LiDAR Project Report Jean Lafitte & Barataria, Louisiana

Prepared For:

United States Geological Survey

Prepared By:

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CONTRACT: #G10PC00093

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TASK ORDER: #G13PD00214

Project Report
LiDAR Collection, Processing, and QA/QC

Jean Lafitte & Barataria LiDAR
Task Order: G13PD00214

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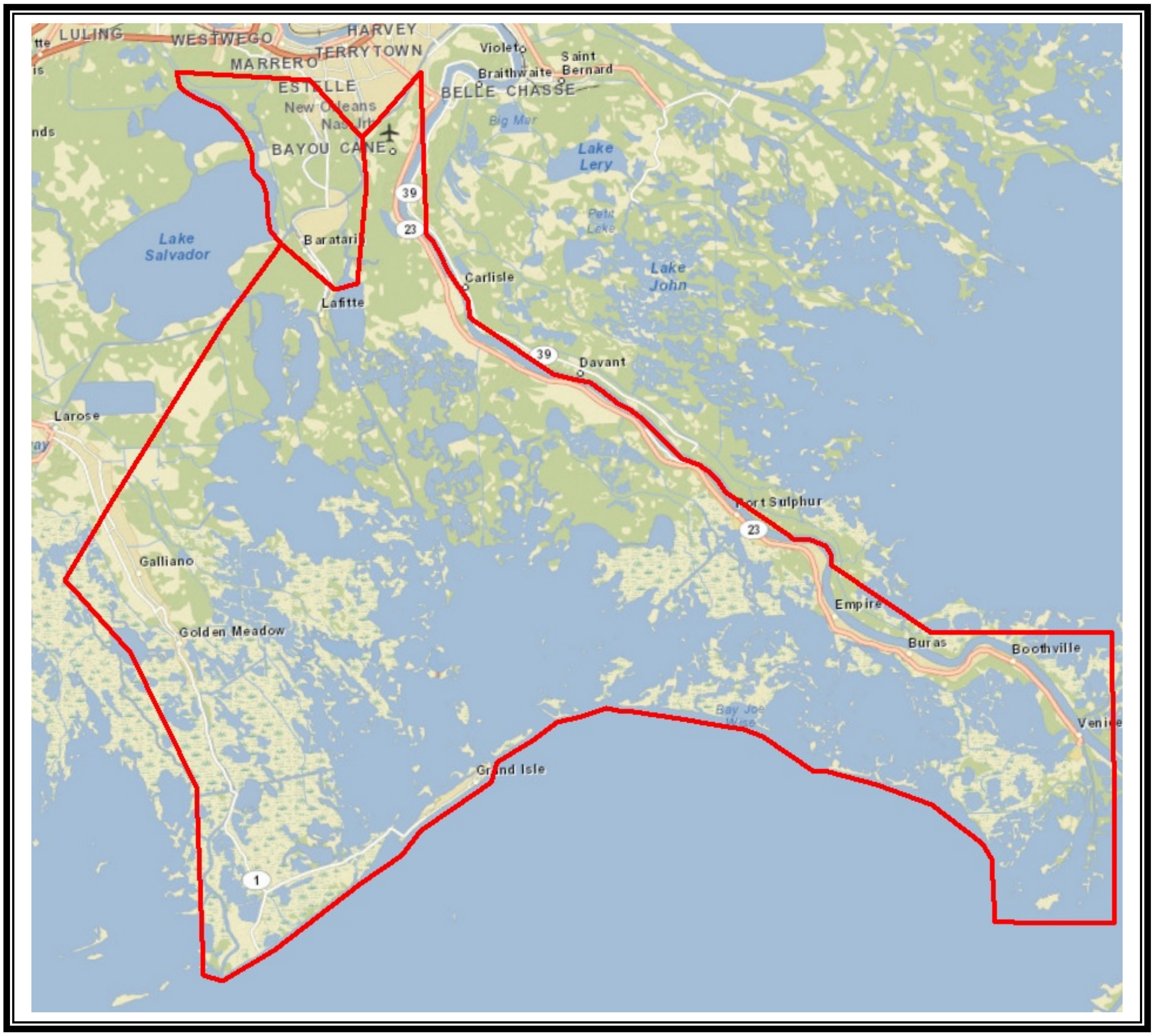
LULING
WESTWEGO
HARVEY
MARRERO
TERRYTOWN
ESTELLE
New Orleans
BAYOU CANE
Violet
Saint Bernard
Braithwaite
BELLE CHASSE
Big Mar
Lake Lery
Lake Salvador
Barataria
Lafitte
Carlisle
Lake John
Davant
Larose
Port Sulphur
Galliano
Golden Meadow
Empire
Buras
Boothville
Grand Isle
Bay Joe Wise

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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 Jean Lafitte and Barataria area located in South of New Orleans, Louisiana. The Jean Lafitte LiDAR survey encompasses 77 square miles and Barataria LiDAR survey encompasses approximately 1408 square miles. Aerial LiDAR data was collected utilizing an ALS60 Sensor. The ALS60 is a discrete return topographic LiDAR mapping system manufactured by Leica Geosystems. LiDAR data collected for the Jean Lafitte survey area has a nominal pulse spacing of 1m and Barataria has a nominal pulse spacing of 2 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 1500 meter x 1500 meter grid aligned and named according the US National Grid conventions. 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: UTM Zone 15 Meters

