Tools, Tips, and Workflows

LP360 Rail Extraction Tools

LP360, versions 2016.1 and above

B S A U | A W G

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Overview

LP360 includes tools to automatically extract a rail alignment (centerline) feature as a polyline as well as classify "top of rail" from LAS files derived from Laser Intensity Detection and Ranging (LIDAR) points. This feature is implemented as a semi-automated Point Cloud Task (PCT) and is available in the Advanced version of both LP360 for ArcGIS® and LP360 (the standalone version of LP360 for Microsoft Windows®). While introduced some time ago into LP360, this PCT has been improved with the recently released version 2017.1 of LP360/LP360 for ArcGIS.

We used to recommend using this PCT within LP360 for ArcGIS since we had only rudimentary feature editing tools in LP360 prior to the 2016.1 release of LP360. Now, with the advanced tools of LP360 2017.1, LP360 is a much faster and more flexible editing environment for LIDAR extracted features than is ArcGIS.

We have made several enhancements to the rail extractor PCT in 2017.1:

- Better extraction from "thinner" data such as helicopter LIDAR
- An experimental capability of spanning sections of track where the rails are not above the rail bed (for example, at-grade intersections)

*Figure **1*** is a depiction of a typical extraction of the alignment and top of rail. The alignment is collected as a set of 3-dimensional polyline features in Shape file format. The top of rail points have their Classification Attribute set to the class number being used for rail (10 is the American Society for Photogrammetry and Remote Sensing, ASPRS, standard). The rail centerline elevation is at the top of rail since this is the convention used by most American rail lines performing data extraction in support of the Positive Train Control initiative.

Figure 1: A typical Alignment (green line), top of rail (red points) extraction

Rail alignment/point extraction requires relatively high density LIDAR data. Prior to version 2017.1, we recommended using mobile laser scanning (MLS) data at 80 points per square meter (ppm) or greater. With the improved algorithms of 2017.1 you can now successfully extract from data as low as 40 ppm such as data collected from helicopter airborne laser scanning (ALS).

We use a track definition "template' to control the extraction algorithm. We include predefined descriptors for American Standard Gauge in both feet and meters. We also provide a dialog for defining other track gauges. We currently do not have a graphical template to aid in specifying the parameters so please contact support@geocue.com for assistance with defining other track gauges.

Experimental Features

In release 2016.1 of LP360/LP360 for ArcGIS we introduced the idea of 'experimental' features. These are features in the products denoted "EXP." An EXP feature is one that is not fully baked. You can use it, but use it with caution. It may not be entirely fleshed out or, more typically, it is a feature whose user interface has not been finalized. In some cases, we may withdraw an EXP feature entirely. We introduced the notion of experimental features because we have customers who request very specific features and want access to those features during their formative stages. One of the features in the improved rail extraction PCT is an EXP feature.

How Rail Extraction Works

The Rail Extraction PCT is a semi-automated task in that you must provide the task with starting information. This starting information is in the form of a “seed” centerline. This seed is a short line that you have drawn in the approximate centerline (the “alignment”) of the track where you want extraction to begin. The extractor PCT will take that seed and attempt to extend it along the track in the direction of the line (where line direction is the direction from a lower numbered vertex to a higher numbered vertex). You can optionally have the task classify the top of rail LAS points. The algorithm can attempt to extract to a stopping point that you have defined or continue until it is “lost.”

The seed line can be interactively drawn using the Line tool from the PCT toolbar or you can specify an input seed file. The input seed file can contain multiple seed lines. These will be executed in the order in which they appear in the seed file.

The result is a set of alignment (centerline) features and, optionally, classified top of rail LAS points.

The algorithm is not perfect (usually because of sparse point data issues) nor does it connect the alignment segments. However, the new Feature Analyst and Edit tools in LP360 (sorry, the Feature Edit and Analysis tools are not available in LP360 for ArcGIS) make for a very strong and efficient interactive edit environment.

Parameters

The first step, like all Point Cloud Tasks (PCT), is to set parameters. Once you have a set that work for you, the PCT can be saved under a specific name so that you can reuse your settings.

