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Using Terrasolid to Evaluate the Achievable Accuracy of Low-Cost Lidar Systems for Topographical Mapping

ASPRS Mid-South | April 20, 2023

Agenda

Section 1 | Error Budgets with Lidar

Section 2 | How to Test Accuracy with Lidar

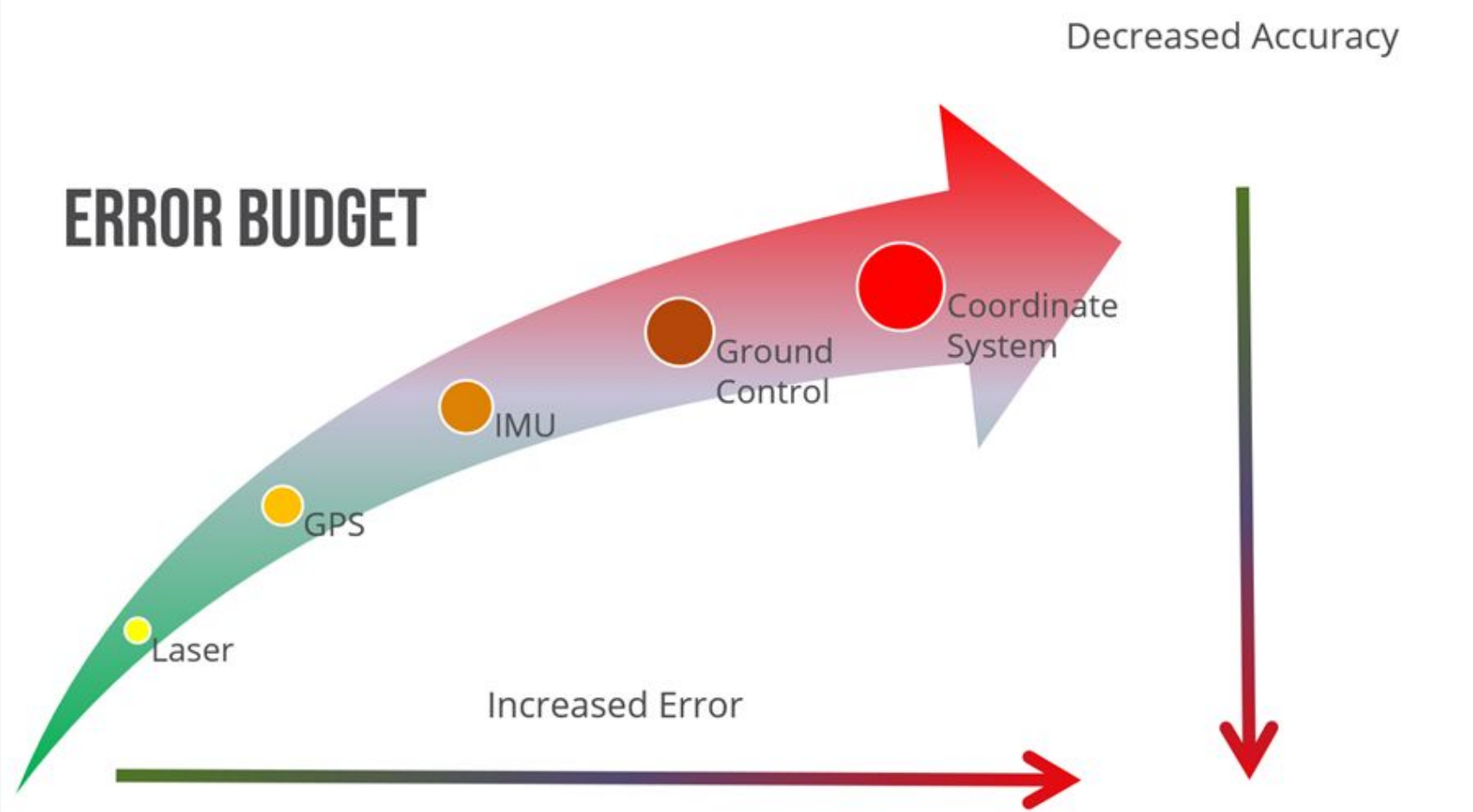
Section 3 | L1 Accuracy Performance Over Time

Section 4 | Project Level Accuracy Testing

Section 5 | Testing Conclusions

Section 1

Error Budgets with Lidar



Laser Precision Errors

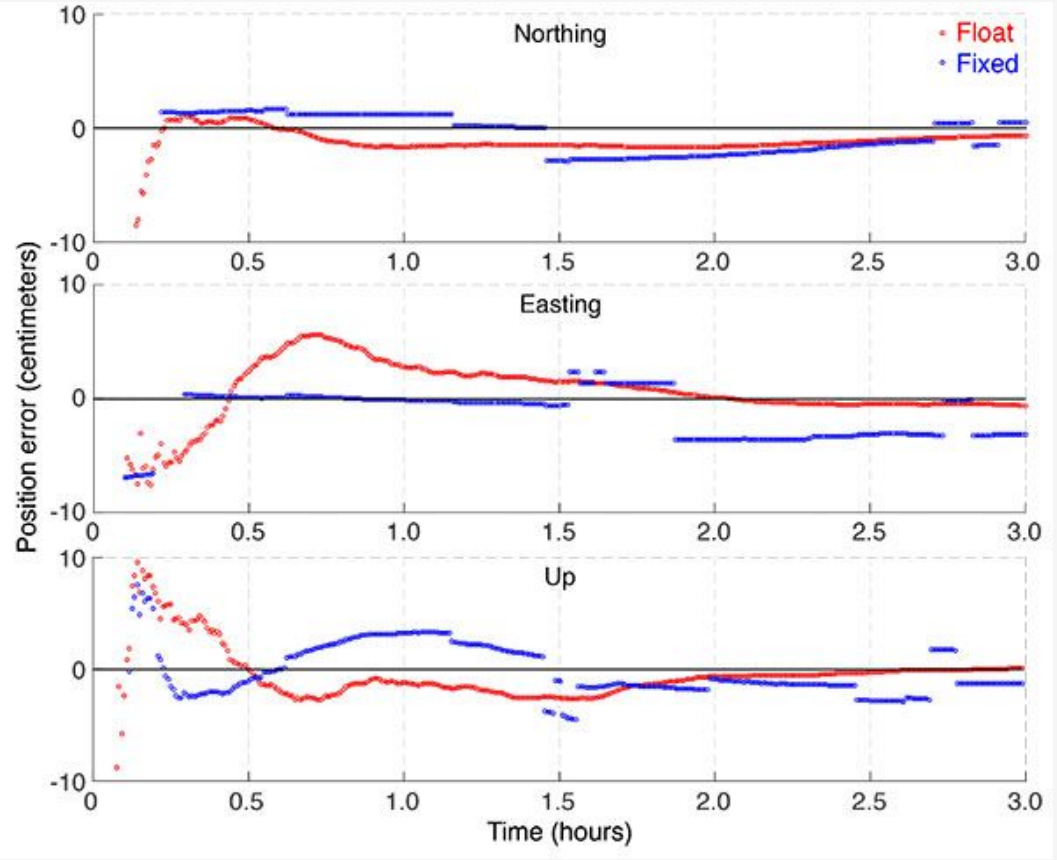
- Livox Avia Scanner has a precision of .78 inches (1.98 cm) at 65 feet (19.8 m).
- Linear Scale – the sensor only has a precision of 4.9 inches (12.446 cm) when flown at 400 feet (121.92 m).

Livox Avia Accuracy

Altitude (ft | m)	Laser Accuracy (in | cm)
100 ft | 30.48 m	1.2 | 3.048 cm
200 ft | 60.96 m	2.4 | 6.096 cm
300 ft | 121.92 m	4.9 | 12.446 cm

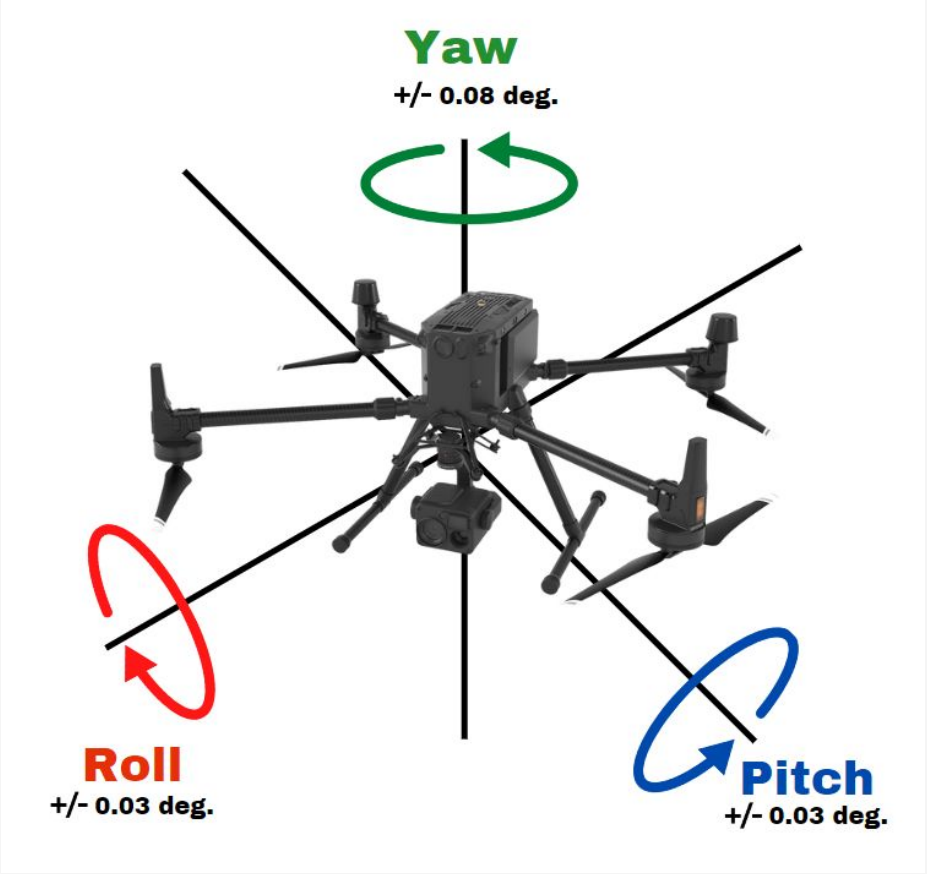
GNSS Accuracy Error

- GNSS systems will introduce positional error as low as 0.75 inches and as high as 30 meters.
- Precise location requires synchronization either in real-time (RTK) or in post processing (PPK) with a static GNSS observation for high accuracy positioning.



IMU and Optical Flow Sensor Errors

- Orientation errors are a function of the quality of the IMU
- The IMU in the L1 is a MEMS IMU
- The accuracy of the IMU is ~0.03 deg. in roll and pitch and 0.08 deg. in yaw
- Yaw drift can be a major source of error. The optical flow system helps correct this.
- The higher you fly, the greater your angle errors will become.



