Project Report

FY13 Suwannee River water Management LiDAR Area 3 Florida State Plane North

Prepared For:

United States Geological Survey

Prepared By:

Digital Aerial Solutions, LLC

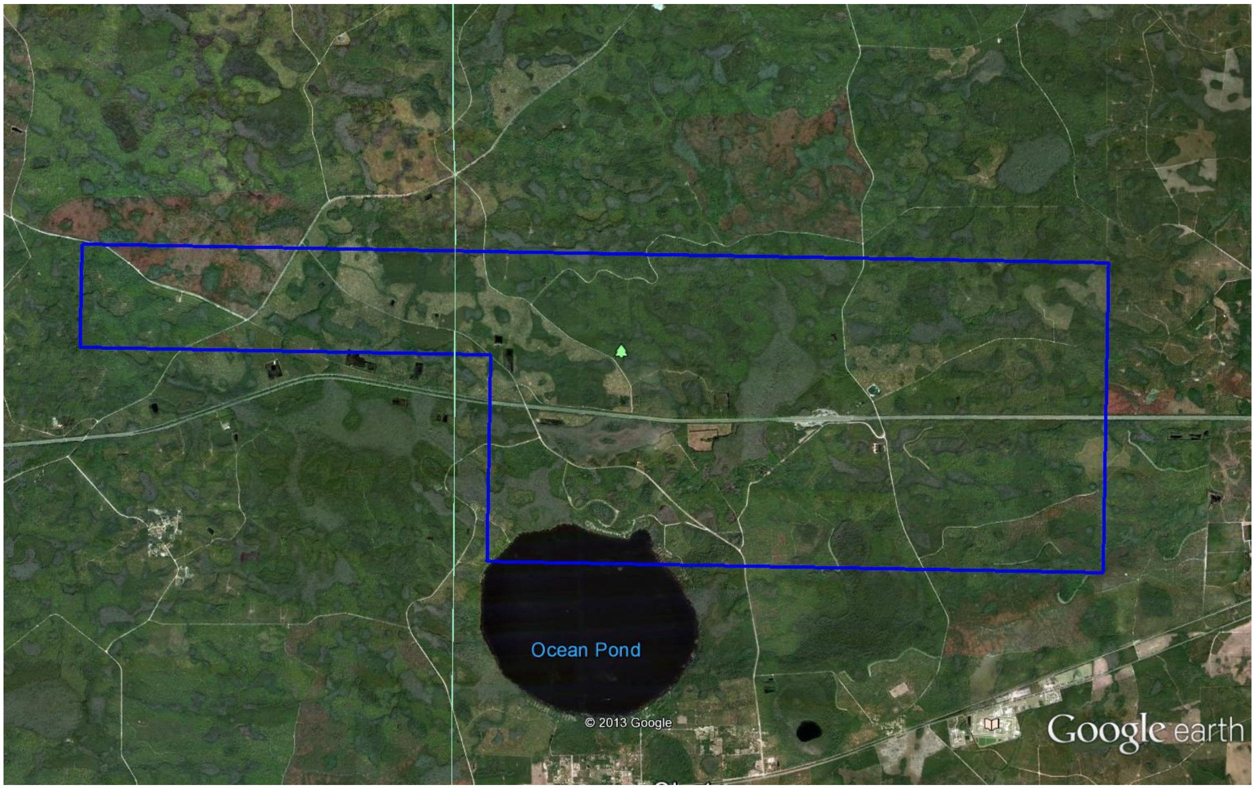
CONTRACT: #G10PC00093
CONTRACTOR: DIGITAL AERIAL SOLUTIONS
TASK ORDER: #G13PD00141

Project Report
LiDAR Collection, Processing, and QA/QC

2013 Suwannee Management LiDAR Task Order G13PD00141

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



Suwannee FY13 Area 3 Area of Interest

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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 Suwannee Management, FL. The FY13 Suwannee Management survey Area3 encompasses approximately 25 square miles. Aerial LiDAR data was collected utilizing an ALS60. The ALS60 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the Suwannee Management survey has a nominal pulse spacing of 0.9 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, and bare-earth DEM tiles. Point cloud deliverables are stored in the LAS version 1.2 format, point data record format 1. The tiling scheme for tiled deliverables is a 4900 feet x 4900 feet grid. All deliverables were generated in conformance with the *U.S. Geological Survey National Geospatial Program Guidelines and Base Specifications, Version 1.*

2 Spatial Reference System

The spatial reference of the data is as follows.

