



FUGRO GEOSPATIAL, INC.

Accuracy Report

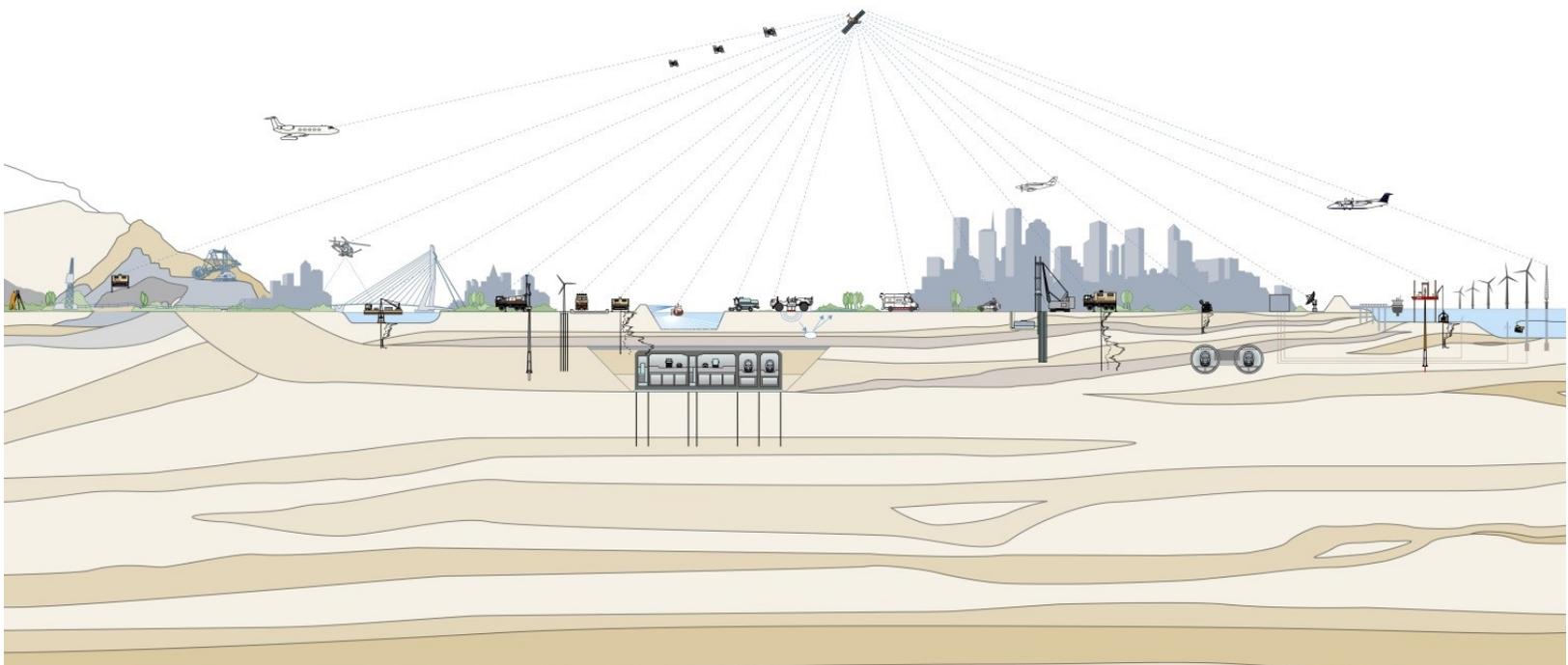
TX_Matagorda_Bay_2018_D18

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

Raw Flight Lines	$RMSE_z$ (non-vegetated)	NVA at 95-percent confidence level
Specification (cm)	≤ 10	≤ 19.6
Calculated Values (cm)	4.1	8.1
<i>Specification (m)</i>	≤ 0.100	≤ 0.196
<i>Calculated Values (m)</i>	0.041	0.081
Number of points	46	46

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 – 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)	3.5	6.8	23.6
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>	<i>≤ 0.294</i>
<i>Calculated Values (m)</i>	<i>0.035</i>	<i>0.068</i>	<i>0.236</i>
Number of points	36	36	17

