LiDAR Data Calibration Report

Terrapoint #: 2011-103-U
FEMA Virginia LiDAR (T/O G11PD00089) – Worcester Area
Originally submitted: Thursday, April 14, 2011

Presented to:

Dewberry

Submitted by:

Terrapoint aerial services

Client Program Management Group
Ottawa, Canada

EXECUTIVE SUMMARY

This LiDAR project was to provide high accuracy, calibrated multiple return LiDAR for 3341 square miles (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 Worcester County area, the primary deliverable product is raw calibrated LiDAR. Classified data will be submitted at a later date.

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 kinematic and static Terrapoint 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 $RMSE_Z$ (0.038m x 1.960) when compared to 2735 GPS kinematic check points.
- The LiDAR dataset was tested to 0.059m vertical accuracy at 95% confidence level based on consolidated $RMSE_Z$ (0.03m x 1.960) when compared to 13 GPS static check points.

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

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

INTRODUCTION

LiDAR data is remotely sensed high-resolution elevation data collected by an airborne collection platform. By positioning laser range finding with the use of 1 second GPS with 200 Hz inertial measurement unit corrections; Terrapoint'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 data was to produce high accuracy 3D terrain geospatial products for flood mapping and other applications.

This report covers the LiDAR processing methods and deliverable products. A GPS Validation Report has been included as an appendix.

Please note that this report focuses solely on the Terrapoint activities pertaining to the LiDAR data 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. Flights were flown with a minimum of 6 satellites in view (13° above the horizon) and with a PDOP of better than 4. Distances from base station to aircraft were kept to a maximum of 40km.

For all flights, the GPS data can be classified as excellent, with GPS residuals of 3cm 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 and compile any data if not complete.

Subsequently the mission points are output using Optech's Dashmap, initially with default values from Optech or the last mission calibrated for system. The initial point generation for each mission calibration is 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 with the 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 collected GPS kinematic validation points for absolute vertical accuracy purposes.

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

1.3. Vertical Bias Resolution

When the LiDAR data was compared to the GPS kinematic and static points, a bias was detected. Hence the following corrections were applied:

Mission	Total Vertical Adjustment (m)
o111084a	0.2
o111084b	0.2
o111085a	0.2
o111087a	0.2
o111088a	0.23

1.4. Deliverable Product Generation

The raw, unclassified LiDAR data were delivered in LAS format 1.2 adjusted GPS time, both as raw strips, with files bigger than 2 GB split in 2 both. Header is populated with the projection information and the withheld angles (+/-2deg) are flagged using the Withheld bit.

All products were delivered in State Plane Maryland (1900) US Survey feet, NAD83(NSRS 07), 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 list provides a step-by-step explanation of the process used by Terrapoint to review the data prior to customer delivery.

2.1. Calibration Setup and Data Inventory

Data collected by the LiDAR unit is reviewed for completeness, acceptable 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 points for each mission calibration are inspected for flight line errors, 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.

Relative accuracy and internal quality are checked using at least 3 regularly spaced QC blocks in which points from all lines are loaded and inspected. Vertical differences between ground surfaces of each line are displayed. 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, flightline to flightline and mission to mission agreement. For this project the specifications used are as follow: Relative accuracy <= 7cm RMSEZ within individual swaths and <=10 cm RMSEZ or within swath overlap (between adjacent swaths) .

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

2.3. Absolute accuracy

A preliminary $RMSE_z$ error check is performed at this stage of the project life cycle in the raw LiDAR dataset against GPS static and kinematic data and compared to $RMSE_z$ project specifications. The LiDAR data is examined in open, flat areas away from breaks. Lidar ground points for each flightline generated by an automatic classification routine are used.

3. Vertical Positional Accuracy

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) in when compared to Terrapoint kinematic and static GPS checkpoints.

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

- The LiDAR dataset was tested to 0.074m vertical accuracy at 95% confidence level based on consolidated $RMSE_z$ (0.038m x 1.960) when compared to 2735 GPS kinematic check points.
- The LiDAR dataset was tested to 0.059m vertical accuracy at 95% confidence level based on consolidated $RMSE_z$ (0.03 x 1.960) when compared to 13 GPS static check points.

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

4. Conclusion

Overall the LiDAR data products collected for Dewberry meets or exceed the requirements set out in the Statement of Work for this project. The quality control requirements of Terrapoint's Quality management program were adhered to throughout the acquisition stage of this project to ensure product quality.

Appendix A GPS Validation

Static GPS Validation
UTM18 meters

K:\11103u_Virginia\2_Operations\5_Ground_Truthing\All STATIC_Worcester.txt

Number	Easting	Northing	Known Z	Laser Z	Dz
1	488816.982	4239791.120	2.258	2.230	-0.028
2	484713.985	4248321.657	4.453	4.440	-0.013
3	475575.345	4233604.997	11.105	11.140	+0.035
4	480432.824	4238946.413	13.124	13.130	+0.006
5	489611.994	4240414.649	1.686	1.690	+0.004
6	481638.722	4243124.176	7.676	7.710	+0.034
7	483887.467	4240151.216	2.862	2.900	+0.038
8	481002.384	4253605.299	10.200	10.240	+0.040
9	485353.200	4254515.591	5.590	5.620	+0.030
10	495341.897	4254596.371	2.330	2.320	-0.010
11	492302.963	4242590.216	1.065	1.080	+0.015
12	494322.651	4248913.289	2.169	2.120	-0.049
13	487935.263	4232076.766	2.149	2.110	-0.039

Average dz +0.005
Minimum dz -0.049
Maximum dz +0.040
Average magnitude 0.026
Root mean square 0.030
Std deviation 0.031

Kinematic GPS Validation

Sample Size	2735	Points
average	0.016	metres
RMSE	0.038	metres
NSSDA	0.074	metres