Vertical Spatial Reference

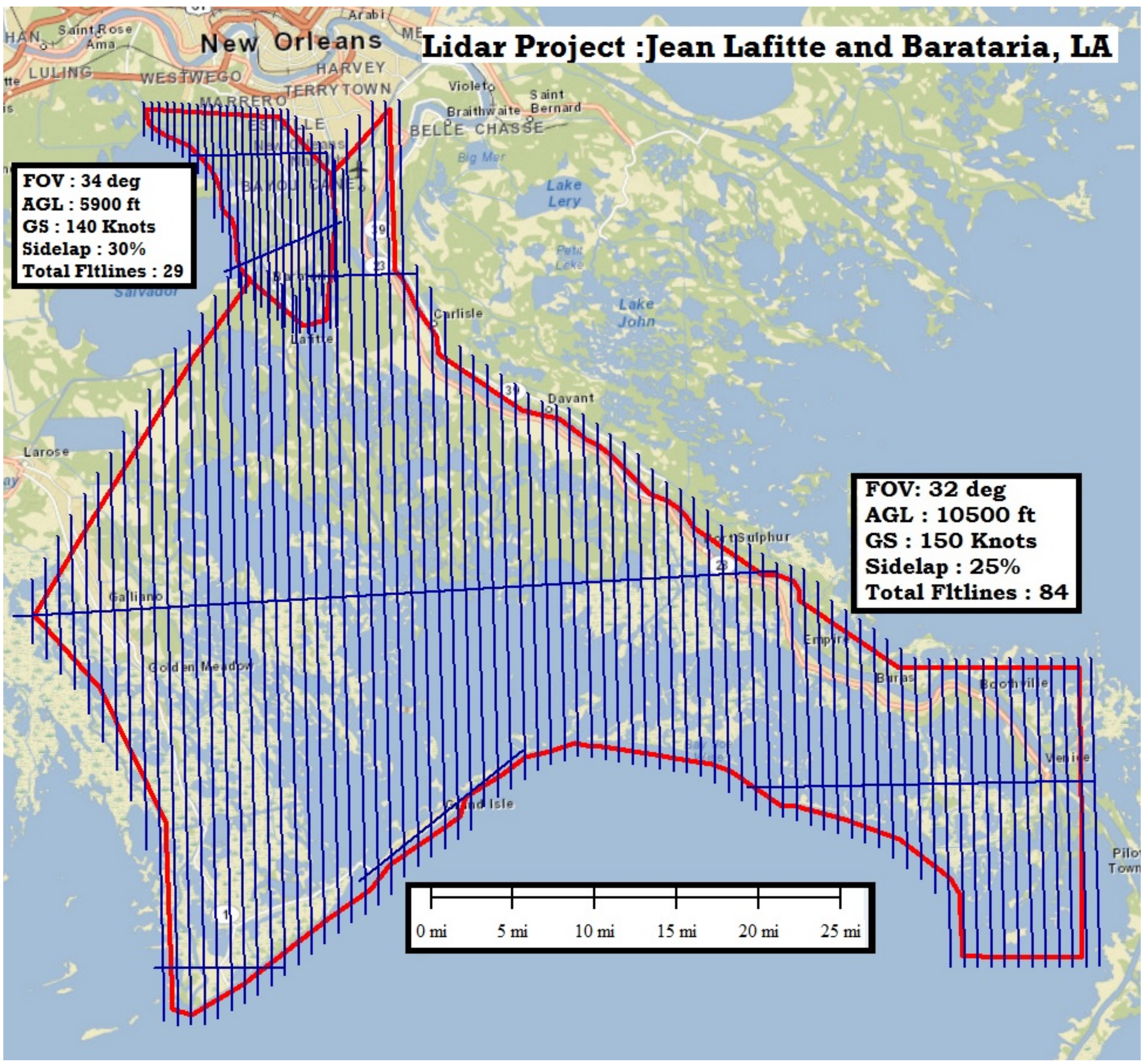
All datasets are available with orthometric elevation; point cloud datasets are also available with ellipsoid heights

- Datum: North American Vertical Datum of 1988 (GEOID09)

3 LiDAR Acquisition

3.1 Survey Area

The Jean Lafitte survey covers 77 square miles and Barataria survey covers approximately 1408 square miles.Both survey areas located in South of New Orleans, Louisiana. The LiDAR survey flight plan for Jean Lafitte consists of 27 flight lines and 2 control flight lines. The Barataria flight plan consisted of 79 survey flight lines and 5 control flight 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 Jean Lafitte and Barataria LiDAR projects are summarized below.

Parameter	Value
Flying Height Above Ground Level	5,900 ft.
Nominal Sidelap	30%
Nominal Speed Over Ground	140 knots
Field of View	34°
Laser Rate	127.5 kHz
Scan Rate	51.8 hz
Maximum Cross Track Spacing	1.3 meters
Maximum Along Track Spacing	1.3 meters
Average Spacing	0.79 meters

Parameter	Value
Flying Height Above Ground Level	10,500 ft.
Nominal Sidelap	25%
Nominal Speed Over Ground	150 knots
Field of View	32°
Laser Rate	90 kHz
Scan Rate	32.8 hz
Maximum Cross Track Spacing	2.0 meters
Maximum Along Track Spacing	2.0 meters
Average Spacing	1.34 meters

3.3 Acquisition Mission

The acquisition mission for the Jean Lafitte and Barataria LiDAR survey was coordinated to be acquired in 1 week. Collection began on March 5th 2013 and was completed on March 8th, 2013. A complete flightlog 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 Jean Lafitte and Barataria 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 Jean Lafitte and Barataria LiDAR projects 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 Barataria 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 Barataria 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 Jean Lafitte and Barataria LiDAR projects, 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 1500 meter x 1500 meter US National Grid LAS format 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 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, triangulated irregular network (TIN) surface models built from the classified point clouds, Lidar Intensity images and Ortho images of the project area provided by the client 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 Barataria 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 GeoTIFF.

5 Quality Control

5.1 Point Clouds

Accuracy and completeness of the LiDAR point clouds directly impacts the quality of all other 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 40km. For Jean Lafitte and Barataria LiDAR projects, 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 jean Lafitte and Barataria 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 Jean Lafitte and Barataria surveys, 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 swath FVA of the calibrated LAS TIN tested RMSEz 0.062 meters and 0.122 meters at the 95% confidence level in open terrain. Bare earth FVA of the DEM tested at an RMSEz of 0.055 meters and 0.109 meters at the 95% confidence level in open terrain. The full calculations for all check points can be found in Appendix B.

Swath FVA of TIN

$RMSE_Z$ =	0.062	meters
NSSDA=	0.122	meters

Bare Earth FVA of DEM

$RMSE_Z$ =	0.055	meters
NSSDA=	0.109	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 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

DAS Digital Aerial Solutions

ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60	N6130_090724		Sensor Operator/s
				-	Bertin Evina-Ze
Date/Julian:	3/5/2013 Jean Lafitte	Mem Drive MM60	Int. Time: TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	700.3	1-600049630	140		MWAZ
Hobbs ST	696.3	LIFT A	TAR ALT AGL (ft):	Flight Plan(s): Base Height:	Aircraft / Airport Idnt:
Flight Time	4.0		5,900	New Orleans 1.500	421C 112MJ / KGAO

