



FUGRO GEOSPATIAL, INC.

Accuracy Report – USGS Lidar Acquisition

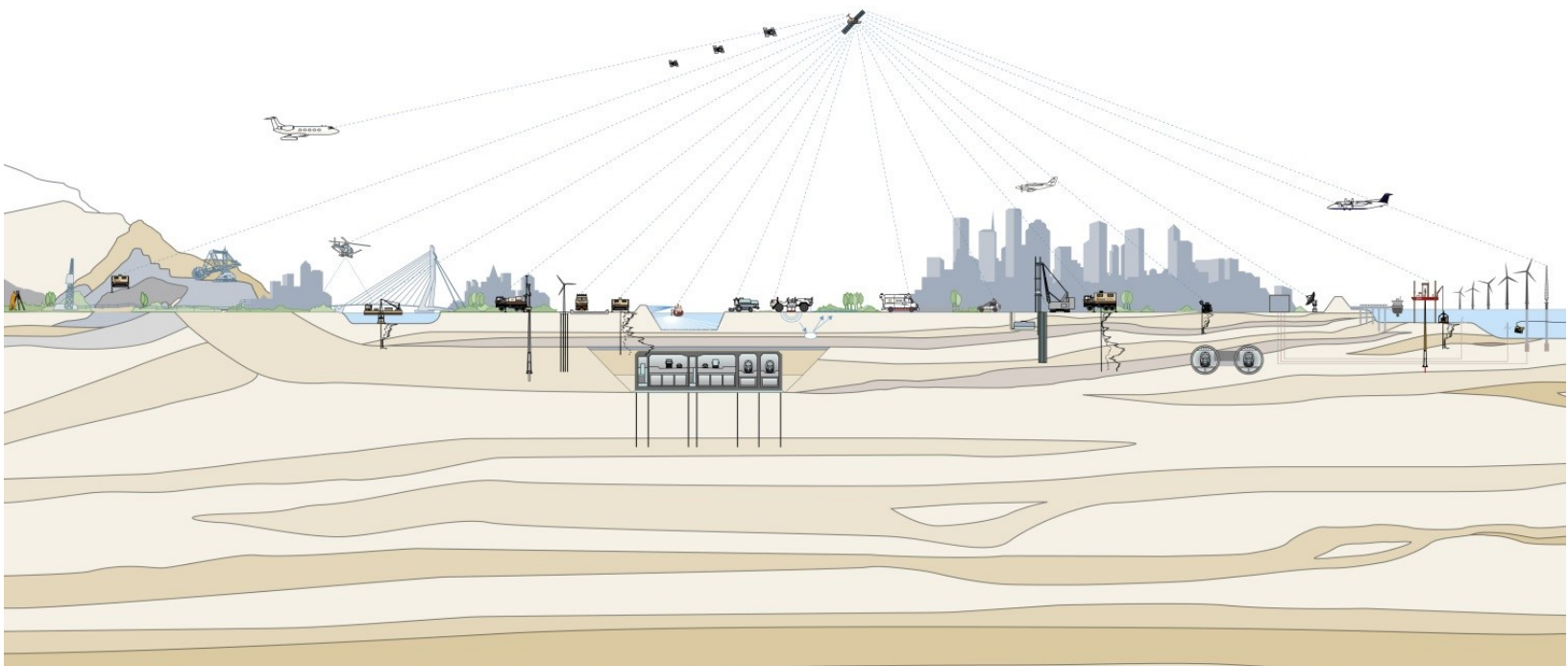
TX_Hurricane_2018_D18_Supplemental
Block 1

Prepared for:

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

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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 (check points against swaths covering Pilot AOI)

Raw Flight Lines	RMSE _z (non-vegetated)	NVA at 95-percent confidence level
Specification (cm)	≤ 10	≤ 19.6
Calculated Values (cm)	3.9	7.6
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>
<i>Calculated Values (m)</i>	<i>0.039</i>	<i>0.076</i>
Number of points	53	53

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 2: Accuracy of the Derived DEM – Block 1 (UTM14)

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)	3.7	7.2	18.9
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>	<i>≤ 0.294</i>
<i>Calculated Values (m)</i>	<i>0.037</i>	<i>0.072</i>	<i>0.189</i>
Number of points	53	53	33

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 larger than 50 square meters (m²). 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 33 flat open sample areas over the Block1 AOI. The results are shown in the table below, please also refer to:

Harvey_Block1_RA_Smooth_Surface_Repeatability_UTM14.shp

Table 3: Relative Vertical Accuracy, Smooth Surface Repeatability

RMSD _z (m)	Area (sq m)
0.0180	78.227
0.0190	172.26
0.0179	202.38
0.0189	1124.8
0.0197	104.64
0.0189	201.85
0.0188	232.37
0.0218	229.38
0.0204	425.78
0.0193	218.12
0.0165	326.34



0.0180	444.43
0.0189	225.26
0.0159	297.76
0.0193	314.7
0.0201	199.31
0.0178	134.74
0.0195	190.16
0.0196	223.42
0.0238	131.49
0.0179	147.7
0.0177	144.16
0.0159	109.54
0.0207	367.26
0.0203	242.77
0.0218	174.43
0.0222	126.38
0.0150	194.62
0.0198	159.32
0.0196	188.08
0.0218	274.78
0.0175	248.04
0.0170	366.87

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 project specifications. Consideration will be given for the effect of the expected isolated excursions over limits.

The result of the evaluation over 27 samples throughout Block 1 AOI is shown in the table below, please also refer to:

Harvey_Block1_RA_Swath_Overlap_UTM14.shp

Table 4: Relative Vertical Accuracy, Overlap Consistency

RMSDz (m)	Max_DZ (m)	Min_DZ (m)	Area (sq m)
0.0261	0.0669	-0.0344	1095.9
0.0359	0.1102	-0.0975	1809.2
0.0287	0.1016	-0.1019	883
0.0262	0.0935	-0.0881	1783
0.0216	0.0615	-0.0494	588.15
0.0380	0.1273	-0.0809	3052.3
0.0298	0.0414	-0.0760	943.09
0.0461	0.0116	-0.1219	2890.4
0.0370	0.0441	-0.1163	2118.7
0.0395	0.0527	-0.1388	743.05
0.0190	0.0278	-0.0532	1365.3
0.0680	0.1056	-0.0210	1209.6
0.0451	0.0348	-0.1080	1575.3
0.0206	0.0637	-0.1128	1142.1
0.0204	0.0224	-0.0667	822.32
0.0176	0.0587	-0.0324	658.39
0.0182	0.0516	-0.0547	1568.6
0.0455	0.1247	-0.0228	1096
0.0255	0.0711	-0.0575	651.53
0.0318	0.0574	-0.0861	2372.2
0.0399	0.1027	-0.0474	1060
0.0277	0.0196	-0.0636	600.75
0.0148	0.0309	-0.0432	548.36
0.0311	0.1408	-0.0518	1380
0.0178	0.0482	-0.0331	3359.9
0.0712	0.1027	0.0401	843.27
0.0159	0.0473	-0.0517	2230.4