Compare LiDAR Data to a Site Survey

Overview: Compare a LiDAR TIN surface to a georeferenced site survey in AutoCAD Civil 3D. Develop vertical error statistical values that will show how well the LiDAR surface matches the site survey.
Refer to NRCS National Instruction Part 305 – *Interim Guidance Using LiDAR for Planning and Designing Engineering Practices* (Oct 2022).

Values reported:

RMSEz (Root Mean Square Error Z-elevation) is a computed statistic that indicates how much error in the vertical direction is present in a set of data.
95% Confidence [Accuracy(z)] reflects the predicted vertical accuracy that 95% of the data is expected to be within.

Software: AutoCAD Civil 3D 2020, Civil 3D Workspace, NRCS C3D 2020 customization.

Notation: Button to Press *Displayed Text* **Icon** Action {Text to Enter} *Menu Item…*

A. Create the Ognd LiDAR surface.

Refer to the instructions for *LiDAR Data Use in CAD* or *LAS LiDAR Data into CAD.*

B. Import surveyed ground points in the project

Refer to the instructions for *Importing Survey Coordinate Point Files.*

C. Determine elevation differences of the LiDAR surface compared to selected surveyed points using the NRCS *Point to Surface Compare* tool.

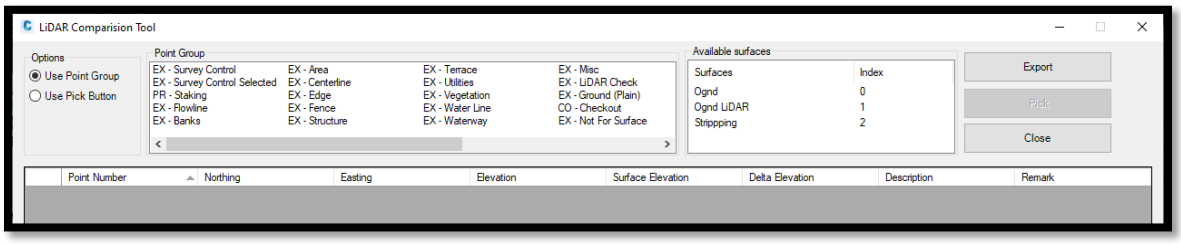
Determine which surveyed points should be used for comparing to the LiDAR surface.
Note: If you are wanting to determine adjustment values for a LiDAR surface to match a survey consider the following:

- Avoid using points where LiDAR would be adversely affected by vegetation
- Avoid using points that are at or near sharp grade breaks (flowlines, banks)
- Avoid points that would have changed since the LiDAR data collection due to construction or erosion.
- Use points spread across the site

The NRCS tool allows the user to utilize points by selecting a Point Group or by selecting the points manually in CAD.
You may want to check various sets of points:
EX – Ground (Plain) - Useful to determine how much you might adjust the data by.
EX – Surface - Points in the Ognd surface to see how all the points compare.

Run the *Point to Surface Compare* tool:

1) Click *NRCS… NRCS C3D…*  *Point to Surface Compare…*



To use Point Groups to select points:

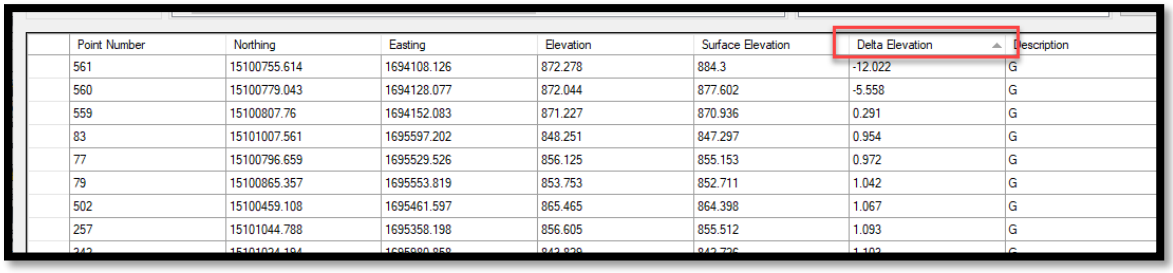
2) In the *Options* area click *Use Point Group*
3) In the *Point Group* area click on the group name. E.g. [*EX – Ground (Plain)*]
   The points will appear in the table with position and elevation.

Optionally- Select points manually in CAD:

4) In the *Options* area click *Use Pick Button*.
5) In the CAD drawing using Point Groups to control the displayed points can be useful. *Isolate Objects* can also be helpful. Once you have points displayed like you want then from the *LiDAR Comparison Tool* click Pick.
6) In the CAD drawing select the points you want to use for the comparison. To add points: click on individual points or use a selection window.
7) Use Shift+Click to deselect points.
8) Press Enter when done choosing survey points.
   The points will appear in the table with position and elevation.