The PCT is depicted in *Figure* ***2***. The following bulleted list briefly explains the various parameters. You can refer to the on-line help for more detailed information.

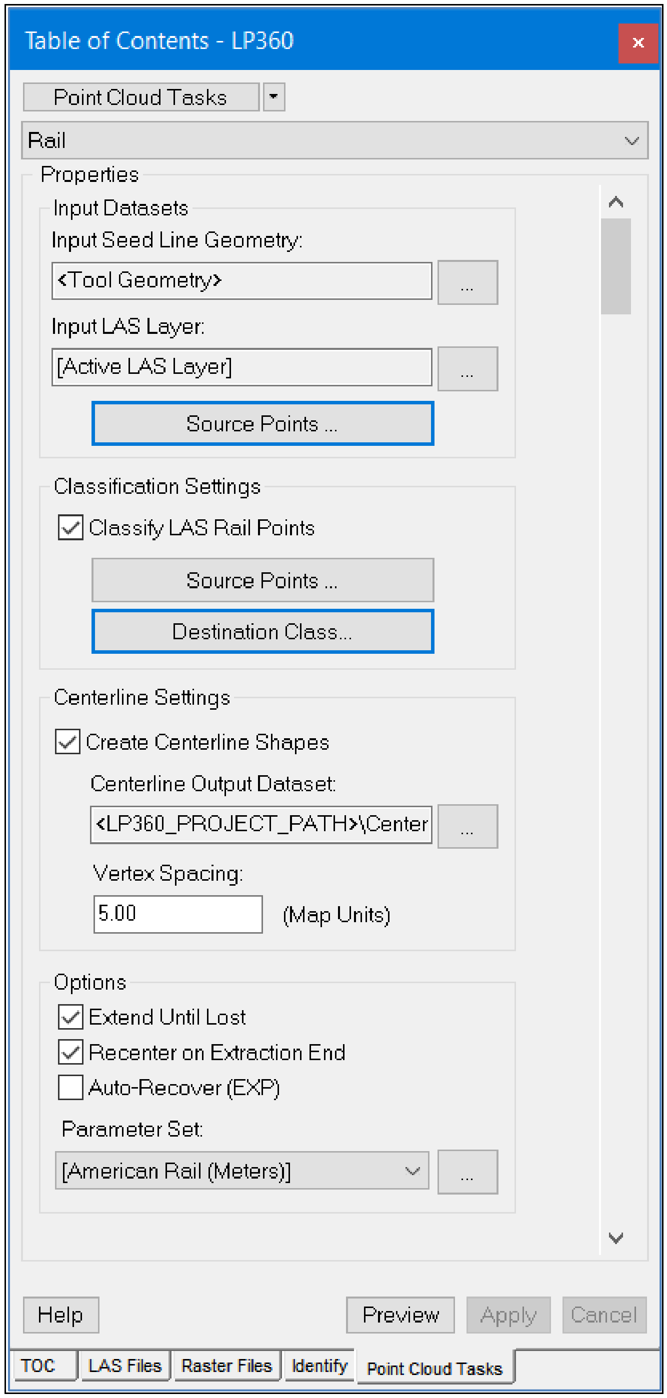

Figure 2: Rail Extraction PCT Parameters

- Input Seed Line Geometry – You can set this for interactive drawing (<Tool Geometry>), to use *selected* features, an external shape file or a layer in the Table of Contents (TOC). If you have used PCTs in LP360, you are familiar with these options.

