

Georeferencing Zeb-Rovo handheld lidar point cloud

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ArcGIS Pro 2.6.2 & CloudCompare 2.9.1

Situation: You have a handheld lidar LAS file without a coordinate system that you want to georeference.

General workflow: you can georeference a point cloud in CloudCompare using reference points with known coordinates. Cloud compare assigns the coordinate numbers to your point cloud, but you have to specify which coordinate system you are using in ArcGIS.

This workflow roughly follows this tutorial: <https://www.youtube.com/watch?v=eG-oj22YrY>

CloudCompare is open source software that you can download here: <https://www.danielgm.net/cc/>

Step 1. Create reference points in ArcGIS Pro

You need digital reference points for which you know the coordinates to georeference the lidar point cloud. Ideally, you would place some kind of spheres in the field that you recognize in the 3D point cloud and measure the coordinates with a detailed (D)GPS device (as demonstrated in the video).

If you don't have such points, as in this case, you have to visually identify recognizable points in already existing data. In this example this is a DTM with a 0.5 meter resolution. "Recognizable" means that you can manually point out these corresponding reference points in the lidar point cloud as well. Roads can be useful for this. **You need at least 4 reference points.**

The easiest way is to make a point feature class in ArcGIS: Geoprocessing | **Create Feature Class** | Geometry Type = Point | Coordinate system = coordinate system of existing DTM.

To add points manually: Edit tab | Create | select reference point feature class | Create a point feature

Don't forget to save your edits!

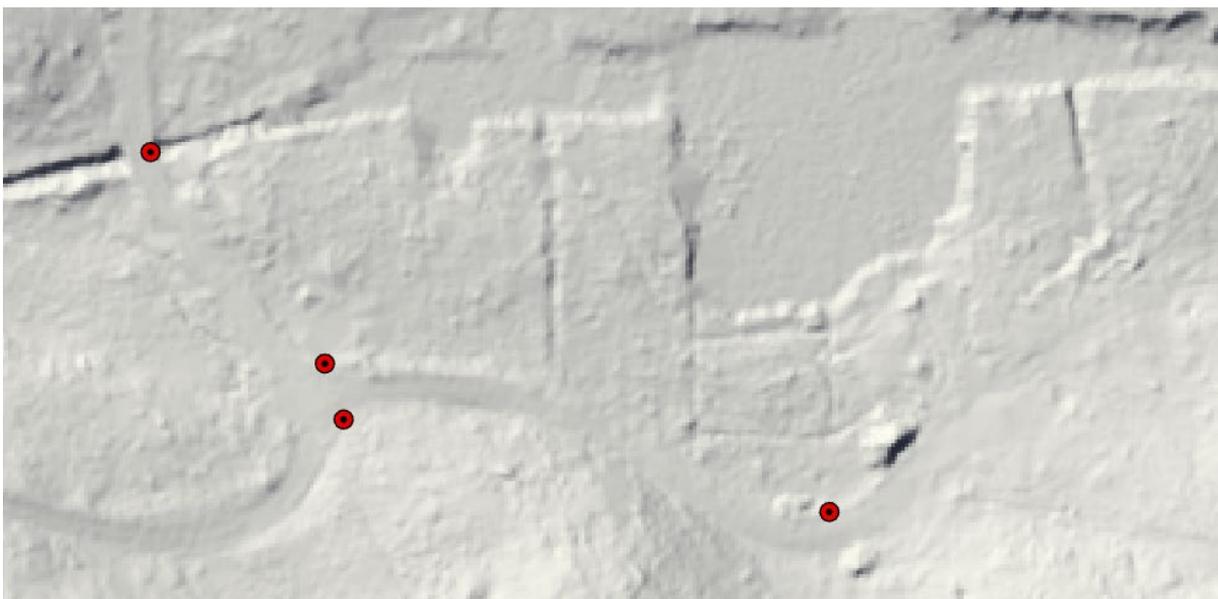


Figure 1. Example of manually chosen reference points at characteristic parts of the road, visible in the already existing 0.5 m DTM (2D top view). These locations are relatively easy to find in the point cloud.

Step 2. Make .txt file with reference points coordinates

Cloud compare only needs a .txt file with X, Y and Z values to import your points. You therefore first need to add the coordinates of your reference points to your attribute table and then copy them to a table in a .txt file.

1. Add XY coordinates to your attribute table: Geoprocessing | **Add XY Coordinates**
2. Add Z values: Geoprocessing | **Add Surface Information** | Input surface: your terrain model | Output property: Z
3. Make a new .txt file (for example in notepad) and manually¹ copy-paste the coordinates from the attribute table. I used tabs as column separator.

