LIDAR Vertical Accuracy Assessment Report – Aerotec, LLC

The vertical accuracy of airborne LIDAR data is important for all types of applications related to digital terrain modeling: electric power transmission engineering, pipeline engineering, land planning, surface mining, highway design, railroad design, airport long-range planning, etc. Aerotec deploys some of the most accurate LIDAR technology currently available. In order to demonstrate Aerotec's LIDAR accuracy and to provide a base format for accuracy assessment, Aerotec conducted its own accuracy assessment over an area of approximately one square mile with varied terrain. This "test" terrain contained topographic features that would be experienced by any of Aerotec's customers.

Aerotec's test terrain was centered on the Bessemer Airport which sits on the crest of a small mountain southwest of Birmingham, Alabama. The Bessemer Airport test area contains flat, steep, and rolling terrain with portions of the area being covered by

1. Grassy areas (maintained and not maintained),
2. Tall grass and brush (3' to 5' tall),
3. Built-up areas (hangars, offices, fuel tanks, and other structures),
4. Hard surfaces (open roads and runways constructed of various materials), and
5. Forest/Woods (10' to 50' pine and hardwoods in leaf-on conditions).

Aerotec's experienced field personnel captured GPS coordinates (x, y, z) for three locations (points) in each of the five (5) types/classes of terrain identified above (e.g., three points per class of terrain/cover) using Aerotec's Trimble 5700 GPS units. Two base points (first order monuments) were occupied by Aerotec's GPS Ground Reference Stations (Trimble 5700 GPS units) and baselines were established using Aerotec's standard operating procedures. While collecting the coordinate data of each test location, Aerotec's field crews occupied each location for twenty (20) minutes. After completing the field data capture operations, the field crews compiled their results into a spreadsheet for further analysis by Aerotec's Geomatics Engineering staff.

The preliminary spreadsheet data was received by the Geomatics Engineering staff on April 26, 2007. The z-coordinate (elevation) of each test location was compared to the interpolated (digital terrain model – TIN model including all "bare earth" classified data points with an average distance between points of 15 inches) LIDAR elevation of that horizontal location – Aerotec had previously scanned the test area using its standard production airborne LIDAR instrument configuration (helicopter outfitted with Aerotec's TopEye LIDAR instrument – elliptical scan pattern). Statistical tests were performed (primarily Root Mean-square Error calculation) to determine the vertical accuracy of the airborne LIDAR data. The statistical tests (as shown in the attached spreadsheet) provided RMSE determinations for land classes considering:

1. All checkpoint locations (15 locations)
2. 100%, 95%, and 68% Confidence Levels

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Results

All data was reviewed and further analyzed to assess the quality of the data. The review process examined the statistics for the combined land classes and the trends for each specific land class or type of terrain. The following graphs and figures illustrate the data quality as per RMSE criteria.

Table 1 (below) summarizes the RMSE using:

- All of the checkpoints
- Checkpoints categorized by land cover class

Table 1. RMSE by Land Class

%	RMSE (ft)	# of Points	Land Class
100	0.038 ft	15	All
20	0.015 ft	3	Grassy Area
20	0.038 ft	3	Tall Grass & Weeds
20	0.074ft	3	Built Up Areas
20	0.012 ft	3	Open Hard Areas
20	0.092 ft	3	Forest/Woods

Figure 1 (below) illustrates the RMSE (Root Mean Squared Error) by specific Land Class Types