- Input LAS Layer – the layer that contains the LAS data from which you are extracting the alignment. If you are going to classify top of rail, the data must be loaded for Read/Write.
- Source Points – this allows you to filter points to include only those that are candidate rail points. If no classification has been performed, you would typically not apply a source filter.
- Classify LAS Rail Points (option check) – check this box if you want to classify the top of rail points. The related options are:
    - Source points – these are points to be considered as top of rail. For example, if you have already classified Ground, you would filter these out of consideration
    - Destination Class – the class to assign to the extracted points (for example, the standard ASPRS rail class is 10)
- Create Centerline Shapes – this option is checked if you want to extract the alignment (centerline). You can classify top of rail points without extracting the centerline. I always check this box because, even if I do not want a centerline, it gives me feedback as to where the algorithm was applied
    - Centerline Output Dataset – this is the file (specified using Input/output Manager, IOM) where the centerline data will be written
    - Vertex Spacing – this specifies, in map units, the spacing of vertices in the centerline file. Note that you can always respace later using either the Feature Edit tool for respacing or the Respacing Point Cloud Task
- Options:
    - Extend until lost – You generally want this option set. It tells the algorithm to extend the seed line until it can no longer find rails.
    - Recenter on Extraction End – this tells LP360 to recenter the Map View on the last extracted vertex. This makes it easy to see where the current extraction stopped if you are interactively digitizing seed lines.
    - Auto-Recover (EXP) – This is a new option in the Rail Extraction PCT. It causes the extraction algorithm to attempt to extrapolate across areas where it has lost the rails. This is the typical case when encountering at-grade intersections. It is marked as an experimental (EXP) feature because we have not yet exposed any tuning parameters (although they are in an external XML file) and we may change the way feature is implemented.

Using the Tools

The first step is to set parameters (discussed in the prior section) for extraction such as whether you want the alignment vector, top of rail classified and so forth. These parameters can be saved as a custom Point Cloud Task, eliminating the need to set parameters each time you intend to use the tool.

I will first discuss the extraction process without the new Auto-Recover option.

Once parameters are set, the extraction process begins. There are two modes of semi-automated operation. In the first (and most common mode), the user draws a short, two-point line (the "seed") extending in the track direction in which she would like to extract. The task then attempts to continue this line until it becomes "lost" (assuming the Extend until Lost option is checked). As the extraction proceeds, the user is informed of progress in terms of units of length extracted in the status section of the Map View. The interaction is depicted in *Figure* ***3***. Here the white line denotes the digitizing action by the user. The green arrow indicates the direction the user has digitized the white, two-point line. The red arrows indicate that this seed line is placed approximately at the track alignment (centerline).