Sources of Error

- Every component of the system adds error to your system
- Total Potential Error is quite High
- It's important to have a testing process to address each source of error

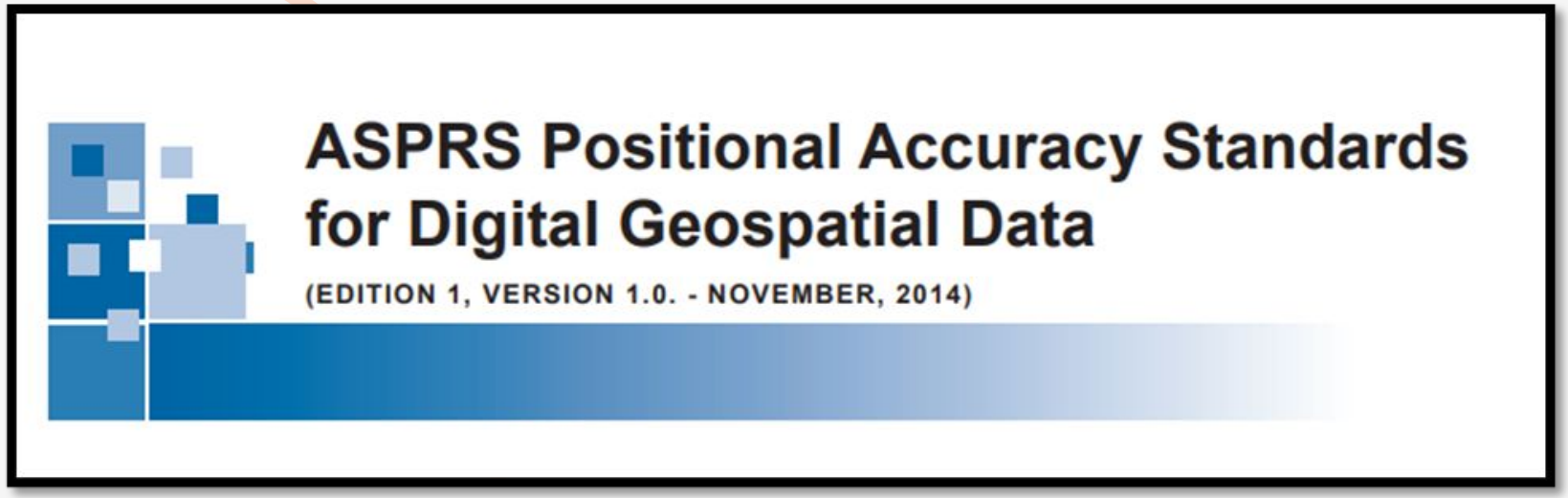
DJI L1 Sources of Error

Altitude (ft)	Laser Accuracy (in)	GPS Elevation Accuracy (in)	GPS Horizontal Accuracy (in)	IMU Horizontal Accuracy (in)	Total Potential Error Propagation (in)
100 ft | 30.48m	1.2	2.0	0.8	0.62 – 1.67	4.62 – 5.67
200 ft | 60.96m	2.4	2.0	0.8	1.25 – 3.35	6.45 – 8.55
400 ft | 121.92m	4.9	2.0	0.8	2.5 – 6.70	10.2 – 14.4

Section 2

How do we test Mapping Accuracies?

Historical Geospatial Accuracy Standards		
Agency	Standard	Year
U.S. Bureau of the Budget	National Map Accuracy Standards	1941
American Society of Photogrammetry and Remote Sensing	Accuracy Standards for Large-Scale Maps	1990
Federal Geographic Data Committee	National Standards for Spatial Data Accuracy	1998
United States Geological Survey	Lidar Base Specifications	2012
American Society of Photogrammetry and Remote Sensing	Positional Accuracy Standards for Geospatial Data	2014



ASPRS Vertical Accuracy/ Quality

Examples for Elevation Data (feet/meters)

ASPRS Tables B.7 – B.9 Vertical Accuracy/Quality Examples for Digital Elevation Data (feet/meters), Legacy Standards, and Recommended Point Densities

	Absolute Accuracy Class			Relative Accuracy (where applicable)			Contour interval comparisons		Point Density/Spacing	
Vertical Accuracy Class	RMSEz Non-Vegetated (ft | m)	NVA at 95% Confidence Level (ft | m)	VVA at 95th Percentile (ft | m)	Within-Swath Hard Surface Repeatability (Max Diff) (ft | m)	Swath-to-Swath Non-Veg Terrain (RMSDz) (ft | m)	Swath-to-Swath Non-Veg Terrain (Max Diff) (ft | m)	Equivalent Class 1 contour interval per ASPRS 1990 (ft | m)	Equivalent contour interval per NMAS (ft | m)	Rec. Minimum NPD (pls/m²)	Rec Maximum NPS (ft | m)
0.033ft | 0.010m	0.03 | 0.009	0.07 | 0.021	0.10 | 0.03	0.02 | 0.006	0.03 | 0.009	0.52 | 0.158	0.10 | 0.03	0.11 | 0.033	≥20	≤ 0.72 | ≤ 0.219
0.082ft | 0.024m	0.08 | 0.024	0.16 | 0.048	0.25 | 0.076	0.05 | 0.015	0.07 | 0.021	0.13 | 0.039	0.23 | 0.70	0.27 | 0.082	16.00	0.82 | 0.249
0.164ft | 0.049m	0.16 | 0.048	0.32 | 0.097	0.49 | 0.149	0.10 | 0.03	0.13 | 0.039	0.26 | 0.079	0.49 | 0.149	0.54 | 0.164	8.00	1.15 | 0.350
0.328ft | 0.099m	0.33 | 0.100	0.64 | 0.195	0.98 | 0.298	0.20 | 0.06	0.26 | 0.079	0.53 | 0.161	0.98 | 0.298	1.08 | 0.329	2.00	2.33 | 0.710
0.492ft | 0.149m	0.49 | 0.149	0.99 | 0.301	1.48 | 0.451	0.30 | 0.09	0.39 | 0.118	0.76 | 0.231	1.48 | 0.451	1.62 | 0.493	1.00	3.28 | 0.999
0.656ft | 0.199m	0.66 | 0.201	1.29 | 0.392	1.97 | 0.6	0.39 | 0.118	0.52 | 0.158	1.05 | 0.320	1.97 | 0.600	2.16 | 0.658	0.50	4.59 | 1.399
1.092ft | 0.332m	1.09 | 0.332	2.15 | 0.652	3.28 | 0.999	0.66 | 0.201	0.88 | 0.268	1.75 | 0.553	3.28 | 0.999	3.59 | 1.094	0.25	6.56 | 1.999

“Standard Grade”

- A naming convention is required to allow for better conversations regarding desired accuracy outcomes.
- Most mapping products in the United States are designed to meet this accuracy/quality

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“Max Grade”

- Sometimes referred to as “design grade” or ”survey grade” (both are terrible names).
- Very few remote sensing products in the United States meet this accuracy/quality

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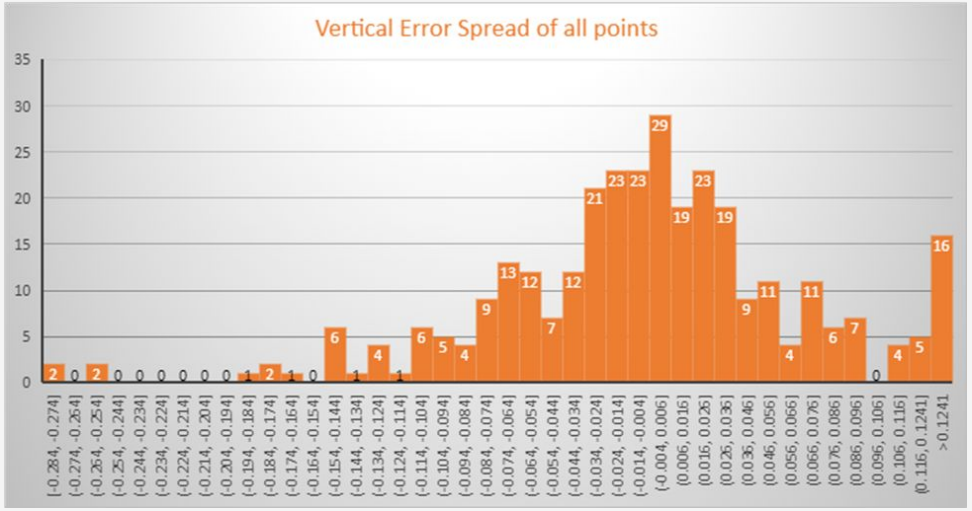
Section 3

L1 accuracy performance over time

- All project listed utilized digitally leveled control with a vertical accuracy of ~0.01ft.
- All projects were ground classified using the Terrasolid L1 Wizard



Project Name	Date Flown	Units (ft/meters)	Project RMSEz	Project Min	Project Max	Std Deviation
Lg Pump Station	20220707	ft	0.0103	-0.0143	0.0133	0.0118
Mohawk Park	20200114	ft	0.0206	-0.0319	0.021	0.0238
Nelson WWTP	20220325	ft	0.0316	-0.0548	0.0364	0.0346
KTA F3	20211214	ft	0.0322	-0.059	0.0602	0.033
KTA F1	20211214	ft	0.0323	-0.0653	0.075	0.033
Evergy Olathe	20220615	ft	0.0397	-0.0719	0.0399	0.0443
PBI Gordon	20220506	ft	0.0399	-0.0611	0.0382	0.0444
TTL Patterson	20220801	ft	0.0426	-0.0476	0.0697	0.0467
Route 2	20220812	ft	0.045	-0.07	0.088	0.046
Chanute Bridge	20220913	ft	0.0455	-0.0512	0.0733	0.0525
TTL Jefferson	20220802	ft	0.0495	-0.0654	0.0734	0.0553
Leander Water Improvement	20220516	ft	0.052	-0.0825	0.063	0.0556
KDOT Sedgwick Butler	20220703	ft	0.0525	-0.0843	0.0894	0.0531
Sar-Ko-Par	20211006	ft	0.056	-0.056	0.111	0.061
TTL Texarkana	20220801	ft	0.0625	-0.0786	0.1217	0.0667
KTA F2	20211214	ft	0.0632	-0.0893	0.2223	0.0644
Stormy Hollow	20220823	ft	0.0665	-0.1312	0.067	0.0718
McIntyre Sewer	20211102	ft	0.068	-0.148	0.124	0.07
123rd Street Olathe	20220706	ft	0.068	-0.091	0.153	0.07
Southbridge Apartment Site 2	20220606	ft	0.0691	-0.1375	0.0618	0.0745
Belvidere IL	20220920	ft	0.0696	-0.0952	0.0919	0.075
Henry Atlanta GA	20220810	ft	0.074	-0.152	0.119	0.076
83rd St	20220328	ft	0.0755	-0.1192	0.1204	0.08
SJRWP Houston M1	20220218	ft	0.0773	-0.1315	0.155	0.0826
Four County TLine	20220308	ft	0.0783	-0.144	0.0952	0.0875
158th and State	20220901	ft	0.079	-0.0881	0.1574	0.0852
Tonganoxi Detention Basin	20220527	ft	0.0806	-0.113	0.0913	0.093
Southbridge Apartment Site 1	20220606	ft	0.0832	-0.125	0.1472	0.0911
SJRWP Houston M3	20220511	ft	0.0838	-0.1508	0.1465	0.0863
New Century Basins	20220209	ft	0.122	-0.1412	0.2073	0.1364
SJRWP Houston M2	20220429	ft	0.1387	-0.2604	0	0.0897
Walla Walla Kellogg Hollow	20220311	ft	0.1428	-0.1841	0.1911	0.1505
Basehor Civic Campus	20220215	ft	0.1852	-0.2783	0.2251	0.1979
Basehor Pump Station	20220215	ft	0.2297	-0.2841	0.3437	0.2652
		Min (ft)	0.010	-0.284	0.000	0.012
		Max (ft)	0.230	-0.014	0.344	0.265
		Median (ft)	0.067	-0.090	0.092	0.070
		Mean (ft)	0.073	-0.111	0.109	0.077

Accuracy Over Time Conclusion

Vertical accuracies suitable for “standard grade” and in some cases suitable for “max grade” topo.

