

[CI124549]

Feature extraction from point clouds – how to make sense of the data!

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Learning Objectives

- Point Cloud Visualization in Recap and Infracworks
- Analysis and extraction of terrain and linear features of point clouds
- Exchange of features between InfraWorks and Civil3D
- Best practices for terrain generation from point clouds in Civil3D

Description

Design projects need to rely on quality data for existing conditions in order to be successful. Point cloud data collected from mobile or terrestrial laser scanning, or even from UAVs fit into this, however, they are challenging to use effectively on their own. This class will provide the necessary information to import, process and extract relevant 2D and 3D features in InfraWorks and exchange them with Civil3D for design. The class will also cover best practices for working with these large datasets and extracted features for detailed terrain and existing conditions models.

At the end of the class, attendees will be able to use point cloud data more efficiently, and be able to extract linear and point features for further use in InfraWorks and Civil3D.

Speaker(s)

Kevin is a Practice Service Technology Lead and UAS Operations manager at Stantec. His group has been collecting, processing and extraction data from terrestrial and mobile laser scanning for the past 9 years, and with UAS for the past 4. With the amount of data collection technology being utilized at Stantec, Kevin is always looking for better ways to leverage processing software to enhance and improve data extraction methods. He is leading the growth of UAS operations at Stantec for survey, mapping and inspection purposes.

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Point Cloud Visualization

Autodesk has advanced the ability to utilize point cloud information over the last several years. Using programs like Autodesk Recap, users can import large point cloud datasets with tools for managing, cropping and visualizing in an efficient way. This class won't focus on importing data into Recap, but assumes knowledge of import data into Recap is known.

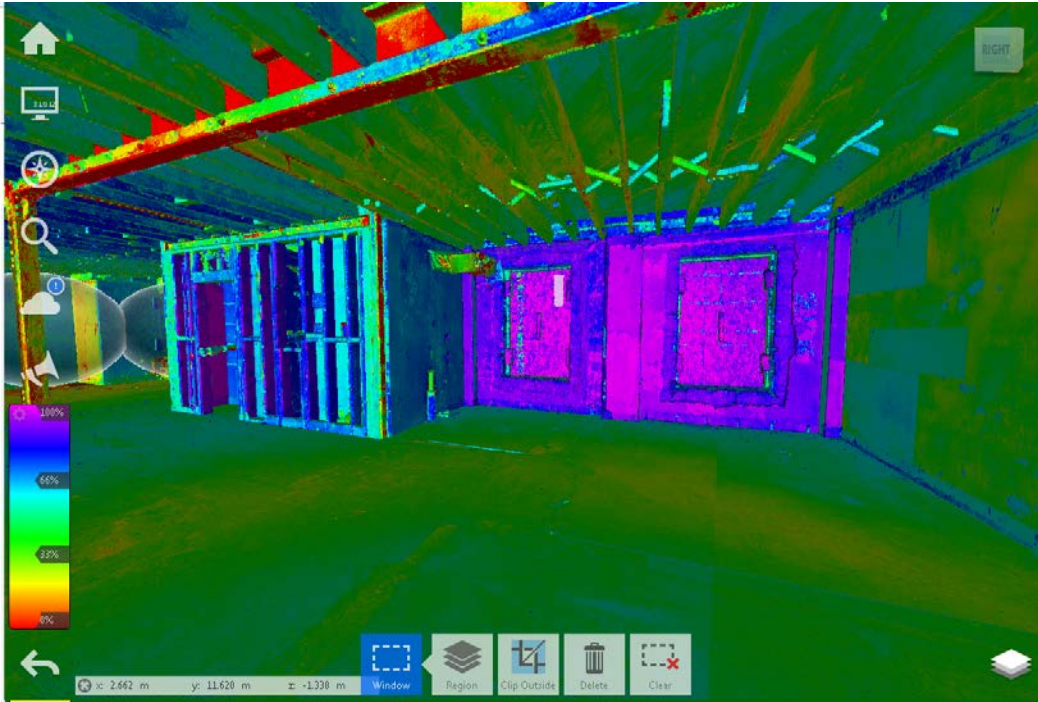
Autodesk Recap

Recap offers a wide range of visual styling options for the better viewing of point cloud data. Depending on how the data is collected will determine if all the visual styles are available.