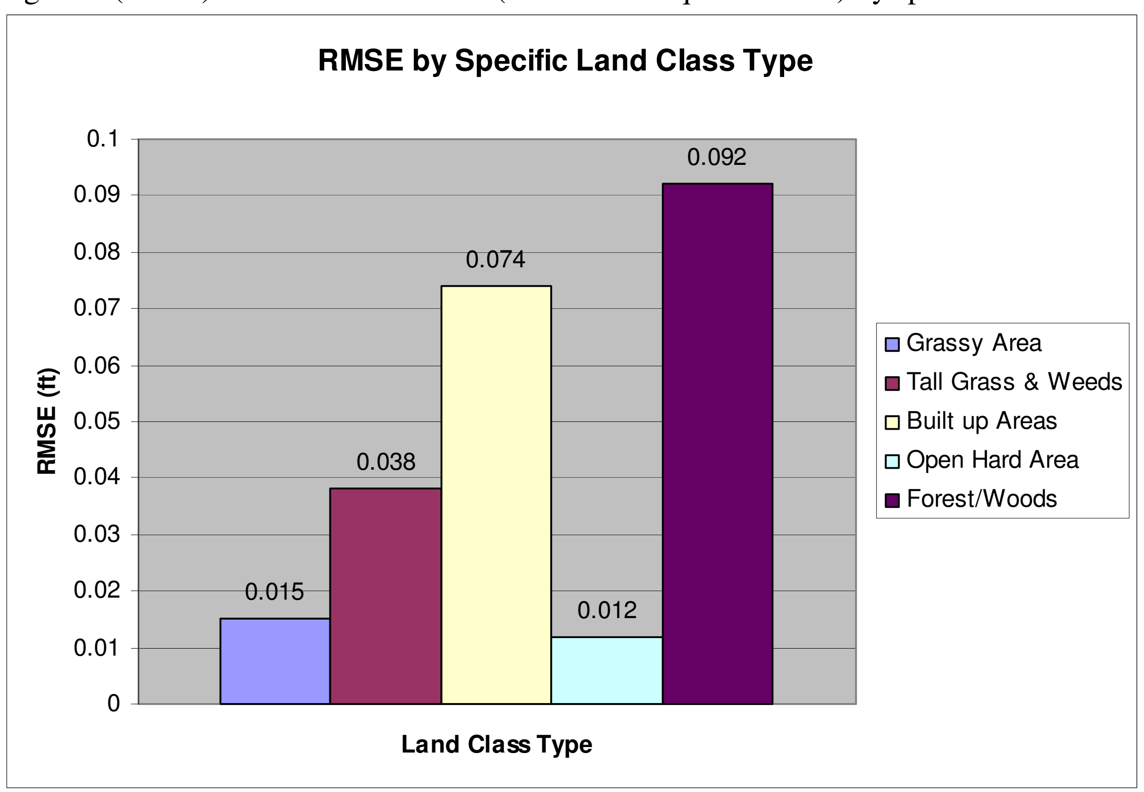

Figure 2 (below) illustrates the magnitude of the difference in elevation (ft) between the checkpoints and their corresponding LIDAR data by specific land class type and sorted from lowest to highest elevation difference.