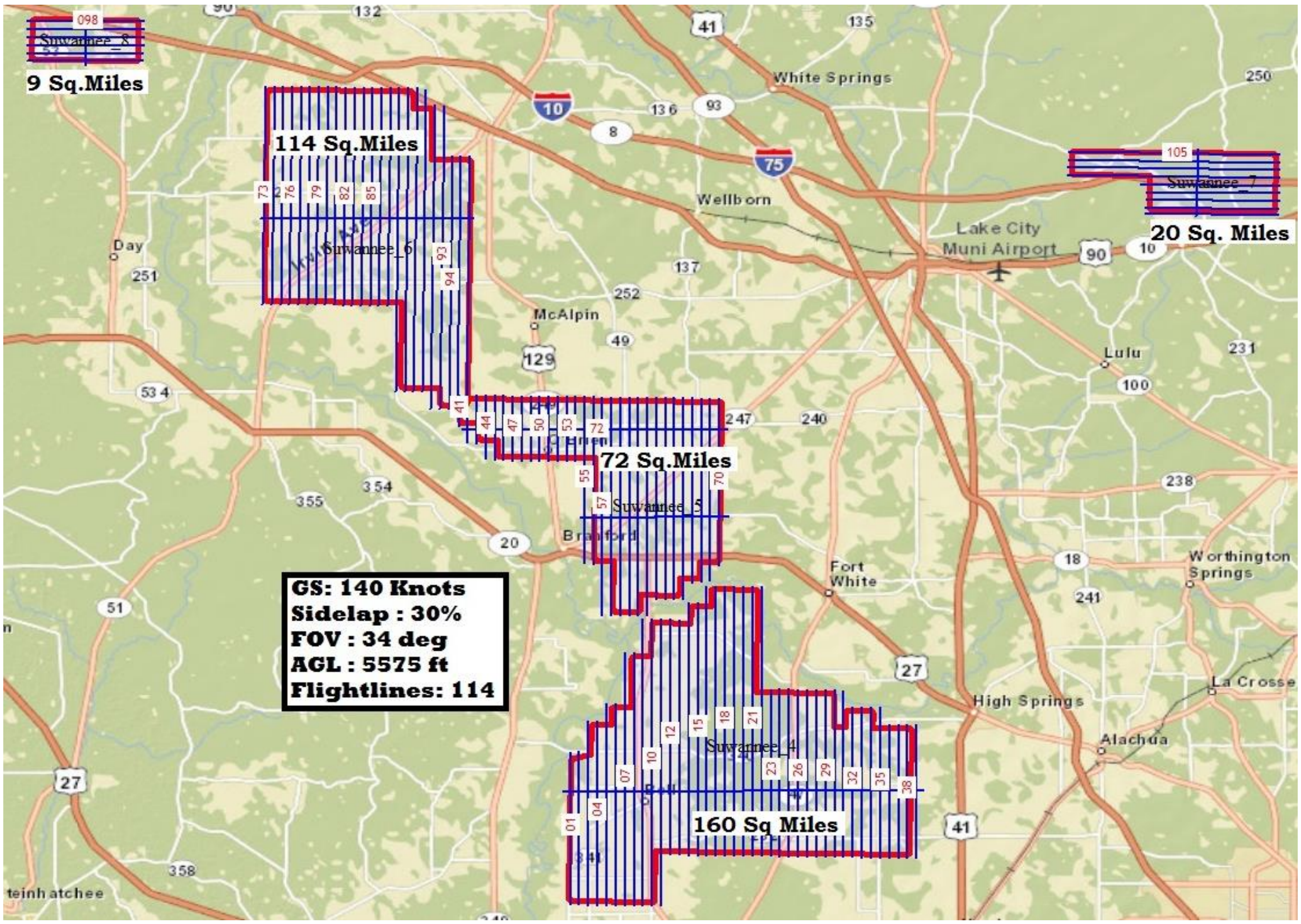
Horizontal Spatial Reference
- Datum: North American Datum of 1983 (National Spatial Reference System 2007)
- Coordinates: State Plane Florida North

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 (GEOID09)

3 LiDAR Acquisition

3.1 Survey Area

The FY13 Suwannee Management Area3 survey covers approximately 25 square miles located in north central Florida. The flight plan consisted of 10 survey lines and
1 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 FY 13 Suwannee River water Management Area3 LiDAR project are summarized below.

Parameter	Value
Flying Height Above Ground Level	5,575 feet
Nominal Sidelap	30%
Nominal Speed Over Ground	140 knots
Field of View	34°
Laser Rate	200 kHz
Scan Rate	68.4 hz
Maximum Cross Track Spacing	0.98 meters
Maximum Along Track Spacing	0.98 meters
Average Spacing	1 meters

3.3 Acquisition Mission

The acquisition mission for the FY 13 Suwannee River water Management Area3 LiDAR survey was coordinated to be acquired in 1 week. Collection began on February 4th 2013 and was completed on February 16th, 2013, A complete flight log for the acquisition mission may be found in Appendix A.

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	ALS60 – SN6130	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 IPAS software. IPAS 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 dataset in Leica's IPAS software through Kalman filtering techniques. IPAS 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 sensor ranging data and the final sensor trajectory from IPAS were processed in Leica's ALSPP software to produce the LiDAR elevation point cloud swaths for each flightline, stored in LAS version 1.2 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. The LiDAR data collected for the Suwannee Management survey Area3 passed these quality control checks.

Swath point clouds were assigned a unique File Source ID within the LAS file format before further processing. Swath files for the FY 13 Suwannee River water Management Area3 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 ALSPP software for the ALS60 sensor system. Terrasolid's Terramatch software was used to calculate the IMU bore-site and mirror scale parameters for the FY13 Suwannee Management's Area3 LiDAR data. 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. The FY13 Suwannee Management survey Area3 did not support this requirement, due to the large water area within the 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 FY 13 Suwannee River water Management Area3 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 4900 feet x 4900 feet tiles for point cloud classification and derived product creation. It is important to note that US National Grid tiles are non- orthogonal when stored and displayed in a geographic coordinate system. As a result, tiled vector data does not have overlap, but tiled raster data does have overlap to permit seamless display of the data products.

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 – Noise
- Class 9 – Water
- Class 10 – Ignored Ground
- Class 11 – Withheld
- Class 17 – Reserve
- Class 18 – Reserve

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 105 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 the project US National Grid index.

The data collected for the Suwannee Management LiDAR Area 3 survey maintained significant point density in the water, marsh, and swamp, 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 and the NGP version 13 guidelines. 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 float Arc Grid.

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 Suwannee Management 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 ALSPP 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.

Horizontal accuracy assessments of LiDAR data require the presence of vertical targets such as buildings within in the survey area. Field check points are surveyed at the corners of the building roofs, and the surveyed locations compared to the estimated corner locations in the LiDAR point cloud. The FY 13 Suwannee Management survey Area3 did not present any accessible buildings for use as vertical targets. From the manufacturer's specifications, the estimated horizontal accuracy at one sigma, based on flying height for the project, is between 10cm and 20cm.

Absolute vertical accuracy assessments for the point cloud data are made against ground check point data. For the FY13 Suwannee Management Area3 survey, 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 as described in NDEP Elevation Guidelines Version 1. The FVA of the TIN tested RMSEz 0.193 feet and 0.377 feet at the 95% confidence level in open terrain. FVA of the DEM tested at an RMSEz of 0.196 feet and 0.387 feet at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B. Note that the Urban category comprised 1.21% of landcover across these areas, as a result no Urban checkpoints are collected.

FVA of TIN

$RMSE_Z$ =	0.193	feet
NSSDA=	0.377	feet

FVA of DEM

$RMSE_Z$ =	0.196	feet
NSSDA=	0.387	feet

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 NGP version 1 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 US National Grid tile index.