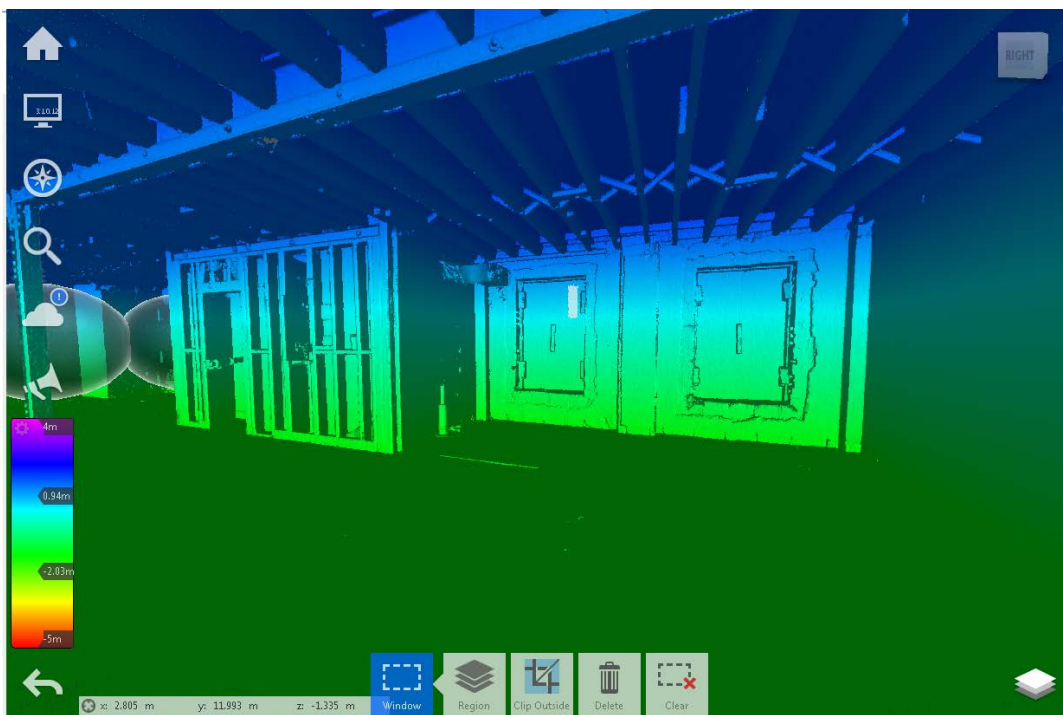
RGB - When a point cloud is collected along with high resolution imagery, Recap has the ability to assign a color index value to each 3D point. This visual style is ideal for the most realistic view of a point cloud.



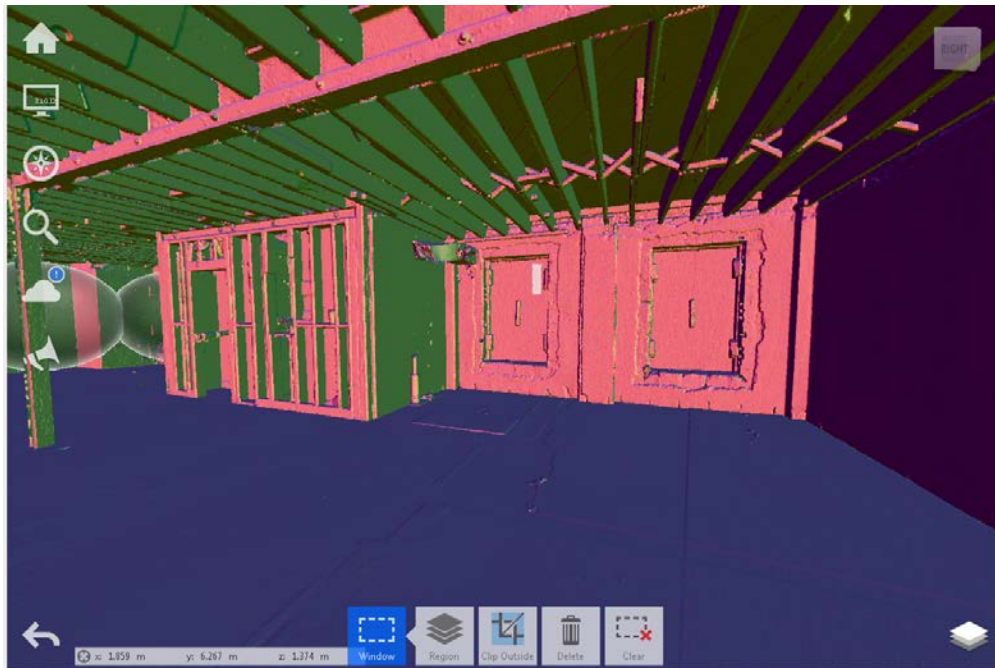
Intensity - Laser scanners have the ability to collect a reflectance value of each 3D point. This is the native viewing setting for points cloud when imagery is not collected.



