Tools

Rut Analysis using Terrasolid

TerraScan, TerraModeler, TerraMatch versions 014.005 and above

GeoCue Group Support
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1 Introduction

One of the many applications that are suited to the use of mobile LIDAR analysis, is the identification and measurement of ruts and potholes. Here we will discuss the preparation of the data, ways to visualize rutting, the classification of pot holes, and the production of road section parameters.

2 Prepare Data

As with any kind of LIDAR dataset, it is important to prepare it for your specific application. Ensure that the data is calibrated, that the most accurate points are used for processing, and that the surface of the road is classified.

2.1 Calibrate Data

For mobile scanning projects, the quality of GPS positioning and thus, the quality of the trajectory is usually not as good and constant as it is for airborne projects due to GPS gaps caused by large buildings, trees, rock formations, etc. along the roads. Also known as urban canyons. Hence, the positional accuracy of the trajectory can vary a lot during a drive session.

Adjustments of mobile laser data in TerraMatch is based upon tie line observations of features along a drive. These are typically collected on flat ground and from high intensity features, such as paint markings or other photo identifiable markings. Many tie lines can be obtained automatically form the dataset, including signal markers of user specified patterns. Before moving ahead with classification and analysis of mobile data, it is important to make sure that the data is matched together. Failure to do so can lead to misclassification of points which can hinder analysis.

For more information about the mobile LIDAR calibration process, see the following post on our searchable support knowledge base:

http://support.geocue.com/terramatch-mobile-laser-data/

2.2 Cut Overlap

Cut overlap command removes laser points from locations where laser data from multiple lines overlap leaving the most accurate points while ensuring data coverage. There are several methods for cutting overlap, but for this workflow one would use the cut by range method. The cut by range removes laser points from the edges of a line if the same location is covered by points from a shorter measurement distance since points closer to the mobile laser scanner are more accurate. The method requires trajectory information and matching line numbers between the points and trajectories.

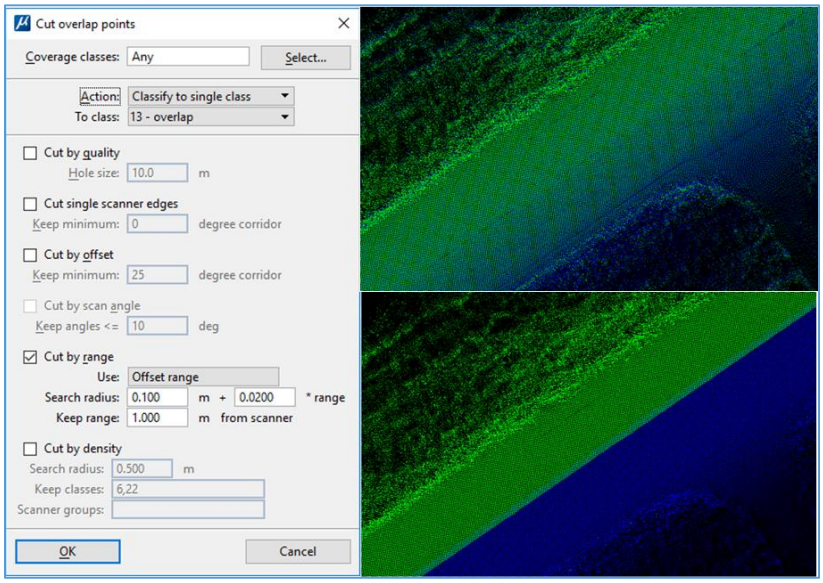

Figure 1: Left-Cut overlap dialog, Upper Right-Before cut overlap, Lower Right- After cut overlap

2.3 Hard Surface Classification

The Hard Surface routine in TerraScan is best suited for classifying ground in mobile laser data sets and in data sets where there is mainly hard ground surface, such as paved roads or other areas. The routine classifies the dominant median surface points in contrast to the typical airborne ground routine. The hard surface routine is not sensitive to low error points in the point cloud, therefore, you do not need to run any low point classification before classifying ground with this routine. However, you may run other routines in order to limit the amount of points in the source class for the hard surface routine.