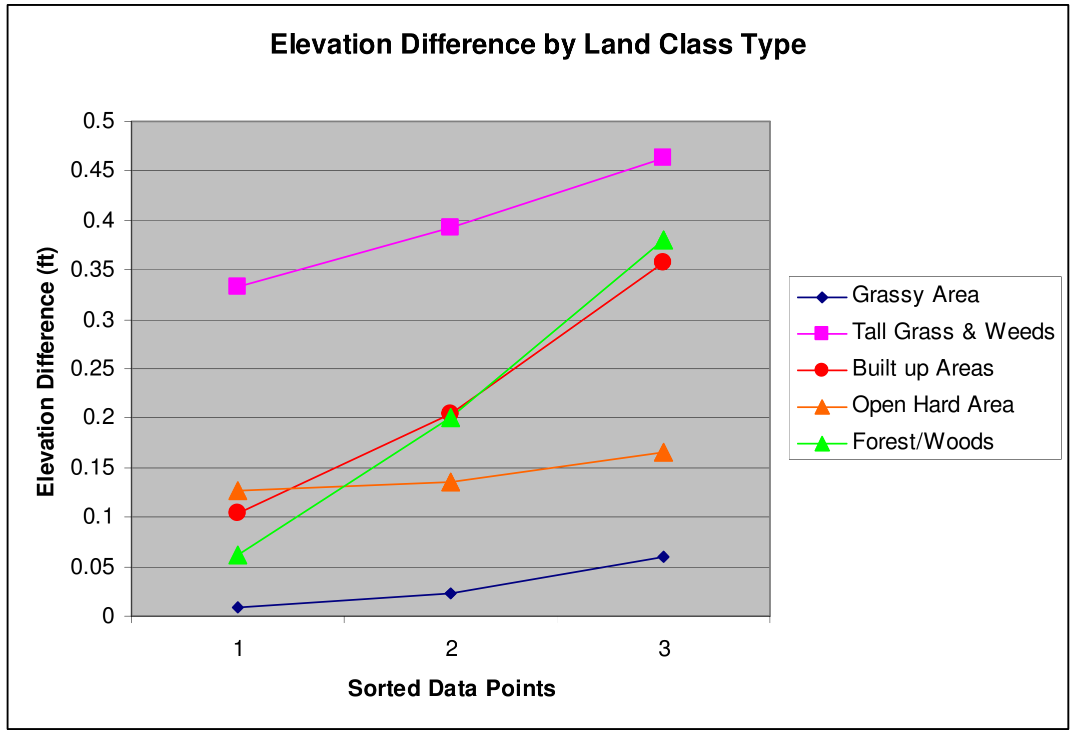

Figure 3 (below) illustrates the frequency distribution of the associated elevation differences between all the data checkpoints and the interpolated LIDAR (TIN model) values.