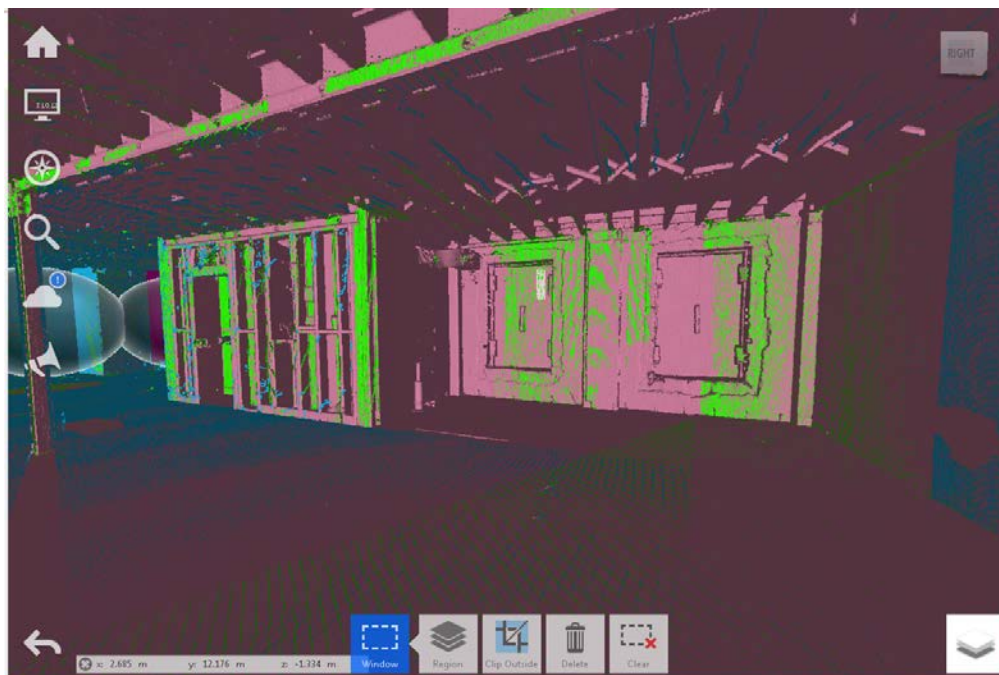
Elevation - As each 3D point has an elevation value, a point cloud can be viewed by a color elevation **range**. This visual style is ideal for surface topography.



Normals - During the preprocessing stage in Recap on import, normals are calculated to determine the planarity of surfaces and how surfaces relate to each other. This visual style is ideal for modeling in 3D to determine the relationship between surfaces.