Review Delta Elevations:

9) In the *Available surfaces* area click on the LiDAR Surface [*Ogrnd LiDAR*]
   The table will now show the *Surface Elevation* at the points and the *Delta Elevation* between the points and the surface at the same XY locations.



Point Number	Northing	Easting	Elevation	Surface Elevation	Delta Elevation	Description
561	15100755.614	1694108.126	872.278	884.3	-12.022	G
560	15100779.043	1694128.077	872.044	877.602	-5.558	G
559	15100807.76	1694152.083	871.227	870.936	0.291	G
83	15101007.561	1695597.202	848.251	847.297	0.954	G
77	15100796.659	1695529.526	856.125	855.153	0.972	G
79	15100865.357	1695553.819	853.753	852.711	1.042	G
502	15100459.108	1695461.597	865.465	864.398	1.067	G
257	15101044.788	1695358.198	856.605	855.512	1.093	G

10) Click on the *Delta Elevation* column header to sort from min to max. Then click again to sort from max to min. Review the data for extreme outliers and examine whether those should be removed from the comparison.

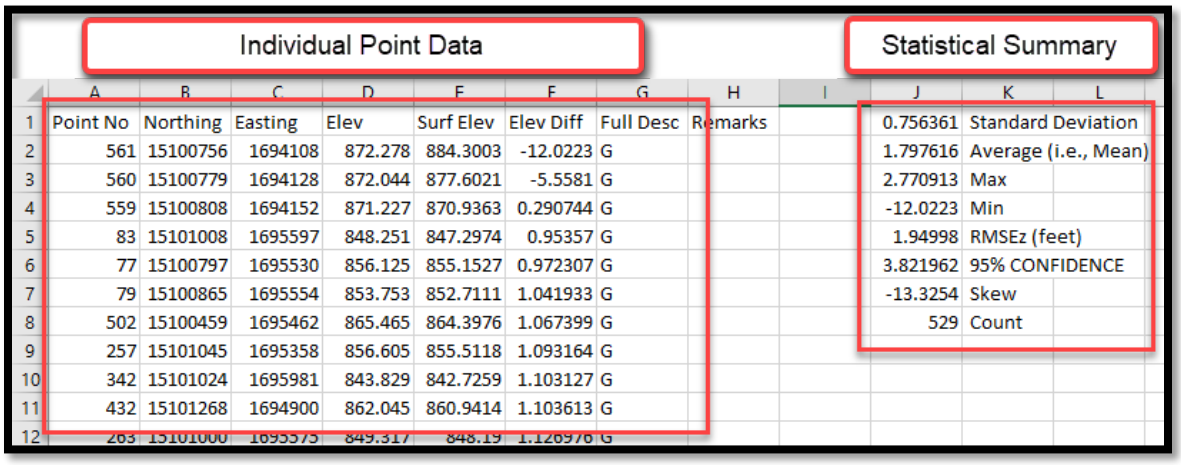
D. Compute the average error and other statistics which might be used to adjust or evaluate the LiDAR surface.

To create a spreadsheet showing the statistical results,

11) Click on the *Point Number* column to sort from min to max. Then click Export
12) Browse to a location for saving the output file as an .xlsx and enter a filename. E.g {*Jasper Pond G vs LiDAR*} Click Save.
13) Click OK Click Close

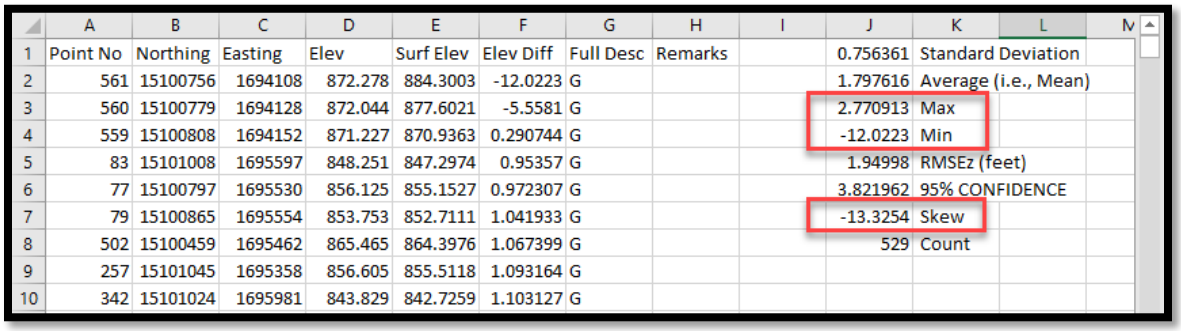
Review data quality (statistics)

14) Use Windows File Explorer to browse to the file that you exported. E.g {*Jasper Pond G vs LiDAR.xlsx*}. Double click on the file to open it with Excel.