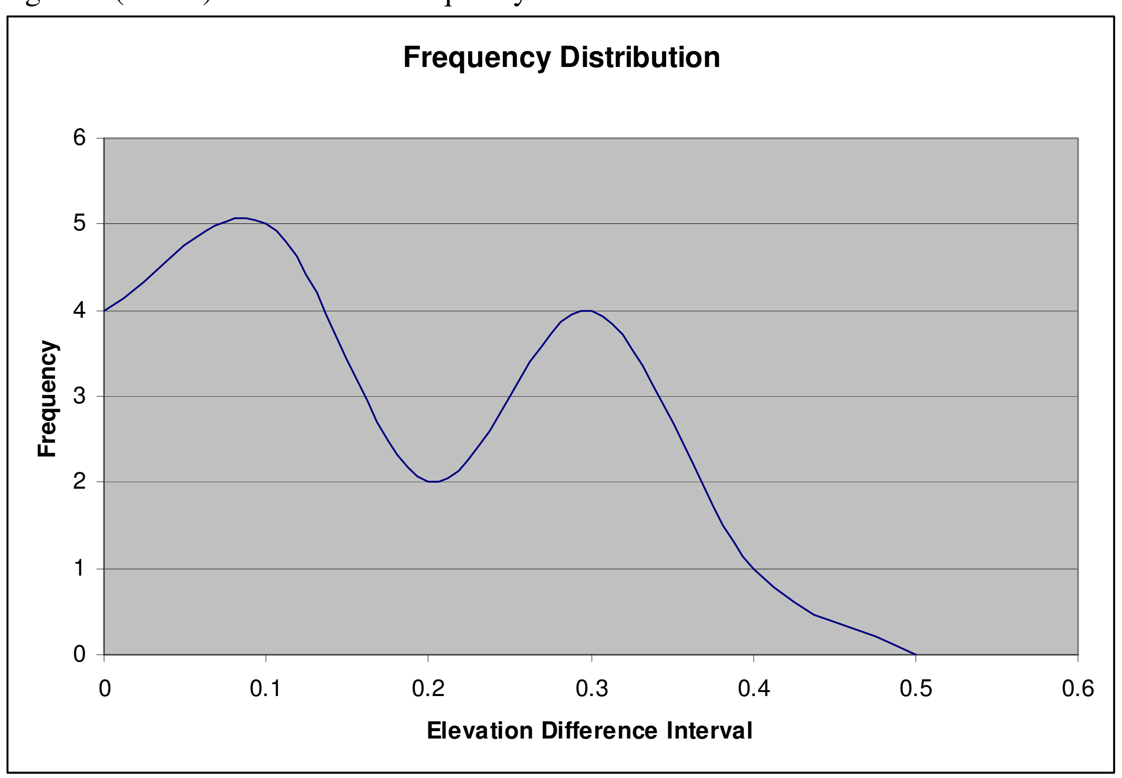

Table 2 (below) illustrates the spreadsheet with all the check points data compiled

Lidar Quality Assurance Spreadsheet

Date:	4/25/2007
Customer:	Aerotec Test
Project Name:	Bessemer Airport
Field Surveyors:	Danny Gay, Curtis Canibano, and Justin Barker
Processor:	Kurtis Bahan
Data Analysist:	William Wallace and Justin Barker

Base Station Point

Name or PID #:	Aerotec Spike	DH2700
Latitude:	33 18 27.55845	33 18 48.45045
Longitude:	86 55 45.49004	86 55 27.52163
Ellipsoid Height:	178.132 m	183.190 m
Orthometric Height:	207.100 m	212.200 m
Geiod Height:	-28.996 m	-29.070 m