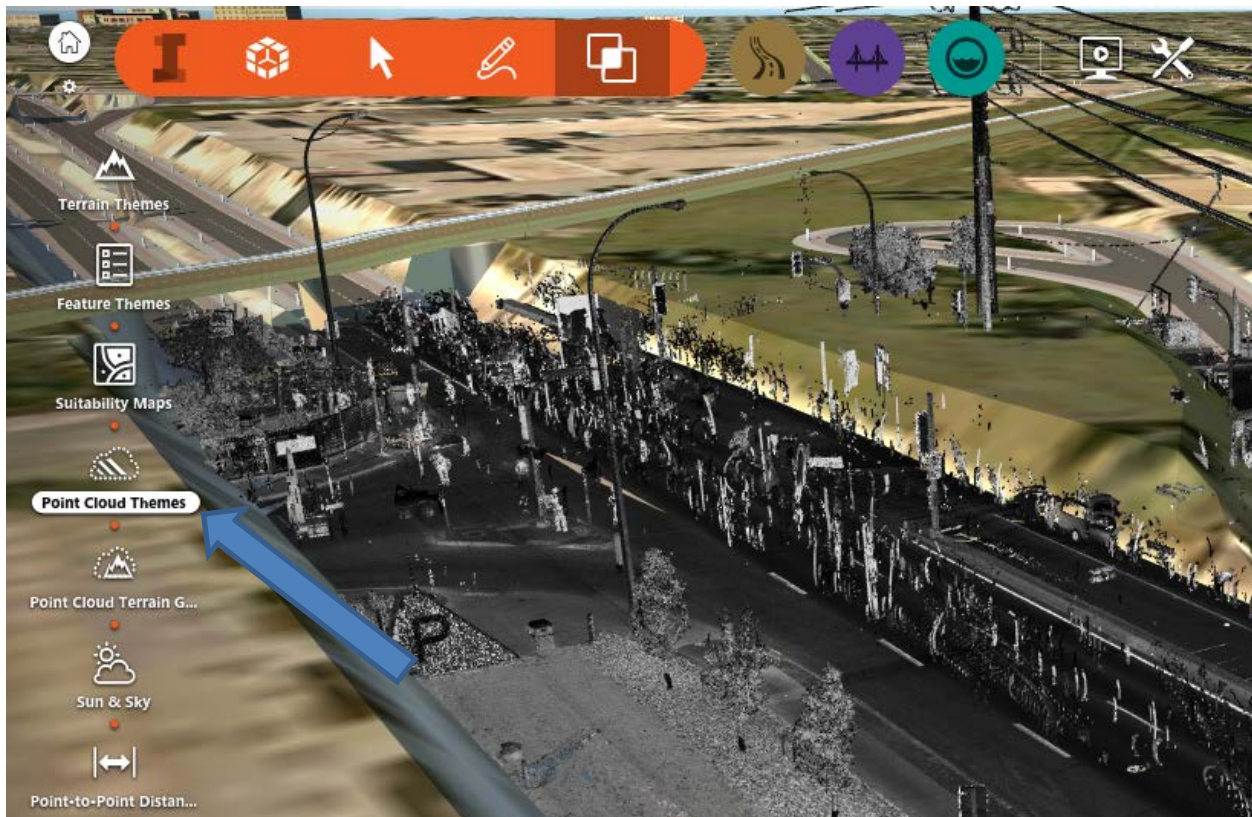
Scan Location - For a dataset derived from terrestrial laser scanning, scans can be colored by scan location to determine data overlap. This isn't a commonly used visual setting.




Autodesk InfraWorks

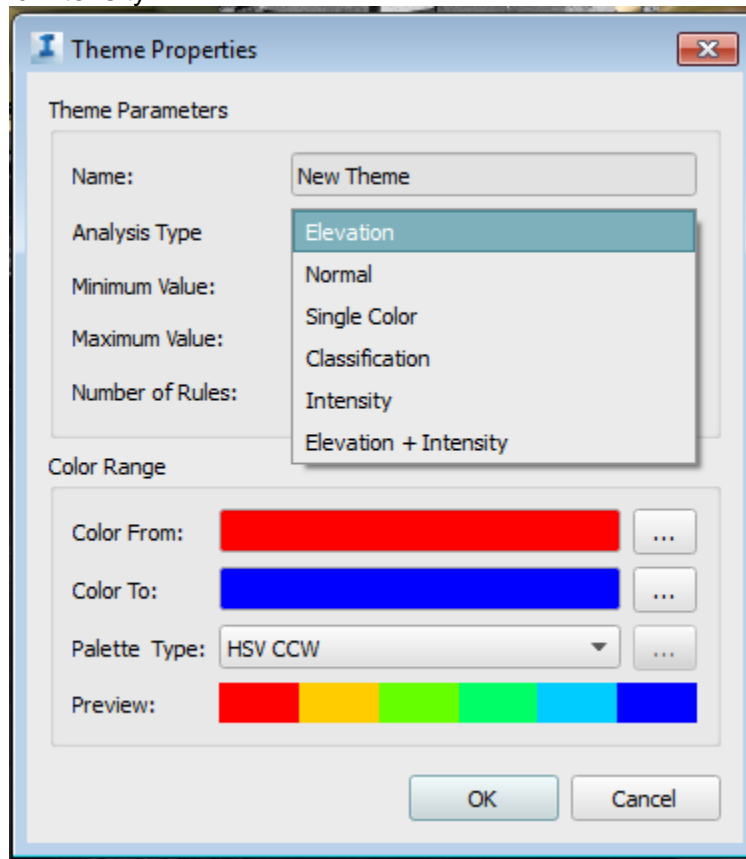
Infraworks has been able to ingest point cloud data for the last few years, and the visual quality in the software has been advanced substantially. On first import of a point cloud, it will default to RGB if color imagery was collected, or given a black and white intensity view when RGB is not present.