Appendix A. Flight Logs

ALS60 LiDAR Flight Log

Project	Suwannee 2013	ALS60	N6130_090724		Sensor Operator/s
				-	Bertin Evina-Ze
Date/Julian:	2/4/2013 Lake City	Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	671.7	3-600093051		140	BD2712	MWAZ
Hobbs ST	667.5	LIFT A		TAR ALT AGL (ft): Flight Plan(s):	Base Height: Aircraft	Airport Idnt:
Flight Time	4.2			5,575 Block 7 AND Block 5	1.500 421C 112MJ	LCQ

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
Block 7						-	-	-	138				Static Alignment
		105		18:24	18:28	5,690	271	130	137	18	1.3	0.6	
		106		18:31	18:35	5,690	91	143	136	18	1.2	0.6	
		107		18:39	18:43	5,712	271	130	135	17	1.4	0.7	
		108		18:47	18:50	5,701	91	140	134	17	1.4	0.7	
		109		18:54	18:57	5,701	271	128	133	17	1.3	0.7	
		110		18:59	19:03	5,740	91	141	132	18	1.4	0.6	
		111		19:07	19:09	5,718	271	130	131	18	1.1	0.6	
		112		19:13	19:15	5,721	91	141	131	18	1.1	0.6	
		113		19:19	19:22	5,726	271	128	130	17	1.2	0.7	
		114		19:27	19:29	5,718	1.4	137	130	18	1.0	0.6	X-STRIP
		114		19:31	19:33	5,754	181.4	123	129	18	1.0	0.6	X-STRIP

ALS60 LiDAR Flight Log

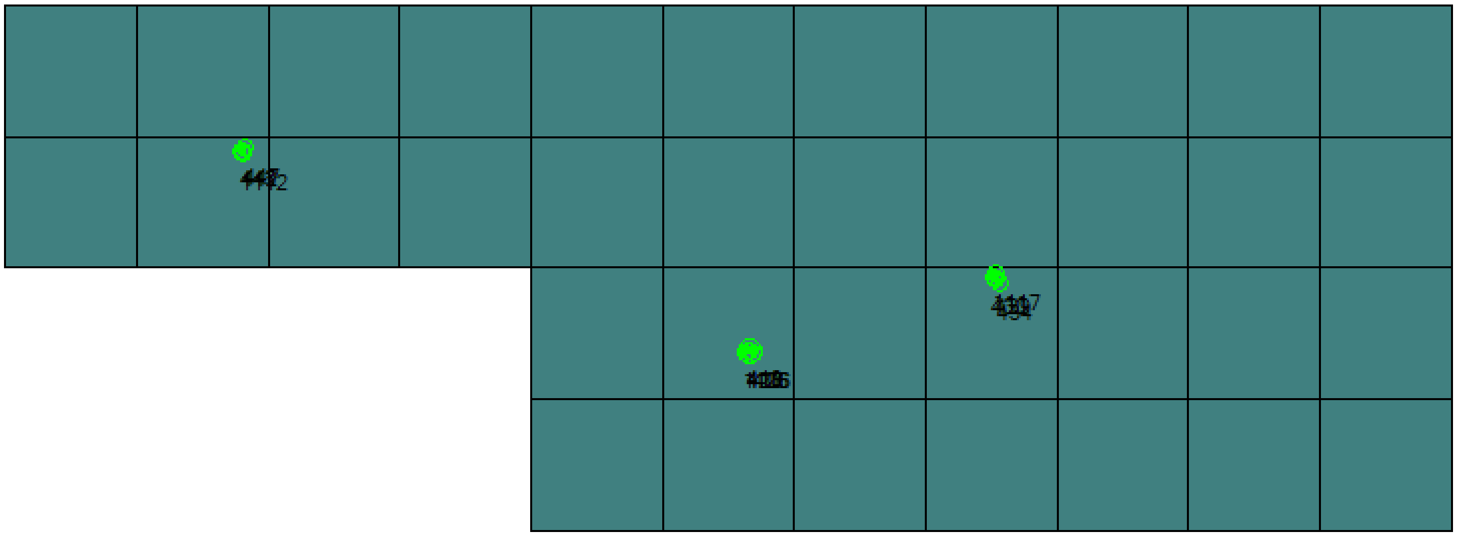
Project	Suwannee 2013	ALS60	N6130_090724		Sensor Operator/s
				-	Bertin Evina-Ze
Date/Julian:	2/16/2013 Lake City	Mem Drive MM60	Int. Time:	TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	683.3	3-600093051		140	BD2712	MWAZ
Hobbs ST	682.6	LIFT A		TAR ALT AGL (ft): Flight Plan(s):	Base Height: Aircraft	Airport Idnt:
Flight Time	0.7			5,575 Block 7	1.500 421C 112MJ	LCQ

Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
Block 7						-	-	-	39				Static Alignment
		108	130216_131854	13:18	13:21	5,700	91.0	140	38	15	1.4	0.7	REFLY
		109	130216_132650	13:26	13:29	5,700	271.0	131	38	15	1.4	0.7	REFLY
		110	130216_133256	13:32	13:35	5,700	91.0	140	37	15	1.4	0.7	REFLY
		114	130216_134026	13:40	13:41	5,700	01.4	138	37	15	1.3	0.7	X-STRIP- REFLY
		114	130216_134517	13:45	13:46	5,700	181.4	140	36	16	1.1	0.6	X-STRIP- REFLY

Appendix B. Vertical Accuracy Calculations

Tiled-Data Area

Note: The Urban category comprised 1.21% of landcover across these areas, as a result no Urban checkpoints are collected.
Three check points where considered outliers and excluded from the Vertical accuracy report. Check points BrushLand 405, Forested 1109, Forested 1115 were taken in obscured area in which position and conditions were less than favorable.



LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	CVA
LAS				
ALL	13			0.675
FVA	6	0.377		
Tallweeds	2		0.544	
Brushland	2		0.413	
Forested	3		0.803	
Total	13			
DEM				
ALL	13			0.705
FVA	6	0.387		
Tallweeds	2		0.593	
Brushland	2		0.410	
Forested	3		0.803	
Total	13			

Units: Feet

Coordinates and Offsets of Analyzed Locations

		ID				
			Survey X	**Survey Y**	**Z1**	**Z DEM**	**Z LAS**
					ΔZ DEM	**ΔZ LAS**	**LC Type**
1)	☑	**418**					
			362486.405	3347041.493	48.731	48.704	48.7
					-0.027	-0.031	FVA
2)	☑	**419**					
			362467.978	3347062.546	49.246	49.267	49.255
					0.021	0.009	FVA
3)	☑	**429**					
			365308.871	3347877.537	49.364	49.306	49.287
					-0.058	-0.077	FVA
4)	☑	**430**					
			365269.167	3347889.785	49.478	49.357	49.371
					-0.121	-0.107	FVA
5)	☑	**442**					
			356710.895	3349338.924	47.644	47.679	47.674
					0.035	0.03	FVA
6)	☑	**443**					
			356691.669	3349347.446	47.408	47.445	47.446
					0.037	0.038	FVA
7)	☑	**426**					
			362542.035	3347034.615	48.441	48.485	48.45
					0.044	0.009	Tallweeds

Coordinates and Offsets of Analyzed Locations (Continued)

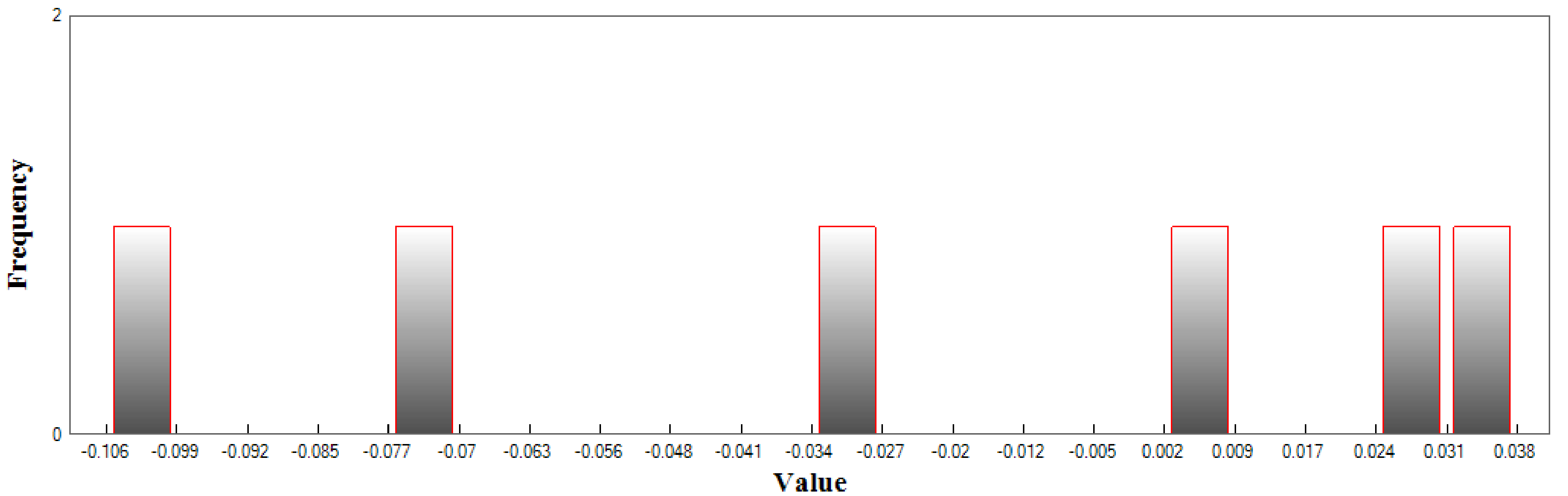
		ID					
			Survey X	Survey Y	Z1	Z DEM	Z LAS
					ΔZ DEM	ΔZ LAS	LC Type
8)	☑	**447**					
			356742.548	3349381.272	47.245	47.433	47.419
					0.188	0.174	Tallweeds
9)	☑	**420**					
			362467.387	3347042.105	48.238	48.241	48.26
					0.003	0.022	Brushland
10)	☑	**434**					
			365341.71	3347820.913	49.025	48.894	48.893
					-0.131	-0.132	Brushland
11)	☑	**1106**					
			362443.943	3347030.771	48.275	48.53	48.53
					0.255	0.255	Forested
12)	☑	**1112**					
			356705.58	3349309.161	47.734	47.608	47.602
					-0.126	-0.132	Forested
13)	☑	**1117**					
			365296.886	3347931.712	47.903	47.747	47.739
					-0.156	-0.164	Forested

LAS

Fundamental Vertical Accuracy

LandCover Type: FVA
Minimum DZ: -0.351
Maximum DZ: 0.124
Mean DZ: -0.075
Mean Magnitude DZ: 0.725
Number Observations: 6
Standard Deviation DZ: 0.193
RMSE Z: 0.193
95% Confidence Level Z: 0.377
Units: Feet