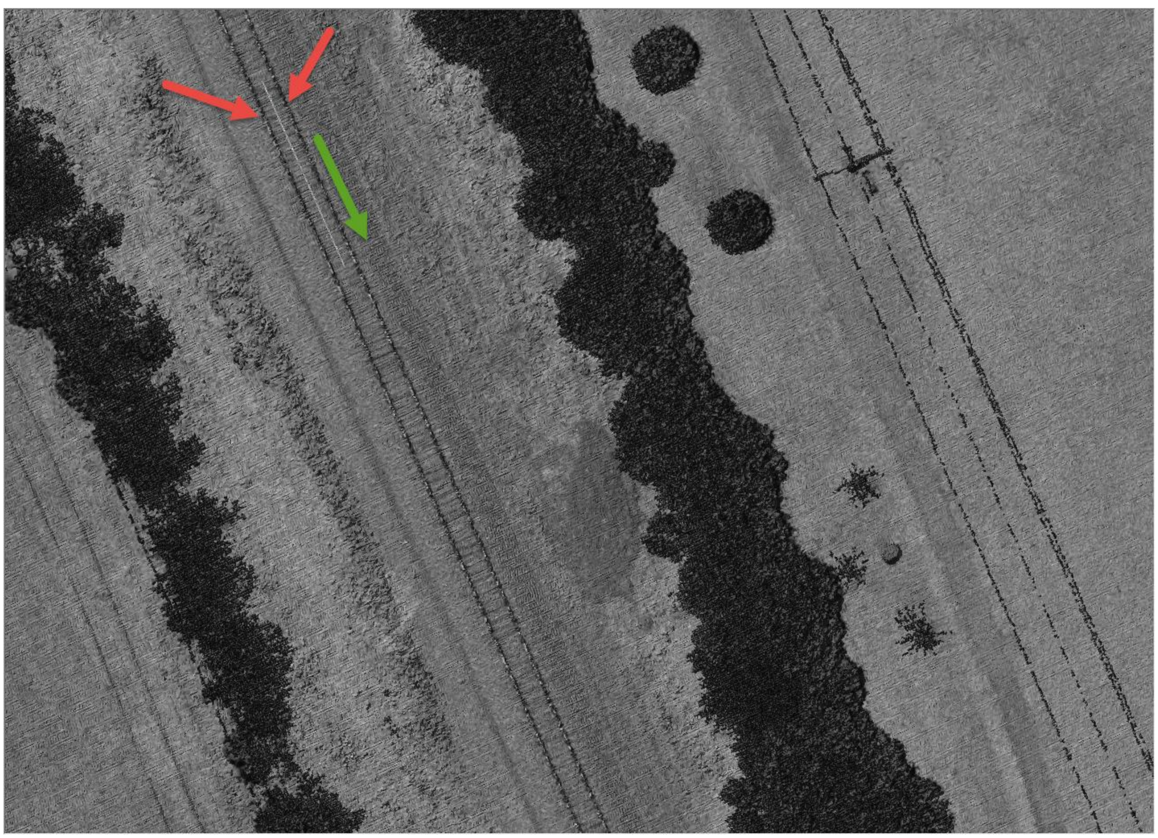

Figure 3: "Seeding" the alignment (red arrows denote the rails, green the "seek" direction

If the Auto-Recover option is not checked, the algorithm will extract until it can no longer detect the rails. The result of the extraction of the seed placed in *Figure* ***3*** is denoted in *Figure* ***4***. Note the extracted green alignment vector that ended when it encountered an at-grade intersection. Notice the classified top of rail shown as the red points in the profile segment at the bottom of *Figure* ***4***. The extraction ended when an at-grade intersection was encountered because the rails are below the street surface at this point. The user would start a new seed segment on the opposite side of the intersection and automatic extraction would proceed until the next obstacle was encountered. The new Feature Edit tools are then used to patch the missing sections.

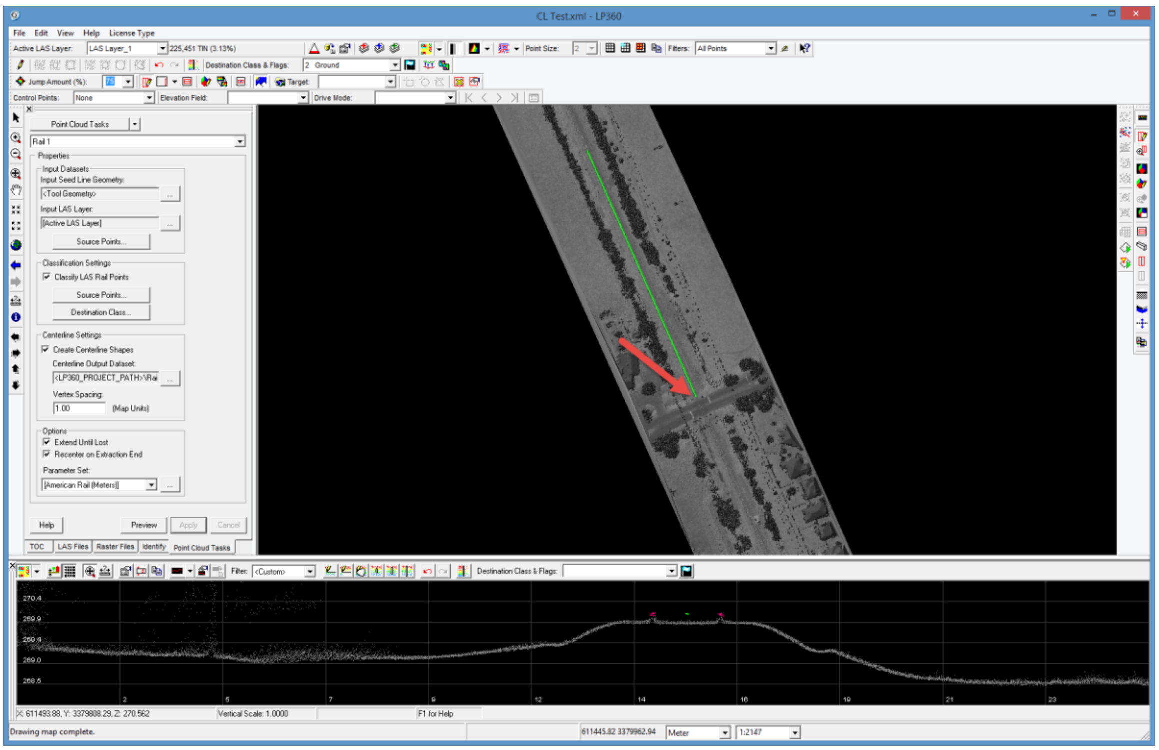

Figure 4: Result of extraction a segment (Map View) and classified rail (Profile View)