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:
						-	-	-	148				Static Alignment
		1	130306_031219	3:12	3:13	5,890	0	124	148	17	1.2	0.6	CLEAR
		2	130306_031646	3:16	3:17	5,890	180	145	148	16	1.2	0.6	CLEAR
		3	130306_032213	3:22	3:23	5,890	0	126	147	16	1.2	0.6	CLEAR
		4	130306_032611	3:26	3:27	5,890	180	145	147	17	1.1	0.7	CLEAR
		5	130306_033046	3:30	3:32	5,890	0	125	147	16	1.1	0.7	CLEAR
		6	130306_033456	3:34	3:36	5,890	180	136	147	16	1.2	0.7	CLEAR
		7	130306_033937	3:39	3:41	5,890	0	125	146	16	1.2	0.7	CLEAR
		8	130306_034418	3:44	3:45	5,890	180	142	146	16	1.2	0.7	CLEAR
		9	130306_034901	3:49	3:51	5,890	0	126	146	15	1.2	0.7	CLEAR
		10	130306_035801	3:58	4:00	5,890	180	143	145	15	1.2	0.7	CLEAR
		11	130306_040358	4:03	4:07	5,890	0	128	144	15	1.5	0.8	CLEAR
		12	130306_041019	4:10	4:14	5,890	180	142	143	15	1.3	0.7	CLEAR
		13	130306_041754	4:17	4:22	5,890	0	125	142	15	1.3	0.7	CLEAR
		14	130306_042553	4:25	4:30	5,890	180	141	141	16	1.1	0.7	CLEAR
		15	130306_043335	4:33	4:38	5,890	0	126	140	16	1.2	0.7	CLEAR
		16	130306_044134	4:41	4:46	5,890	180	138	139	15	1.4	0.8	CLEAR
		17	130306_045030	4:50	4:55	5,890	0	127	137	15	1.5	0.8	CLEAR
		18	130306_045901	4:59	5:03	5,890	180	138	136	14	1.7	0.9	CLEAR
		19	130306_050818	5:08	5:14	5,890	0	126	135	15	1.6	0.8	CLEAR
		20	130306_051655	5:16	5:22	5,890	180	139	134	16	1.1	0.7	CLEAR
		21	130306_052532	5:25	5:31	5,890	0	128	132	16	1.3	0.7	CLEAR
		22	130306_053407	5:34	5:38	5,890	180	137	131	16	1.2	0.7	CLEAR
		23	130306_054230	5:42	5:47	5,890	0	128	130	16	1.3	0.7	CLEAR
		24	130306_055044	5:50	5:55	5,890	180	143	129	16	1.3	0.7	CLEAR
		25	130306_055839	5:58	6:03	5,890	0	127	128	17	1.2	0.6	CLEAR
		26	130306_060559	6:05	6:09	5,890	180	138	127	17	1.2	0.6	CLEAR
		27	130306_061320	6:13	6:15	5,890	0	128	126	18	1.1	0.6	CLEAR
		28	130306_062037	6:20	6:23	5,890	269.8	133	125	19	1.0	0.6	X-STRIP
		28	130306_062810	6:28	6:31	5,890	89.8	137	125	19	1.0	0.6	X-STRIP
		29	130306_063419	6:34	6:37	5,890	248.3	142	124	20	1.0	0.6	X-STRIP
		29	130306_064018	6:40	6:43	5,890	68.3	126	124	20	1.0	0.6	X-STRIP

ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60 N6130_090724		Sensor Operator/s: Bertin Evina-Ze
Date/Julian:	3/6/2013 Barataria	Mem Drive MM60: 1-600049630	Int. Time:	TAR AIRSPD (KNTS): 150
Hobbs End	704.3	LIFT A		Base PID: -
Hobbs ST	700.3		TAR ALT AGL (ft): 10,500	Pilot/s: MWAZ
Flight Time	4.0	Flight Plan(s): New Orleans	Base Height: 1.500	Aircraft: 421C 112MJ; Airport Idnt: KGAO

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:
					-	-	-	123				Static Alignment
	1	130306_080402	8:04	8:05	10,400	0	140	123	17	1.2	0.6	CLEAR
	2	130306_080929	8:09	8:11	10,400	180	148	122	17	1.3	0.6	CLEAR
	3	130306_081537	8:15	8:18	10,400	0	140	122	17	1.4	0.6	CLEAR
	4	130306_082213	8:22	8:26	10,400	180	142	121	17	1.4	0.6	CLEAR
	5	130306_082933	8:29	8:34	10,400	0	142	120	18	1.4	0.6	CLEAR
	6	130306_083805	8:38	8:44	10,400	180	143	120	18	1.2	0.6	CLEAR
	7	130306_084759	8:47	8:55	10,400	0	144	119	18	1.4	0.6	CLEAR
	8	130306_085843	8:58	9:06	10,400	180	146	117	18	1.4	0.6	CLEAR
	9	130306_091103	9:11	9:20	10,400	0	145	116	18	1.3	0.6	CLEAR
	10	130306_092439	9:24	9:38	10,400	180	149	114	18	1.2	0.6	CLEAR
	11	130306_094247	9:42	9:47	10,400	0	141	111	16	1.3	0.6	CLEAR
	12	130306_100028	10:00	10:15	10,400	180	154	109	17	1.2	0.6	CLEAR
	13	130306_101916	10:19	10:34	10,400	0	141	107	18	1.1	0.6	CLEAR
	14	130306_103906	10:39	10:54	10,400	180	152	104	16	1.2	0.6	CLEAR
	83	130306_110120	11:01	11:04	10,400	270	127	104	17	1.1	0.6	X-STRIP
	83	130306_110902	11:09	11:11	10,400	90	134	104	17	1.1	0.6	X-STRIP
	81	130306_112223	11:22	11:29	10,400	270	122	102	17	1.0	0.6	X-STRIP
	81	130306_113400	11:34	11:39	10,400	90	151	102	16	1.1	0.6	X-STRIP

ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60 N6130_090724		Sensor Operator/s: Bertin Evina-Ze
Date/Julian:	3/7/2013 Barataria	Mem Drive MM60: 4-600106558	Int. Time:	TAR AIRSPD (KNTS): 150
Hobbs End	708.9	LIFT A		Base PID: -
Hobbs ST	704.3		TAR ALT AGL (ft): 10,500	Pilot/s: MWAZ
Flight Time	4.6	Flight Plan(s): New Orleans	Base Height: 1.500	Aircraft: 421C 112MJ; Airport Idnt: KGAO

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:
					-	-	-	148				Static Alignment
	15	130307_054653	5:46	6:02	10,388	0	144	145	16	1.3	0.7	CLEAR
	16	130307_060617	6:06	6:21	10,388	180	154	143	18	1.1	0.6	CLEAR
	17	130307_062513	6:25	6:41	10,388	0	145	141	20	1	0.6	CLEAR
	18	130307_064423	6:44	6:59	10,388	180	151	138	18	1.1	0.6	CLEAR
	19	130307_070253	7:02	7:18	10,388	0	145	136	19	1.1	0.6	CLEAR
	20	130307_072152	7:21	7:30	10,388	180	154	134	18	1.2	0.7	CLEAR
	21	130307_073955	7:39	7:53	10,388	0	149	132	18	1.5	0.6	CLEAR
	22	130307_075738	7:57	8:11	10,388	180	152	130	18	1.2	0.7	CLEAR
	23	130307_081503	8:15	8:31	10,388	0	150	127	17	1.4	0.6	CLEAR
	24	130307_083531	8:35	8:51	10,388	180	153	125	19	1.2	0.5	CLEAR
	83	130307_085420	8:54	8:57	10,388	270	132	124	18	1.4	0.6	X-STRIP
	83	130307_090039	9:00	9:03	10,388	90	142	124	18	1.4	0.6	X-STRIP
	81	130307_091253	9:12	9:17	10,388	270	136	123	18	1.3	0.6	X-STRIP
	81	130307_092139	9:21	9:29	10,388	90	154	122	18	1.2	0.6	X-STRIP
	82	130307_093717	9:37	9:39	10,388	270	144	121	16	1.3	0.6	X-STRIP
	82	130307_094258	9:42	9:44	10,388	90	148	121	17	1.2	0.6	X-STRIP

ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60	N6130_090724
Date/Julian:	3/7/2013 Barataria	Sensor Operator/s	Bertin Evina-Ze
Hobbs End	713.7	Mem Drive MM60	4-600106558
Hobbs ST	708.9		LIFT B
Flight Time	4.8	Int. Time:	
TAR AIRSPD (KNTS)	150	TAR ALT AGL (ft):	10,500
Flight Plan(s):	New Orleans	Base PID:	
Base Height:	1.500	Pilot/s	MWAZ
Aircraft	421C 112MJ	Airport Idnt:	KGAO

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:
						-	-	-	121				Static Alignment
		25	130307_111042	11:10	11:27	10,327	0	155	118	17	1	0.7	CLEAR
		26	130307_113220	11:32	11:49	10,327	180	147	116	16	1.1	0.7	CLEAR
		27	130307_115328	11:53	12:10	10,327	0	149	113	15	1.4	0.7	CLEAR
		28	130307_121445	12:14	12:31	10,327	180	148	110	16	1.1	0.7	CLEAR
		29	130307_123517	12:35	12:51	10,327	0	150	108	15	1.4	0.7	CLEAR
		30	130307_125730	12:57	13:10	10,327	180	149	106	15	1.3	0.7	CLEAR
		31	130307_131400	13:14	13:26	10,327	0	145	104	15	1.2	0.7	CLEAR
		32	130307_133017	13:30	13:41	10,327	180	152	103	15	1.3	0.7	CLEAR
		33	130307_134525	13:45	13:55	10,327	0	148	101	15	1.2	0.7	CLEAR
		34	130307_135942	13:59	14:09	10,327	180	154	100	15	1.3	0.7	CLEAR
		35	130307_141327	14:13	14:23	10,327	0	148	98	17	1.1	0.6	CLEAR
		36	130307_142635	14:26	14:37	10,327	180	150	97	16	1.1	0.7	CLEAR
		37	130307_143920	14:39	14:48	10,327	0	148	96	16	1.1	0.7	CLEAR
		82	130307_145211	14:52	14:54	10,327	270	148	95	18	1.2	0.6	X-STRIP
		82	130307_145841	14:58	15:01	10,327	90	148	95	18	1.2	0.6	X-STRIP
		81	130307_150956	15:09	15:16	10,327	270	145	94	19	1.1	0.6	X-STRIP
		81	130307_151923	15:19	15:25	10,327	90	150	93	19	1.1	0.6	X-STRIP
		84	130307_153028	15:30	15:35	10,327	232.9	149	92	18	1.2	0.6	X-STRIP

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ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60	N6130_090724
Date/Julian:	3/8/2013 Barataria	Sensor Operator/s	Meagan McCall
Hobbs End	718.1	Mem Drive MM60	3-600093051
Hobbs ST	713.7		LIFT A
Flight Time	4.4	Int. Time:	
TAR AIRSPD (KNTS)	150	TAR ALT AGL (ft):	10,500
Flight Plan(s):	New Orleans	Base PID:	
Base Height:	1.500	Pilot/s	Janssen
Aircraft	421C 112MJ	Airport Idnt:	KGAO

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:
						-	-	-	149				Static Alignment
		79	130308_064330	6:43	6:50	10,366	0	150	148	18	1.1	0.6	CLEAR
		78	130308_065336	6:53	7:00	10,366	180	150	146	19	1.1	0.6	CLEAR
		76	130308_072847	7:28	7:35	10,366	180	157	144	19	1.1	0.6	CLEAR
		77	130308_073855	7:38	7:46	10,366	0	136	143	17	1.2	0.6	CLEAR
		75	130308_080017	8:00	8:07	10,366	0	135	142	17	1.3	0.6	CLEAR
		74	130308_081044	8:10	8:17	10,366	180	150	141	17	1.4	0.6	CLEAR
		73	130308_082113	8:21	8:28	10,366	0	142	140	18	1.2	0.6	CLEAR
		72	130308_083130	8:31	8:38	10,366	180	150	139	19	1.2	0.5	CLEAR
		71	130308_084130	8:41	8:48	10,366	0	143	138	18	1.4	0.6	CLEAR
		70	130308_085148	8:51	8:58	10,366	180	153	137	18	1.4	0.6	CLEAR
		69	130308_090208	9:02	9:09	10,366	0	141	136	18	1.3	0.6	CLEAR
		68	130308_091220	9:12	9:19	10,366	180	144	135	17	1.3	0.6	CLEAR
		67	130308_092155	9:21	9:27	10,366	0	144	134	18	1.1	0.6	CLEAR
		66	130308_093036	9:30	9:35	10,366	180	154	133	16	1.3	0.6	CLEAR
		65	130308_093835	9:38	9:43	10,366	0	146	132	17	1.2	0.6	CLEAR
		64	130308_094625	9:46	9:51	10,366	180	149	132	18	1.3	0.7	CLEAR
		80	130308_095757	9:57	10:09	10,366	90	136	131	17	1.3	0.7	X-STRIP
		80	130308_101041	10:10	10:16	10,366	270	144	130	17	1.2	0.7	X-STRIP

ALS60 LiDAR Flight Log

Project		ALS60	N6130_090724		Sensor Operator/s
				-	Meagan McCall
Date/Julian:	3/8/2013 Barataria	Mem Drive MM60	Int. Time: TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	722.3	3-600093051	150		MWAZ
Hobbs ST	718.1	LIFT B	TAR ALT AGL (ft):	Flight Plan(s): / Base Height:	Aircraft / Airport Idnt:
Flight Time	4.2		10,500	New Orleans / 1.500	421C 112MJ / KGAO