	A	B	C	D	E	F	G	H	I	J	K	L
1	Point No	Northing	Easting	Elev	Surf Elev	Elev Diff	Full Desc	Remarks		0.756361	Standard Deviation	
2	561	15100756	1694108	872.278	884.3003	-12.0223	G			1.797616	Average (i.e., Mean)	
3	560	15100779	1694128	872.044	877.6021	-5.5581	G			2.770913	Max	
4	559	15100808	1694152	871.227	870.9363	0.290744	G			-12.0223	Min	
5	83	15101008	1695597	848.251	847.2974	0.95357	G			1.94998	RMSEz (feet)	
6	77	15100797	1695530	856.125	855.1527	0.972307	G			3.821962	95% CONFIDENCE	
7	79	15100865	1695554	853.753	852.7111	1.041933	G			-13.3254	Skew	
8	502	15100459	1695462	865.465	864.3976	1.067399	G			529	Count	
9	257	15101045	1695358	856.605	855.5118	1.093164	G					
10	342	15101024	1695981	843.829	842.7259	1.103127	G					
11	432	15101268	1694900	862.045	860.9414	1.103613	G					
12	263	15101000	1695375	849.317	848.19	1.126976	G					

15) Column J has a statistical summary. Look at the Max, Min, and Skew. If those numbers have a wide range, then it is possible that there are some bad shots that need to be removed from the analysis.



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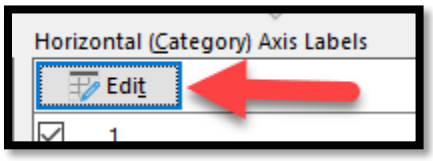
8	502	15100459	1695462	865.465	864.3976	1.067399	G			529	Count		
9	257	15101045	1695358	856.605	855.5118	1.093164	G						
10	342	15101024	1695981	843.829	842.7259	1.103127	G						

In this example Points 561 & 560 have very large elevation differences compared to LiDAR and should be evaluated.

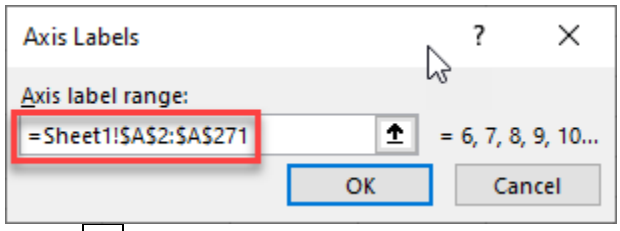
To graphically see data outliers, create a 2D Clustered Column Chart in the spreadsheet.

16) Select column F that contains the *Elev Diff* data.
17) On the *Insert* tab of the ribbon click *Charts… Recommended Charts… All Charts… Column… Clustered Column…* Click Ok.
18) Right click inside the plot area of the chart and click *Select data*.

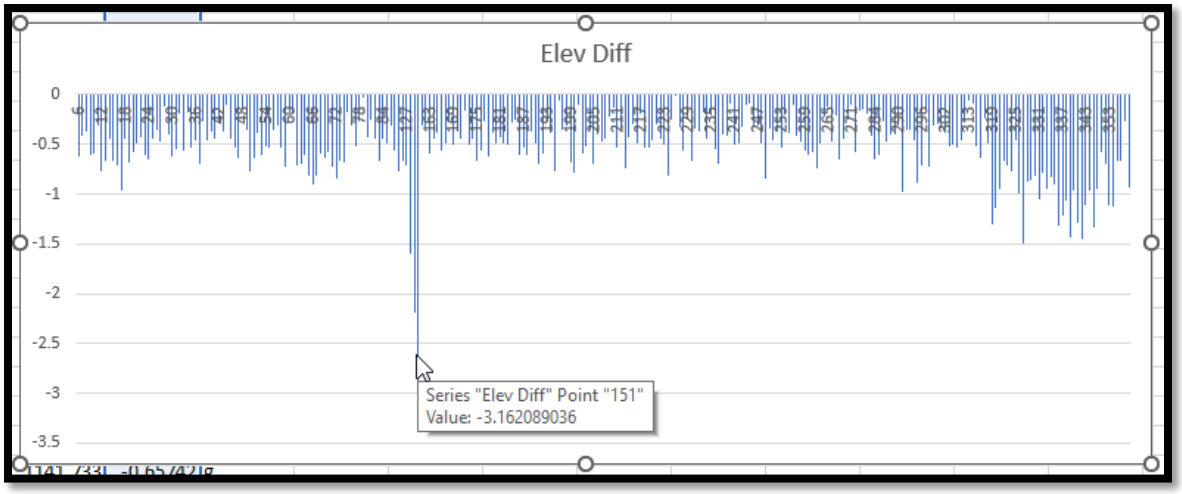
19) In the Horizontal Axis Labels click Edit.