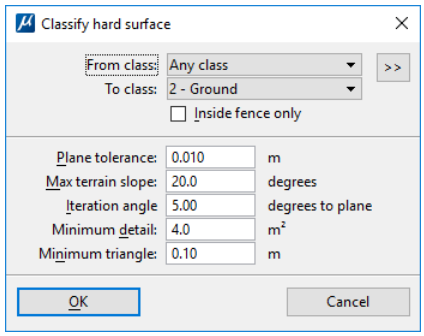

Figure 2: Classify hard surface dialog

The hard surface routine is eager to classify points that form a local plane. The Plane tolerance given in the routine's settings determines how well the points must fit the plane. This is the main parameter controlling how many points are classified into the ground class.

3 Visualize Road Surface

There are several ways to visualize rutting: points can be displayed by slope; or the elevation of the points themselves can be exaggerated to help highlight the change in the road surface; and road section parameters may also be extracted at set intervals along the alignment.

3.1 Slope

To display points by Slope the normal vectors need to be computed for the points. The Compute normal vectors command is used to compute and store two additional attributes for laser points, a dimension and a normal vector. The normal vector is computed for points of planar dimension. It is strongly recommended to have trajectory information available for computing normal vectors for mobile ground-based laser data. The dimension and the three components (XYZ) of the normal vector can only be stored in TerraScan Fast Binary files.

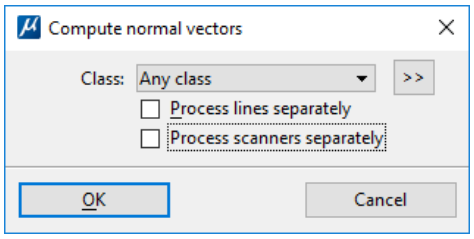

Figure 3: Compute normal vectors dialog

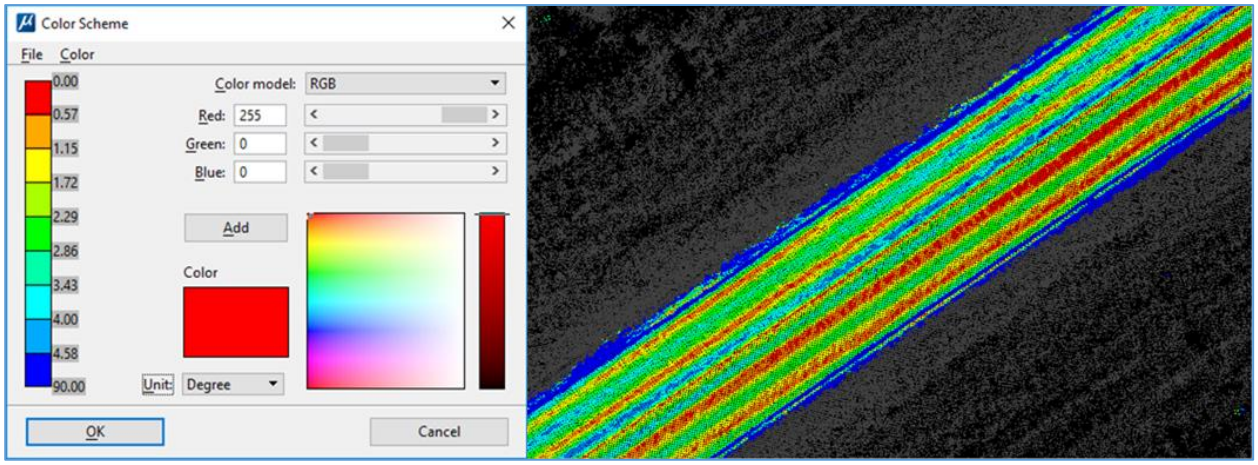

Figure 4: Color by Slope settings and display

3.2 Exaggerate Elevation

As rutting is often quite small and hard to see in a profile view it is helpful to exaggerate the z values of the points using the Transform loaded points command.

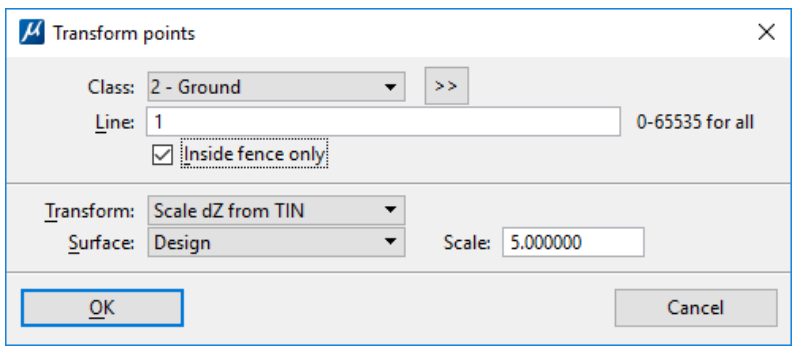

Figure 5: Transform points dialog

The transformation to be used for this process is the “Scale dz from Tin”. This option measures the difference between the points and the reference surface and applies scaled elevation difference values to the original elevation of the points. Note that any processes run after the scaling will need to take into account that the points have been scaled in elevation.