Control Points

Grassy Area		Tall Grass & Weeds		Built-Up Areas		Open Hard Areas		Forest/Woods	
Point 1		Point 1		Point 1		Point 1		Point 1	
Northing:	1205781.310 ft	Northing:	1205151.940 ft	Northing:	1203416.339 ft	Northing:	1203055.365 ft	Northing:	1204320.826
Easting:	2144371.290 ft	Easting:	2144823.229 ft	Easting:	2142192.501 ft	Easting:	2141860.159 ft	Easting:	2143881.593
Ellipsoid Height:	183.190 m	Ellipsoid Height:	180.940 m	Ellipsoid Height:	178.666 m	Ellipsoid Height:	179.753 m	Ellipsoid Height:	174.338
Geoid Height:	-29.070 m	Geoid Height:	-28.999 m	Geoid Height:	-28.995 m	Geoid Height:	-29.994 m	Geoid Height:	-28.997
Antenna Height:	1.463 m	Antenna Height:	1.853 m	Antenna Height:	1.541 m	Antenna Height:	1.532 m	Antenna Height:	1.853
GPS Elevation:	696.391 ft	GPS Elevation:	688.747 ft	GPS Elevation:	681.302 ft	GPS Elevation:	681.014 ft	GPS Elevation:	667.110
Lidar Elevation:	696.450 ft	Lidar Elevation:	689.210 ft	Lidar Elevation:	681.660 ft	Lidar Elevation:	681.180 ft	Lidar Elevation:	667.310
Difference between GPS and Lidar:	0.059 ft	Difference between GPS and Lidar:	0.463 ft	Difference between GPS and Lidar:	0.358 ft	Difference between GPS and Lidar:	0.166 ft	Difference between GPS and Lidar:	0.200
Point 2		Point 2		Point 2		Point 2		Point 2	
Northing:	1203837.500 ft	Northing:	1202903.222 ft	Northing:	1204274.213 ft	Northing:	1205197.937 ft	Northing:	1206299.407
Easting:	2142498.068 ft	Easting:	2141418.656 ft	Easting:	2143126.607 ft	Easting:	2144197.443 ft	Easting:	2145704.154
Ellipsoid Height:	178.757 m	Ellipsoid Height:	178.507 m	Ellipsoid Height:	180.092 m	Ellipsoid Height:	183.739 m	Ellipsoid Height:	182.301
Geoid Height:	-28.995 m	Geoid Height:	-28.994 m	Geoid Height:	-28.997 m	Geoid Height:	-28.998 m	Geoid Height:	-29.001
Antenna Height:	1.853 m	Antenna Height:	1.610 m	Antenna Height:	1.377 m	Antenna Height:	1.561 m	Antenna Height:	1.853
GPS Elevation:	681.601 ft	GPS Elevation:	680.778 ft	GPS Elevation:	685.987 ft	GPS Elevation:	694.104 ft	GPS Elevation:	693.248
Lidar Elevation:	681.610 ft	Lidar Elevation:	681.110 ft	Lidar Elevation:	686.090 ft	Lidar Elevation:	694.230 ft	Lidar Elevation:	693.310
Difference between GPS and Lidar:	0.009 ft	Difference between GPS and Lidar:	0.332 ft	Difference between GPS and Lidar:	0.103 ft	Difference between GPS and Lidar:	0.126 ft	Difference between GPS and Lidar:	0.062
Point 3		Point 3		Point 3		Point 3		Point 3	
Northing:	1203932.325 ft	Northing:	1203062.553 ft	Northing:	1205974.605 ft	Northing:	1203661.339 ft	Northing:	1204901.136
Easting:	2142576.772 ft	Easting:	2141959.895 ft	Easting:	2145229.491 ft	Easting:	2142858.015 ft	Easting:	2144354.118
Ellipsoid Height:	178.645 m	Ellipsoid Height:	178.141 m	Ellipsoid Height:	182.923 m	Ellipsoid Height:	178.132 m	Ellipsoid Height:	181.372
Geoid Height:	-28.996 m	Geoid Height:	-28.994 m	Geoid Height:	-29.000 m	Geoid Height:	-28.996 m	Geoid Height:	-28.998
Antenna Height:	1.853 m	Antenna Height:	1.422 m	Antenna Height:	1.441 m	Antenna Height:	1.853 m	Antenna Height:	1.853
GPS Elevation:	681.237 ft	GPS Elevation:	679.577 ft	GPS Elevation:	695.285 ft	GPS Elevation:	679.554 ft	GPS Elevation:	690.190
Lidar Elevation:	681.260 ft	Lidar Elevation:	679.970 ft	Lidar Elevation:	695.490 ft	Lidar Elevation:	679.690 ft	Lidar Elevation:	690.570
Difference between GPS and Lidar:	0.023 ft	Difference between GPS and Lidar:	0.393 ft	Difference between GPS and Lidar:	0.205 ft	Difference between GPS and Lidar:	0.136 ft	Difference between GPS and Lidar:	0.380
Class Analysis		**Class Analysis**		**Class Analysis**		**Class Analysis**		**Class Analysis**	
Average Difference:	0.030 ft	Average Difference:	0.396 ft	Average Difference:	0.222 ft	Average Difference:	0.143 ft	Average Difference:	0.214
Minimum Difference:	0.009 ft	Minimum Difference:	0.332 ft	Minimum Difference:	0.103 ft	Minimum Difference:	0.126 ft	Minimum Difference:	0.062
Maximim Difference:	0.059 ft	Maximim Difference:	0.463 ft	Maximim Difference:	0.358 ft	Maximim Difference:	0.166 ft	Maximim Difference:	0.380
Standard Deviation:	0.026 ft	Standard Deviation:	0.066 ft	Standard Deviation:	0.128 ft	Standard Deviation:	0.021 ft	Standard Deviation:	0.159
RMSE:	0.015 ft	RMSE:	0.038 ft	RMSE:	0.074 ft	RMSE:	0.012 ft	RMSE:	0.092

Data Analysis	
All points	
Number of Points:	15
Average Difference:	0.201 ft
Minimum Difference:	0.009 ft
Maximim Difference:	0.463 ft
Standard Deviation:	0.148 ft
RMSE:	0.038 ft
Land Class:	All

Confidence Intervals (Mean Difference)	Minimum (ft.)	Maximum (ft.)	Minimum (in.)	Maximum (in.)
95% Confidence Interval	0.126	0.276	1.511	3.313
68% Confidence Interval	0.163	0.393	1.953	4.717