LiDAR Data Calibration Report

GeoDigital #: 239 DEB11-1
FEMA Virginia LiDAR (T/O G11PD00089) – Counties Middle
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Presented to:

Dewberry

Submitted by:

Client Program Management Group
Ottawa, Canada

EXECUTIVE SUMMARY

This LiDAR project was developed with the goal of providing high accuracy, calibrated multiple return LiDAR for an area of 1764 square km (excluding 200* NPS buffer = 150m) representing Dewberry, FEMA Virginia LiDAR acquisition Task Order #6 – (G11PD00089). Data are collected and delivered in compliance with the "U.S. Geological Survey National Geospatial Program Base LiDAR Specifications, Version 13 – ILMF 2010".

This report concerns the New Kent, Charles City and Prince George counties. The primary deliverable product is raw calibrated LiDAR point clouds in flight strips.

The elevation data was verified internally prior to delivery to ensure it met fundamental accuracy requirements; vertical accuracy NSSDA RMSEZ = 9.25cm, NSSDA AccuracyZ 95% = 18 cm or better; in open, non-vegetated terrain when compared to static GeoDigital GPS checkpoints. Below is the summary for both tests:

- The LiDAR dataset was tested to 0.074m vertical accuracy at 95% confidence level, based on consolidated $RMSE_z$ (0.038 x 1.960), when compared to 16 GPS static check points.

In addition to static check points, LiDAR was compared to previously acquired and delivered data to ensure consistency.

Please note that this report focuses solely on the GeoDigital activities pertaining to the LiDAR data calibration component of this project.

All data delivered meets or exceeds GeoDigital deliverable product requirements as set out by GeoDigital Quality Management program.

INTRODUCTION

LiDAR data is remotely sensed high-resolution elevation data. To collect data for this project, GeoDigital used an airborne fixed-wing platform. By positioning laser range finding with the use of 1 second GPS with 200 Hz inertial measurement unit corrections; GeoDigital's LiDAR instruments are able to make highly detailed geospatial elevation products of the ground, man-made structures and vegetation.

The purpose of this LiDAR collection was to produce high accuracy 3D terrain products for flood mapping and other applications.

This report covers the LiDAR calibration and initial processing methods and the development of the deliverable products. A GPS Validation Report has been included as Appendix A.

Please note that this report focuses solely on the GeoDigital activities pertaining to the LiDAR data calibration and initial processing component of this project.

1. LiDAR Data Processing

1.1. Airborne GPS Kinematic

Airborne GPS kinematic data was processed on-site using GrafNav kinematic On-The-Fly (OTF) software. Acquisition flights were performed with a minimum of 6 GPS satellites in view (at least 13° above the horizon) and with a PDOP of better than 4. Distances from base stations to aircraft were kept to a maximum of 40km.

Following a review of all flights, the GPS data can be classified as accurate, with GPS residuals of 5cm average or better but no larger than 10cm being recorded.

1.2. Generation and Calibration of Laser Points (raw data)

The initial step of calibration is to verify availability and status of all needed GPS and Laser data against field notes. Any omissions were rectified at this stage.

Subsequently the laser points for each mission are output using Optech's Dashmap software, initially using default calibration values from Optech, or with the latest calibrations recorded for the sensor system. The points generated for each mission using the initial calibration are reviewed and verified within Microstation/TerraScan for calibration errors. If a calibration error greater than specification is observed within the mission, the roll pitch and scanner scale corrections that need to be applied are calculated. The missions determined to require new calibration values are regenerated and validated internally once again to ensure quality.

All missions are validated against the adjoining missions, for relative vertical biases, and compared against collected GPS static validation points for absolute vertical accuracy confirmation.

On a project-wide level, a supplementary coverage check is carried out, to ensure no data gaps unreported by Field Operations are present.

1.3. Vertical Bias Resolution

In the case of this project, the LiDAR data compared to the GPS static points displayed a vertical bias. Hence the following corrections were applied:

Mission	Total Vertical Adjustment (m)
o311344a	0
o311344b	0
o311345a	0
o311345b	0
o311347a	0
o311347b	-0.03
o311348a	0
o311348b	0
o311349a	0
o311351a	0
o311352a	-0.03
o311352b	-0.05
o311353b	-0.05
o311354b	-0.05
o311362a	-0.05
o311363a	-0.10
o311363b	-0.10
o212090a	0.03
o212091a	0.05
o212092a	0
o212092b	0
o212093a	0
o212093b	-0.05

1.1. Deliverable Product Generation

The raw, unclassified LiDAR data were delivered in LAS format 1.2, using adjusted GPS time. Data was delivered as raw strips, with any files bigger than 2 GB split in two smaller pieces. The header is populated with the projection information and the withheld angles (+/- 2 Deg.) are flagged using the Withheld bit placeholder. One mission had an additional range classified as withheld, please see Appendix B for details.