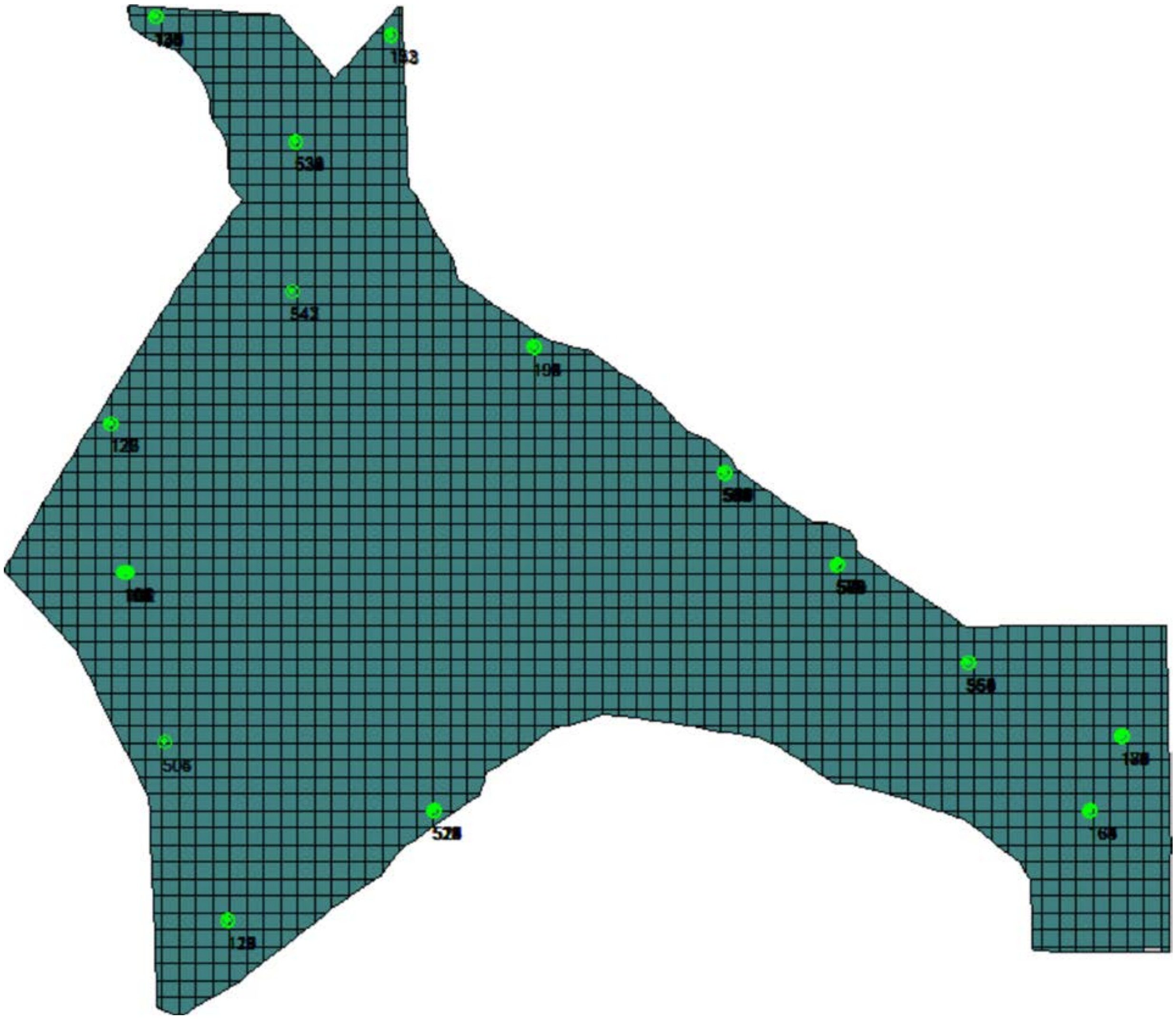
Lift		Flight Line	Mission Line	UTC time: B:	UTC time: E:	GPS Altitude: ASL:	Direction	Speed: kts:	Memory	S/Vs:	Position Acc. PDOP	Position Acc. HDOP	Comments and Conditions:
						-	-	-	130				Static Alignment
		63	130308_115616	11:56	12:01	10,352	0	142	129	15	1.4	0.7	CLEAR
		62	130308_120502	12:05	12:10	10,352	180	147	128	15	1.4	0.7	CLEAR
		61	130308_121350	12:13	12:18	10,352	0	144	127	15	1.2	0.7	CLEAR
		60	130308_122215	12:22	12:27	10,352	180	153	127	16	1.1	0.6	CLEAR
		59	130308_123057	12:30	12:36	10,352	0	146	126	16	1.2	0.7	CLEAR
		58	130308_124021	12:40	12:47	10,352	180	147	125	15	1.3	0.7	CLEAR
		57	130308_125004	12:50	12:55	10,352	0	150	124	15	1.3	0.7	CLEAR
		56	130308_125922	12:59	13:04	10,352	180	141	123	15	1.2	0.7	CLEAR
		55	130308_130903	13:09	13:14	10,352	0	148	122	16	1.1	0.7	CLEAR
		54	130308_131806	13:18	13:24	10,352	180	151	121	15	1.2	0.7	CLEAR
		53	130308_132805	13:28	13:34	10,352	0	143	121	15	1.3	0.7	CLEAR
		52	130308_133755	13:37	13:43	10,352	180	151	120	15	1.3	0.7	CLEAR
		51	130308_134754	13:47	13:54	10,352	0	150	119	15	1.3	0.7	CLEAR
		50	130308_135726	13:57	14:03	10,352	180	149	118	15	1.3	0.7	CLEAR
		49	130308_140714	14:07	14:14	10,352	0	148	117	17	1.1	0.6	CLEAR
		48	130308_141635	14:16	14:23	10,352	180	150	116	16	1.1	0.7	CLEAR
		47	130308_142642	14:26	14:33	10,352	0	146	115	17	1.1	0.6	CLEAR
		46	130308_143705	14:37	14:43	10,352	180	153	114	17	1.2	0.6	CLEAR
		45	130308_144728	14:47	14:54	10,352	0	150	113	18	1.2	0.6	CLEAR
		81	130308_145914	14:59	15:03	10,352	90	147	112	19	1.1	0.6	X-STRIP
		81	130308_150710	15:07	15:11	10,352	270	146	112	19	1.1	0.6	X-STRIP
		80	130308_151750	15:17	15:21	10,352	90	151	111	19	1.1	0.6	X-STRIP
		80	130308_152458	15:24	15:30	10,352	270	140	110	19	1.1	0.6	X-STRIP

ALS60 LiDAR Flight Log

Project	Barataria and Jean Lafitte lidar 2013	ALS60	N6130_090724		Sensor Operator/s
				-	Meagan McCall
Date/Julian:	3/8/2013 Barataria	Mem Drive MM60	Int. Time: TAR AIRSPD (KNTS)	Base PID:	Pilot/s
Hobbs End	724.2	3-600093051	150		MWAZ
Hobbs ST	722.3	LIFT C	TAR ALT AGL (ft):	Flight Plan(s): / Base Height:	Aircraft / Airport Idnt:
Flight Time	1.9		10,500	New Orleans / 1.500	421C 112MJ / KGAO