20) Within the *Axis label range* dialog, select the first cell of the *Point No* values, e.g. [*A2*]. Then shift + click into the final cell of the *Point No* values and the *range* will be filled.



21) Click Ok.
22) When back in the Select Data Source dialog box click Ok.
23) You can resize and move the chart to make the data more easily viewable.
24) Use your cursor to hover over data and show a tooltip containing the *Point No* and the value of the *Elevation Difference*.



25) Save the Excel spreadsheet and close.

If you use the results from the comparison to adjust the LiDAR surface by the computed *Average* value, you should rerun the comparison after adjusting the surface.

Reference:
NRCS National Instruction
Part 305 – Interim Guidance Using LiDAR for Planning and Designing Engineering Practices (Oct 2022)

Figure 2: Comparison of Vertical Accuracies

Equivalent Contour Interval National Map Accuracy Standard (NMAS)	* $RMSE_{(z)}$ NSSDA	* $Accuracy_{(z)}$ NSSDA
0.5 ft	0.15 ft or 4.60 cm	0.30 ft or 9.10 cm
1 ft	0.30 ft or 9.25 cm	0.60 ft or 18.2 cm
2 ft	0.61 ft or 18.5 cm	1.19 ft or 36.3 cm
4 ft	1.22 ft or 37.0 cm	2.38 ft or 72.6 cm
5 ft	1.52 ft or 46.3 cm	2.98 ft or 90.8 cm
10 ft	3.04 ft or 92.7 cm	5.96 ft or 181.6 cm

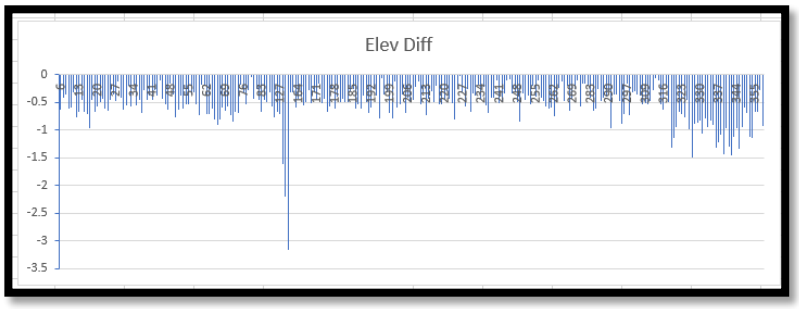
*Note: The RMSE(z) and Accuracy(z) items in Fig 2 are values computed in the Civil 3D NRCS *Point to Surface Compare* tool and are available with the data exported to a spreadsheet.

Example LiDAR Comparison: OpenRange

LiDAR Data Evaluation #1

Comparison: G (Ground) description shots only vs *LiDAR surface*

0.338	Standard Deviation
-0.543	Average (i.e., Mean)
-0.001	Max
-3.162	Min
0.639	RMSEz (feet)
1.252	95% CONFIDENCE
-2.668	Skew
270	Count



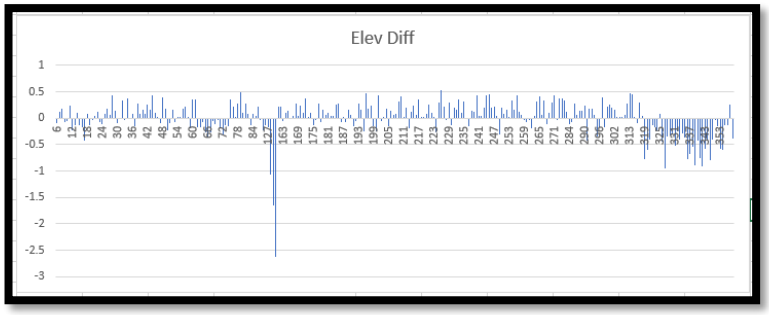
Based on the 95% Confidence (Accuracy_z) value of 1.25', Fig 2 indicates that this data would support 2' contour intervals.

The Average could be used to adjust the LiDAR surface in order to improve the correlation between the surveyed points and the LiDAR surface.

LiDAR Data Evaluation #2 – LiDAR surface adjusted by -0.54'

Comparison: G (Ground) description shots only vs *adjusted LiDAR surface*

0.338	Standard Deviation
-0.003	Average (i.e., Mean)
0.539	Max
-2.622	Min
0.337	RMSEz (feet)
0.661	95% CONFIDENCE
-2.668	Skew
270	Count



Based on the 95% Confidence (Accuracy_z) value of 0.66', Fig 2 indicates that this data would nearly support 1' contour intervals.