Histogram



Min: -0.107
Max: 0.038
Number Of Bins: 20
Bin Interval: 0.007

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Tallweeds

Minimum DZ: 0.009

Maximum DZ: 0.174

Mean DZ: 0.092

Mean Magnitude DZ: 0.303

Number Observations: 2

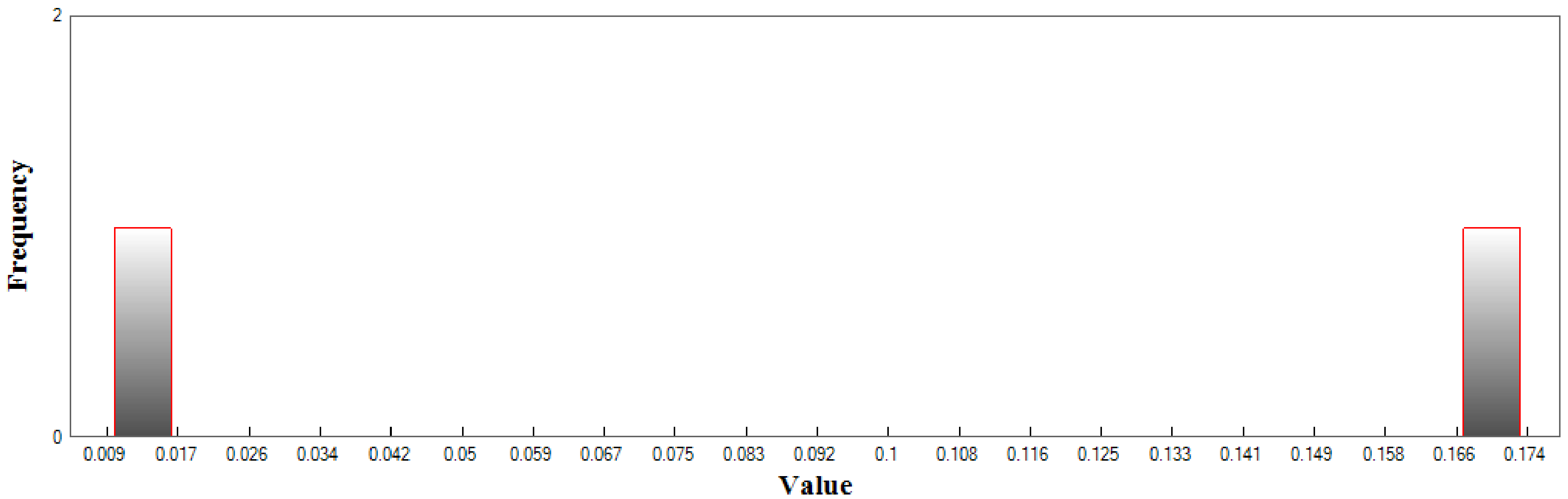
Standard Deviation DZ: 0.383

RMSE Z: 0.403

95th Percentile: 0.544

Units: Feet

Histogram



Min: 0.009

Max: 0.174

Number Of Bins: 20

Bin Interval: 0.008

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Brushland

Minimum DZ: -0.433

Maximum DZ: 0.072

Mean DZ: -0.180

Mean Magnitude DZ: 0.912

Number Observations: 2

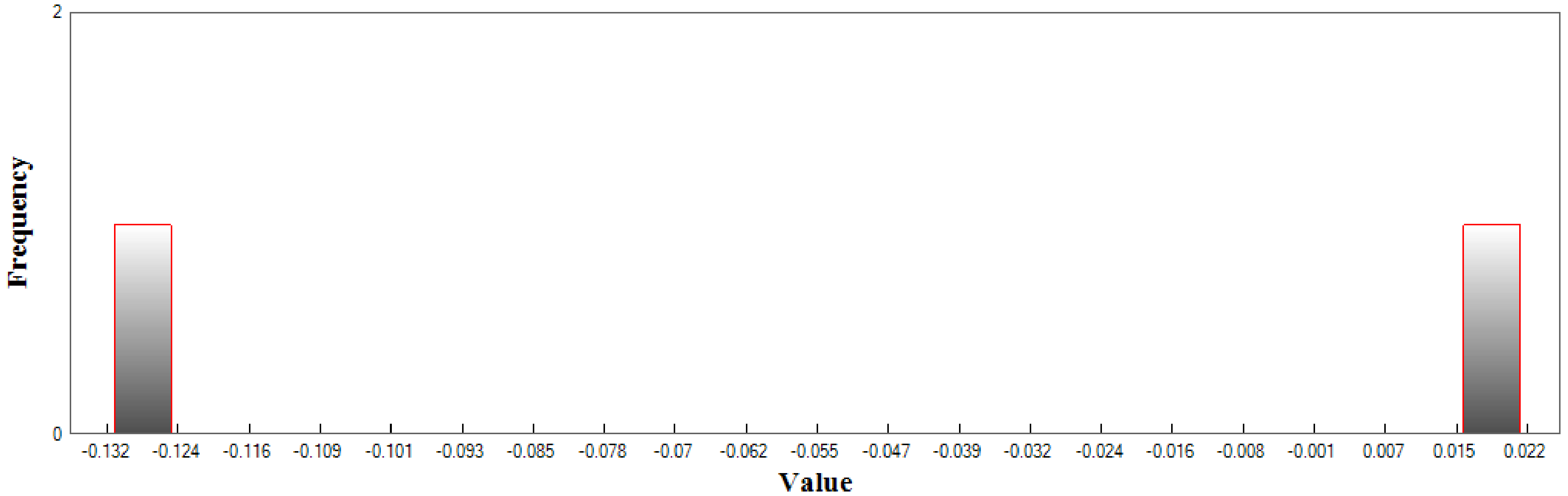
Standard Deviation DZ: 0.357

RMSE Z: 0.311

95th Percentile: 0.413

Units: Feet

Histogram



Min: -0.132

Max: 0.022

Number Of Bins: 20

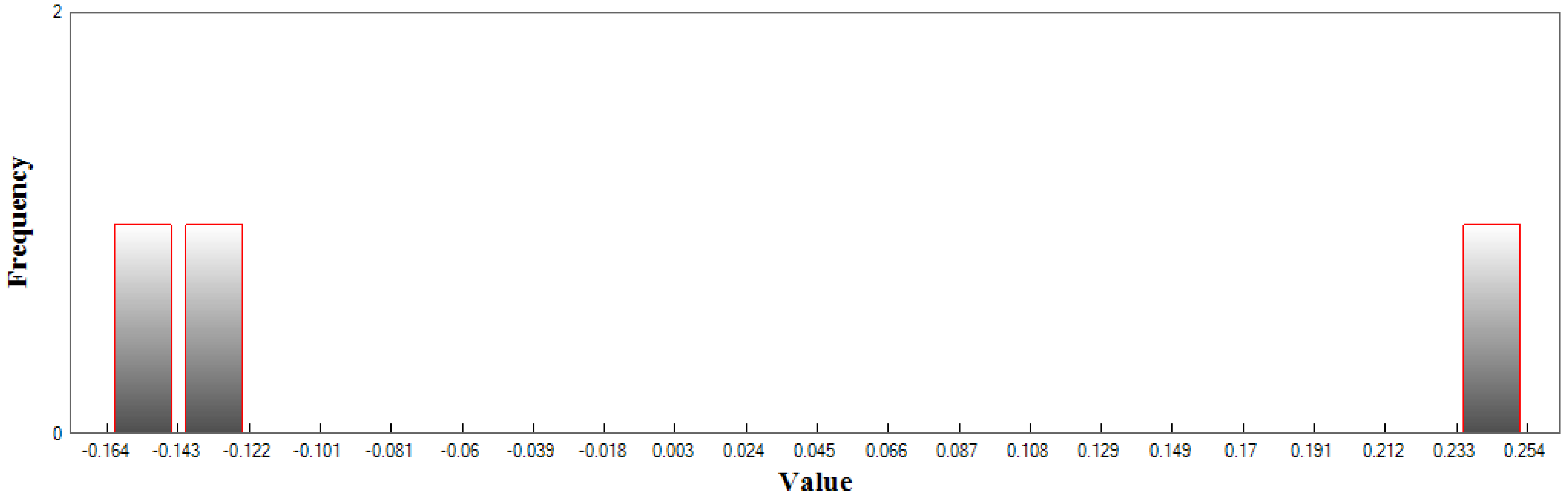
Bin Interval: 0.008

LAS (Continued)

