.1	0.6	
	2	11		03:16	03:23		0	151	738	18	1.1	0.6	
	3	12		03:28	03:36		180	158	735	17	1.3	0.7	
	4	13		03:42	03:49		0	150	731	17	1.2	0.7	
	5	14		03:55	04:02		180	154	728	19	1.1	0.6	
	6	15		04:08	04:16		0	150	725	17	1.1	0.7	
	7	16		04:21	04:29		180	155	722	18	1.0	0.6	
	8	17		04:35	04:42		0	149	719	16	1.3	0.7	
	9	18		04:48	04:55		180	155	716	16	1.3	0.7	
	10	19		05:00	05:08		0	145	713	15	1.3	0.7	
	11	20		05:14	05:23		180	155	705	15	1.5	0.8	
	12	21		05:29	05:39		0	148	701	15	1.5	0.8	
	13	X03		05:44	05:48		270	149	699	17	1.2	0.7	X-strip
	14	22		05:54	06:03		180	155	695	16	1.3	0.7	
	15	X05		06:11	06:14		270	148	693	18	1.1	0.6	X-strip
	16	23		06:23	06:34		180	145		17	1.2	0.7	

DAS Digital Aerial Solutions

20160124-005935

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235							Sensor Operator/s	
								-			Bertin Evina-Ze	
Date/Julian:	01-23-2016		Disk Drive MM70			TAR AIRSPD (KNTS)				Base PID:	Pilot/s	
Hobbs End	3018.5		3-808654C			155				NGS	Mike Millard	
Hobbs ST	3014.2		LIFT			TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:
Flight Time	0.0					6100-6,900		AL_3Counties_PALS80		1.500	421C 13RF	JEXJASPER, AL

Lift		Flight Line	Mission	Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
										(687)				
	1	X03			01:29	01:32	6300	90	155	681	17	1.1	0.6	Cross strip
	2	33			01:40	01:51	6250	180	156	681	15	1.4	0.7	
	3	32			01:56	02:07		0	154	676	15	1.4	0.7	
	4	31			02:12	02:23		180	156	670	17	1.2	0.6	
	5	30			02:29	02:40		0	154	665	18	1.1	0.6	
	6	29			02:45	02:55		180	158	660	18	1.1	0.6	
	7	28			03:00	03:10		0	155	656	16	1.4	0.7	
	8	27			03:15	03:25		180	158	651	17	1.3	0.7	
	9	26			03:31	03:41		0	155	646	16	1.2	0.7	
	10	25			03:46	03:56		180	154	641	16	1.2	0.7	
	11	24			04:02	04:12		0	155	637	17	1.1	0.6	
	12	34			04:17	04:27		180	158	632	16	1.3	0.7	
	13	35			04:34	04:45		0	154	627	16	1.2	0.7	
	14	36			04:49	05:01		180	153	622	15	1.5	0.8	
	15	X05			05:09	05:13		271	155	620	15	1.5	0.9	Cross strip

DAS Digital Aerial Solutions

20160924-154518

ALS80 LiDAR Flight Log

Project	AL3CountyQL2			ALS80	SN 8235							Sensor Operator/s	~~Bertin-Evina-Ze~~ Stanton
Date/Julian:	1/24/16			Disk Drive MM70			TAR AIRSPD (KNTS)			Base PID:		Pilot/s	Mike Millard
Hobbs End	3023.1	2044		3-808654C			155			JFX + Tomo			
Hobbs ST	3018.5	1548	LIFT				TAR ALT AGL (ft):	Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	04.6		A				6100-6,900	AL_3Counties_PALS8		1.500	421C 13RF	JFX	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	SVs:	Position Acc: PDOP	Position Acc: HDOP	Comments and Conditions:
A		1	X03	1614	1618	6303	E	155	~~628~~ 628	18	1.1	0.6	clear X-Strip
		2	049	1622	1631	6285	S	154	618	17	1.3	0.7	clear
		3	048	1636	1645	6260	N	157	613	17	1.3	0.7	clear
		4	047	1650	1659	6261	S	158	610	17	1.3	0.7	clear
		5	046	1705	1714	6245	N	158	605	18	1.2	0.6	clear
		6	045	1720	1729	6245	S	154	601	18	1.1	0.6	clear
		7	044	1734	1744	6221	N	157	597	20	1.0	0.6	clear
		8	043	1750	1801	6198	S	155	592	19	1.0	0.6	clear
		9	042	1806	1817	6243	N	155	587	17	1.2	0.6	clear
		10	041	1824	1835	6226	S	155	582	18	1.1	0.6	clear
		11	040	1841	1852	6216	N	156	577	19	1.1	0.6	clear
		12	039	1858	1908	6236	S	155	572	20	1.0	0.6	clear
		13	038	1913	1924	6268	N	156	567	18	1.2	0.7	clear
		14	037	1930	1941	6254	S	155	561	17	1.2	0.7	clear
		15	X05	1951	1954	6270	E	154	556	18	1.0	0.6	X-Strip
		16	050	2002	2018	6271	N	157	554	18	1.0	0.6	clear end for fuel

DAS Digital Aerial Solutions

20160124-221031

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235							Sensor Operator/s	
								-			Bertin Evina-Ze	
Date/Julian:	1/24/2016		Disk Drive MM70			TAR AIRSPD (KNTS)			Base PID:		Pilot/s	
Hobbs End	3027.6		3-808654C			155					~~Mike Millard~~ MWAZ	
Hobbs ST	2023.1	LIFT				TAR ALT AGL (ft):	Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0	B				6100-6,900	AL_3Counties_PALS80		1.500	421C 13RF		

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B									~~547~~				
	1	X03		22:37	22:40	6300	90	156	545	18	1.1	0.6	X-Strip
	2	61		22:49	23:02		0	158	539	17	1.1	0.7	
	3	60		23:07	2320		180	155	~~534~~	16	1.2	0.7	
	4	59		23:24	23:38		0	154	527	16	1.2	0.7	
	5	58		23:42	23:56		180	156	521	17	1.4	0.7	
	6	57		00:02	00:16		0	156	514	18	1.2	0.6	
	7	56		00:21	00:36		180	155	507	18	1.1	0.6	
	8	55		00:41	00:56		0	156	500	15	1.4	0.7	
	9	54		01:00	01:16		180	154	493	16	1.3	0.6	
	10	53		01:21	01:36		0	155	486	17	1.1	0.7	
	11	52		01:41	01:57		180	155	478	15	1.3	0.7	
	12	51		02:02	02:18		0	156	471	17	1.2	0.6	
	13	X01		02:22	02:25		90	156	469	19	1.1	0.6	

DAS Digital Aerial Solutions

20160125_034009

ALS80 LiDAR Flight Log

Project	AL3CountyQL2			ALS80	SN 8235							Sensor Operator/s	~~Bertin~~ ~~Evina~~ ~~Ze~~ Stanton
Date/Julian:	1/24			Disk Drive MM70			TAR AIRSPD (KNTS)			Base PID:		Pilot/s	
Hobbs End	3031.9	0815		3-808654C			155			JFX temp		Mike Millard	
Hobbs ST	3027.6	0341	LIFT				TAR ALT AGL (ft):	Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.4.3		A				6100-6,900	AL_3Counties_PALS80		1.500	421C 13RF	~~Stanton~~ JFX	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
~~A~~		1	X03	0408	0412	6356	E	157	~~458~~ 457	16	1.3	0.7	X Strip Clear
C		2	074	0418	0427	6322	N	152	467	16	1.3	0.7	Clear
(3)		3	073	0431	0441	6300	S	158	463	15	1.4	0.8	Clear
		4	072	0445	0455	6314	N	156	459	16	1.2	0.7	Clear
		5	071	0458	0508	6324	S	158	454	15	1.5	0.8	Clear
		6	070	0512	0521	6317	N	156	450	16	1.4	0.8	Clear
		7	069	0526	0537	6265	S	155	446	16	1.2	0.7	Clear
		8	068	0542	0552	6284	N	155	441	17	1.2	0.7	Clear
		9	067	0557	0608	6295	S	157	436	17	1.2	0.7	Clear
		10	066	0613	0624	6292	N	154	431	17	1.2	0.7	Clear
		11	065	0628	0640	6280	S	156	426	19	1.0	0.6	Clear
		12	064	0645	0657	6294	N	156	420	18	1.0	0.6	Clear
		13	063	0701	0713	6277	S	155	414	18	1.1	0.6	Clear
		14	062	0718	0730	6292	N	156	409	17	1.1	0.6	Clear
		15	X01	0735	0739	6676	E	152	403	17	1.1	0.7	X Strip clear
		16	075	0743	0752	6278	S	155	401	17	1.2	0.7	Clear end for Dark