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:
						-	-	-	110				Static Alignment
		44	130308_163637	16:36	16:43	10,347	180	147	109	19	1.2	0.6	CLEAR
		43	130308_164750	16:47	16:55	10,347	0	144	108	18	1.2	0.6	CLEAR
		42	130308_165828	16:58	17:06	10,347	180	148	107	18	1.2	0.6	CLEAR
		41	130308_170909	17:09	17:16	10,347	0	153	106	18	1.2	0.7	CLEAR
		40	130308_171953	17:19	17:27	10,347	180	151	105	18	1.1	0.6	CLEAR
		39	130308_173103	17:31	17:38	10,347	0	150	103	19	1	0.6	CLEAR
		38	130308_174154	17:41	17:50	10,347	180	146	102	18	1.2	0.6	CLEAR
		81	130308_175625	17:56	18:00	10,347	90	144	102	19	1.2	0.6	X-STRIP
		81	130308_180320	18:03	18:07	10,347	270	148	101	19	1.1	0.6	X-STRIP

Appendix B. Vertical Accuracy Calculations



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LiDAR Accuracy Assessment Summary

LC Type	# of Points	FVA	SVA	CVA
LAS				
ALL	110			0.203
FVA	61	0.122		
Forested	6		0.121	
URBAN	9		0.146	
Tall weeds	22		0.208	
Brush land	12		0.210	
Total	110			
DEM				
ALL	110			0.173
FVA	61	0.109		
Forested	6		0.109	
URBAN	9		0.119	
Tall weeds	22		0.207	
Brush land	12		0.214	
Total	110			

Units: Meters

topo analyst™
http://www.spatialis.com

PID	Survey X	Survey Y	Survey Z	Z DEM	Z LAS	ΔZ DEM	ΔZ LAS	LC Type
102	765453.788	3259163.479	0.254	0.276	0.316	0.022	0.062	FVA
103	765333.965	3259158.843	-0.056	-0.054	-0.058	0.001	-0.002	FVA
104	765233.832	3259155.151	0.151	0.178	0.162	0.027	0.011	FVA
105	765220.557	3259123.715	0.267	0.285	0.294	0.018	0.026	FVA
106	765218.659	3259154.330	0.266	0.298	0.302	0.032	0.036	FVA
107	765216.943	3259184.870	0.065	0.081	0.085	0.016	0.019	FVA
108	765233.065	3259172.763	-0.501	-0.387	-0.382	0.114	0.119	Forested
109	765037.431	3259158.767	0.373	0.392	0.419	0.020	0.046	FVA
110	765076.190	3259160.359	0.324	0.199	0.168	-0.125	-0.157	FVA
116	774308.721	3228253.191	0.926	1.055	1.052	0.129	0.126	FVA
117	774316.302	3228281.342	0.846	0.892	0.898	0.045	0.052	FVA
118	774328.170	3228322.360	1.066	1.170	1.195	0.104	0.129	FVA
119	774345.804	3228318.686	1.291	1.269	1.280	-0.022	-0.012	URBAN
120	774333.891	3228275.498	1.329	1.324	1.330	-0.005	0.001	URBAN
121	774326.242	3228248.512	1.296	1.294	1.292	-0.002	-0.004	URBAN
126	764013.358	3272351.617	0.296	0.216	0.223	-0.079	-0.072	FVA
127	763972.337	3272355.298	0.374	0.327	0.307	-0.047	-0.067	FVA
128	763918.203	3272360.385	0.691	0.628	0.611	-0.063	-0.080	FVA
130	763939.211	3272340.155	0.390	0.557	0.504	0.167	0.115	Tall weeds
135	767818.706	3308367.342	-0.813	-0.819	-0.816	-0.006	-0.003	FVA
136	767849.863	3308415.895	-0.900	-0.901	-0.903	-0.001	-0.003	FVA
137	767884.376	3308470.043	-1.110	-1.121	-1.112	-0.011	-0.003	FVA
138	767942.539	3308442.878	-1.763	-1.673	-1.674	0.090	0.089	FVA
139	767920.528	3308416.905	-1.775	-1.743	-1.749	0.032	0.026	FVA
140	767871.453	3308355.140	-1.180	-1.183	-1.184	-0.003	-0.004	FVA
141	767881.755	3308348.985	-1.206	-1.194	-1.206	0.012	0.000	FVA
142	767872.299	3308341.228	-1.185	-1.167	-1.177	0.018	0.008	FVA
143	767864.661	3308365.233	-1.253	-1.228	-1.214	0.026	0.039	FVA
144	767888.469	3308401.167	-1.085	-1.091	-1.091	-0.006	-0.006	FVA
148	788792.435	3306746.948	-1.726	-1.761	-1.763	-0.034	-0.037	FVA
152	788719.087	3306853.362	-1.600	-1.718	-1.739	-0.118	-0.138	FVA
153	788712.777	3306842.645	-1.647	-1.686	-1.711	-0.039	-0.064	FVA
163	850649.589	3237999.620	0.725	0.672	0.686	-0.054	-0.040	FVA
164	850679.157	3238042.986	0.616	0.606	0.611	-0.010	-0.005	FVA
165	850703.123	3238077.343	0.650	0.658	0.661	0.008	0.011	FVA
166	850686.516	3238076.992	0.446	0.469	0.497	0.023	0.052	FVA
168	850649.090	3238022.541	0.753	0.759	0.749	0.006	-0.003	FVA
169	850646.082	3238027.972	0.724	0.750	0.703	0.026	-0.021	Tall weeds
171	850677.497	3238072.678	0.520	0.535	0.566	0.014	0.045	Tall weeds
175	853575.735	3244632.160	-1.650	-1.607	-1.610	0.043	0.040	FVA
176	853564.372	3244646.655	-1.630	-1.593	-1.594	0.037	0.036	FVA
177	853549.870	3244635.407	-1.578	-1.528	-1.486	0.050	0.091	FVA
178	853562.799	3244677.425	-1.568	-1.533	-1.524	0.035	0.044	FVA
179	853535.353	3244653.417	-1.739	-1.723	-1.719	0.016	0.020	FVA
180	853507.054	3244628.961	-1.809	-1.816	-1.816	-0.007	-0.007	FVA
181	853491.170	3244648.661	-1.904	-1.833	-1.813	0.071	0.091	Tall weeds
182	853521.520	3244668.284	-2.033	-1.926	-1.900	0.107	0.133	Tall weeds
183	853542.151	3244686.419	-1.994	-1.824	-1.789	0.170	0.205	Tall weeds