OBJECTID *	Shape *	Description	Z	POINT_X	POINT_Y
5	Point	y splitsing noordelijke...	563.154969	-46702.8738	229621.5125
7	Point	brug over smal beekje...	561.104244	-46727.943	229652.1083
8	Point	y splitsing zuidoostelij...	563.688478	-46700.1824	229613.4255
9	Point	flauwe bocht, midden...	563.781141	-46630.3308	229600.0475

Figure 2. example of the reference points attribute table with X and Y coordinates in MGI Austria GK West. Z coordinates are in meters and derived from the DTM.

```
X      Y      Z
-46702.8738    229621.5125    563.154969
-46727.943    229652.1083    561.104244
-46700.1824    229613.4255    563.688478
-46630.3308    229600.0475    563.781141
```

Figure 3. example of .txt file lay-out made with notepad

Step 3. Load point cloud and reference points in CloudCompare

1. Open you LAS file in CloudCompare: file | open | select LAS cloud as file type if you don't see your file
2. Drag and drop your .txt file with reference points in the CloudCompare window. If the preview looks right, click **apply**

¹ Manually copying the coordinates is the fastest approach if you have only a few reference points. If you have more reference points you can also export the attribute table to an Excel spreadsheet and copy all coordinates at once.

Note: CloudCompare often gives the message that your coordinates are too big and suggests rescaling to a smaller, local coordinate system (e.g. in this case the Y coordinates were rescaled by subtracting 229600 from their original value). This is fine, because the coordinates are shifted back to their original values when you export your LAS file (so in this case 229600 is added again to the Y coordinates). Make sure that you use the same rescaling on both the LAS and your reference points if you have to rescale both. More info [here](#).

Step 4. Match reference points with point cloud

See YouTube tutorial for more details:

<https://www.youtube.com/watch?v=eG-oj22YrY>

1. Select the point cloud and the reference points | Go to tools | registration | **Align (points pair picking)** | Aligned = your point cloud, Reference = your reference points (click Swap if this is the other way around) | OK
2. Select the reference points (remind the order!), they become purple, get a code and appear in the reference cloud window.
3. Now select the location of your reference points in the point cloud as precisely as you can. Do this in **the same order** as the reference points. **Do not use the “pick spheres instead of points” function as they do in the video tutorial!**
4. Click **align**, the point cloud now moves to the location of the reference points
5. If you are pleased with the result, click the green tick to complete the alignment, you get the transformation matrix and total RMS error².

Step 5. Export referenced point cloud as LAS

Select your referenced point cloud only | File | Save | save as .las file | choose resolution | OK

I chose the highest resolution, that did not seem to increase the file size significantly. It also makes sure the original accuracy of the data is maintained.

Step 6. Define projection in GIS

The point cloud now has the right coordinates, but still no coordinate system assigned.

1. Open your .las file in an ArcGIS Pro local scene. It will give a “unknown coordinate system” warning.
2. Geoprocessing | **Define Projection** | input dataset: lidar point cloud | Coordinate system: coordinate system of your reference points and terrain data

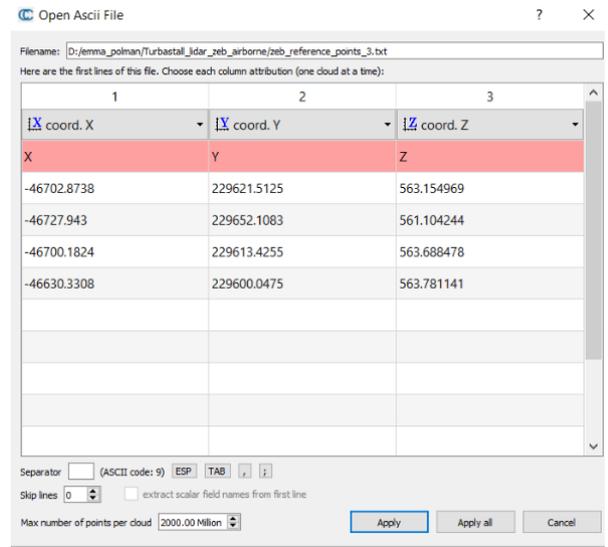


Figure 4. preview when importing reference points in CloudCompare

² I'm not exactly sure how this error is calculated. I had an RMS of ± 1 at the first try.

Step 7. (optional) classify LAS ground

If your lidar data is not yet classified you can do this with **Classify LAS Ground**. Though this tool is intended for aerial lidar data, it seems to perform okay on hand-held lidar.

I ran the tool two times with run 1: Ground Detection Method = Standard Classification and run 2 with Ground Detection Method = Aggressive Detection Method | Reuse existing ground checked.

The method you choose largely depends on how much relief your terrain has. Conservative is best for terrain with minimal curvature, Aggressive classification for terrain with sharper reliefs. It is recommended to use Aggressive classification in a second run of the classification tool after using the standard method.

Look into the documentation of the tool for more advice on which method suits your data best:

<https://pro.arcgis.com/en/pro-app/latest/tool-reference/3d-analyst/classify-las-ground.htm>