DAS Digital Aerial Solutions

(A) 20160129-161131 (B) 20160129_200416

ALS80 LiDAR Flight Log

Project	AL3CountyQL2			ALS80	SN 8235							Sensor Operator/s	Bertin Evina-Ze Wes
Date/Julian:				Disk Drive MM70			TAR AIRSPD (KNTS)			Base PID:		Pilot/s	Mike Millard
Hobbs End	3052.8			3-808654C			155						
Hobbs ST	3047.9		LIFT				TAR ALT AGL (ft):	Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0		A				6100-6,900	AL_3Counties_PALS80		1.500	421C 13RF		Tuscaloosa

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A	1	X-08		1649	1649	6100	90	155	297	18	1.2	0.6	X-Strip - Clear
	2	147		1654	1708	6150	0	155	269	19	1.1	0.6	Clear
	3	146		1713	1727	6140	180	155	262	20	1.0	0.6	"
	4	145		1732	1746	6140	0	155	255	18	1.0	0.6	"
	5	144		1751	1805	6130	180	155	249	17	1.2	0.6	"
	6	143		1809	1824	6130	0	155	240	19	1.1	0.6	"
	7	142		1827	1842	6130	180	155	235	19	1.0	0.6	"
	8	141		1846	1900	6130	0	155	229	17	1.2	0.7	"
	9	140		1904	1918	6130	180	155	222	15	1.3	0.7	"
	10	139		1923	1938	6100	0	155	2	15	1.1	0.6	"End-Config-error shut down
X	11	[redacted]	139	1930	2039	6100	0	155	215	15	1.2	0.7	Re-Fly 139 clear system x2
	12	[redacted]	[redacted] X-06	2044	2046	6100	W270	155	215	14	1.4	0.7	clear
	13	[redacted]	[redacted] 138	2053	2100	6100	180	155	208	14	1.4	0.7	Clear
*	14	[redacted]	~~[redacted]~~ X-08	2111	2112	6100	270	155	208	16	1.2	0.6	
	15	[redacted]	~~[redacted]~~ END										
	16	[redacted]	~~[redacted]~~										
	17												
	18												

DAS Digital Aerial Solutions

20160130_002031

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235								Sensor Operator/s	Bertin Evina-Ze
Date/Julian:	1/29/2016		Disk Drive MM70			TAR AIRSPD (KNTS)			-		Base PID:	Pilot/s	~~Mike Millard~~ MWAC
Hobbs End	3057.8		3-808654C			155							
Hobbs ST	2052.8		LIFT			TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0	5.0	B			6100-6,900		AL_3Counties_PALS80		1.500	421C 13RF	, Tuscaloosa-AT	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B									~~288~~				
	1	X08		00:53	00:59	6,100	91	155	205	17	1.2	0.6	~~X~~-Strip
	2	137		01:04	01:18		0	155	199	18	1.1	0.6	
	3	136		01:22	01:37		180	154	192	16	1.3	0.6	
	4	135		01:42	01:56		0	155	186	18	1.2	0.6	
	5	134		02:00	02:15		180	153	179	18	1.1	0.6	
	6	133		02:20	02:33		0	155	173	17	1.2	0.7	
	7	132		02:37	02:51		180	151	167	16	1.4	0.7	
	8	131		02:55	03:09		0	154	160	17	1.3	0.7	
	9	130		03:13	03:25		180	156	155	16	1.2	0.7	
	10	129		03:30	03:42		0	156	~~149~~	17	1.1	0.6	
	11	128		03:47	03:59		180	155	143	15	1.5	0.8	
	12	127		04:03	04:15		0	156	137	15	1.3	0.7	
	13	X06		04:21	04:25		91	155	136	14	1.4	0.8	X-Strip
	14	126		04:31	04:44		180	155	130	15	1.2	0.7	
	15	125		04:48	05:00		0	155	124	14	1.6	0.9	
	16	124		05:04	05:16		180	155	119	15	1.3	0.7	

6.

237 729 69664 Christine Evina

6729 69664

DAS
Digital Aerial Solutions

20160130_150929

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235								Sensor Operator/s	Bertin Evina-Ze Neo
Date/Julian:	1/30/16		Disk Drive MM70			TAR AIRSPD (KNTS)			-		Base PID:	Pilot/s	Mike Millard
Hobbs End	30624		3-808654C			155							
Hobbs ST	3057.8		LIFT			TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0		B			6100-6,900		AL_3Counties_PALS80		1.500	421C 13RF	TAY (Tuscaloosa, AL)	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B	1	X-08		1533	1537	6100	90	155	116	18	1.1	0.6	Clear - X-Strip
	2	161		1542	1556	6200	0	155	110	20	1.0	0.6	Clear
	3	160		1600	1614	6200	180	155	103	16	1.4	0.7	"
	4	159		1617	1631	6200	0	155	97	17	1.3	0.7	"
	5	158		1635	1649	6200	180	155	90	18	1.2	0.6	"
	6	157		1653	1707	6200	0	155	84	18	1.2	0.6	"
	7	156		1712	1726	6125	180	155	77	20	1.1	0.6	"
	8	155		1730	1744	6200	0	155	70	18	1.2	0.6	"
	9	154		1748	1803	6200	180	155	63	16	1.3	0.7	"
	10	153		1806	1821	6200	0	155	57	17	1.1	0.6	"
	11	152		1824	1839	6130	180	155	50	17	1.1	0.6	"
	12	151		1842	1857	6140	0	155	43	15	1.3	0.7	"
	13	150		1859	1915	6140	180	155	36	15	1.3	0.7	"
	14	[illegible]	162	1919	1932	6240	0	158	30	15	1.2	0.7	"
	15	X-06		1939	1942	6200	270	155	28	17	1.0	0.6	" X-Strip

DAS Digital Aerial Solutions

20160130-204334

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235								Sensor Operator/s	
									-			Bertin Evina-Ze	
Date/Julian:	01-30-2016		Disk Drive MM70			TAR AIRSPD (KNTS)				Base PID:		Pilot/s	
Hobbs End	5062.1		3-808654C (704)			155						~~Mike Millard~~ MWAZ	
Hobbs ST	5062.4		LIFT			TAR ALT AGL (ft):		Flight Plan(s):		Base Height:		Aircraft	Airport Idnt:
Flight Time	0.0 4.7		B			6100-6,900		AL_3Counties_PALS80		1.500		421C 13RF	JFX Tuscaloosa, AL

Lift		Flight Line	Mission	Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
B					2					7245				
	1	X08			21:08	21:09	6,100	91	152	744	17	1.1	0.6	X-Strip
	2	148			21:13				155					ABORT
	3	X07			21:20	21:28		90	159	740	16	1.2	0.7	X-Strip
	4	188			21:33	21:34	6,400	0	155	739	15	1.2	0.7	
	5	187			21:39	21:40		180	157	739	15	1.2	0.7	
	6	186			21:44	21:46		0	154	738	14	1.3	0.7	
	7	185			21:51	21:53		180	145	737	14	1.3	0.7	
	8	184			21:57	21:59		0	150	736	14	1.3	0.7	
	9	183			22:05	22:07		180	148	735	16	1.1	0.7	
	10	182			22:11	22:13		0	152	734	17	1.1	0.6	
	11	181			22:18	22:20	6,450	180	152	733	16	1.1	0.7	
	12	180			22:24	22:26	6,500	0	152	732	16	1.1	0.7	
	13	179			22:31	22:33	6,465	180	155	731	18	1.1	0.7	
	14	178			22:38	22:41	6,440	0	156	730	17	1.1	0.6	
	15	177			22:47	22:50		180	155	728	16	1.2	0.7	
	16	176			22:55	23:01		0	157	725	16	1.3	0.7	
	17	175			23:06	23:11		180	150	723	16	1.3	0.7	
	18	174			23:16	23:22	6,300	0	154	720	17	1.4	0.6	
	19	173			23:26	23:33	6,400	180	156	717	18	1.1	0.7	
	20	172			23:37	23:43		0	154	714	19	1.1	0.6	
	21	171			23:48	23:54		180	154	711	18	1.1	0.7	
	22	170			23:58	00:08	6,250	0	155	706	18	1.1	0.7	
	23	X06			00:13	00:18		270	152	704	16	1.4	0.6	X-Strip
	24	148			00:25	00:39	6,100	180	155	697	16	1.4	0.6	
	25	149			00:46	01:00		0	156	690	16	1.5	0.6	
	26	169			01:06	01:16		180	156	686	17	1.1	0.6	
	27	168												

MS 149

169
168

DAS
Digital Aerial Solutions

20160131_022804

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235							Sensor Operator/s	
Date/Julian:	1/30/16										Wes B. [redacted]	
Hobbs End	3071.7		Disk Drive MM70		TAR AIRSPD (KNTS)			-		Base PID:	Pilot/s	
Hobbs ST	3067.1		3-808654C		155						Mike Millard	
Flight Time	0.0		LIFT		TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
			C		6100-6,900		AL_3Counties_PALS80		1.500	421C 13RF		

