



FUGRO GEOSPATIAL, INC.

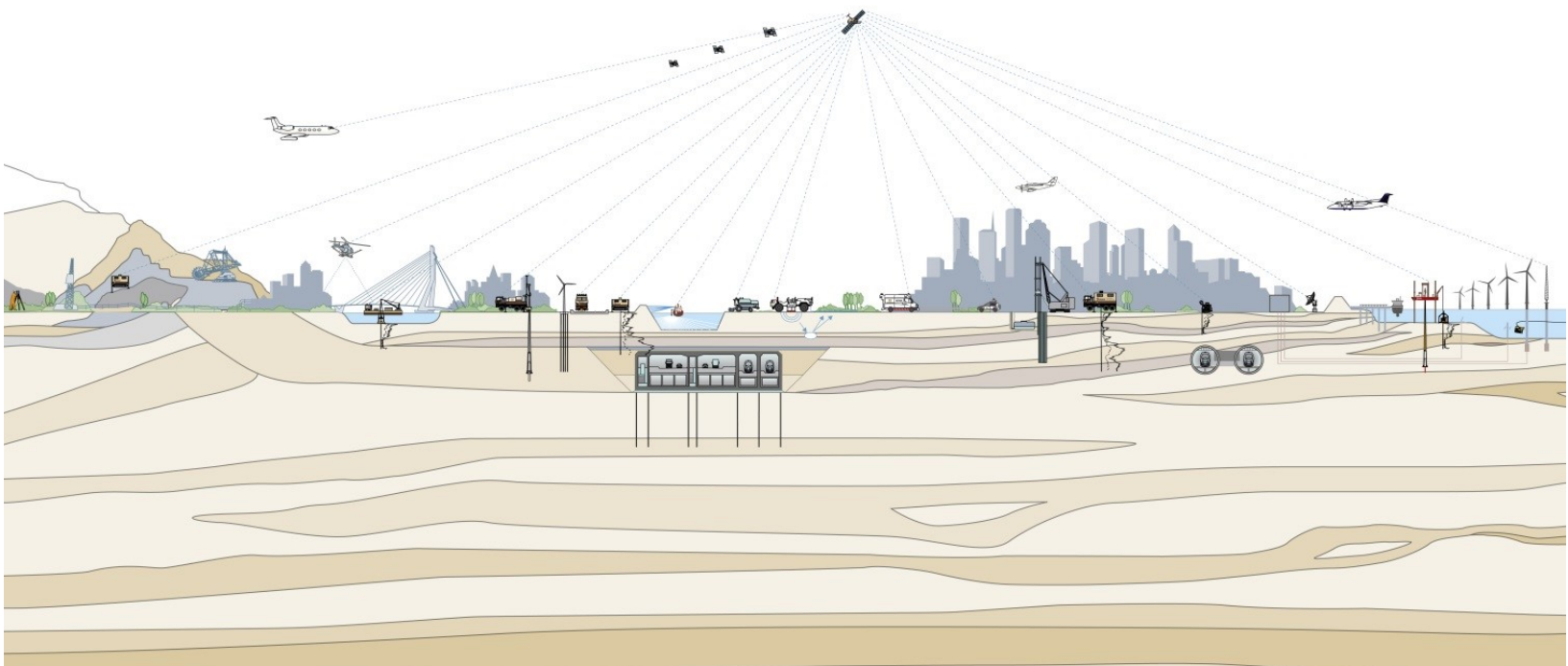
Accuracy Report – Howard County Collection

Prepared for:

United States Geological Survey
1400 Independence Road
Rolla, MO 65401
(573) 308-3689

March 4, 2020

USGS Contract: G17PC00015
USGS Task Order: 140G0218F0449





1. ACCURACY REPORTING

Data collected under this Task Order meets the National Standard for Spatial Database Accuracy (NSSDA) accuracy standards. The NSSDA standards specify that vertical accuracy be reported at the 95 percent confidence level for data tested by an independent source of higher accuracy.