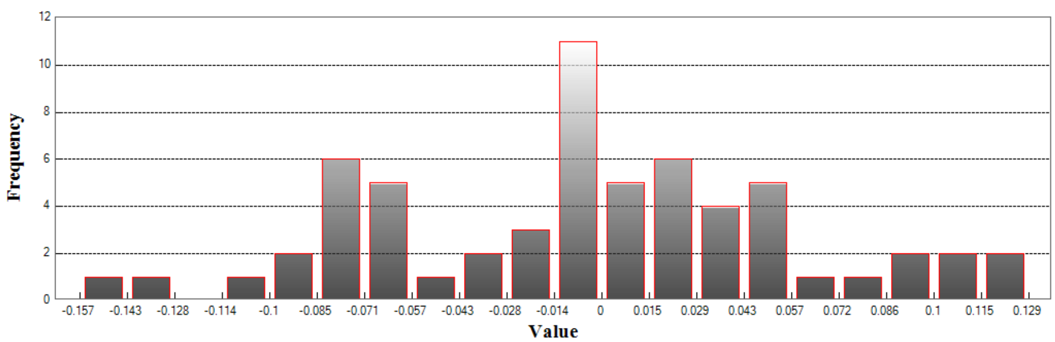
191	801422.630	3279145.757	-0.268	-0.314	-0.361	-0.046	-0.093	FVA
192	801453.299	3279133.330	-0.369	-0.378	-0.453	-0.009	-0.085	FVA
193	801459.128	3279146.062	-0.552	-0.558	-0.574	-0.006	-0.022	Tall weeds
194	801430.302	3279162.135	-0.357	-0.431	-0.481	-0.074	-0.124	Tall weeds
195	801396.118	3279173.842	-0.434	-0.490	-0.487	-0.056	-0.053	Tall weeds
504	768703.946	3244078.618	0.536	0.573	0.558	0.036	0.022	FVA
505	768695.522	3244101.422	0.650	0.671	0.699	0.021	0.048	FVA
506	768715.840	3244104.622	0.371	0.403	0.397	0.032	0.026	FVA
513	792562.278	3238015.656	0.865	0.959	0.968	0.094	0.104	Forested
514	792545.855	3238024.258	0.650	0.723	0.771	0.073	0.121	Forested
515	792566.811	3237998.723	0.796	0.910	0.922	0.114	0.126	Brush land
516	792578.899	3237992.465	0.823	0.944	0.955	0.121	0.132	Brush land
517	792610.155	3237982.437	1.058	0.971	0.988	-0.086	-0.069	FVA
518	792587.985	3238016.550	0.913	0.823	0.839	-0.090	-0.074	FVA
519	792569.052	3238046.042	0.842	0.762	0.772	-0.079	-0.069	FVA
520	792597.827	3238027.742	0.470	0.615	0.591	0.145	0.121	Tall weeds
521	792602.220	3238042.931	0.430	0.606	0.590	0.176	0.161	Tall weeds
522	792602.174	3238056.716	0.666	0.714	0.720	0.047	0.054	URBAN
523	792613.939	3238068.484	0.603	0.635	0.609	0.032	0.006	URBAN
524	792626.589	3238076.915	0.663	0.723	0.732	0.060	0.069	URBAN
529	780348.914	3297323.877	1.117	1.096	1.100	-0.021	-0.017	FVA
530	780349.692	3297355.361	1.088	1.084	1.087	-0.004	-0.001	FVA
531	780350.662	3297393.875	1.089	1.062	1.066	-0.027	-0.022	FVA
532	780332.151	3297372.136	0.121	0.325	0.324	0.204	0.203	Brush land
533	780324.863	3297329.211	0.096	0.319	0.307	0.223	0.211	Brush land
534	780364.393	3297308.016	0.640	0.681	0.664	0.041	0.025	Tall weeds
535	780364.910	3297354.266	0.803	0.866	0.877	0.064	0.074	Tall weeds
536	780366.703	3297396.800	0.769	0.772	0.777	0.003	0.007	Tall weeds
541	780016.604	3284067.804	0.957	1.060	1.071	0.103	0.113	FVA
542	779993.061	3284100.622	1.057	1.125	1.131	0.068	0.074	FVA
543	779964.999	3284140.411	0.947	1.038	1.048	0.091	0.101	FVA
547	780011.910	3284112.358	0.097	0.237	0.209	0.140	0.112	Tall weeds
554	839876.085	3251175.963	-0.051	-0.061	-0.042	-0.010	0.009	FVA
555	839904.569	3251162.290	-0.017	-0.032	-0.036	-0.015	-0.019	FVA
556	839939.120	3251144.737	0.003	0.015	0.008	0.012	0.004	FVA
559	839886.660	3251148.260	-0.259	-0.013	-0.031	0.246	0.228	Tall weeds
560	839873.687	3251151.686	-0.322	-0.171	-0.119	0.150	0.203	Brush land
561	839848.903	3251161.689	-0.298	-0.091	-0.090	0.206	0.208	Brush land
567	828387.830	3259815.959	-0.465	-0.450	-0.473	0.014	-0.008	Brush land
568	828401.305	3259844.406	-0.475	-0.442	-0.428	0.033	0.047	Brush land
569	828416.773	3259855.003	-0.327	-0.164	-0.157	0.163	0.170	Brush land
570	828415.512	3259867.658	-0.377	-0.312	-0.278	0.065	0.099	Forested
571	828410.389	3259889.808	-0.408	-0.439	-0.444	-0.031	-0.036	Forested
572	828393.642	3259919.028	-0.179	-0.247	-0.237	-0.068	-0.058	Forested
573	828392.786	3259898.591	-0.116	-0.169	-0.160	-0.053	-0.044	FVA
574	828358.258	3259889.899	-0.056	-0.154	-0.164	-0.099	-0.109	FVA
575	828333.993	3259928.058	0.270	0.185	0.213	-0.085	-0.057	FVA
576	828291.010	3259851.073	-0.860	-0.652	-0.652	0.208	0.209	Tall weeds
577	828278.968	3259822.798	-0.921	-0.756	-0.749	0.165	0.172	Tall weeds

578	828266.341	3259794.445	-0.784	-0.636	-0.598	0.147	0.186	Tall weeds
583	818358.097	3268097.057	-0.321	-0.374	-0.392	-0.053	-0.071	FVA
584	818341.847	3268075.936	-0.289	-0.384	-0.377	-0.095	-0.087	FVA
585	818321.135	3268047.644	-0.170	-0.242	-0.248	-0.072	-0.078	FVA
589	818414.915	3268063.809	-0.455	-0.441	-0.444	0.014	0.011	Brush land
590	818405.025	3268038.568	-0.541	-0.445	-0.439	0.096	0.102	Brush land
591	818383.225	3268010.645	-0.635	-0.480	-0.493	0.155	0.143	Brush land
592	818340.003	3267956.073	-0.444	-0.452	-0.416	-0.007	0.028	Tall weeds
593	818355.585	3267924.888	-0.378	-0.281	-0.269	0.097	0.109	Tall weeds
594	818365.325	3267901.105	-0.805	-0.635	-0.628	0.170	0.176	Tall weeds
596	818274.215	3268012.847	-0.406	-0.510	-0.519	-0.103	-0.113	URBAN
597	818258.943	3268027.972	-0.429	-0.542	-0.503	-0.113	-0.075	URBAN
598	818243.321	3268040.223	-0.434	-0.556	-0.603	-0.122	-0.169	URBAN