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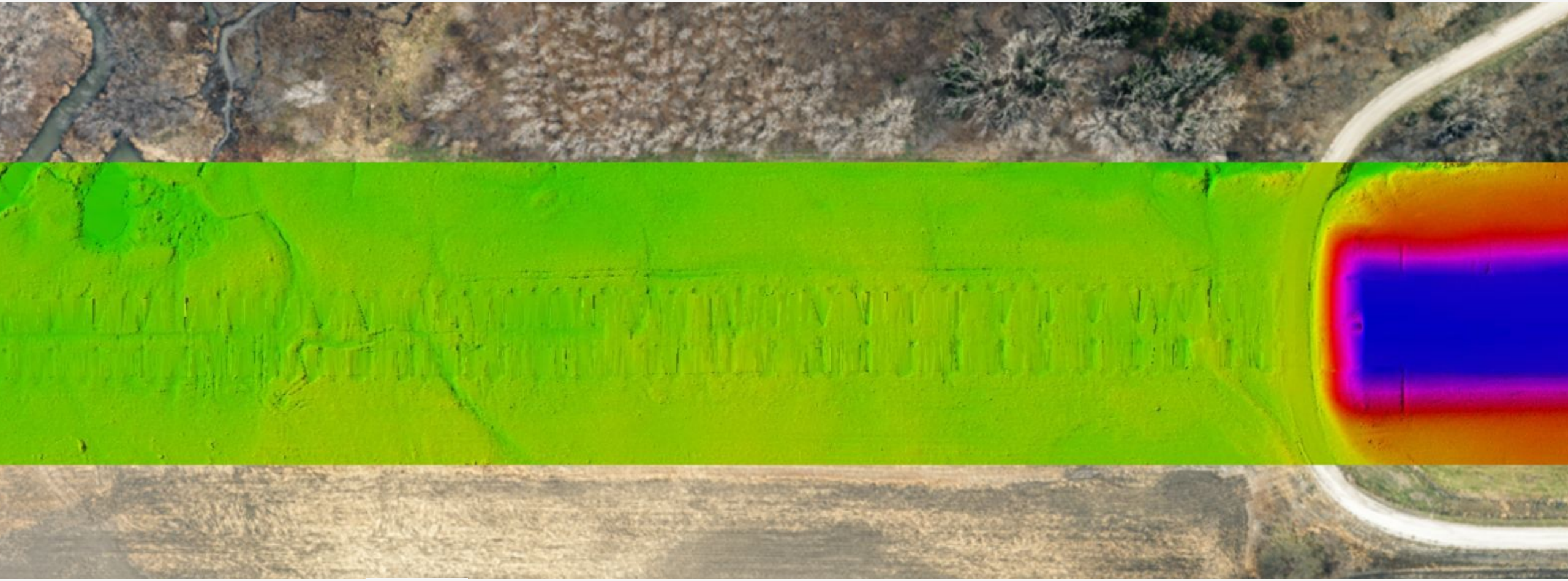
Section 4

Project Level Testing



Testing Matrix

- DJI Zenmuse L1 - 3 flights with different mission profiles
- 10 control points were collected
- 30 ground validation points were collected for absolute accuracy assessment
- Mobile Lidar and Photogrammetry were collected at the same time
- All remote sensing data was collected in the same day and survey was collected within a week.

Mission Description	Altitude	Scan pattern	Pulse Repetition Rate	Speed
Flight 1	200	Repetitive	160	10 m/s
Flight 2	100	Repetitive	160	10 m/s
Flight 3	200	Non-Repetitive	240	10 m/s

All 3 Flights are Suitable for “Standard Grade”
2 Flights suitable for “Max Grade” Topo

Flight 1 Ground Checks Z Debias only				
Number	Easting	Northing	Known Z	DZ
1	9571859.129	263217.19	1132.379	-0.022
2	9571554.007	262590.136	1126.948	0.034
3	9571258.043	262134.009	1128.451	-0.022
4	9570426.334	260559.812	1129.23	-0.018
5	9570123.529	260098.069	1129.329	-0.027
6	9569803.173	259537.407	1132	-0.017
7	9569809.768	259470.506	1133.1	-0.064
8	9570066.434	259914.915	1130.416	-0.065
9	9570378.755	260391.009	1128.548	-0.029
10	9571196.058	261935.696	1129.392	-0.009
11	9571522.449	262442.442	1126.773	-0.003
12	9571814.101	263041.493	1129.36	0.003
20	9571248.08	262117.622	1128.501	0.025
21	9571192.59	262013.752	1128.921	0.034
22	9571189.701	261926.361	1129.356	0.021
23	9571244.09	261944.952	1128.926	0.023
24	9571319.951	262077.757	1128.606	0.034
25	9570382.963	260559.341	1128.83	0.002
26	9570402.3	260498.624	1129.015	-0.019
27	9570309.973	260355.696	1128.945	-0.022
28	9570268.19	260188.261	1128.935	0.021
29	9570157.922	259998.164	1130.665	0.022
30	9570359.586	260716.919	1110.194	0.075
Minimum	-0.0653			
Maximum	0.075			
Average	-0.0009			
Average magnitude	0.0265			
Root mean square	0.0323			
Std deviation	0.033			

Flight 2 Ground Checks Z Debias only				
Number	Easting	Northing	Known Z	DZ
1	9571859.129	263217.19	1132.379	0.023
2	9571554.007	262590.136	1126.948	0.005
3	9571258.043	262134.009	1128.451	-0.008
4	9570426.334	260559.812	1129.23	-0.013
5	9570123.529	260098.069	1129.329	-0.031
6	9569803.173	259537.407	1132	-0.074
7	9569809.768	259470.506	1133.1	-0.073
8	9570066.434	259914.915	1130.416	0.008
9	9570378.755	260391.009	1128.548	0.031
10	9571196.058	261935.696	1129.392	0.018
11	9571522.449	262442.442	1126.773	-0.001
12	9571814.101	263041.493	1129.36	0.071
20	9571248.08	262117.622	1128.501	-0.004
21	9571192.59	262013.752	1128.921	-0.064
22	9571189.701	261926.361	1129.356	0.032
23	9571244.09	261944.952	1128.926	-0.051
24	9571319.951	262077.757	1128.606	0.027
25	9570382.963	260559.341	1128.83	-0.007
26	9570402.3	260498.624	1129.015	-0.019
27	9570309.973	260355.696	1128.945	-0.089
28	9570268.19	260188.261	1128.935	0.016
29	9570157.922	259998.164	1130.665	0.079
30	9570359.586	260716.919	1110.194	0.222
Minimum	-0.0893			
Maximum	0.2223			
Average	0.0043			
Average magnitude	0.042			
Root mean square	0.0632			
Std deviation	0.0644			

Flight 3 Ground Checks Z Debias only				
Number	Easting	Northing	Known Z	DZ
1	9571859.129	263217.19	1132.379	0.05
2	9571554.007	262590.136	1126.948	-0.004
3	9571258.043	262134.009	1128.451	-0.028
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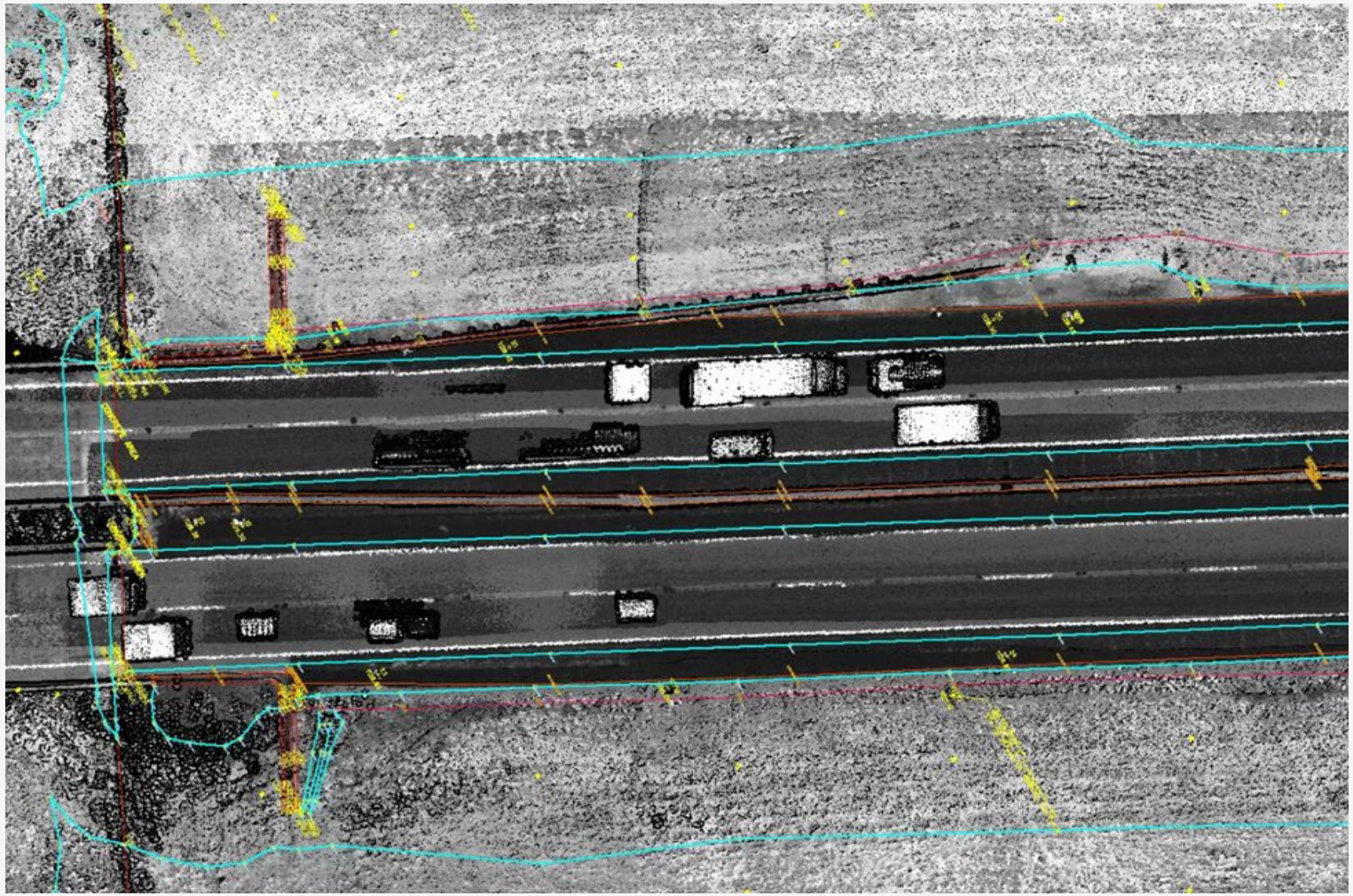
10	9571196.058	261935.696	1129.392	0.015
11	9571522.449	262442.442	1126.773	0.034
12	9571814.101	263041.493	1129.36	-0.037
20	9571248.08	262117.622	1128.501	0.005
21	9571192.59	262013.752	1128.921	0.01
22	9571189.701	261926.361	1129.356	-0.002
23	9571244.09	261944.952	1128.926	-0.009
24	9571319.951	262077.757	1128.606	0.043
25	9570382.963	260559.341	1128.83	-0.012
26	9570402.3	260498.624	1129.015	-0.024
27	9570309.973	260355.696	1128.945	-0.032
28	9570268.19	260188.261	1128.935	0.025
29	9570157.922	259998.164	1130.665	0.06
30	9570359.586	260716.919	1110.194	0.056
Minimum	-0.059			
Maximum	0.0602			
Average	0.0001			
Average magnitude	0.0263			
Root mean square	0.0322			
Std deviation	0.033			