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	SVs:	Position Acc: PDOP	Position Acc: HDOP	Comments and Conditions:
C	1	X-08		0253	0257	6100	270	155	685	16	1.2	0.7	X-Strip - Clear
	2	115		0308	0313	6190	0	155	679	17	1.1	0.6	Clear
	3	X-06		0314	0319	6140	90	155	678	16	1.1	0.6	X-Strip - Clear
	4	123		0325	0337	6140	180	155	672	16	1.1	0.6	Clear
	5	122		0339	0353	6140	0	155	665	15	1.3	0.7	Clear
	6	121		0357	0409	6140	180	155	661	15	1.3	0.7	Clear
	7	120		0412	0424	6160	0	155	655	14	1.3	0.8	Clear
	8	119		0428	0440	6175	180	155	650	15	1.2	0.7	Clear
	9	118		0444	0456	6190	0	155	644	14	1.4	0.8	Clear
	10	117		0459	0511	6200	180	155	638	15	1.4	0.7	Clear
	11	116		0514	0526	6250	0	155	632	16	1.3	0.7	Clear
	12	NX-06		0536	0548	6255	90	155	630	16	1.3	0.7	X-Strip - Clear
	13	168		0545	0554	6260	180	155	628	16	1.2	0.7	Clear
	14	167		0558	0609	6260	0	155	623	16	1.2	0.7	Clear
	15	166		0612	0623	6245	180	155	618	16	1.1	0.7	Clear
	16	165		0629	0640	6260	0	155	612	16	1.1	0.7	Clear
	17	X-07		0653	0654	6140	270	155	611	16	1.2	0.7	Clear
		End											

DAS Digital Aerial Solutions

20160127_225627

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235							Sensor Operator/s	
Date/Julian:	1/27/16		Disk Drive MM70			TAR AIRSPD (KNTS)			-	Base PID:	Pilot/s	Wes Blankenship
Hobbs End	3042.2		3-808654C			155					Mike Millard	
Hobbs ST	37.3	LIFT				TAR ALT AGL (ft):	Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0	A				6100-6,900	AL_3Counties_PALS8		1.500	421C 13RF		Walker County

Lift	#	Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: Kts:	Available MM Space	SVs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A	#								397	15			
	1	X-03		2322	2327	6300	90	155	395	15	1.4	0.7	X-Strip -Clear
	2	86	*Abort*	2331	[illegible]	6400	80°	155	[illegible]	16	1.4	0.7	Abort ~~clear~~
	3	86		2341	2344	6400	80	157	390	17	1.2	0.6	clear
	4	85		2354	2402	6400	180	155	387	17	1.2	0.6	Clear
	5	84		0005	0014	6400	80	155	383	17	1.1	0.6	"
	6	83		0018	0027	6400	180	157	380	17	1.2	0.6	"
	7	82		0031	0040	6400	80	155	374	15	1.4	0.7	"
	8	81		0043	0052	6400	180	155	372	16	1.3	0.6	"
	9	80		0057	0105	6350	0	155	368	15	1.4	0.7	"
	10	79		0108	0117	6313	180	155	365	17	1.1	0.6	"
	11	78	0121	0117	0130	6400	0	155	360	16	1.2	0.6	"
	12	77		0134	0143	6400	180	155	356	15	1.4	0.7	"
	13	76		0147	0152	6400	0	157	352	17	1.1	0.6	"
	14	X-01		0200	0203	6400	90	157	351	17	1.2	0.6	" X-Strip
	15	X-03	0223	[illegible]	0226	6400	270	155	349	17	1.2	0.6	" X-Strip
	16	01		0230	0234	6480	180	155	348	18	1.1	0.6	"
	17	02		0238	0241	6450	0	158	346	18	1.1	0.6	"
	18	03		0245	0249	6500	180	155	345	17	1.3	0.6	"
	19	04		0253	0259	6500	0	155	344	17	1.3	0.6	"
	20	05		0300	0303	6460	180	155	342	18	1.1	0.6	"
	21	06		0309	0311	6450	0	156	340	17	1.3	0.6	"
	22	07		0316	0319	6450	180	155	339	18	1.3	0.6	"
	23	08		0325	0327	6450	0	155	337	18	1.1	0.6	"
	24	09		0330	0334	6450	180	156	336	17	1.2	0.6	"
	25	X-04		0337	0340	6350	270	155	335	18	1.0	0.6	X-Strip Clear

DAS Digital Aerial Solutions

20160128_164224 (1)

ALS80 LiDAR Flight Log

Project	AL3CountyQL2		ALS80	SN 8235								Sensor Operator/s	[redacted]ze Wes
Date/Julian:	1/28/16		Disk Drive MM70			TAR AIRSPD (KNTS)			-		Base PID:	Pilot/s	Blankenship
Hobbs End			3-808654C			155						Mike [redacted] Was	
Hobbs ST	3042.4	LIFT				TAR ALT AGL (ft):		Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:	
Flight Time	0.0	A				6100-6,900		AL_3Counties_PALS8(		1.500	421C 13RF	Walker Count	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
A	1	X-01		1705	1911	6700	90	155	333	20	1.1	0.6	X-Strip
	2	114		1717	1718	6750	180	155	331	21	1.0	0.6	Clear
	3	113		1722	1724	6880	90	155	331	21	1.0	0.6	"
	4	112		1727	1729	6880	180	155	330	21	1.0	0.6	"
	5	111		1732	1734	6880	90	155	330	21	1.0	0.6	"
	6	110		1739	1740	6850	180	155	329	19	1.1	0.6	"
	7	109		1744	1746	6820	90	155	328	19	1.1	0.6	"
	8	108		1750	1752	6780	180	155	327	18	1.1	0.6	"
	9	107		1755	1759	6780	90	155	326	18	1.1	0.6	"
	10	106		1802	1805	6690	180	155	325	18	1.1	0.6	"
	11	105		1809	1813	6680	90	155	323	18	1.1	0.6	"
	12	104		1818	1821	6659	180	155	322	17	1.6	0.6	"
	13	103		1825	1829	6650	90	155	320	18	1.1	0.6	"
	14	102		1833	1838	6610	180	155	318	18	1.1	0.6	"
	15	101		1841	1846	6580	0	155	316	18	1.0	0.6	"
	16	100		1850	1855	6570	180	155	314	17	1.2	0.7	"
	17	99		1859	1904	6560	0	155	312	16	1.2	0.8	"
	18	98		1907	1912	6550	180	155	310	15	1.4	0.9	"
	19	97		1916	1921	6554	0	155	308	16	1.3	0.9	"
	20	96		1925	1931	6540	180	155	306	15	1.2	0.8	"
	21	95		1935	1940	6530	0	155	304	15	1.2	0.7	"
	22	94		1945	1950	6530	180	155	301	17	1.1	0.7	"
	23	93		1953	2000	6500	0	155	298	17	1.0	0.6	"
	24	92	2004	2006	2010	6500	180	155	295	16	1.1	0.6	"
	25	91		2015	2022	6465	0	155	293	14	1.4	0.8	"
	26	90		2027	2033	6460	180	155	290	15	1.2	0.7	"
	27	89		2037	2045	6440	0	155	286	15	1.2	0.7	"

DAS
Digital Aerial Solutions

20160128_164224 (2)

ALS80 LiDAR Flight Log																	
Project	AL3CountyQL2				ALS80	SN 8235									Sensor Operator/s		
												-			Bonnie Linda Ze Wes Blankenship		
Date/Julian:	1/28/16				Disk Drive MM70			TAR AIRSPD (KNTS)					Base PID:		Pilot/s		
Hobbs End					3-808654C			155							Mike [redacted] was		
Hobbs ST				LIFT				TAR ALT AGL (ft):			Flight Plan(s):		Base Height:	Aircraft	Airport Idnt:		
Flight Time	0.0			A				6100-6,900			AL_3Counties_PALS80		1.500	421C 13RF		Walker	

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Available MM Space	S/Vs:	Position Acc PDOP	Position Acc HDOP	Comments and Conditions:
A	28	88		2048	2055	6421	180	155	293	14	1.4	0.7	Clear
	29	87	2057	[redacted]	2102	6400	0	155	280	14	1.4	0.7	Clear
	30	X02		2125	2129	6630	90	155	278	15	1.2	0.7	X-Strip

Appendix B. Vertical Accuracy Calculations

Project Information

Prepared By: Kenneth L. Coffey
Project Name: BAA AL 3 County - QL2 LiDAR
Sensor Info: Leica ALS80 SN# 8235
Required Nominal Pulse Spacing: 0.7
Vendor Name: Digital Aerial Solutions .LLC
Units: Meters
Percent of Extent Tolerance: Extents Not Checked
Date of Aquisition: Start: 1/19/2016 Finish: 2/16/2016