- **Importing** - Point clouds can be imported similarly to any other data format in Infraworks, but it has to be in the Recap scan project format (RCP) before import. Once imported, the data can be assigned a coordinate system, scale, translation, etc.
- **Styling** - Upon first import, RGB is the default style that is assigned in Infraworks. If color was not collected during the scan, then it is a black and white intensity view of the point cloud. Infraworks does have functionality to style a point cloud like Recap, however, these styles must be defined manually.
- Choose Point Cloud Themes



- Press the  icon to add a new theme

- Now you can customize by elevation, normal, single color, classification, intensity, or elevation and intensity



Usability of Point Cloud in Infraworks

The tools in Infraworks have advanced significantly this past year. It used to be primarily for visualization purposes, but now with more automated tools for feature extraction, it is becoming a more robust tool for point clouds. However, there are still many limitations for robust use including:

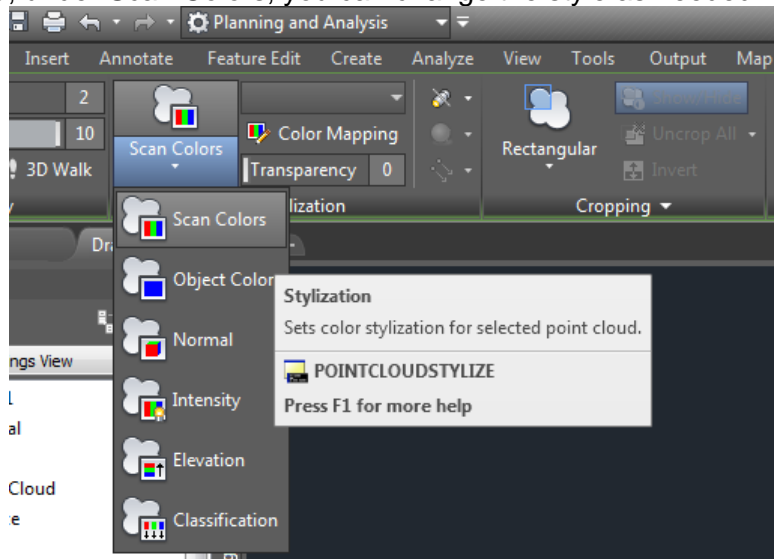
- Limited tools to manually work with point cloud
- No editing of point cloud in Infraworks
- Limited tools to clip, organize and manage point clouds
- Requires disk space – on import of an RCP project, a copy of the entire point cloud data is placed in the Infraworks working directory structure. Ensure there is adequate local storage depending on the size of the point cloud file
- Unified data – this will enhance to performance of the point cloud in Infraworks. Ensure the scan locations are not needed for further functionality, as they are all merged into one large scan file.

The automated extraction tools recently introduced will be discussed in the next sections.