Supplemental Vertical Accuracy

LandCover Type: Forested
Minimum DZ: -0.164
Maximum DZ: 0.255
Mean DZ: -0.045
Mean Magnitude DZ: 1.404
Number Observations: 3
Standard Deviation DZ: 0.764
RMSE Z: 0.626
95th Percentile: 0.803
Units: Feet

Histogram



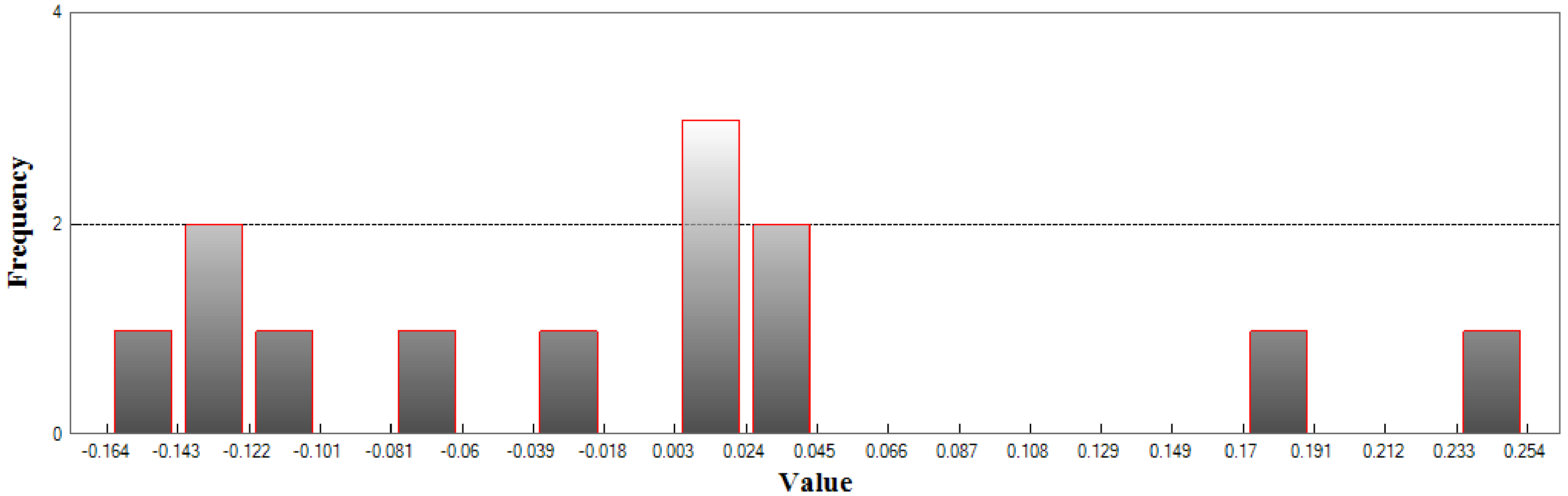
Min: -0.164
Max: 0.255
Number Of Bins: 20
Bin Interval: 0.021

LAS (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.538
Maximum DZ: 0.836
Mean DZ: -0.026
Mean Magnitude DZ: 0.987
Number Observations: 13
Standard Deviation DZ: 0.400
RMSE Z: 0.383
95th Percentile: 0.675
Units: Feet

Histogram



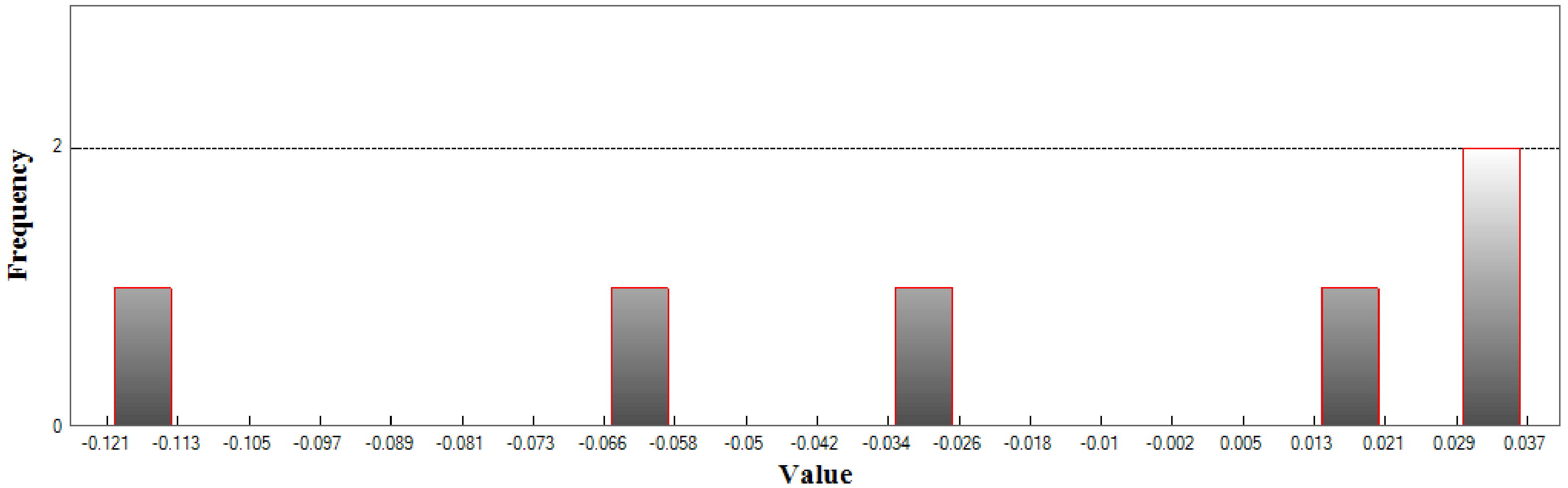
Min: -0.164
Max: 0.255
Number Of Bins: 20
Bin Interval: 0.021