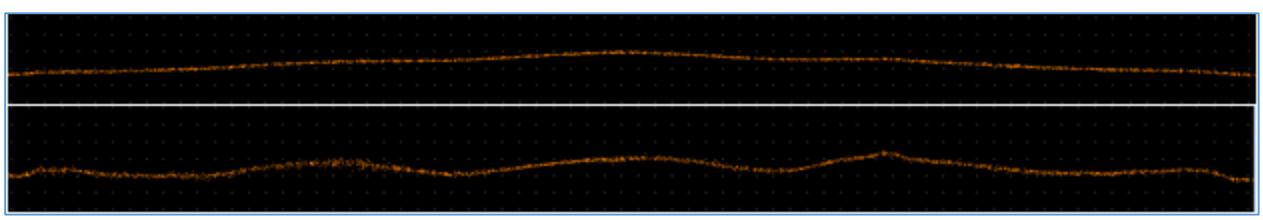

Figure 6: Top- original profile, Bottom- profile after exaggeration

4 Classify Pot Holes

Points that represent ruts and pot holes can be classified by comparing the elevation of the road points to a reference surface, such as a design surface. The points below this surface can be reclassified into the pot hole class.

4.1 Create design surface

If one doesn't exist a design surface can be created from the road crown breakline and the edge of pavement section breaklines. Using the Triangulate Elements tool a reference surface can be generated.

The Triangulate Elements tool, in TerraModeler, creates a surface model from graphical elements filtered by level, element type, and symbology. You can save the filtering rules to a text file for later use.

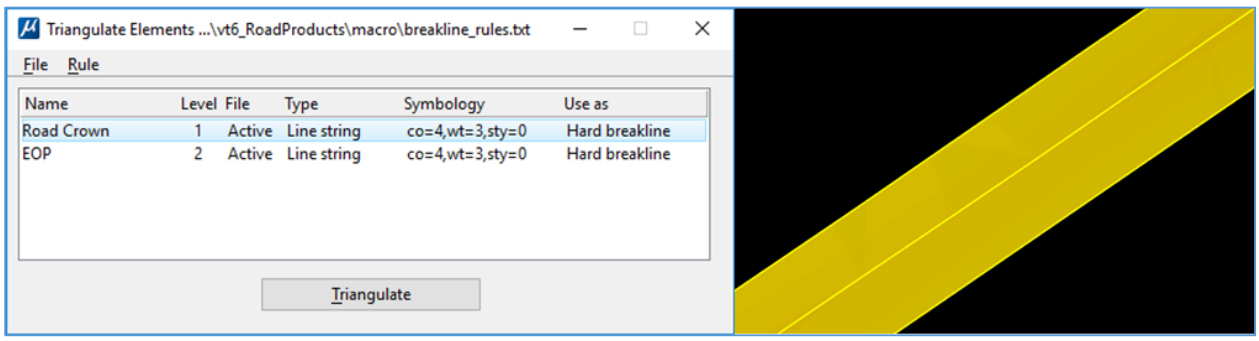

Figure 7: Triangulate Elements settings and resulting surface

4.2 Classify points

Now all that remains is to classify points that fall below this reference surface. This can be done using the By height above ground routine. The By height from ground routine classifies points which are within a given height range compared to the reference surface. For instance, any ruts greater than 2cm can be classified as potholes.