Conventional Survey Comparison



Initial Results are Excellent

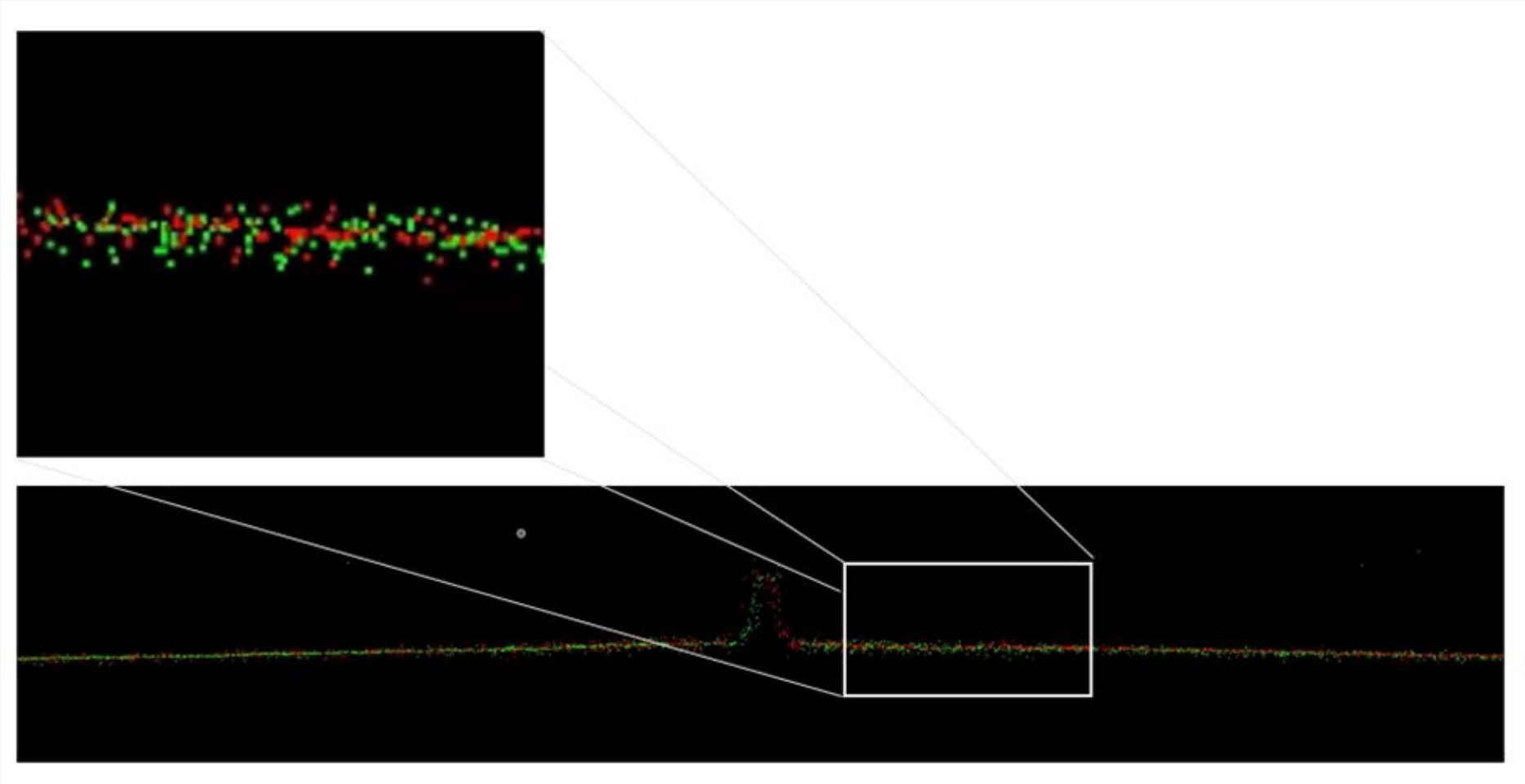
- RMSEz for each project was 5 hundredths of a foot or below
- These results indicate that the DJI L1 is suitable for producing “standard grade” and max grade topo
- However, there are more metrics that need to be looked at – Relative Accuracies

Flight 1: 176 surveyed points	
Average dz	-0.005
Minimum dz	-0.099
Maximum dz	0.107
Average magnitude	0.035
Root mean square	0.044
Std deviation	0.044

Flight 2: 176 surveyed points	
Average dz	-0.005
Minimum dz	-0.23
Maximum dz	0.114
Average magnitude	0.037
Root mean square	0.05
Std deviation	0.05

Flight 3: 176 surveyed points	
Average dz	0.002
Minimum dz	-0.263
Maximum dz	0.107
Average magnitude	0.031
Root mean square	0.043
Std deviation	0.043

Relative Fit is Noisy



Effective Lidar Macros

- Terrasolid is the most trusted Lidar processing software in the world
- Terrasolid has developed processing wizards designed with the L1 to achieve optimal results

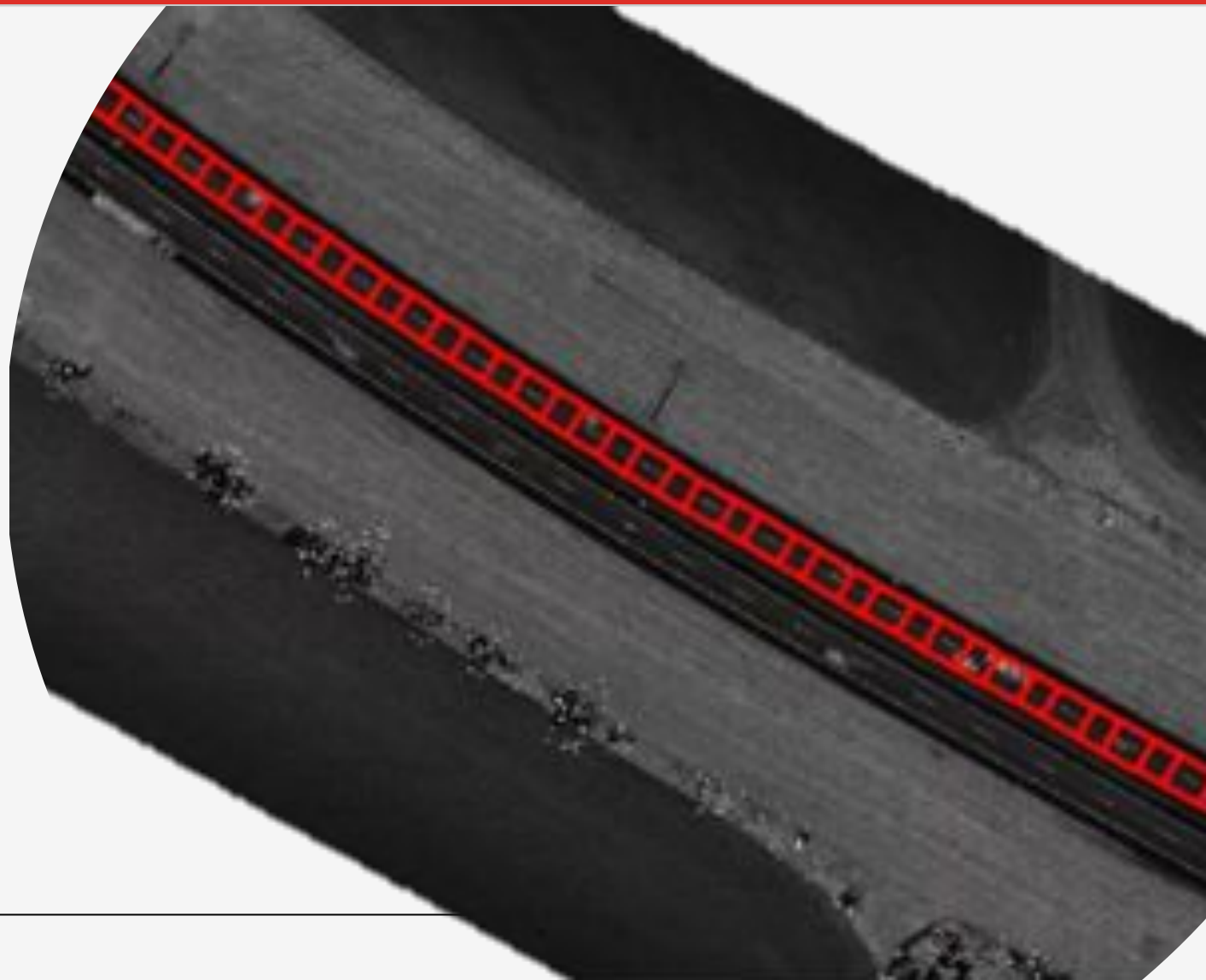
Testing Laser Precision using a Planar Fit Model

- The 3 flights were divided into two groups
- Group 1 – all unclassified points
- Group 2 – ran Terrasolid's L1 classification wizard to separate estimated ground points