DEM

Fundamental Vertical Accuracy

LandCover Type: FVA
Minimum DZ: -0.396
Maximum DZ: 0.121
Mean DZ: -0.204
Mean Magnitude DZ: 0.731
Number Observations: 6
Standard Deviation DZ: 0.206
RMSE Z: 0.196
95% Confidence Level Z: 0.387
Units: Feet

Histogram



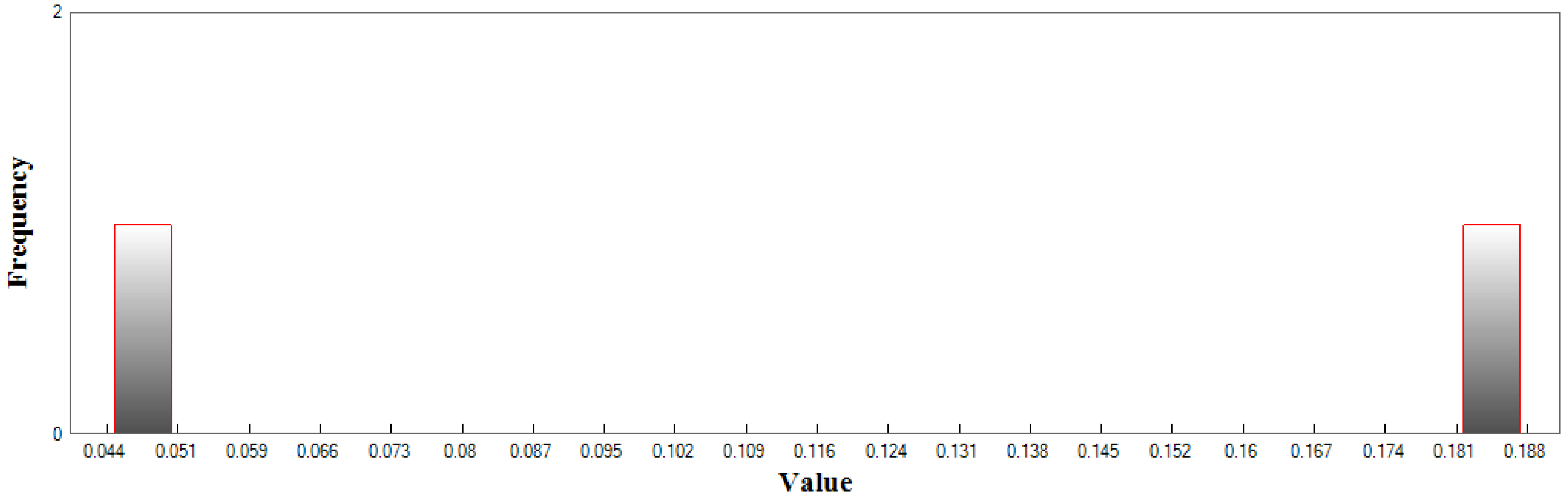
Min: -0.121
Max: 0.037
Number Of Bins: 20
Bin Interval: 0.008

DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Tallweeds
Minimum DZ: 0.144
Maximum DZ: 0.616
Mean DZ: 0.380
Mean Magnitude DZ: 1.115
Number Observations: 2
Standard Deviation DZ: 0.334
RMSE Z: 0.449
95th Percentile: 0.593
Units: Feet

Histogram



Min: 0.044
Max: 0.188
Number Of Bins: 20
Bin Interval: 0.007

DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Brushland

Minimum DZ: -0.429

Maximum DZ: 0.009

Mean DZ: -0.209

Mean Magnitude DZ: 0.849

Number Observations: 2

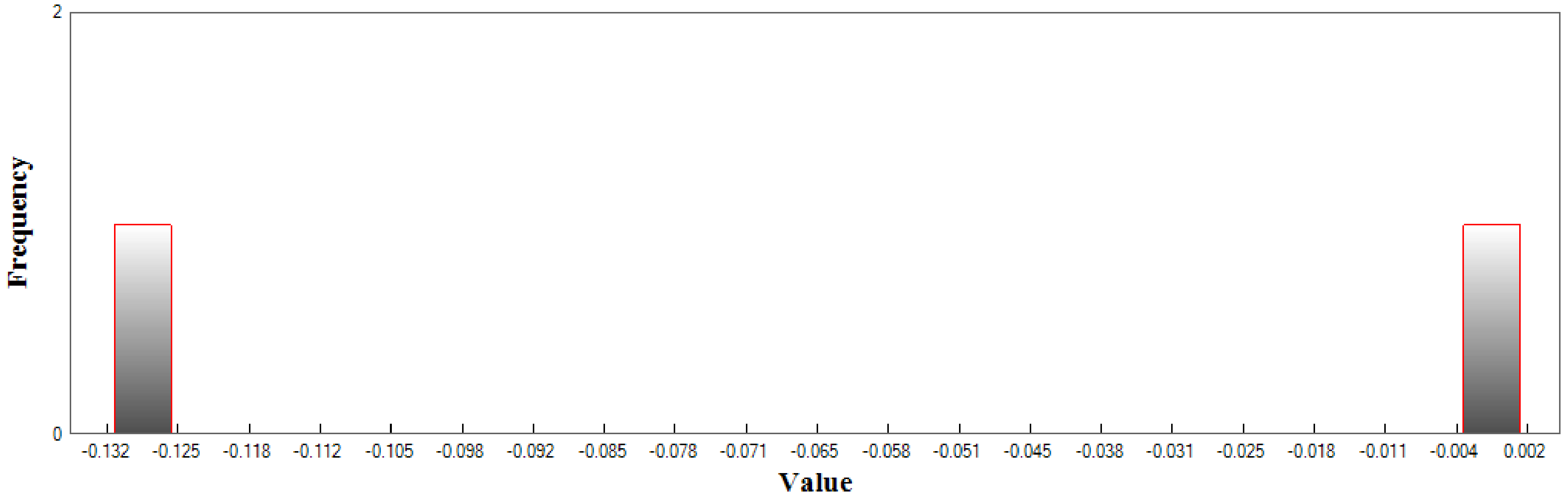
Standard Deviation DZ: 0.311

RMSE Z: 0.305

95th Percentile: 0.410

Units: Feet

Histogram



Min: -0.131

Max: 0.003

Number Of Bins: 20

Bin Interval: 0.007

DEM (Continued)