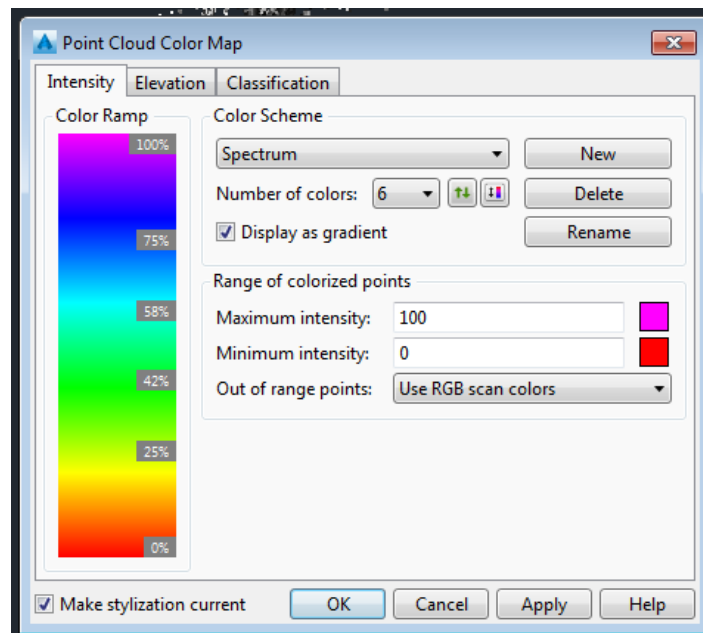
Autodesk Civil 3D

Similarly to Infraworks, a point cloud file can be imported into Civil3D. Once the point cloud is inserted into Civil3D it can be styled.

- Select the point cloud, and this will change to the point cloud ribbon
- Once selected, under Scan Colors, you can change the style as needed



- Under Color Mapping in the ribbon, these styles can be customized as well.



Tips for better performance of points clouds

- Unified data – this will enhance to performance of the point cloud in Civil3D. Ensure the scan locations are not needed for further functionality, as they are all merged into one large scan file.
- Split large datasets into multiple projects – tile datasets prior to importing.
- Assign regions to the Recap project file.

Point Cloud Feature Extraction

Point clouds are a great dataset for Infrastructure projects, however they can be challenging to work with efficiently. As these types of projects can be quite large, the point cloud files become even more difficult to handle due to the file sizes. The point cloud itself is considered non-intelligent (only a mess of 3D points), it is necessary to extract usable data from the point cloud for design purposes.

Depending on the level of information needed to extract (ie. Ground surface, curb and gutter, utilities, paint lines, etc.), this will determine how much time and effort is needed to do so. As there are many ways to do this, the next section will focus on various methods.

Manual Workflow

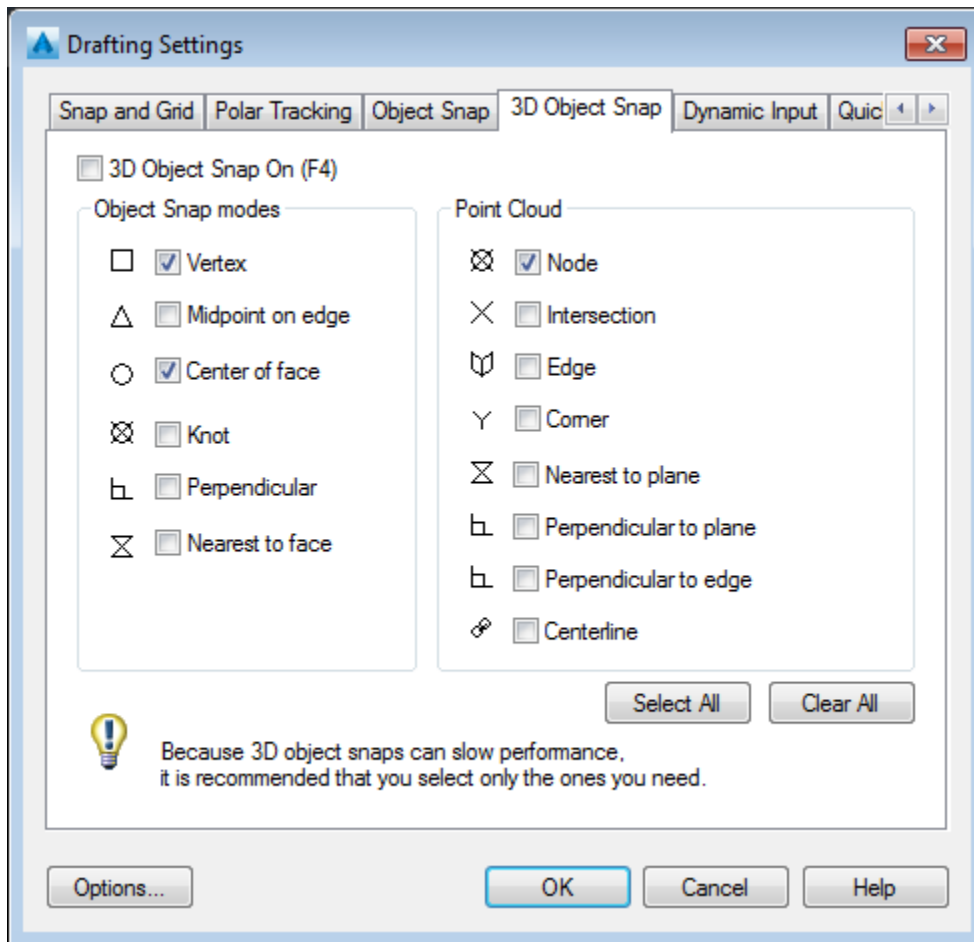
Typically, manual extraction of data from point clouds is done when limited information is needed from it for design. It is a time-consuming process to fully extract data manually, but is necessary on many occasions for certain features.