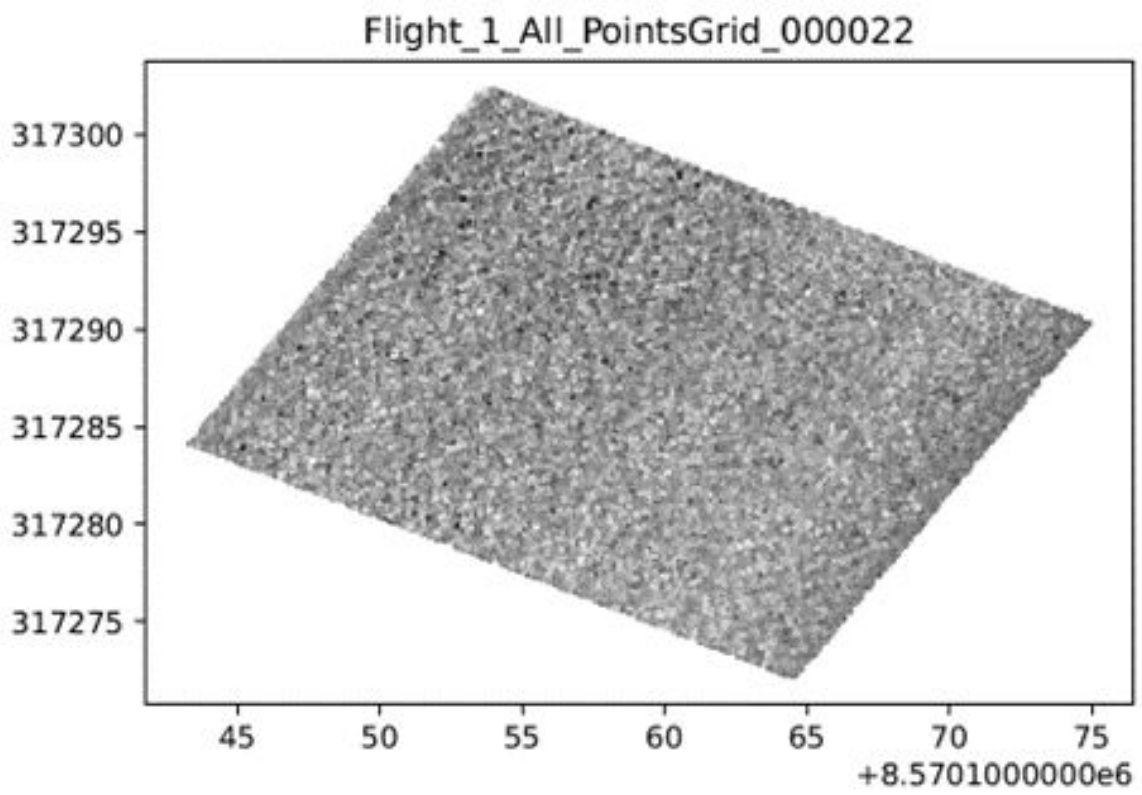
Mission Description	Altitude	Scan pattern
Flight 1 All Points	200	Repetitive
Flight 2 All Points	100	Repetitive
Flight 3 All Points	200	Non-Repetitive
Flight 1 Ground Points	200	Repetitive
Flight 2 Ground Points	100	Repetitive
Flight 3 Ground Points	200	Non-Repetitive

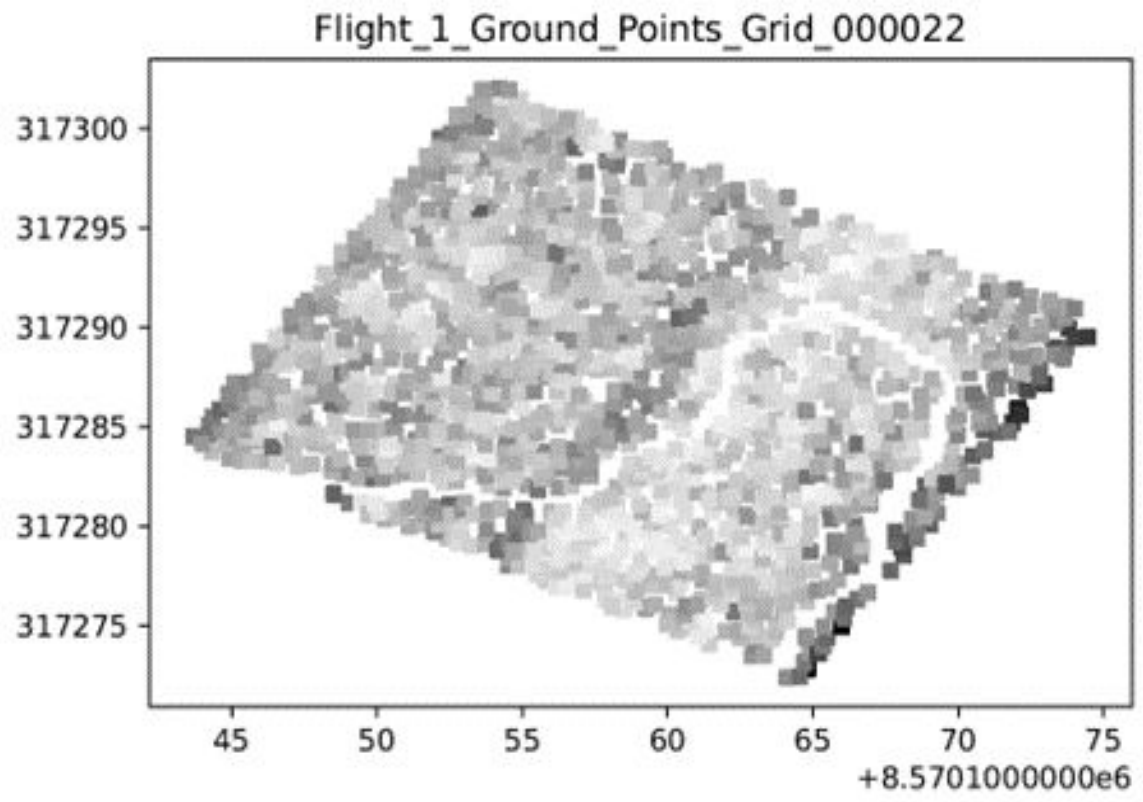
Planar Fitting Analysis

- To test within-swath relative accuracy, planar features were selected
- The distance from plane to points was calculated and plotted on a histogram