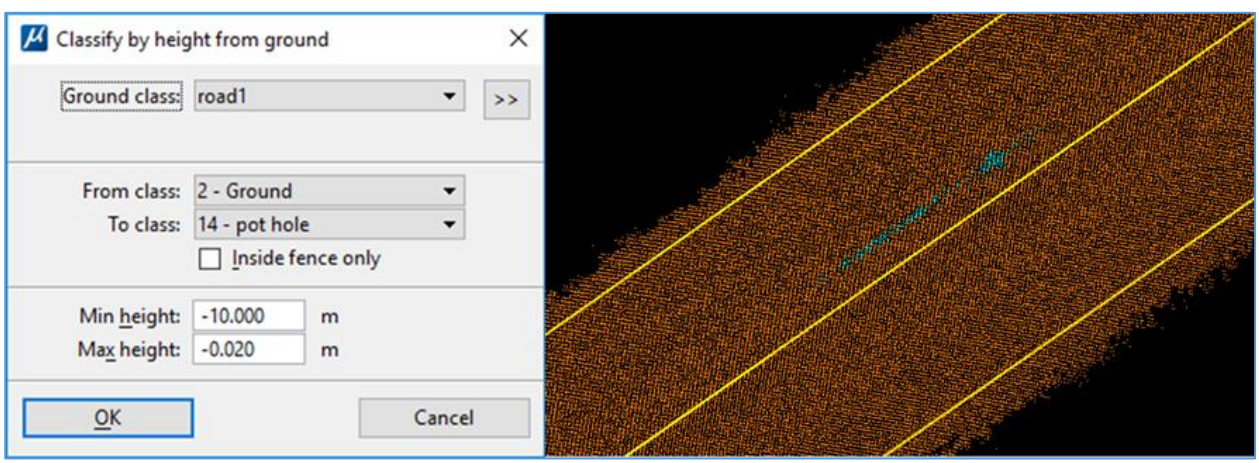

Figure 8: Classify by height from ground and the resulting pot hole classification

5 Create Road Profiles

Road profiling is another useful tool for road analysis. These profiles are a series of two dimensional slices of the surface of a road, used to convey information about the road at each profile location.

5.1 Compute section parameters

Compute section parameters action extracts information from cross sections at regular intervals along a road. The extraction requires a high density of points on the road surface. Therefore, the action is only suited for MLS data sets. It requires the classification of points on the road surface using the Hard Surface routine. Additionally, points close to the surface points should be classified using the By height from ground routine, for example points within an elevation range of ±1 cm.

The section parameter extraction relies on an alignment element, in this process, the road center line. An Offset parameter in the action settings defines on which side of the alignment (left or right) the cross sections are extracted. The left or right side is defined relative to the digitization direction of the alignment element. For projects with multiple drive passes, the Compute section parameters action needs to be used for each pass. The cross section parameters that can be extracted are:

- **Edge to edge slope** - slope from the middle of the two leftmost points to the middle of the two rightmost points.
- **Cross section roughness** - average distance of points to a line connecting the left- and rightmost points.
- **Maximum deviation** - maximum distance from a point to a line connecting the left- and rightmost points. The value is positive if the point is above the line and negative if the point is below the line.
- **Maximum rut depth** - maximum elevation distance from a point to a line connecting two other points in the section. The elevation distance is always measured downward from the line to the point.
- **Left rut depth** - the left rut is searched in an interval from the left edge to the first point on the right side of the cross section center. The left rut depth is the Maximum rut depth within this interval (see illustration below).
- **Right rut depth** - the right rut is searched in an interval from the right edge to the first point on the left side of the cross section center. The right rut depth is the Maximum rut depth within this interval (see illustration below).

Figure 9: Example left and right rut depth in profile

•**Left rut water depth** - searched in the same interval as the **Left rut depth**. The rut water depth is the maximum elevation difference from a point to a water surface in the left rut (see illustration below).

•**Right rut water depth** - searched in the same interval as the **Right rut depth**. The rut water depth is the maximum elevation difference from a point to a water surface in the right rut (see illustration below).

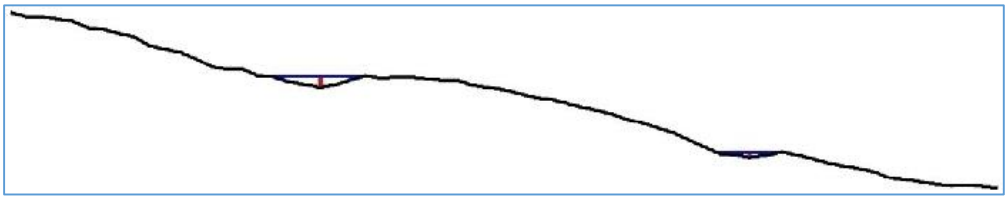

Figure 10: Example left and right rut water depth in profile

•**Section elevations** - elevation distances between points to the fitted section line. The line is fitted to all points of a cross section within a given tolerance. The elevation distance is measured at given regular steps along the cross section, for example every 5 cm.