Supplemental Vertical Accuracy

LandCover Type: Forested

Minimum DZ: -0.511

Maximum DZ: 0.836

Mean DZ: -0.029

Mean Magnitude DZ: 1.387

Number Observations: 3

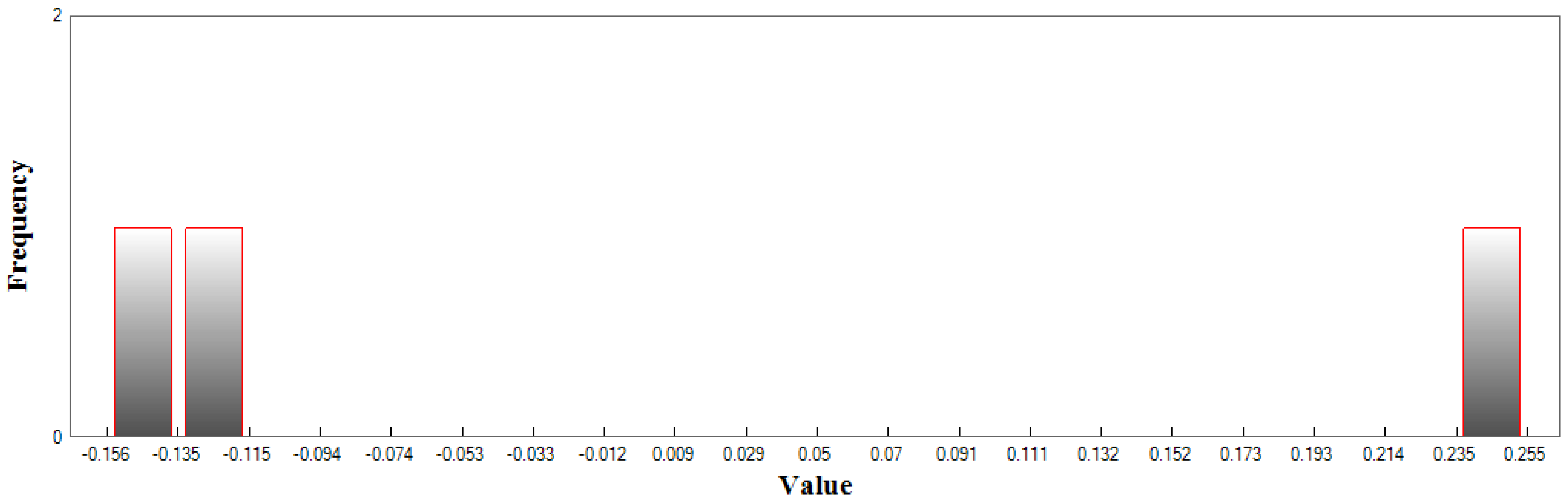
Standard Deviation DZ: 0.751

RMSE Z: 0.613

95th Percentile: 0.803

Units: Feet

Histogram



Min: -0.156

Max: 0.255

Number Of Bins: 20

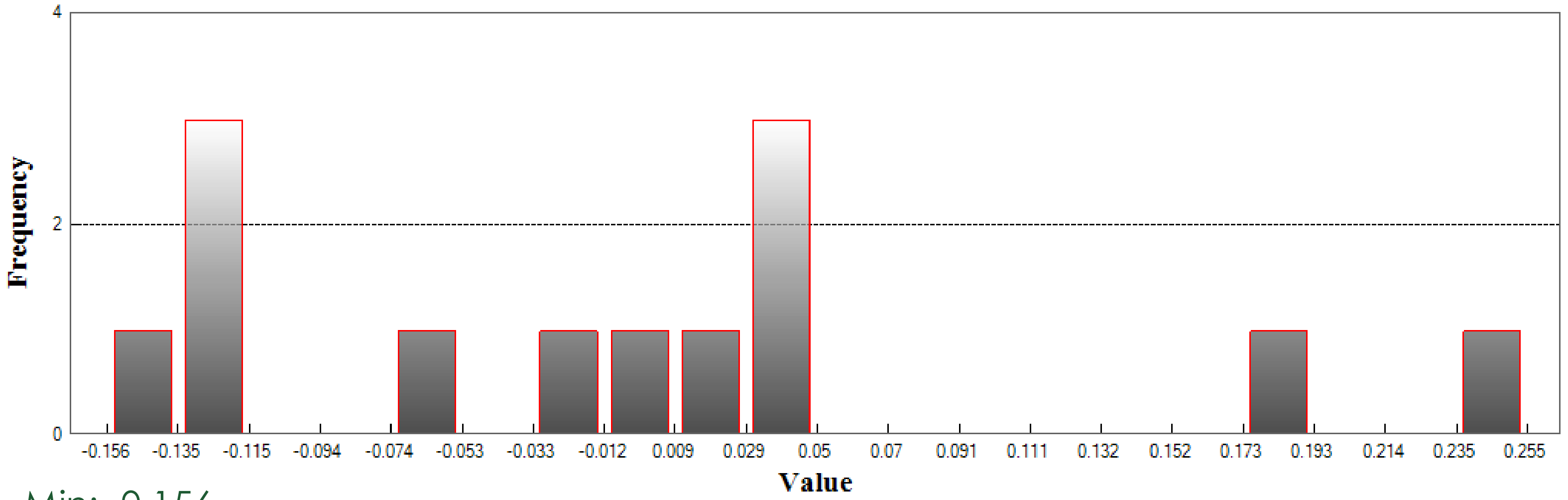
Bin Interval: 0.021

DEM (Continued)

Consolidated Vertical Accuracy

LandCover Type: ALL
Minimum DZ: -0.511
Maximum DZ: 0.836
Mean DZ: -0.009
Mean Magnitude DZ: 0.997
Number Observations: 13
Standard Deviation DZ: 0.403
RMSE Z: 0.387
95th Percentile: 0.705
Units: Feet

Histogram



Min: -0.156
Max: 0.255
Number Of Bins: 20
Bin Interval: 0.021