Metadata Information

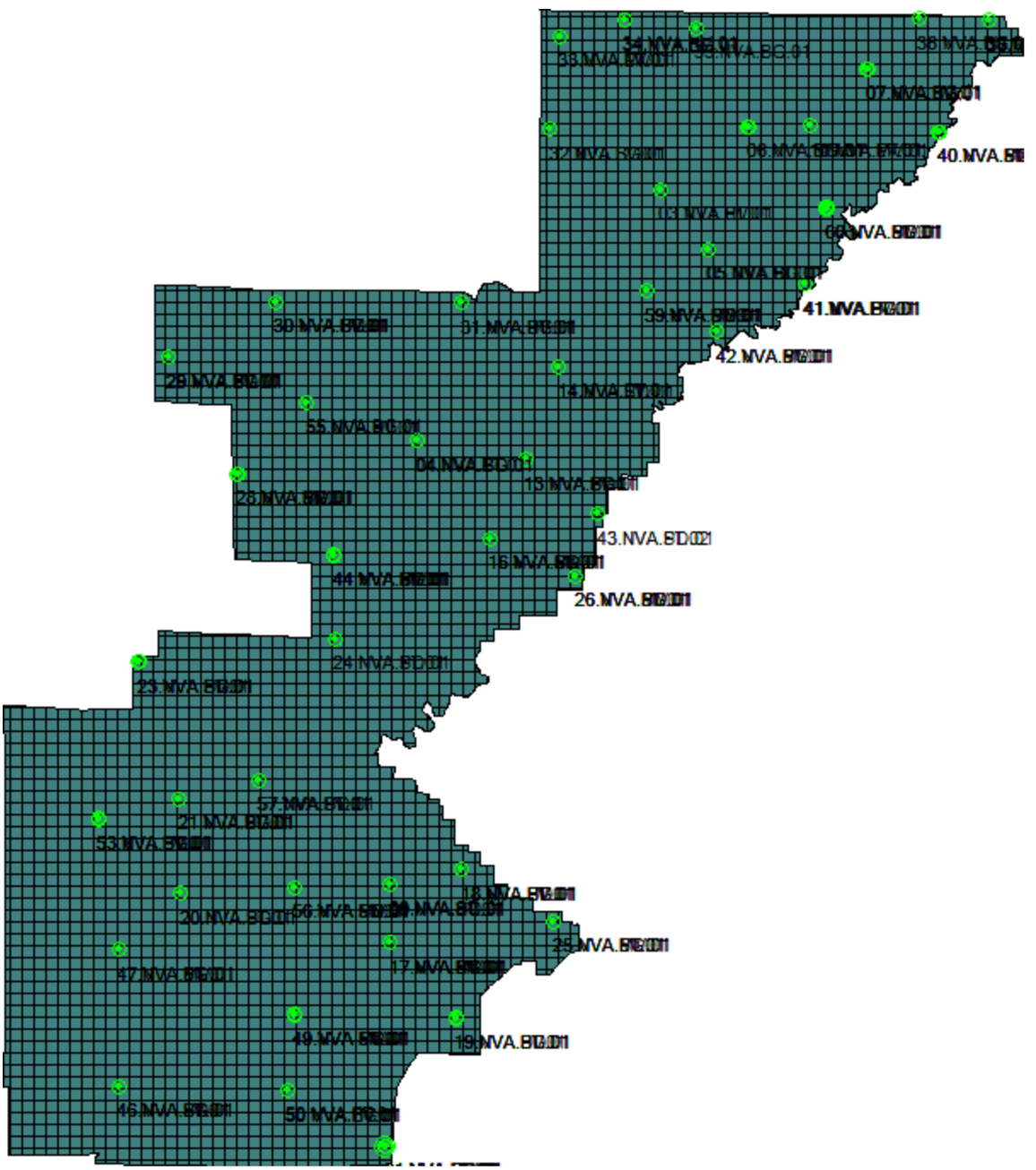
Tile Index:
- Path: Z:\Accuracy_Reports\LiDAR_Alabama_3CO\Index\Clip_BAA_AL_3County_QL2_LiDAR_TileGrid.shp
- Number of Polys: 0

Intensity:
- Tile Index Attribute: Not Specified
- Path to Data: Not Specified

DEM:
- Tile Index Attribute: Tile_Name
- Path to Data: Z:\Accuracy_Reports\LiDAR_Alabama_3CO\DEM

LAS:
- Tile Index Attribute: Tile_Name
- Path to Data: Z:\Accuracy_Reports\LiDAR_Alabama_3CO\LAS_Final_Accuracy

Tiled-Data Area



LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	CVA
LAS				
ALL	173			0.166
NVA	107	0.166		
VVA	66		0.213	
Total	173			
DEM				
ALL	173			0.168
NVA	107	0.171		
VVA	66		0.207	
Total	173			

Units: Meters

Coordinates and Offsets of Analyzed Locations

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
1)	☑	01.NVA.BG.01					
			616290.89	335528.62	86.84	86.95	86.962
					NVA	0.11	0.122
2)	☑	01.NVA.PT.01					
			616345.43	335540.4	89.69	89.763	89.744
					NVA	0.073	0.054
3)	☑	01.NVA.PT.02					
			616345.83	335541.96	89.9	89.908	89.973
					NVA	0.008	0.073
4)	☑	01.NVA.SD.01					
			616338.61	335521.08	87.87	87.95	87.932
					NVA	0.08	0.062
5)	☑	03.NVA.PT.01					
			650810.91	455879.17	191.95	192.084	192.079
					NVA	0.134	0.129
6)	☑	04.NVA.BG.01					
			620318.77	424270.46	106.8	106.751	106.745
					NVA	-0.049	-0.055
7)	☑	04.NVA.PT.01					
			620256.89	424251.66	106.52	106.487	106.456
					NVA	-0.033	-0.064

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
8)	☑	04.NVA.SD.01					
			620289.16	424266.22	106.93	106.865	106.851
					NVA	-0.065	-0.079
9)	☑	05.NVA.BG.01					
			656895.56	448373.32	188.72	188.883	188.88
					NVA	0.163	0.16
10)	☑	05.NVA.PT.01					
			656846.07	448342.81	189.36	189.508	189.522
					NVA	0.148	0.162
11)	☑	05.NVA.SD.01					
			656841.1	448363.66	189.58	189.732	189.741
					NVA	0.152	0.161
12)	☑	06.NVA.BG.01					
			661882.26	463797.73	236.44	236.545	236.538
					NVA	0.105	0.098
13)	☑	07.NVA.BG.01					
			676897.4	471008.67	279.08	279.109	279.11
					NVA	0.029	0.03
14)	☑	07.NVA.SD.01					
			676905.86	470982.55	278.56	278.633	278.625
					NVA	0.073	0.065

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
15)	☑	09.NVA.BG.01					
			616890.65	368420.2	202.39	202.298	202.285
					NVA	-0.092	-0.105
16)	☑	09.NVA.PT.01					
			616904.62	368392.51	201.57	201.476	201.466
					NVA	-0.094	-0.104
17)	☑	09.NVA.SD.01					
			616915.34	368440.06	200.74	200.651	200.676
					NVA	-0.089	-0.064
18)	☑	10.NVA.PT.01					
			669755.92	463888.04	253.14	253.22	253.219
					NVA	0.08	0.079
19)	☑	13.NVA.BG.01					
			633881.93	421906.07	87.87	87.975	87.96
					NVA	0.105	0.09
20)	☑	13.NVA.PT.01					
			633891.04	421936.04	89.41	89.523	89.474
					NVA	0.113	0.064
21)	☑	13.NVA.SD.01					
			633890.67	421917.41	88.4	88.498	88.494
					NVA	0.098	0.094

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
22)	☑	14.NVA.PT.01					
			638078.18	433613.47	101.22	101.347	101.343
					NVA	0.127	0.123
23)	☑	14.NVA.SD.01					
			638070.43	433524.29	100.4	100.551	100.549
					NVA	0.151	0.149
24)	☑	16.NVA.BG.01					
			629401.68	411999.37	161.2	161.317	161.309
					NVA	0.117	0.109
25)	☑	16.NVA.PT.01					
			629374.58	411991.02	161.72	161.784	161.798
					NVA	0.064	0.078
26)	☑	16.NVA.SD.01					
			629393.65	411980.05	162	162.099	162.084
					NVA	0.099	0.084
27)	☑	17.NVA.BG.01					
			616915.16	361083.58	182.77	182.617	182.617
					NVA	-0.153	-0.153
28)	☑	17.NVA.PT.01					
			616904.24	361073.21	182.32	182.204	182.206
					NVA	-0.116	-0.114

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
29)	☑	18.NVA.BG.01					
			625885.78	370353.61	139.74	139.782	139.768
					NVA	0.042	0.028
30)	☑	18.NVA.PT.01					
			625867.26	370355.59	140.29	140.287	140.286
					NVA	-0.003	-0.004
31)	☑	18.NVA.SD.01					
			625858	370355.66	140.19	140.197	140.244
					NVA	0.007	0.054
32)	☑	19.NVA.BG.01					
			625108.5	351627.65	161.3	161.319	161.316
					NVA	0.019	0.016
33)	☑	19.NVA.PT.01					
			625095.16	351651.12	160.75	160.725	160.735
					NVA	-0.025	-0.015
34)	☑	19.NVA.SD.01					
			625105.36	351641.68	160.88	160.887	160.886
					NVA	0.007	0.006
35)	☑	20.NVA.BG.01					
			590588.38	367301.73	119.01	119.002	119.006
					NVA	-0.008	-0.004