1.1 Positional Accuracy

Before classification and development of derivative products from the point cloud, the absolute and relative vertical accuracies of the point cloud were verified.

1.2 Absolute Vertical Accuracy

Unclassified Lidar Point Cloud Data: The Non-Vegetated Vertical Accuracy (NVA) of the Lidar Point Cloud data was calculated against TINs derived from the final calibrated and controlled swath data. The required accuracy (ACC_z) is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on $RMSE_z$ of 10 cm in the “open terrain” and/or “Urban” land cover categories. This is a required accuracy. Please refer to the table below for the achieved accuracies. The raw swath point cloud data met the required accuracy levels before point cloud classification and derivative product generation.

Table 1: Accuracy of the Lidar Point Cloud Data

Raw Flight Lines	$RMSE_z$ (non-vegetated)	NVA at 95-percent confidence level
Specification (cm)	≤ 10	≤ 19.6
Calculated Values (cm)	3.4	6.8
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>
<i>Calculated Values (m)</i>	<i>0.034</i>	<i>0.068</i>
Number of points	18	18

Bare Earth Surface: The accuracy (ACC_z) of the derived DEM was calculated and is being reported in three (3) ways:

- 1. $RMSE_z$ (Non-Vegetated):** The required $RMSE_z$ is ≤ 10 cm.
- 2. Non-Vegetated Vertical Accuracy (NVA):** The required NVA is: ≤ 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on $RMSE_z$ of 10 cm in the “open terrain” and/or “Urban” land cover categories. This is a required accuracy.
- 3. Vegetated Vertical Accuracy (VVA):** The required VVA is: ≤ 29.4 cm at a 95th percentile level, derived according to ASPRS Guidelines, Vertical Accuracy for Reporting LiDAR Data, i.e. based on the 95th percentile error in Vegetated land cover categories combined (Tall Grass, Brush, Forested Areas). This is a required accuracy.



Please refer to the table below for the achieved accuracies.

Table 2a: Accuracy of the Derived DEM for State Plane Feet Delivery

DEM	RMSE _z (non-vegetated)	NVA at 95-percent confidence level	VVA at 95th percentiles
Specification (cm)	≤ 10	≤ 19.6	≤ 29.4
Calculated Values (cm)	3.9	7.7	6.1
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>	<i>≤ 0.294</i>
<i>Calculated Values (m)</i>	<i>0.039</i>	<i>0.077</i>	<i>0.061</i>
Number of points	17	17	1

Table 2b: Accuracy of the Derived DEM for Albers Meters Delivery

DEM	RMSE _z (non-vegetated)	NVA at 95-percent confidence level	VVA at 95th percentiles
Specification (cm)	≤ 10	≤ 19.6	≤ 29.4
Calculated Values (cm)	4.0	7.8	2.6
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>	<i>≤ 0.294</i>
<i>Calculated Values (m)</i>	<i>0.040</i>	<i>0.078</i>	<i>0.026</i>
Number of points	17	17	1

1.3 Relative Accuracy

Smooth Surface Repeatability: In ideal theoretical conditions, smooth surface repeatability is a measure of variations documented on a surface that would be expected to be flat and without variation. Users of lidar technology commonly refer to these variations as “noise.” Single-swath data was assessed using only single returns in non-vegetated areas. Repeatability was evaluated by measuring departures from planarity of single returns from hard planar surfaces, normalizing for actual variation in the surface elevation. Repeatability of only single returns was then assessed at multiple locations within hard surfaced areas (for example, parking lots or large rooftops).

Each sample area was evaluated using a signed difference raster (maximum elevation – minimum elevation) at a cell size equal to twice the ANPS, rounded up to the next integer. Sample areas were approximately 50 square meters (m²) or larger. The maximum acceptable variations within sample areas for this project is 6 cm. Isolated noise is expected within the sample areas and was disregarded.