Fundamental Vertical Accuracy - LAS

LandCover Type: FVA
Minimum DZ: -0.157
Maximum DZ: 0.129
Mean DZ: -0.004
Mean Magnitude DZ: 0.22
Number Observations: 61
Standard Deviation DZ: 0.063
RMSE Z: 0.062
95% Confidence Level Z: 0.122
Units: Meters

Histogram



Min: -0.157
Max: 0.129
Number Of Bins: 20
Bin Interval: 0.014

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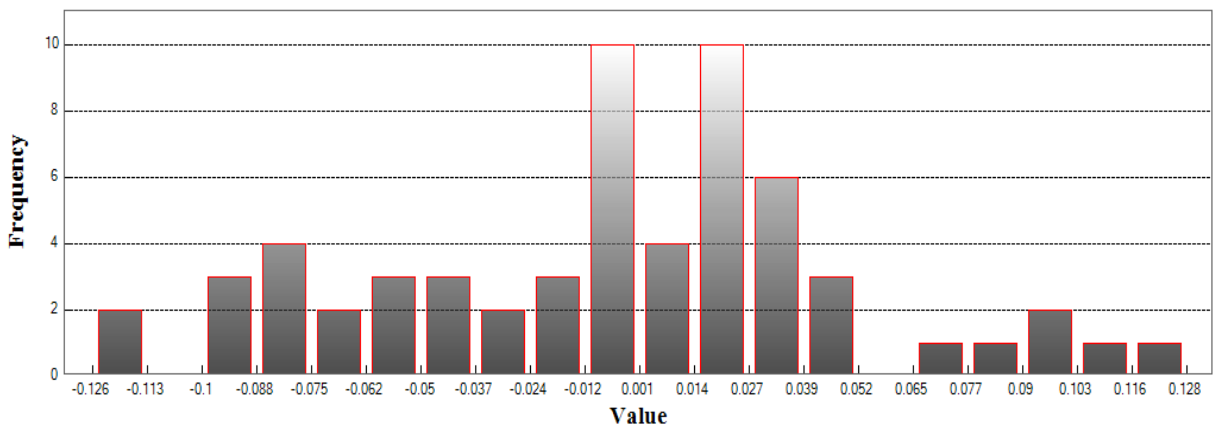
Fundamental Vertical Accuracy – DEM

Land Cover Type: FVA
Minimum DZ: -0.125
Maximum DZ: 0.129
Mean DZ: -0.005
Mean Magnitude DZ: 0.207
Number Observations: 61
Standard Deviation DZ: 0.056
RMSE Z: 0.055
95% Confidence Level Z: 0.109
Units: Meters

Histogram



Min: -0.125
Max: 0.129
Number Of Bins: 20
Bin Interval: 0.013

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Supplemental Vertical Accuracy - Tall weeds	
LAS	DEM
Land Cover Type: Tall weeds Minimum DZ: -0.124 Maximum DZ: 0.228 Mean DZ: 0.09 Mean Magnitude DZ: 0.331 Number Observations: 22 Standard Deviation DZ: 0.094 RMSE Z: 0.129 95th Percentile: 0.208 Units: Meters	Land Cover Type: Tall weeds Minimum DZ: -0.074 Maximum DZ: 0.246 Mean DZ: 0.092 Mean Magnitude DZ: 0.323 Number Observations: 22 Standard Deviation DZ: 0.089 RMSE Z: 0.126 95th Percentile: 0.207 Units: Meters

Supplemental Vertical Accuracy - Brush land	
LAS	DEM
Land Cover Type: Brush land Minimum DZ: -0.008 Maximum DZ: 0.211 Mean DZ: 0.129 Mean Magnitude DZ: 0.361 Number Observations: 12 Standard Deviation DZ: 0.077 RMSE Z: 0.149 95th Percentile: 0.21 Units: Meters	Land Cover Type: Brush land Minimum DZ: 0.014 Maximum DZ: 0.223 Mean DZ: 0.124 Mean Magnitude DZ: 0.353 Number Observations: 12 Standard Deviation DZ: 0.074 RMSE Z: 0.143 95th Percentile: 0.214 Units: Meters

Supplemental Vertical Accuracy - Forested	
LAS	DEM
Land Cover Type: Forested Minimum DZ: -0.058 Maximum DZ: 0.121 Mean DZ: 0.058 Mean Magnitude DZ: 0.299 Number Observations: 6 Standard Deviation DZ: 0.082 RMSE Z: 0.095 95th Percentile: 0.121 Units: Meters	Land Cover Type: Forested Minimum DZ: -0.068 Maximum DZ: 0.114 Mean DZ: 0.041 Mean Magnitude DZ: 0.272 Number Observations: 6 Standard Deviation DZ: 0.073 RMSE Z: 0.078 95th Percentile: 0.109 Units: Meters

Supplemental Vertical Accuracy - URBAN	
LAS	DEM
LandCover Type: URBAN Minimum DZ: -0.169 Maximum DZ: 0.069 Mean DZ: -0.027 Mean Magnitude DZ: 0.236 Number Observations: 9 Standard Deviation DZ: 0.078 RMSE Z: 0.078 95th Percentile: 0.146 Units: Meters	LandCover Type: URBAN Minimum DZ: -0.122 Maximum DZ: 0.06 Mean DZ: -0.025 Mean Magnitude DZ: 0.237 Number Observations: 9 Standard Deviation DZ: 0.071 RMSE Z: 0.071 95th Percentile: 0.119 Units: Meters

Consolidated Vertical Accuracy	
LAS	DEM
LandCover Type: ALL Minimum DZ: -0.169 Maximum DZ: 0.228 Mean DZ: 0.031 Mean Magnitude DZ: 0.269 Number Observations: 110 Standard Deviation DZ: 0.089 RMSE Z: 0.094 95th Percentile: 0.203 Units: Meters	LandCover Type: ALL Minimum DZ: -0.125 Maximum DZ: 0.246 Mean DZ: 0.03 Mean Magnitude DZ: 0.259 Number Observations: 110 Standard Deviation DZ: 0.084 RMSE Z: 0.089 95th Percentile: 0.173 Units: Meters