All products were delivered in UTM 18 north meters, NAD83(NSRS07), NAVD88(Geoid09).

2. Quality Control for Data Processing LiDAR Calibration

Quality assurance and quality control procedures for the raw LiDAR data are performed in an iterative fashion through the entire data processing cycle.

The following sections provide a step-by-step explanation of the process used by GeoDigital to review the data prior to customer delivery:

2.1. Calibration Setup and Data Inventory

Data collected by the LiDAR sensor is reviewed for completeness, acceptable point-density and to make sure all data is captured without errors or corrupted values. In addition, all GPS, aircraft trajectory, mission information, and ground control files are reviewed and logged into a database.

2.2. Boresight and Relative accuracy

The initial LiDAR points for each mission calibration are inspected for flight line errors in roll, pitch, mirror scale, and heading. The coverage is checked for flight line overlap, slivers or gaps in the data, point data minimums, or issues with the LiDAR unit or GPS. Roll, pitch and scanner scale are optimized during the calibration process until the relative accuracy is met.

All missions are checked for relative accuracy and internal quality. To do so, three regularly spaced QC blocks are place at the outer extents and middle of each mission. The blocks are placed over feature rich areas to best test the calibration solution. The size of the QC blocks are created to load no more than 15 million points each. Within the QC blocks all points from all flight lines are loaded and meticulously inspected to ensure the flight lines meet the required specification. Vertical differences between ground surfaces of each line are displayed using a color-by-distance algorithm. Color scale is adjusted so that errors greater than the specifications are flagged. Cross sections are visually inspected across each block to validate point-to-point, flight line-to–flight line and mission-to-mission agreement. For this project the criteria for acceptance were as follows:

- Relative accuracy <= 7cm $RMSE_z$ within individual flight line swaths $RMSE_z$ <=10 cm within swath overlap (between adjacent flight lines)

A different set of QC blocks are generated for final review after all transformations have been applied.

2.3. Absolute Accuracy

A preliminary $RMSE_z$ check is performed at this stage of the project life cycle by comparing the raw LiDAR dataset against static GPS data and $RMSE_z$ project specifications. The LiDAR data is examined in open, flat areas. LiDAR ground points for each flight line generated by an automatic classification routine are used.

Results:

Prior to delivery, the elevation data was verified internally to ensure it met fundamental accuracy requirements of 18.5cm vertical accuracy at the 95% confidence level (2 sigma = RMSE * 1.96) when compared to GeoDigital static GPS checkpoints.

- The LiDAR dataset was tested to 0.074m vertical accuracy at 95% confidence level based on consolidated $RMSE_z$ (0.038 x 1.960) when compared to 16 GPS static check points.

Data is compiled to meet 1m horizontal accuracy at the 95% confidence level (2 sigma = RMSE * 1.96)

In addition to static check points, LiDAR was compared to previously acquired and delivered data to ensure consistency

A detailed comparison is provided in Appendix A - GPS Validation.

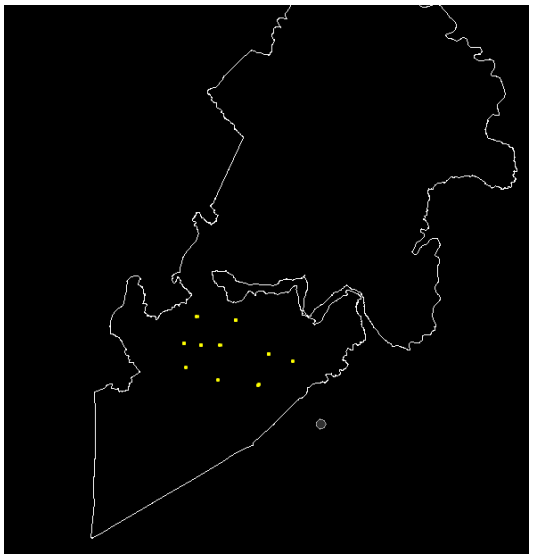
3. Conclusion

Overall, the LiDAR data products collected for Dewberry meet or exceed the requirements set out in the Statement of Work for this project. The quality control requirements of GeoDigital's Quality Management Program were adhered to throughout the acquisition stage of this project.