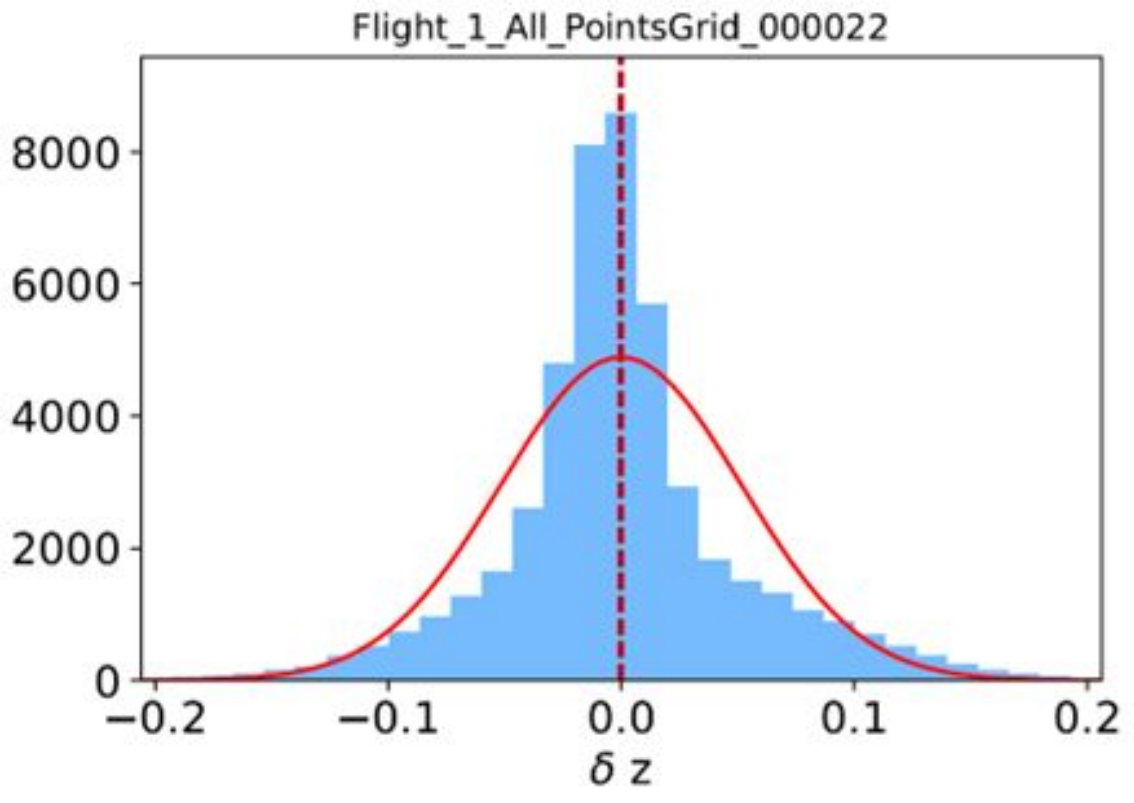


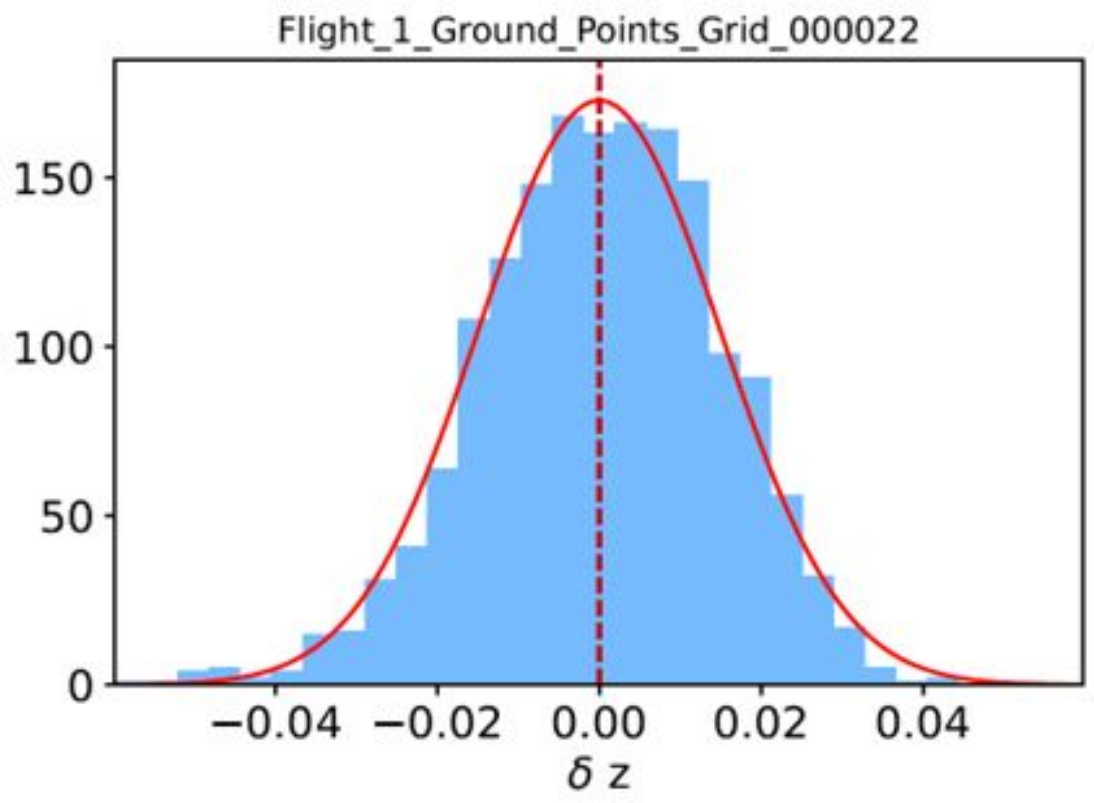
Example / Planar Fit Model



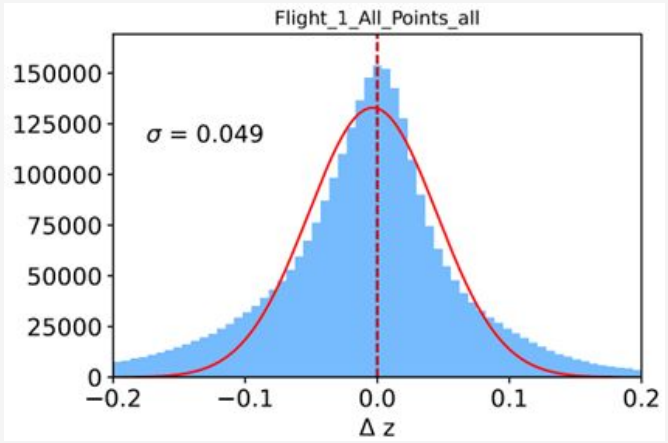


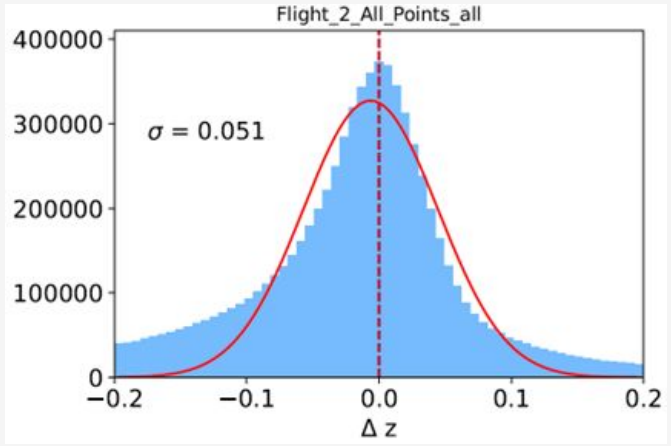
Unclassified Points vs. Ground Classified Points

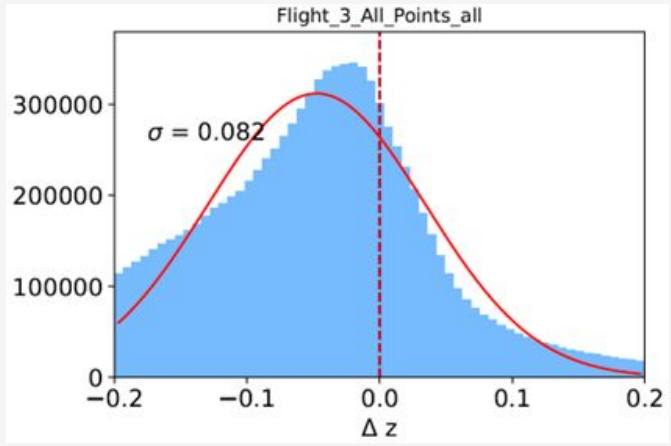


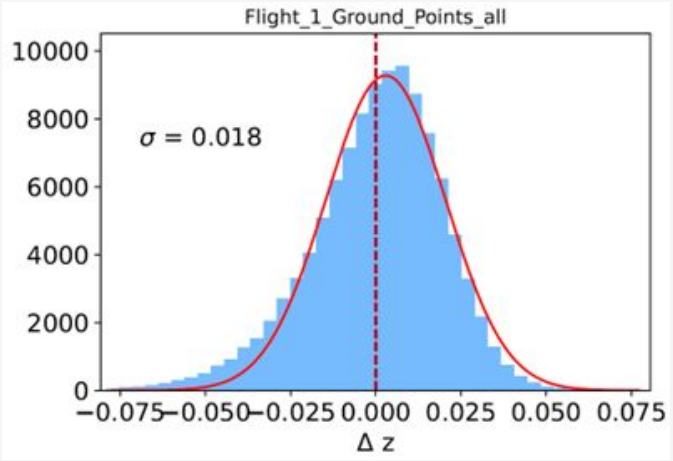


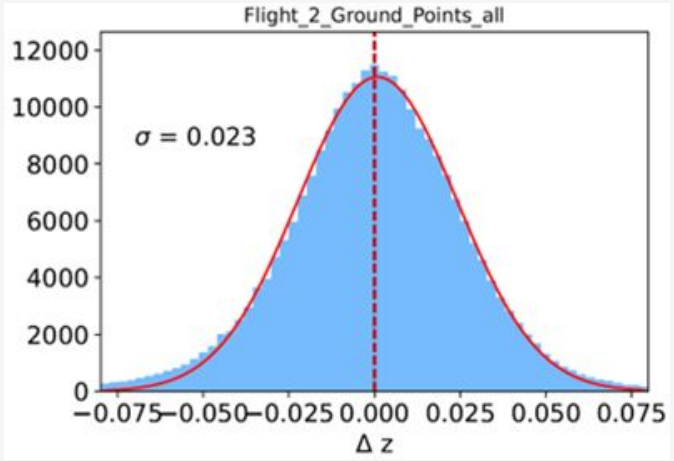
A Favorable Pattern Begins to Emerge

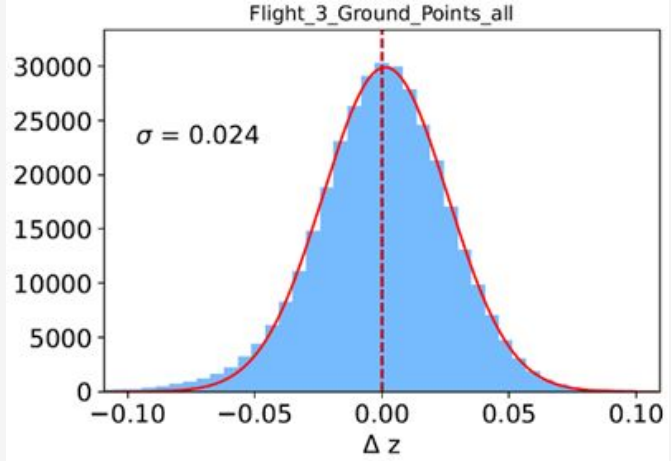












5x Improvements on Planar Fitting using Terrasolid's L1 Processing Wizard

ASPRS Tables B.7 – B.9 Vertical Accuracy/Quality Examples for Digital Elevation Data (feet/meters), Legacy Standards, and Recommended Point Densities

Vertical Accuracy Class	Absolute Accuracy Class			Relative Accuracy (where applicable)			Contour interval comparisons		Point Density/Spacing	
	RMSEz Non-Vegetated (ft | m)	NVA at 95% Confidence Level (ft | m)	VVA at 95th Percentile (ft | m)	Within-Swath Hard Surface Repeatability (Max Diff) (ft | m)	Swath-to-Swath Non-Veg Terrain (RMSDz) (ft | m)	Swath-to-Swath Non-Veg Terrain (Max Diff) (ft | m)	Equivalent Class 1 contour interval per ASPRS 1990 (ft | m)	Equivalent contour interval per NMAS (ft | m)	Rec. Minimum NPD (pls/m^2)	Rec Maximum NPS (ft | m)
0.033ft | 0.010m	0.03 | 0.009	0.07 | 0.021	0.10 | 0.03	0.02 | 0.006	0.03 | 0.009	0.52 | 0.158	0.10 | 0.03	0.11 | 0.033	≥20	≤ 0.72 | ≤ 0.219
0.082ft | 0.024m	0.08 | 0.024	0.16 | 0.048	0.25 | 0.076	0.05 | 0.015	0.07 | 0.021	0.13 | 0.039	0.23 | 0.70	0.27 | 0.082	16.00	0.82 | 0.249
0.164ft | 0.049m	0.16 | 0.048	0.32 | 0.097	0.49 | 0.149	0.10 | 0.03	0.13 | 0.039	0.26 | 0.079	0.49 | 0.149	0.54 | 0.164	8.00	1.15 | 0.350
0.328ft | 0.099m	0.33 | 0.100	0.64 | 0.195	0.98 | 0.298	0.20 | 0.06	0.26 | 0.079	0.53 | 0.161	0.98 | 0.298	1.08 | 0.329	2.00	2.33 | 0.710
0.492ft | 0.149m	0.49 | 0.149	0.99 | 0.301	1.48 | 0.451	0.30 | 0.09	0.39 | 0.118	0.76 | 0.231	1.48 | 0.451	1.62 | 0.493	1.00	3.28 | 0.999
0.656ft | 0.199m	0.66 | 0.201	1.29 | 0.392	1.97 | 0.6	0.39 | 0.118	0.52 | 0.158	1.05 | 0.320	1.97 | 0.600	2.16 | 0.658	0.50	4.59 | 1.399
1.092ft | 0.332m	1.09 | 0.332	2.15 | 0.652	3.28 | 0.999	0.66 | 0.201	0.88 | 0.268	1.75 | 0.553	3.28 | 0.999	3.59 | 1.094	0.25	6.56 | 1.999

Section 5

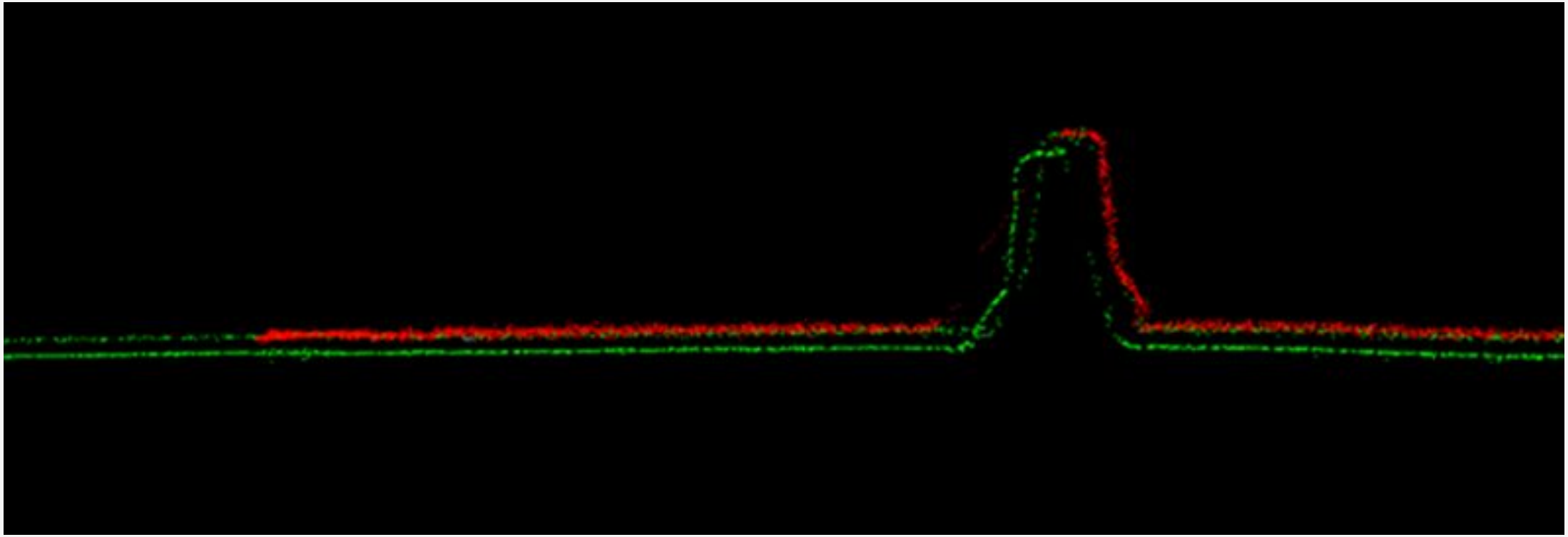
Testing Conclusions

In swath analysis conclusion

In our testing, the DJI Zenmuse L1 meets ASPRS's spec for "Standard Grade", but not "Max Grade" Data.