Manual extraction is typically best for the following:

- Utility extraction (manholes, valves, power poles, etc.)
- Trees (trunk location and drip line)
- Power lines
- Surface points (noisy / occluded areas)

Autodesk offers some basic tools for the manual extraction of features from point cloud data using the 3D Object Snaps for point cloud tools in Autocad. Autocad (and all verticals including C3D) has the following tools:

- Node
- Intersection
- Edge
- Corner
- Nearest to plane
- Perpendicular to plane
- Perpendicular to edge
- Centerline



Using these tools in Autocad products objects such as block, C3D points, or 3D linework can be manually placed using the point cloud.

Some challenges using these tools include:

- Incorrect snap locations
- Can't snap to center of object (ie. Power pole, tree trunk, etc.)
- Time consuming

Tips for manually placing features include:

- Crop the point cloud to view smaller areas of data
- Crop horizontal planes of the point cloud to aid in extraction building outlines and vertical features (power poles, trees, etc.)
- Change the visual style to intensity or normal view

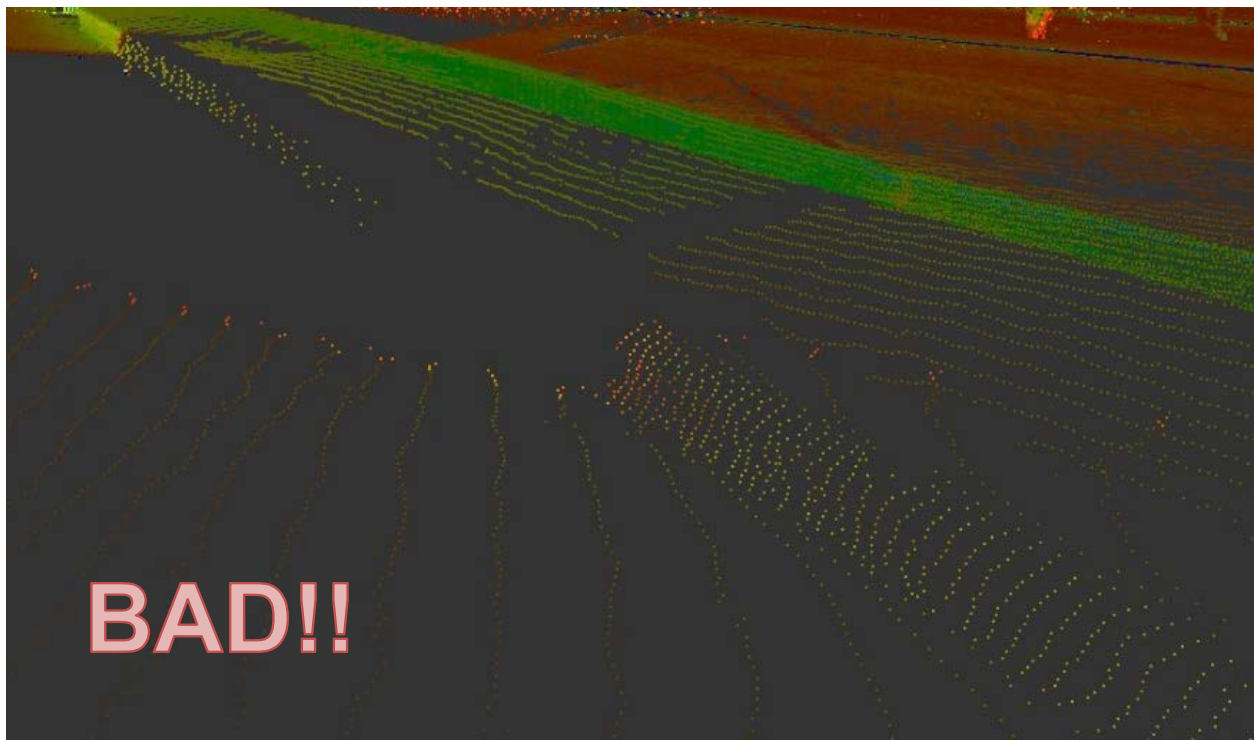
Automated Workflow Tips

This is the method of extraction that had increased development focus of late as end users of point cloud data are looking for the “easy button” solution.



This type of automated extraction is challenging for many reasons. It requires the following to be successful:

- Seamless point cloud datasets
 - Minimal occluded areas (lack of point cloud data)
 - Consistent density of data (not dense in areas and sparse in others)



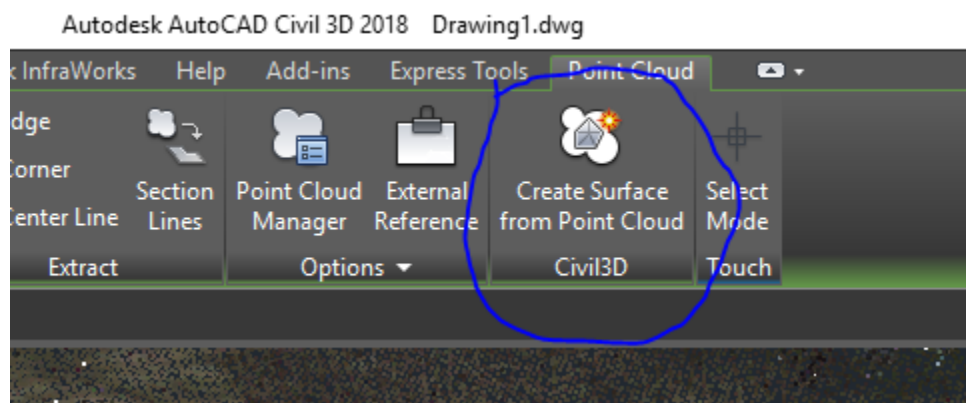