This routine writes the section parameters into text files, one for each block binary file of a TerraScan project.

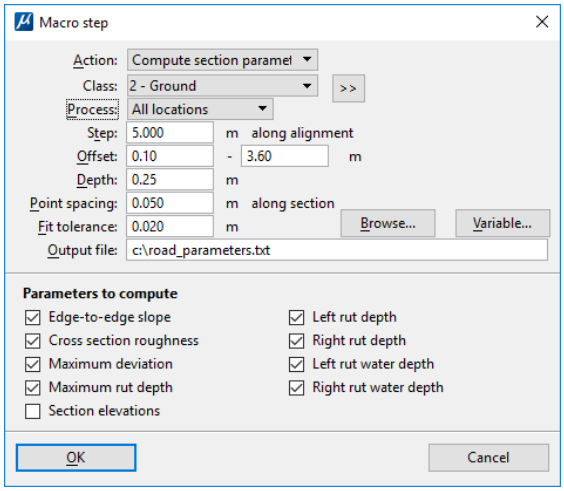

Figure 11: Compute section parameters macro step

5.2 Read/Section Parameters

Read / Section parameters command reads text files that have been created using the Compute Section Parameters macro step. It is used to draw the section parameter values into the design file which will allow its visualization. The section parameter values are drawn as MicroStation text and linear elements into the design file. The settings in the Road Section Parameters category of the TerraScan Settings determines the symbology (level, color, text size), and unit definitions of the parameters.

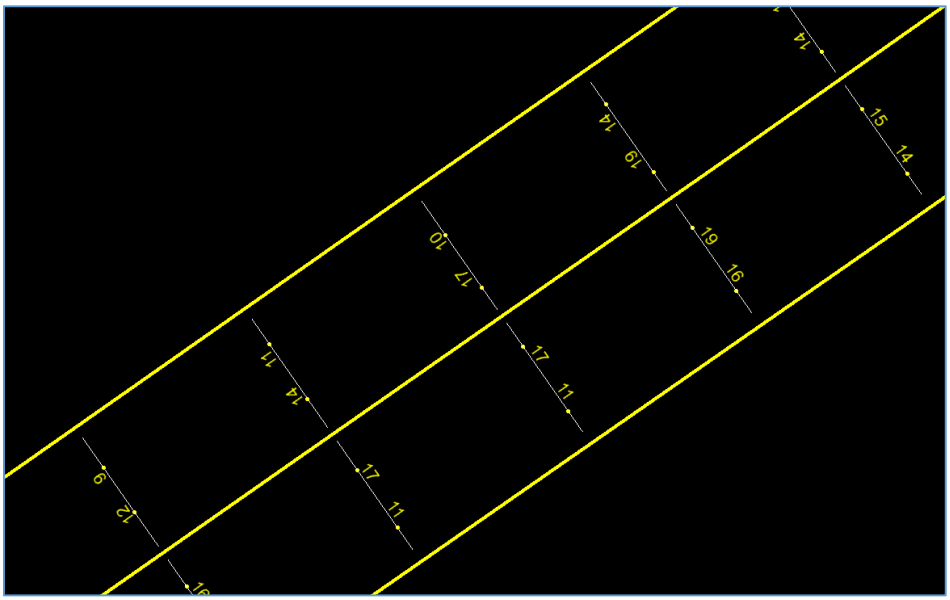

Figure 12: Section lines with left and right rut depth values written into design file

6 Present findings

One useful demonstration technique is to produce a fly-thru video using TerraPhoto which follows along the sensor trajectory. This will assist in the visualization of the state of the surveyed road. The look of this visualization can be improved by extracting colors from imagery that was gathered simultaneously with the LIDAR data and assigning them to the points. The pothole class can also be assigned a unique color that will stand out against the other points. Utilizing this technique will make it look like you are driving down the road and it will allow those responsible for the maintenance and care of the road to better visualize their charge.

Figure 13: A screen shot of a flythrough of a mobile dataset that highlights pot holes in orange

For additional information concerning rut analysis using the Terrasolid products please contact the GeoCue Group Support Team at support@geocue.com.