Swath to Swath Fit

- Swath to Swath analysis helps us to understand how well the inertial navigation system (INS) performed.
- IMU and GPS inaccuracies have the potential to create large misalignments.



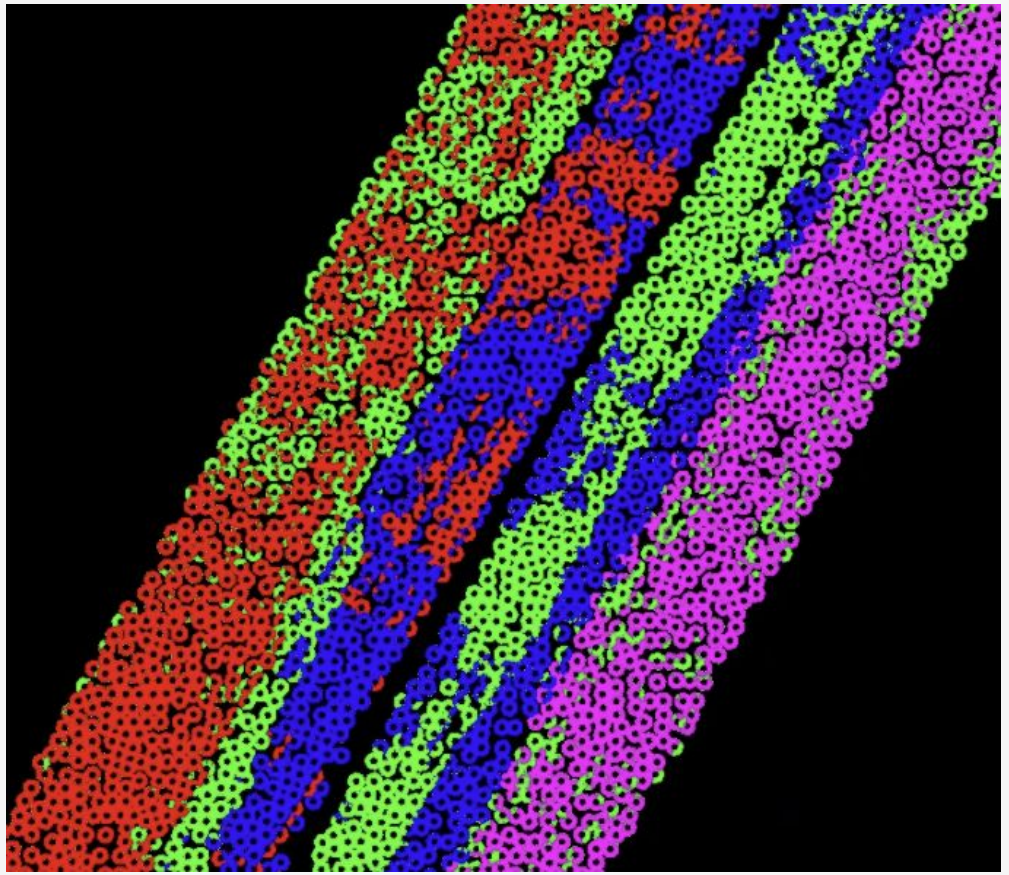
Relative Swath to Swath Analysis Accuracy Requirements

ASPRS Tables B.7 – B.9 Vertical Accuracy/Quality Examples for Digital Elevation Data (feet/meters), Legacy Standards, and Recommended Point Densities

	Absolute Accuracy Class			Relative Accuracy (where applicable)			Contour interval comparisons		Point Density/Spacing	
Vertical Accuracy Class	RMSEz Non-Vegetated (ft | m)	NVA at 95% Confidence Level (ft | m)	VVA at 95th Percentile (ft | m)	Within-Swath Hard Surface Repeatability (Max Diff) (ft | m)	Swath-to-Swath Non-Veg Terrain (RMSDz) (ft | m)	Swath-to-Swath Non-Veg Terrain (Max Diff) (ft | m)	Equivalent Class 1 contour interval per ASPRS 1990 (ft | m)	Equivalent contour interval per NMAS (ft | m)	Rec. Minimum NPD (pls/m²)	Rec Maximum NPS (ft | m)
0.033ft | 0.010m	0.03 | 0.009	0.07 | 0.021	0.10 | 0.03	0.02 | 0.006	0.03 | 0.009	0.52 | 0.158	0.10 | 0.03	0.11 | 0.033	≥20	≤ 0.72 | ≤ 0.219
0.082ft | 0.024m	0.08 | 0.024	0.16 | 0.048	0.25 | 0.076	0.05 | 0.015	0.07 | 0.021	0.13 | 0.039	0.23 | 0.70	0.27 | 0.082	16.00	0.82 | 0.249
0.164ft | 0.049m	0.16 | 0.048	0.32 | 0.097	0.49 | 0.149	0.10 | 0.03	0.13 | 0.039	0.26 | 0.079	0.49 | 0.149	0.54 | 0.164	8.00	1.15 | 0.350
0.328ft | 0.099m	0.33 | 0.100	0.64 | 0.195	0.98 | 0.298	0.20 | 0.06	0.26 | 0.079	0.53 | 0.161	0.98 | 0.298	1.08 | 0.329	2.00	2.33 | 0.710
0.492ft | 0.149m	0.49 | 0.149	0.99 | 0.301	1.48 | 0.451	0.30 | 0.09	0.39 | 0.118	0.76 | 0.231	1.48 | 0.451	1.62 | 0.493	1.00	3.28 | 0.999
0.656ft | 0.199m	0.66 | 0.201	1.29 | 0.392	1.97 | 0.6	0.39 | 0.118	0.52 | 0.158	1.05 | 0.320	1.97 | 0.600	2.16 | 0.658	0.50	4.59 | 1.399
1.092ft | 0.332m	1.09 | 0.332	2.15 | 0.652	3.28 | 0.999	0.66 | 0.201	0.88 | 0.268	1.75 | 0.553	3.28 | 0.999	3.59 | 1.094	0.25	6.56 | 1.999

Swath to Swath Quantitative Analysis Methodology

- Using TerraMath, planar tie lines were collected between flight lines to measure mismatch
- RMSDz and Max Difference was measured in each mission



Swath to Swath Quantitative Analysis Results

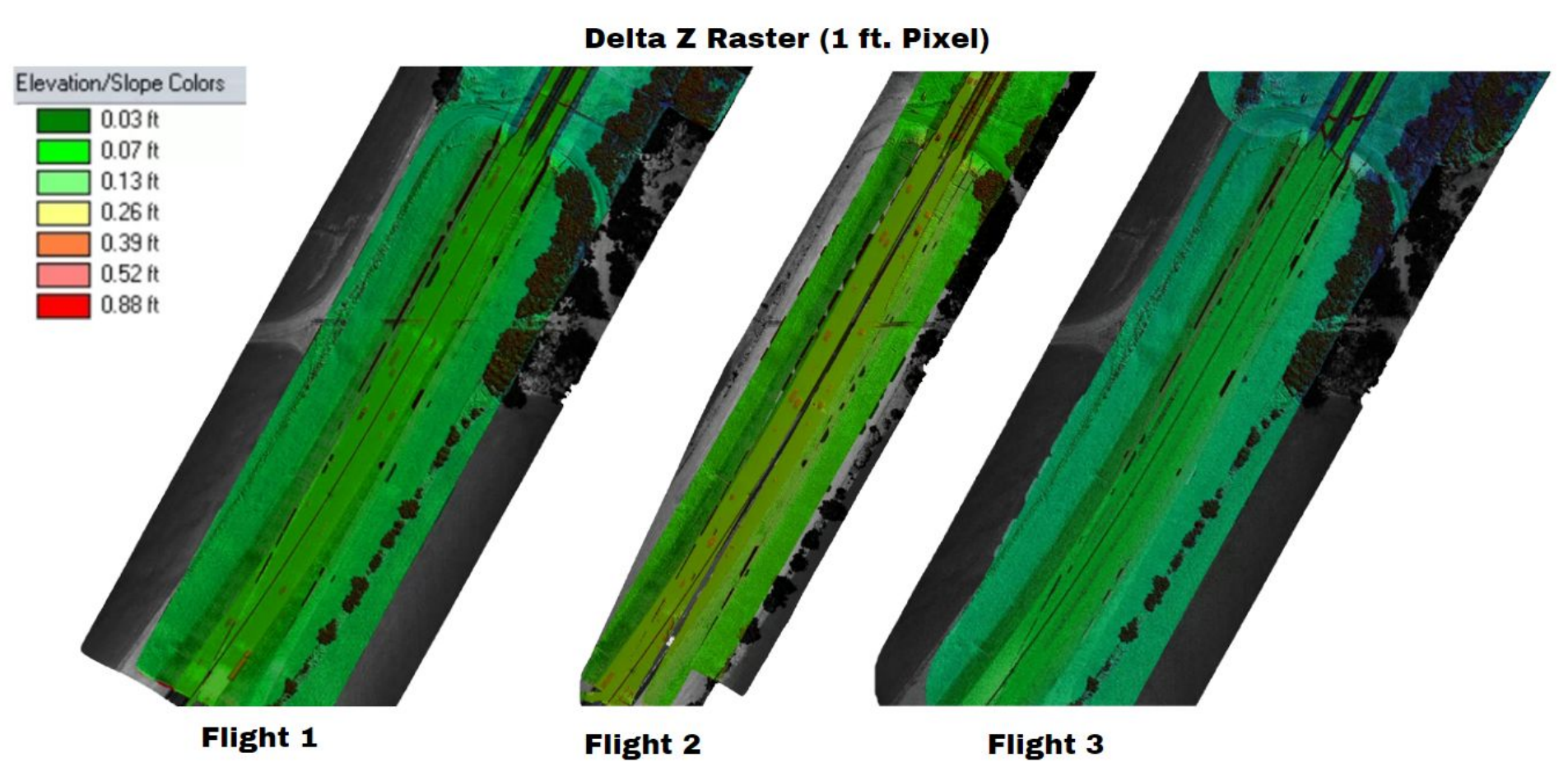
Flight 1		
RMSDz (ft | m)	0.032	0.010
Average Mismatch (ft | m)	0.022	0.007
Maximum Mismatch (ft | m)	0.308	0.094