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
36)	☑	20.NVA.PT.01					
			590562.16	367281.34	119.11	119.101	119.1
					NVA	-0.009	-0.01
37)	☑	20.NVA.SD.01					
			590600.02	367308.38	119.09	119.079	119.085
					NVA	-0.011	-0.005
38)	☑	21.NVA.BG.01					
			590308.16	379200.59	115.28	115.252	115.239
					NVA	-0.028	-0.041
39)	☑	21.NVA.PT.01					
			590317.78	379217.78	116.54	116.522	116.532
					NVA	-0.018	-0.008
40)	☑	21.NVA.SD.01					
			590326.1	379233.55	117.04	117.049	117.016
					NVA	0.009	-0.024
41)	☑	23.NVA.BG.01					
			585242.56	396478.9	100.79	100.726	100.754
					NVA	-0.064	-0.036
42)	☑	23.NVA.PT.01					
			585285.54	396450.85	100.59	100.571	100.577
					NVA	-0.019	-0.013

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
43)	☑	23.NVA.SD.01					
			585276.63	396479.53	100.73	100.677	100.673
					NVA	-0.053	-0.057
44)	☑	24.NVA.PT.01					
			609961.96	399347.62	170.49	170.512	170.496
					NVA	0.022	0.006
45)	☑	24.NVA.SD.01					
			609967.38	399363.61	171.24	171.242	171.262
					NVA	0.002	0.022
46)	☑	25.NVA.BG.01					
			637465.46	363777.04	190.71	190.759	190.691
					NVA	0.049	-0.019
47)	☑	25.NVA.PT.01					
			637452.55	363785.73	192.14	192.116	192.118
					NVA	-0.024	-0.022
48)	☑	26.NVA.BG.01					
			640238.87	407263.77	135	135.197	135.223
					NVA	0.197	0.223
49)	☑	26.NVA.PT.01					
			640200.21	407234.56	133.47	133.614	133.616
					NVA	0.144	0.146

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
50)	☑	26.NVA.SD.01					
			640188.24	407228.35	133.05	133.227	133.223
					NVA	0.177	0.173
51)	☑	28.NVA.BG.01					
			597637.72	420128.33	125.56	125.583	125.584
					NVA	0.023	0.024
52)	☑	28.NVA.PT.01					
			597656.33	420095.47	126.8	126.798	126.8
					NVA	-0.002	0
53)	☑	28.NVA.SD.01					
			597647.47	420123.85	125.58	125.629	125.597
					NVA	0.049	0.017
54)	☑	29.NVA.BG.01					
			588949.3	434789.28	170.63	170.69	170.691
					NVA	0.06	0.061
55)	☑	29.NVA.PT.01					
			588937.98	434802.95	171.07	171.193	171.181
					NVA	0.123	0.111
56)	☑	29.NVA.SD.01					
			588962.16	434796.72	170.61	170.677	170.689
					NVA	0.067	0.079

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
57)	☑	30.NVA.BG.01					
			602421.14	441718.01	176.1	176.129	176.111
					NVA	0.029	0.011
58)	☑	30.NVA.PT.01					
			602431.4	441728.64	175.68	175.727	175.717
					NVA	0.047	0.037
59)	☑	30.NVA.SD.01					
			602421.8	441732.38	175.51	175.542	175.549
					NVA	0.032	0.039
60)	☑	31.NVA.BG.01					
			625922.6	441636.06	194.29	194.397	194.394
					NVA	0.107	0.104
61)	☑	31.NVA.PT.01					
			625902.4	441640.07	193.86	193.939	193.954
					NVA	0.079	0.094
62)	☑	32.NVA.BG.01					
			637021.3	463474.94	277.93	278.033	278.022
					NVA	0.103	0.092
63)	☑	32.NVA.SD.01					
			637036.32	463487.43	278.82	278.954	278.944
					NVA	0.134	0.124

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
64)	☑	33.NVA.PT.01					
			638220.43	475127.26	294.5	294.66	294.655
					NVA	0.16	0.155
65)	☑	34.NVA.BG.01					
			646342.82	477170.57	324.49	324.615	324.635
					NVA	0.125	0.145
66)	☑	34.NVA.SD.01					
			646346.23	477197.09	324.72	324.865	324.877
					NVA	0.145	0.157
67)	☑	35.NVA.BG.01					
			655333.15	476184.32	291	291.162	291.155
					NVA	0.162	0.155
68)	☑	36.NVA.BG.01					
			683366.78	477376.42	308.84	308.83	308.83
					NVA	-0.01	-0.01
69)	☑	38.NVA.PT.01					
			692199	477101.58	309.02	309.135	309.121
					NVA	0.115	0.101
70)	☑	40.NVA.BG.01					
			685885.8	463157.68	234.32	234.341	234.349
					NVA	0.021	0.029

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
71)	☑	40.NVA.PT.01					
			685899.03	463180.38	235.04	235.102	235.094
					NVA	0.062	0.054
72)	☑	40.NVA.SD.01					
			685895.67	463171.53	234.74	234.8	234.792
					NVA	0.06	0.052
73)	☑	41.NVA.BG.01					
			669101.51	443947.39	140.87	140.935	140.934
					NVA	0.065	0.064
74)	☑	41.NVA.PT.01					
			669066.68	443930.98	141.41	141.55	141.541
					NVA	0.14	0.131
75)	☑	41.NVA.SD.01					
			669083.44	443918.84	141.88	142.03	142.011
					NVA	0.15	0.131
76)	☑	42.NVA.BG.01					
			657957.05	437923.22	118.94	119.1	119.08
					NVA	0.16	0.14
77)	☑	42.NVA.PT.01					
			657973.18	437935.32	119.49	119.65	119.646
					NVA	0.16	0.156

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
78)	☑	43.NVA.PT.02					
			642983.76	415072.76	143.32	143.411	143.393
					NVA	0.091	0.073
79)	☑	43.NVA.SD.01					
			642990.8	415057.8	143.44	143.511	143.501
					NVA	0.071	0.061
80)	☑	44.NVA.BG.01					
			609812.78	409836.88	115.34	115.32	115.313
					NVA	-0.02	-0.027
81)	☑	44.NVA.PT.01					
			609815.76	409920.86	118	117.952	117.987
					NVA	-0.048	-0.013
82)	☑	44.NVA.SD.01					
			609807.61	409852.3	115.31	115.282	115.286
					NVA	-0.028	-0.024
83)	☑	46.NVA.BG.01					
			582775.15	343024.31	43.98	43.959	43.982
					NVA	-0.021	0.002
84)	☑	46.NVA.PT.01					
			582736.46	343033.84	44.76	44.749	44.745
					NVA	-0.011	-0.015

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
85)	☑	46.NVA.SD.01					
			582761.35	343016.74	44.06	44.042	44.043
					NVA	-0.018	-0.017
86)	☑	47.NVA.BG.01					
			582769.98	360254.95	71.03	71.006	70.97
					NVA	-0.024	-0.06
87)	☑	47.NVA.PT.01					
			582757.59	360262.54	70.73	70.737	70.733
					NVA	0.007	0.003
88)	☑	49.NVA.BG.01					
			604766.28	352046.35	90.26	90.262	90.279
					NVA	0.002	0.019
89)	☑	49.NVA.PT.01					
			604755.78	352052.51	90.37	90.41	90.391
					NVA	0.04	0.021
90)	☑	50.NVA.BG.01					
			603926.24	342490.02	85.44	85.421	85.409
					NVA	-0.019	-0.031
91)	☑	50.NVA.PT.01					
			603885.56	342547.3	89.04	89.023	89.035
					NVA	-0.017	-0.005

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
92)	☑	53.NVA.BG.01					
			580160.26	376700.51	125.34	125.357	125.355
					NVA	0.017	0.015
93)	☑	53.NVA.PT.01					
			580169.47	376648.57	125.05	125.063	125.064
					NVA	0.013	0.014
94)	☑	53.NVA.SD.01					
			580174.44	376685.38	125.46	125.445	125.443
					NVA	-0.015	-0.017
95)	☑	55.NVA.BG.01					
			606390.99	429041.15	132.36	132.38	132.359
					NVA	0.02	-0.001
96)	☑	55.NVA.PT.01					
			606388.73	428991.63	132.08	132.107	132.107
					NVA	0.027	0.027
97)	☑	56.NVA.BG.01					
			604789.37	368052.81	149.22	149.2	149.196
					NVA	-0.02	-0.024
98)	☑	56.NVA.PT.01					
			604801.46	368038.23	149.72	149.688	149.685
					NVA	-0.032	-0.035