Table 3: Accuracy of the Derived DEM – UTM15

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)	5	9.9	17.2
<i>Specification (m)</i>	<i>≤ 0.100</i>	<i>≤ 0.196</i>	<i>≤ 0.294</i>
<i>Calculated Values (m)</i>	<i>0.05</i>	<i>0.099</i>	<i>0.172</i>
Number of points	10	10	5

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 37 flat open sample areas over the AOI. The results are shown in the table below, please also refer to:

MB_Lidar_Relative_Accuracy-Smooth_Surface_Repeatability_UTM14.shp

Table 3: Relative Vertical Accuracy, Smooth Surface Repeatability

Area	RMSDz (m)
198.58 sq m	0.031775
93.794 sq m	0.030341
621.5 sq m	0.041992
418.06 sq m	0.037888
603.32 sq m	0.032919
573.16 sq m	0.032120
439.92 sq m	0.034224
163.46 sq m	0.039684
282.92 sq m	0.031834
434.33 sq m	0.030896
491.93 sq m	0.033045
510.98 sq m	0.024543
332.42 sq m	0.023808
343.29 sq m	0.034523
353.59 sq m	0.031979
349.22 sq m	0.031730
558.21 sq m	0.029538
186.37 sq m	0.029437
280.76 sq m	0.030300
166.9 sq m	0.031126
269.69 sq m	0.032668
389.93 sq m	0.031112
494.66 sq m	0.038576
580.73 sq m	0.040754
399.17 sq m	0.034888
366.9 sq m	0.045140
161.67 sq m	0.039746
212.77 sq m	0.040587
318 sq m	0.031070
228.79 sq m	0.028567
239.1 sq m	0.031306
272.38 sq m	0.033614
380.19 sq m	0.039193
543.04 sq m	0.044106
401.02 sq m	0.024101
545.06 sq m	0.023974
298.31 sq m	0.031315



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 28 samples throughout the AOI is shown in the table below, please also refer to:

MB_Lidar_Relative_Accuracy_Swath_Overlap_UTM14.shp

Table 4: Relative Vertical Accuracy, Overlap Consistency

RMSDz (m)	Max_DZ (m)	Min_DZ (m)	Area
0.0234	0.0768	-0.0774	1368.5 sq m
0.0253	0.1001	-0.0535	3595.6 sq m
0.0181	0.0743	-0.0597	5145.6 sq m
0.0264	0.0797	-0.0771	4639.8 sq m
0.0401	0.0882	-0.1310	9316.8 sq m
0.0312	0.1268	-0.1069	4441.6 sq m
0.0415	0.1316	-0.0913	2527.7 sq m
0.0330	0.0920	-0.0048	2252.8 sq m
0.0407	0.0947	-0.0142	4978.4 sq m
0.0250	0.1136	-0.0576	4557.7 sq m
0.0378	0.1139	-0.1082	1609.8 sq m
0.0496	0.0936	-0.1413	3484.9 sq m
0.0253	0.0618	-0.0899	4907.6 sq m

**USGS
ACCURACY REPORT**



0.0262	0.0906	-0.1341	7168.3 sq m
0.0521	0.1354	-0.0613	4724.5 sq m
0.0543	0.1334	-0.0472	2936.3 sq m
0.0305	0.0880	-0.0685	2108.1 sq m
0.0228	0.0879	-0.0913	7201 sq m
0.0343	0.1361	-0.1113	4130 sq m
0.0265	0.0802	-0.0814	3079.7 sq m
0.0256	0.0548	-0.0980	3391.4 sq m
0.0256	0.0577	-0.0795	4521.9 sq m
0.0477	0.0233	-0.0938	1339.8 sq m
0.0358	0.0914	-0.0705	3503 sq m
0.0369	0.1290	-0.1116	4527.3 sq m
0.0269	0.0742	-0.0749	2358 sq m
0.0209	0.0532	-0.0559	1909.8 sq m
0.0442	0.1166	-0.0418	940.43 sq m