The second mode of operation is to construct a three-point seed line. The first two points of the digitized seed line form the starting "hint" and the final point is the terminus (rather than the "extend until lost" option). This is used for digitizing specific segments. Note that you must uncheck "Extend Until Lost" to use this mode (we will change this in 2017.2 to ignore this option when in three-point mode).

Auto-Recover

The new Auto-Recover option will attempt to recover the extraction operation when the algorithm becomes "lost" over relatively short expanses such as at-grade intersections and trestles. This mode is enabled by checking the "Auto-Recover (EXP)" option in the parameter set. Again, we have indicated this as an experimental feature (EXP) because we will probably make some additional changes as we receive customer feedback.

In Auto-Recover mode, we do a bit of "hunting" when the algorithm loses the rails. This basically consists of using prior known good points to extrapolate over the "lost" section to see if we can begin detecting again. If we are successful, we fill in the centerline for the lost section and continue the march along the rail. Note that we do not attempt to classify top of rail in the lost section since the reason we are lost is that we could not find the rails!

This new feature dramatically reduces the amount of feature editing needed in the QC stage of the process.

Note that the recovery algorithm uses a lot of parameters. We have chosen a set that works in most cases. We have not exposed an interface for setting the recover parameters. We do intend to expose a simplified version that will be useful once we have some feedback on typical projects.

Cleanup

When semi-automatic extraction is complete, it is necessary to correct any errors in the track alignment features. The best way to do this is to load the centerline features into the new Feature Analyst tool introduced in LP360 2017.1. You can immediately select a feature from a tabular view, go directly to the first and last vertex with the Map View automatically recentering on each selection. Using the Snapping option of the Feature Edit tools, you can quickly snap in any missing elements – their Z values will automatically be correctly set (ensure Auto Z is off during these operations).

It may also be necessary to clean up some of the classified points for top of rail at locations where the automatic extraction became "confused." This is easily accomplished with LP360's interactive classification tools.

Discussion

The key to a successful rail extraction project is adequate point densities. For this reason, most rail projects will require a data set collected from a helicopter or a mobile laser scanning system. As discussed earlier in this paper, a density of about 40 pts/m^2 or greater (Nominal Point Spacing, NPS, of around 16 cm or smaller) will provide good results. While we have had success with point densities as low as 20 pts/m^2 using very clean LIDAR data, this is not generally recommended. You should note that this is an improvement by a factor of two over previous versions of LP360.

Of course, the major improvement to this version of the extraction tool is the Auto-Recover option. One of my test sets is a 20 mile stretch of rail in Texas. This data set has many at-grade intersections per mile of track. I used to have to fill in these gaps with manual editing. The new Auto-Recover algorithms bridges these except for one trestle. The problem in this particular area is noisy LIDAR data caused by the complexity of the trestle structure. However, with LP360's new Feature Edit tools, I was able to immediately drive to this gap and repair it with two clicks. Very, very nice!!

The alignment features collected by the rail extraction algorithms are true three dimensional polylines. The vertex spacing is specified by the user (for example, every 1 meter). The elevation for the vertex (Vertex Z) is computed from the mean value of the elevation of the top of rail at a point perpendicular to the vertex. As mentioned earlier, this is the required scheme for the United States Federal Rail Administration's Positive Train Control system.

Conclusion:

The Rail Extraction tools in LP360 make short work of collecting track centerline (alignment) and of classifying top of rail. The improvements in 2017.1 significantly speed up the process. The new Feature Analyst tools allow very rapid movement through large datasets for the QC and repair stage. Note that we strongly recommend that you use LP360 rather than LP360 for ArcGIS for rail extraction since the new Feature Edit/Analyst tools are only in the standalone version.