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
99)	☑	56.NVA.SD.01					
			604815.38	368056.99	150.23	150.245	150.241
					NVA	0.015	0.011
100)	☑	57.NVA.PT.01					
			600357.21	381515.02	161	160.934	160.948
					NVA	-0.066	-0.052
101)	☑	57.NVA.SD.01					
			600347.56	381536.03	160.78	160.735	160.732
					NVA	-0.045	-0.048
102)	☑	59.NVA.BG.01					
			649093.24	443080.58	171.37	171.501	171.493
					NVA	0.131	0.123
103)	☑	59.NVA.PT.01					
			649076.81	443064.12	171.24	171.367	171.361
					NVA	0.127	0.121
104)	☑	59.NVA.SD.01					
			649102.06	443067.87	171.7	171.837	171.81
					NVA	0.137	0.11
105)	☑	60.NVA.BG.01					
			671759	453516.42	183.33	183.401	183.392
					NVA	0.071	0.062

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
106)	☑	60.NVA.PT.01					
			671781.97	453602.93	185.42	185.499	185.472
					NVA	0.079	0.052
107)	☑	60.NVA.SD.01					
			671744.01	453536.15	183.88	184.036	183.989
					NVA	0.156	0.109
108)	☑	01.VVA.HV.01					
			616358.39	335514.34	88.11	88.25	88.221
					VVA	0.14	0.111
109)	☑	01.VVA.LV.01					
			616332.1	335538.75	89.13	89.321	89.29
					VVA	0.191	0.16
110)	☑	01.VVA.MV.01					
			616303.76	335542.1	88.49	88.644	88.589
					VVA	0.154	0.099
111)	☑	03.VVA.HV.01					
			650809.5	455860.61	191.05	191.242	191.242
					VVA	0.192	0.192
112)	☑	06.VVA.MV.01					
			661930.16	463802.12	235.04	235.152	235.154
					VVA	0.112	0.114

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
113)	☑	07.VVA.HV.01					
			676910.76	471009.59	278.82	278.885	278.874
					VVA	0.065	0.054
114)	☑	07.VVA.LV.01					
			676892.71	471024.25	278.78	278.907	278.892
					VVA	0.127	0.112
115)	☑	09.VVA.HV.01					
			616893.43	368427.56	202.51	202.468	202.468
					VVA	-0.042	-0.042
116)	☑	10.VVA.LV.01					
			669759.9	463897.53	253.19	253.243	253.261
					VVA	0.053	0.071
117)	☑	10.VVA.MV.01					
			669754.51	463897.32	253.13	253.236	253.234
					VVA	0.106	0.104
118)	☑	13.VVA.LV.01					
			633872.78	421896.89	87.33	87.439	87.459
					VVA	0.109	0.129
119)	☑	14.VVA.LV.01					
			638049.48	433528.95	100.3	100.457	100.439
					VVA	0.157	0.139

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
120)	☑	16.VVA.LV.01					
			629405.1	411987.11	161.23	161.36	161.385
					VVA	0.13	0.155
121)	☑	16.VVA.MV.01					
			629417.38	411996.12	161.58	161.686	161.682
					VVA	0.106	0.102
122)	☑	17.VVA.HV.01					
			616889.46	361078.41	182.48	182.373	182.371
					VVA	-0.107	-0.109
123)	☑	17.VVA.LV.01					
			616887.44	361107.02	183.26	183.224	183.205
					VVA	-0.036	-0.055
124)	☑	17.VVA.MV.01					
			616882.48	361107.16	183.12	183.096	183.136
					VVA	-0.024	0.016
125)	☑	18.VVA.HV.01					
			625898.39	370352.69	138.79	138.856	138.854
					VVA	0.066	0.064
126)	☑	18.VVA.LV.01					
			625830.22	370345.81	140.34	140.485	140.502
					VVA	0.145	0.162

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
127)	☑	19.VVA.HV.01					
			625123.26	351609.71	162.39	162.395	162.381
					VVA	0.005	-0.009
128)	☑	21.VVA.HV.01					
			590317.56	379180.66	115.48	115.44	115.446
					VVA	-0.04	-0.034
129)	☑	23.VVA.HV.01					
			585225.31	396469.49	99.81	99.751	99.744
					VVA	-0.059	-0.066
130)	☑	25.VVA.LV.01					
			637439.21	363789.85	192.25	192.335	192.333
					VVA	0.085	0.083
131)	☑	25.VVA.MV.01					
			637448.23	363793.77	192.91	192.902	192.925
					VVA	-0.008	0.015
132)	☑	26.VVA.HV.01					
			640194.32	407253.91	134.01	134.129	134.162
					VVA	0.119	0.152
133)	☑	26.VVA.MV.01					
			640229.97	407195.55	132.56	132.878	132.882
					VVA	0.318	0.322

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
134)	☑	28.VVA.HV.01					
			597656.22	420142.84	124.68	124.691	124.702
					VVA	0.011	0.022
135)	☑	28.VVA.MV.01					
			597694.47	420123.03	124.16	124.434	124.362
					VVA	0.274	0.202
136)	☑	29.VVA.HV.01					
			588964.47	434820.13	170.62	170.704	170.711
					VVA	0.084	0.091
137)	☑	29.VVA.LV.01					
			588989.26	434768.26	170.56	170.66	170.669
					VVA	0.1	0.109
138)	☑	30.VVA.HV.01					
			602425.58	441705.2	176.19	176.224	176.222
					VVA	0.034	0.032
139)	☑	30.VVA.LV.01					
			602433.36	441696.09	176.38	176.486	176.481
					VVA	0.106	0.101
140)	☑	31.VVA.HV.01					
			625926.06	441630.48	194.19	194.304	194.286
					VVA	0.114	0.096

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
141)	☑	32.VVA.LV.01					
			637016.8	463480.25	278.9	279.043	279.05
					VVA	0.143	0.15
142)	☑	33.VVA.LV.01					
			638208.02	475119.39	294.93	295.142	295.15
					VVA	0.212	0.22
143)	☑	33.VVA.MV.01					
			638211.86	475129.99	294.58	294.732	294.753
					VVA	0.152	0.173
144)	☑	34.VVA.HV.01					
			646366.74	477247.61	325.42	325.501	325.492
					VVA	0.081	0.072
145)	☑	36.VVA.HV.01					
			683361.53	477370.93	308.63	308.622	308.632
					VVA	-0.008	0.002
146)	☑	38.VVA.LV.01					
			692191.67	477107.95	309.41	309.572	309.627
					VVA	0.162	0.217
147)	☑	38.VVA.MV.01					
			692182.85	477110.06	309.1	309.207	309.202
					VVA	0.107	0.102

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
148)	☑	40.VVA.LV.01					
			685877.2	463155.94	233.91	233.998	234.005
					VVA	0.088	0.095
149)	☑	40.VVA.MV.01					
			685880.68	463167.82	234.52	234.568	234.573
					VVA	0.048	0.053
150)	☑	41.VVA.HV.01					
			669129.75	443966.68	139.94	140.056	140.052
					VVA	0.116	0.112
151)	☑	41.VVA.LV.01					
			669058.65	443945.89	141.81	141.926	141.954
					VVA	0.116	0.144
152)	☑	42.VVA.HV.01					
			657947.23	437932.62	118.8	118.945	118.946
					VVA	0.145	0.146
153)	☑	42.VVA.MV.01					
			657964.78	437940.16	119.11	119.4	119.42
					VVA	0.29	0.31
154)	☑	44.VVA.HV.01					
			609823.22	409857.22	114.79	114.754	114.773
					VVA	-0.036	-0.017

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
155)	☑	44.VVA.LV.01					
			609801.4	409857.14	115.07	115.133	115.157
					VVA	0.063	0.087
156)	☑	44.VVA.MV.01					
			609797.44	409874.03	115.29	115.261	115.265
					VVA	-0.029	-0.025
157)	☑	46.VVA.LV.01					
			582780.63	343016.14	43.8	43.876	43.838
					VVA	0.076	0.038
158)	☑	47.VVA.MV.01					
			582772.7	360244.69	71.31	71.331	71.299
					VVA	0.021	-0.011
159)	☑	49.VVA.HV.01					
			604743.07	352098.3	90.54	90.423	90.478
					VVA	-0.117	-0.062
160)	☑	49.VVA.LV.01					
			604789.77	352044.05	90.23	90.371	90.359
					VVA	0.141	0.129
161)	☑	49.VVA.MV.01					
			604753.78	352109.48	89.76	89.798	89.793
					VVA	0.038	0.033

Coordinates and Offsets of Analyzed Locations (Continued)