Flight 2		
RMSDz (ft | m)	0.029	0.009
Average Mismatch (ft | m)	0.02	0.006
Maximum Mismatch (ft | m)	0.587	0.179

Flight 3		
RMSDz (ft | m)	0.031	0.009
Average Mismatch (ft | m)	0.021	0.006
Maximum Mismatch (ft | m)	0.406	0.124

Relative Accuracy (where applicable)		
Within-Swath Hard Surface Repeatability (Max Diff) (ft | m)	Swath-to-Swath Non-Veg Terrain (RMSDz) (ft | m)	Swath-to-Swath Non-Veg Terrain (Max Diff) (ft | m)
0.02 | 0.006	0.03 | 0.009	0.05 | 0.016
0.05 | 0.015	0.07 | 0.021	0.13 | 0.039
0.10 | 0.03	0.13 | 0.039	0.26 | 0.079
0.20 | 0.06	0.26 | 0.079	0.53 | 0.161

Swath to Swath Quantitative Results



Full Data Analysis Conclusions

- Not perfect, but MORE than acceptable to produce “Standard Grade” based on ASPRS specification
- When utilizing lasers of this precision, proper ground filtering (as provided by Terrasolid) is a necessity
- Testing standards need to address laser precision vs. derived produce precision for new generation of Lidar system

References

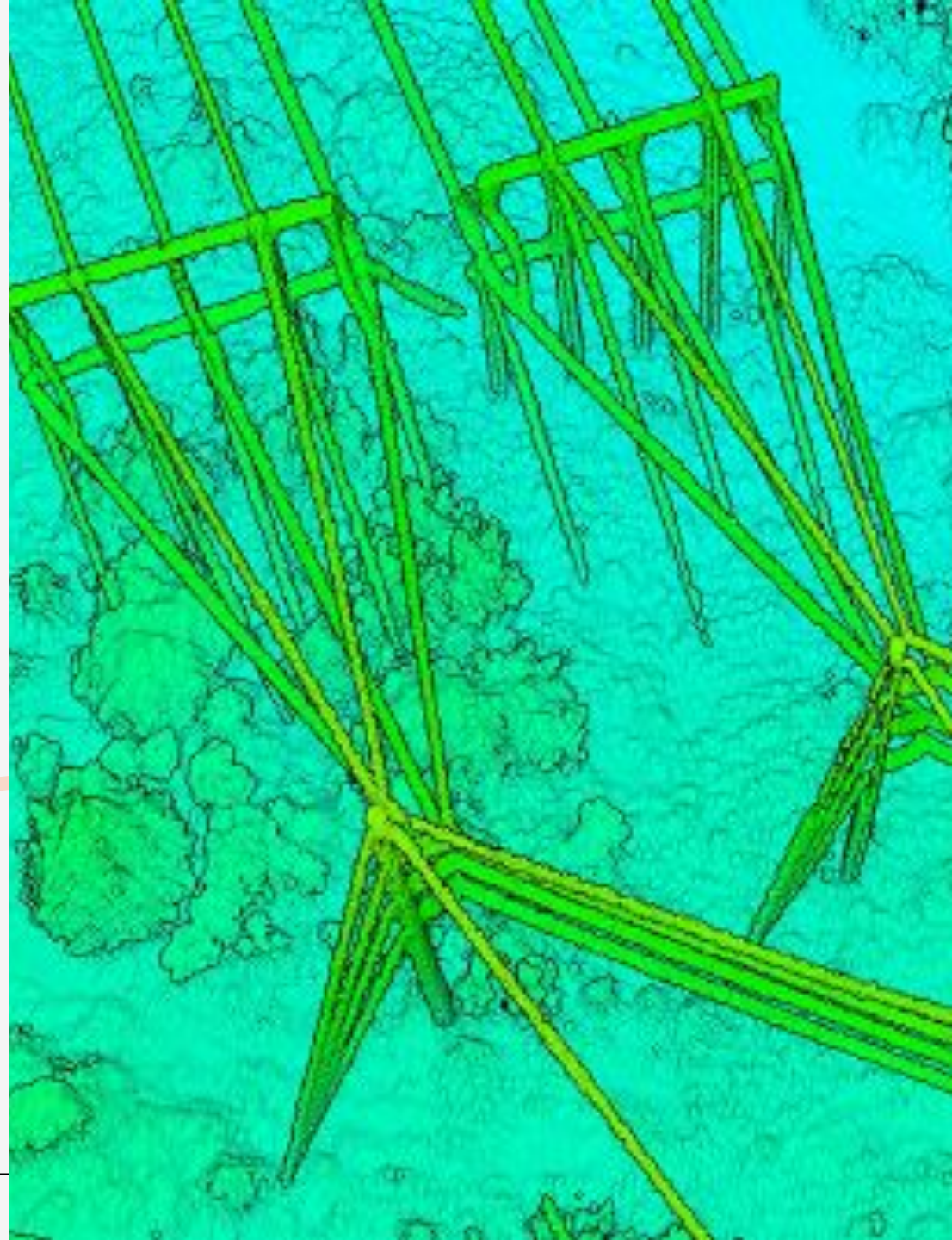
ASPRS Positional Accuracy Standards for Digital Geospatial Data Version 1.0 – November 2014

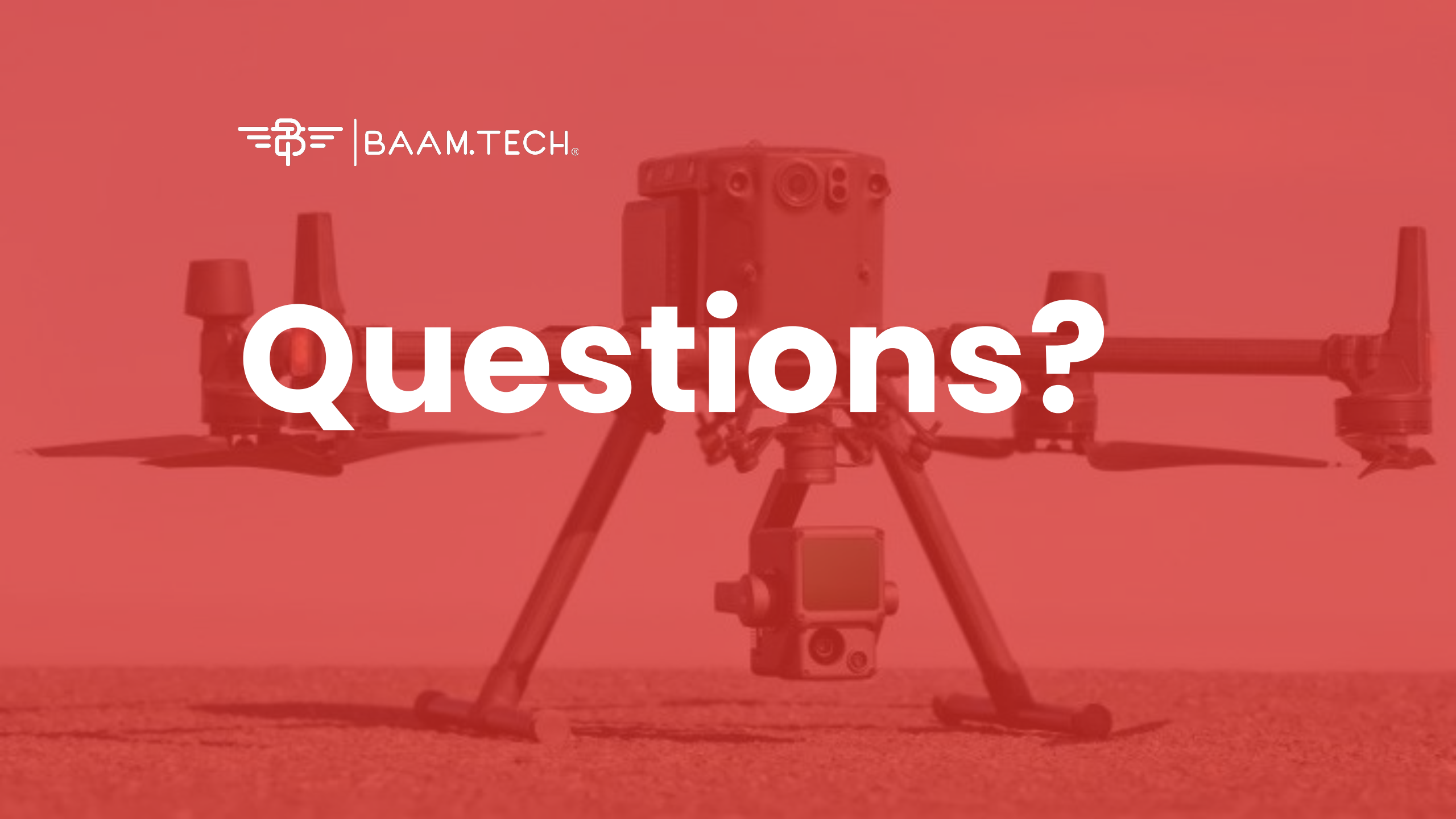
Geospatial Positioning Accuracy Standards Part 3: National Standards for Spatial Data Accuracy

National Mapping Program Map Accuracy Standards

ASPRS Accuracy Standards for Large-Scale Maps

USGS Lidar Base Specification

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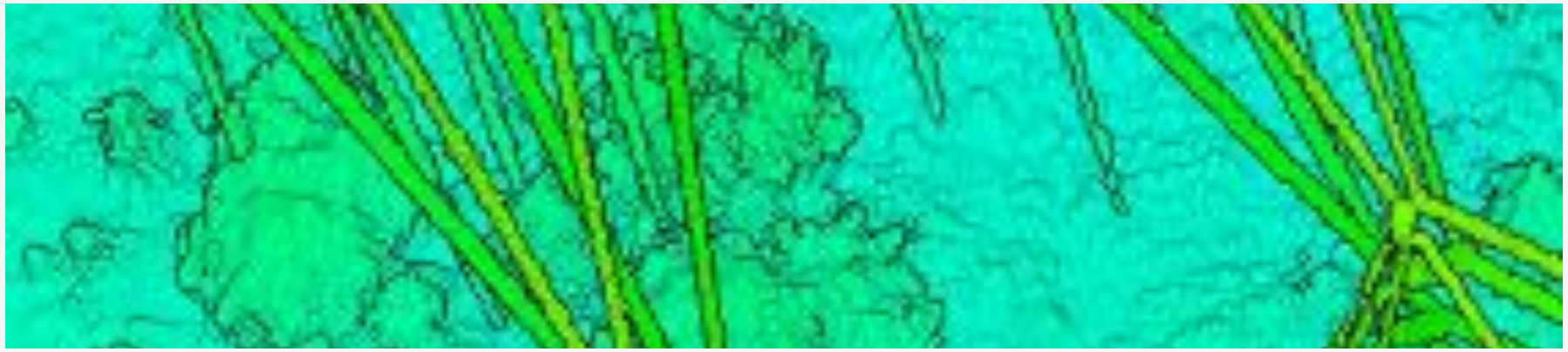
Questions?



Phone: 833.222.6832 **Address:** 15501 W 100th Terr, Lenexa, KS 66219 **Web:** www.baam.tech