Appendix A GPS Validation

Static GPS Validation – Control Reports Generated in TerraScan

All locations are presented in UTM18 meters



JD349GT Static

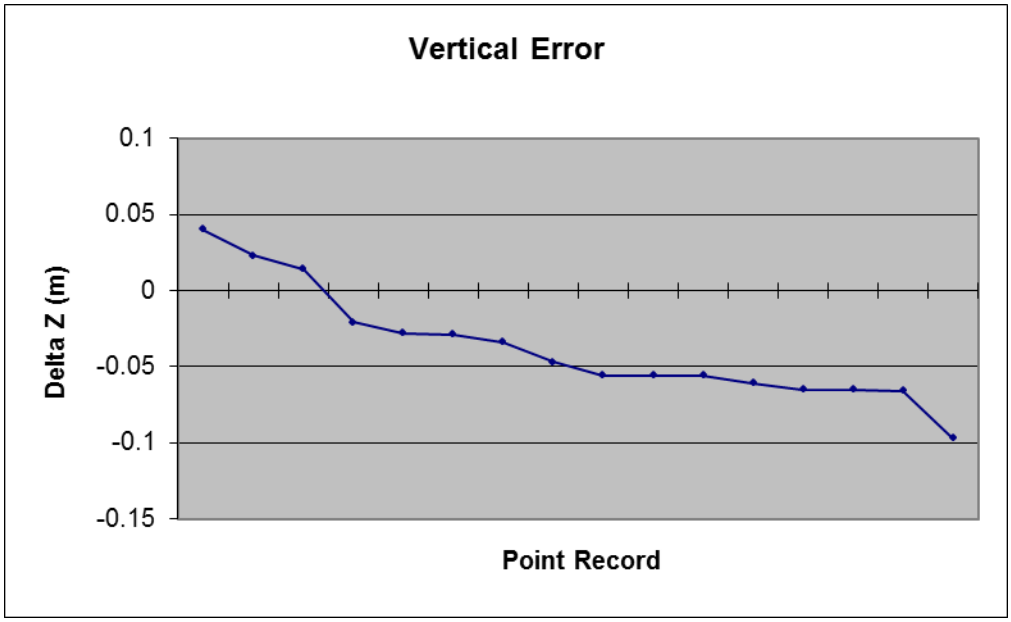
Number	Easting	Northing	Known Z	Laser Z	Dz
301517.667	4122974.104	40.670	40.710	+0.040	
309454.258	4117573.096	36.457	36.480	+0.023	
303916.433	4118184.473	38.956	38.970	+0.014	
304119.089	4123023.792	38.331	38.310	-0.021	
303886.769	4118204.508	38.888	38.860	-0.028	
310861.008	4121811.770	34.079	34.050	-0.029	
310846.999	4121800.256	33.864	33.830	-0.034	
299178.108	4123262.278	37.747	37.700	-0.047	
314070.625	4120772.022	20.126	20.070	-0.056	
309344.952	4117520.791	37.956	37.900	-0.056	
301558.617	4123023.859	41.566	41.510	-0.056	
299442.908	4119875.620	38.871	38.810	-0.061	
299222.595	4123236.680	38.225	38.160	-0.065	
314082.142	4120733.952	20.575	20.510	-0.065	

304170.810	4122992.772	37.406	37.340	-0.066
299467.511	4119928.825	39.727	39.630	-0.097

Average dz -0.038
Minimum dz -0.097
Maximum dz +0.040
Average magnitude 0.047
Root mean square 0.052
Std deviation 0.037

Static GPS Validation – Overall Summary Statistics

Sample Size	16	Points
Average	-0.038	meters
RMSE	0.052	meters
NSSDA	0.102	meters



Appendix B Supplementary Adjustments

Mission o11352b has an extra range that was classified as withheld at ≤-14 and ≥19 degrees.

This delivery includes data to replace line 012_s1c1_o311363a_36312 from mission o311363a. The data from this line should be removed and replaced by re-flight data 013_S1C1_o212093b_29343 from mission o212093b.

In the course of completing a quality control assesment of all field data, an issue was indentify relating to LiDAR intensity. As result, the acquisition platform was redeployed to the field and 6 missions were recollected. In order to reduce the effects of temporal changes (foliage growth), modified flight plan parameters were employed. To ensure penetration to the ground swath overlap was increased to 75% from 55%.