		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					LC Type	ΔZ DEM	ΔZ LAS
162)	☑	50.VVA.HV.01					
			603891.03	342512.22	86.52	86.501	86.512
					VVA	-0.019	-0.008
163)	☑	50.VVA.LV.01					
			603902.9	342474.24	84.2	84.287	84.322
					VVA	0.087	0.122
164)	☑	53.VVA.HV.01					
			580149.8	376682.93	125.18	125.191	125.201
					VVA	0.011	0.021
165)	☑	53.VVA.LV.01					
			580168.23	376668.73	125.34	125.354	125.353
					VVA	0.014	0.013
166)	☑	55.VVA.HV.01					
			606409.93	428977.69	131.39	131.387	131.398
					VVA	-0.003	0.008
167)	☑	56.VVA.HV.01					
			604767.91	368045.78	148.38	148.364	148.385
					VVA	-0.016	0.005
168)	☑	56.VVA.MV.01					
			604781.48	368016.89	148.92	149.014	148.969
					VVA	0.094	0.049

Coordinates and Offsets of Analyzed Locations (Continued)

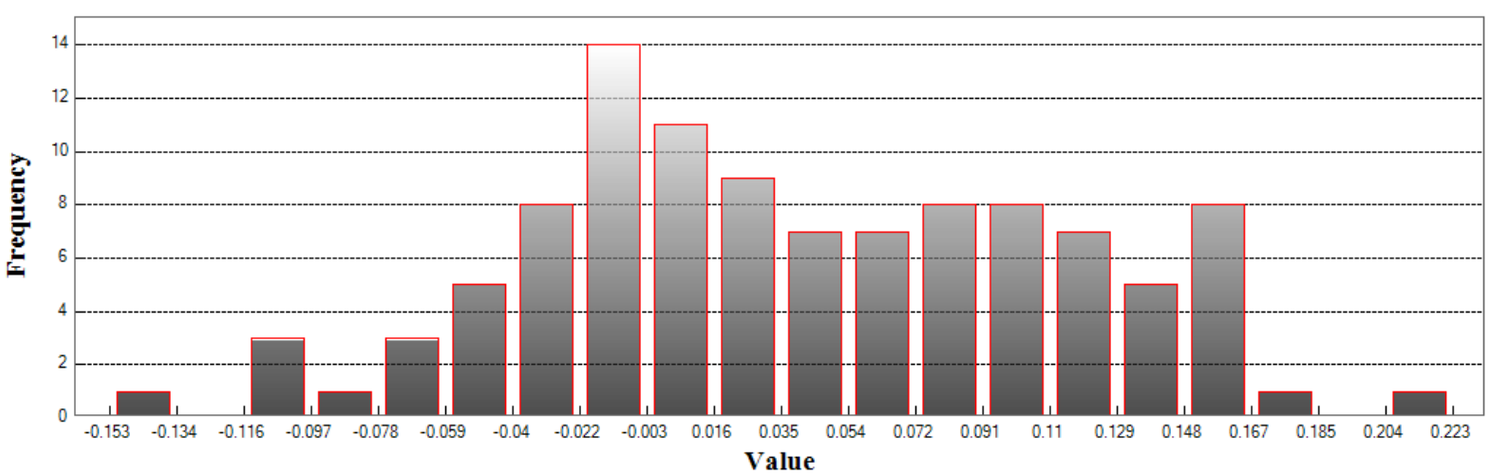
	ID	Survey X	Survey Y	Z1	Z DEM	Z LAS
				LC Type	ΔZ DEM	ΔZ LAS
169)	57.VVA.HV.01					
		600339.99	381544.24	160.9	160.925	160.925
				VVA	0.025	0.025
170)	59.VVA.HV.01					
		649164.27	443096.89	177	177.083	177.097
				VVA	0.083	0.097
171)	59.VVA.MV.01					
		649159.63	443084.45	176.75	176.868	176.874
				VVA	0.118	0.124
172)	60.VVA.HV.01					
		671736.95	453548.72	184.38	184.407	184.435
				VVA	0.027	0.055
173)	60.VVA.MV.01					
		671801.12	453516.85	185.61	185.794	185.674
				VVA	0.184	0.064

LAS

Fundamental Vertical Accuracy

LandCover Type: NVA
Minimum DZ: -0.153
Maximum DZ: 0.223
Mean DZ: 0.041
Mean Magnitude DZ: 0.258
Number Observations: 107
Standard Deviation DZ: 0.074
RMSE Z: 0.084
95% Confidence Level Z: 0.166
Units: Meters

Histogram



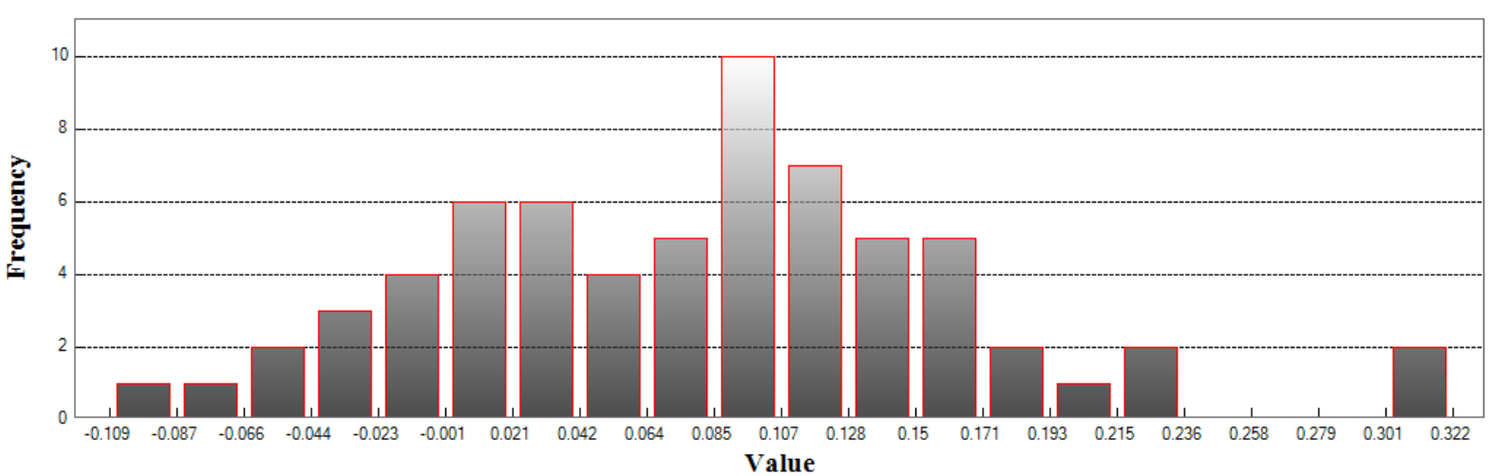
Min: -0.153
Max: 0.223
Number Of Bins: 20
Bin Interval: 0.019

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: VVA
Minimum DZ: -0.109
Maximum DZ: 0.322
Mean DZ: 0.079
Mean Magnitude DZ: 0.304
Number Observations: 66
Standard Deviation DZ: 0.084
RMSE Z: 0.115
95th Percentile: 0.213
Units: Meters

Histogram



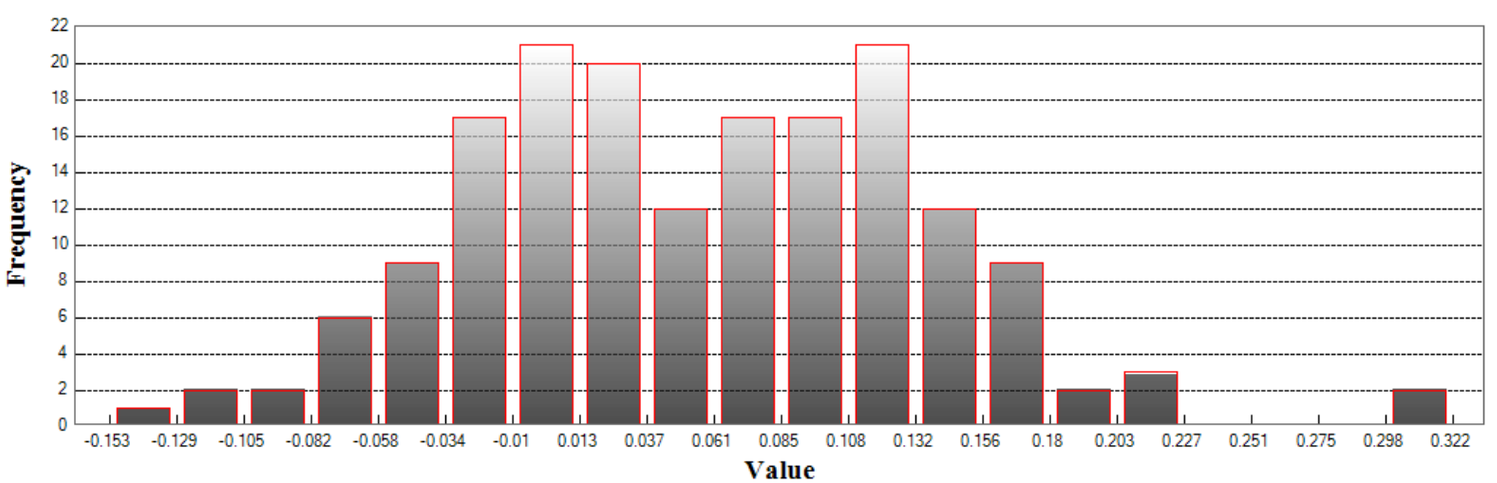
Min: -0.109
Max: 0.322
Number Of Bins: 20
Bin Interval: 0.022