The evaluation was done on 21 flat open sample areas over the Howard County AOI. The results are shown in the table below, please also refer to:

USGS_Howard_County_Lidar_Relative_Accuracy_Smooth_Surface_Repeatability_Albers.shp

Or

USGS_Howard_County_Lidar_Relative_Accuracy_Smooth_Surface_Repeatability_StatePlane.shp

Table 3: Relative Accuracy, Smooth Surface Repeatability

Area	RMSDZ_Corr
339.74 sq m	0.012460
399.55 sq m	0.014682
273.2 sq m	0.016822
423.68 sq m	0.020767
187.16 sq m	0.017934
294.19 sq m	0.020595
342.88 sq m	0.018069
462.13 sq m	0.015813
364.6 sq m	0.014363
265.47 sq m	0.018691
219.82 sq m	0.023743
113.06 sq m	0.022969
264.22 sq m	0.023530
260.28 sq m	0.015400
417.09 sq m	0.018089
332.03 sq m	0.017985
380.95 sq m	0.014892
280.07 sq m	0.016399
243.38 sq m	0.014998
299.71 sq m	0.013019
223.97 sq m	0.016637

Overlap Consistency: Overlap consistency is a measure of geometric alignment of two overlapping swaths; the principles used with swaths can be applied to overlapping lifts and projects as well. Overlap consistency is the fundamental measure of the quality of the calibration or boresight adjustment of the data from each lift, and is of particular importance as the match between the swaths of a single lift is a strong indicator of the overall geometric quality of the data, establishing the quality and accuracy limits of all downstream data and products.

Overlap consistency was assessed at multiple locations within overlap in non-vegetated areas of only single returns.



Each overlap area was evaluated using a signed difference raster with a cell size equal to twice the ANPS, rounded up to the next integer. The difference rasters are visually examined using a bicolor ramp from the negative acceptable limit to the positive acceptable limit. Although isolated excursions beyond the limits are expected and accepted, differences in the overlaps shall not exceed the following limits:

1. Swath overlap difference, $RMSDz \leq 8$ cm
2. Swath overlap difference, maximum ± 16 cm

The difference rasters are also statistically summarized to verify that root mean square difference in z (RMSDz) values do not exceed the 8 cm maximum. Consideration will be given for the effect of the expected isolated excursions over limits.

The result of the evaluation over 20 samples throughout the Howard County AOI can be seen in the table below. Please also refer to:

USGS_Howard_County_Lidar_Relative_Accuracy_Flightline_Overlap_Albers.shp

Or

USGS_Howard_County_Lidar_Relative_Accuracy_Flightline_Overlap_StatePlane.shp

Table 4: Relative Accuracy, Overlap Consistency

RMS_DZ	Max_DZ	Min_DZ	Area sq m
0.0244	0.057	-0.0892	4103.1632
0.0194	0.0305	-0.0484	2131.0348
0.0234	0.0355	-0.0691	7392.9779
0.0336	0.0108	-0.077	802.3847
0.0269	0.0346	-0.0752	4500.0506
0.0145	0.0249	-0.039	613.8399
0.0268	0.0336	-0.0925	18408.6690
0.0155	0.0799	-0.0593	8130.1454
0.0166	0.0747	-0.0483	7227.1476
0.0219	0.0222	-0.0584	1036.0129
0.0238	0.1082	-0.0646	2118.1883
0.0246	0.0291	-0.0778	10811.1825
0.0195	0.0627	-0.0536	1062.2231
0.0223	0.0678	-0.0464	4031.4278
0.0537	0.1028	-0.002	4193.9521
0.0217	0.0619	-0.0539	1244.2938
0.031	0.0281	-0.079	16285.3327
0.0205	0.0449	-0.0613	6417.7435
0.023	0.0717	-0.0375	3620.7813
0.0261	0.0369	-0.0584	600.8964