LAS (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.153
Maximum DZ: 0.322
Mean DZ: 0.056
Mean Magnitude DZ: 0.277
Number Observations: 173
Standard Deviation DZ: 0.08
RMSE Z: 0.097
95th Percentile: 0.166
Units: Meters

Histogram



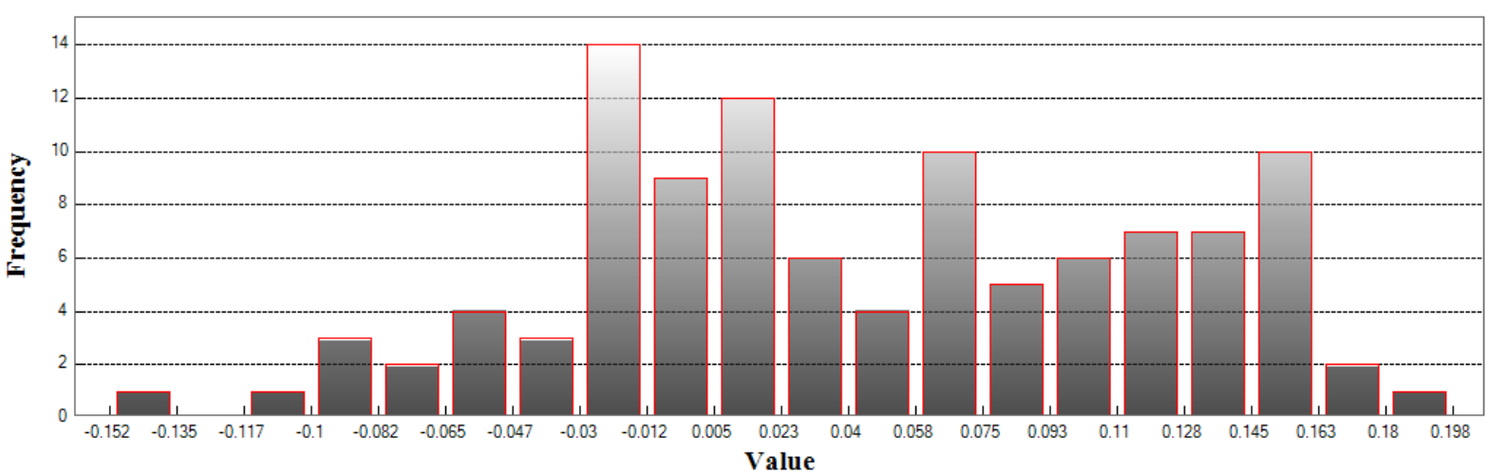
Min: -0.153
Max: 0.322
Number Of Bins: 20
Bin Interval: 0.024

DEM

Fundamental Vertical Accuracy

LandCover Type: NVA
Minimum DZ: -0.153
Maximum DZ: 0.197
Mean DZ: 0.044
Mean Magnitude DZ: 0.264
Number Observations: 107
Standard Deviation DZ: 0.076
RMSE Z: 0.087
95% Confidence Level Z: 0.171
Units: Meters

Histogram



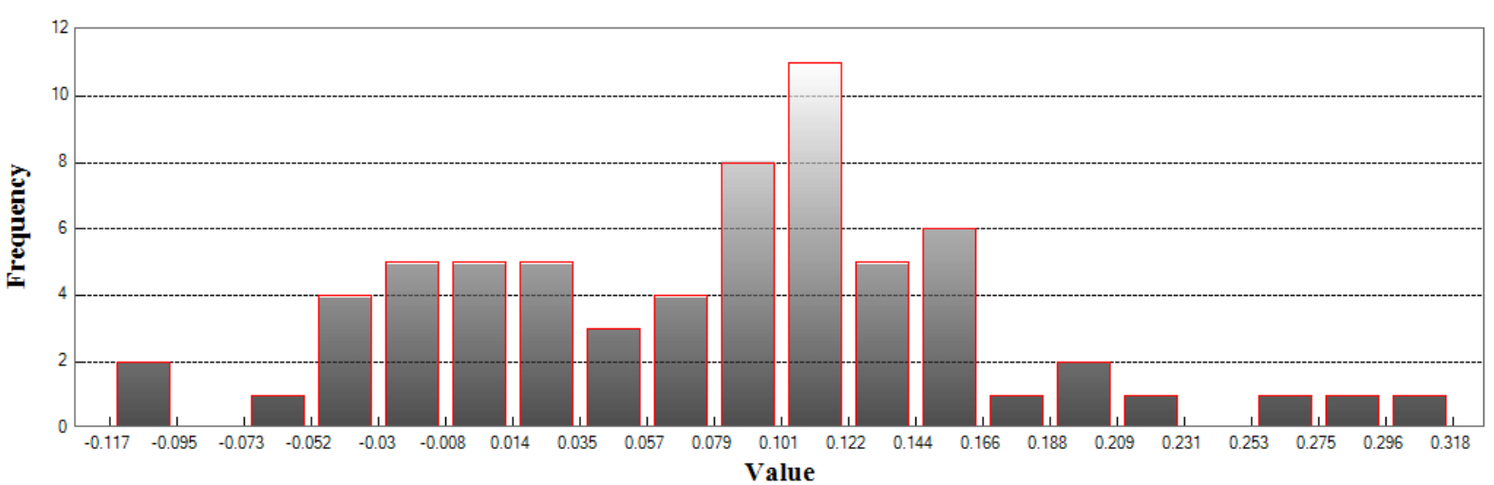
Min: -0.153
Max: 0.197
Number Of Bins: 20
Bin Interval: 0.018

DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: VVA
Minimum DZ: -0.117
Maximum DZ: 0.318
Mean DZ: 0.079
Mean Magnitude DZ: 0.309
Number Observations: 66
Standard Deviation DZ: 0.088
RMSE Z: 0.117
95th Percentile: 0.207
Units: Meters

Histogram



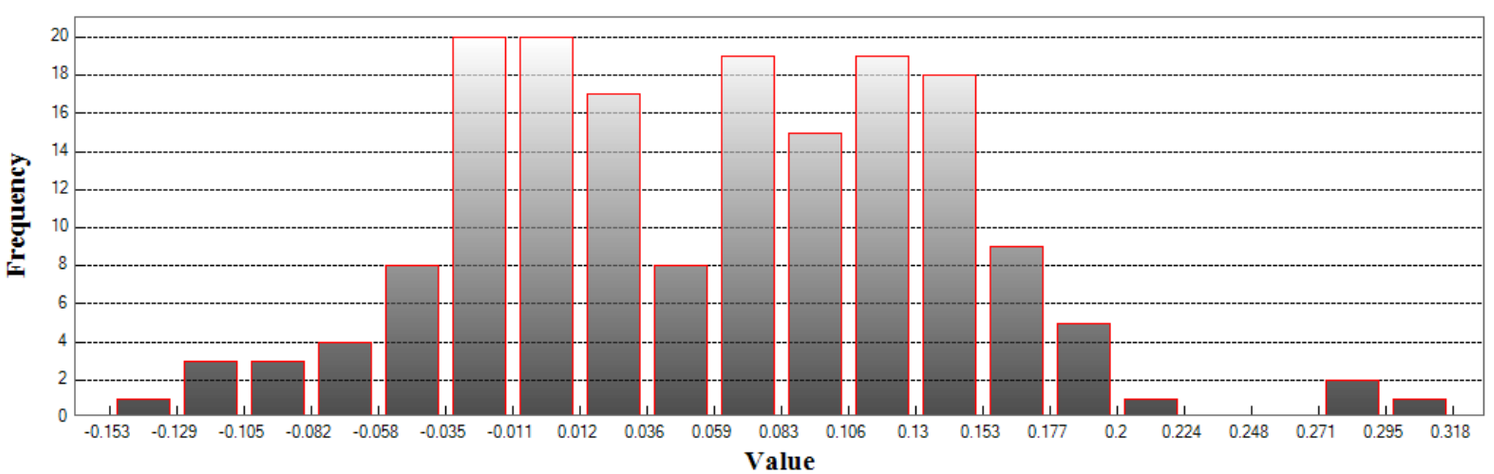
Min: -0.117
Max: 0.318
Number Of Bins: 20
Bin Interval: 0.022

DEM (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.153
Maximum DZ: 0.318
Mean DZ: 0.057
Mean Magnitude DZ: 0.282
Number Observations: 173
Standard Deviation DZ: 0.082
RMSE Z: 0.1
95th Percentile: 0.168
Units: Meters

Histogram



Min: -0.153
Max: 0.318
Number Of Bins: 20
Bin Interval: 0.024