- Type of sensors used for collection. Point clouds datasets vary in accuracy (terrestrial, mobile, aerial, or photogrammetry), which can make it harder to extract various features.
 - Aerial Lidar – typically collected very high with less dense point cloud (5-20 points per sq. meter). Good for general topography but not for accurate extraction of defined features (ie. Curbs)
 - Mobile Lidar – more accurate than aerial, however does vary based on quality of system used, collection methodology, amount and quality of ground control points, and quality of vendor collecting. With a high quality dataset, this is the preferred method of data collection for infrastructure projects due to the consistently spaced data, but has challenges of line of sight.
 - Terrestrial – most commonly method of point cloud data, but does vary based on quality of system used, data registration methods (targeted vs. cloud to cloud), amount and quality of ground control points, and quality of vendor. With a high quality dataset, automated extraction can be successful but still has challenges with occluded areas, vegetation, and line of sight issues.
 - Photogrammetry – with the advancements and interest in drones, photogrammetric processing is allowing for more use of this data for infrastructure work. It is not the preferred method for collection due to regulatory hurdles (over people and roads, etc.).

Civil 3D Surface Creation

Civil3D has had tools for a while now to create a surface from a point cloud, including a way to filter a point cloud in order to derive a ground surface. The automation of this workflow can be successful for general terrain, but does struggle with accurately defining hard features (edges, curb, etc.).

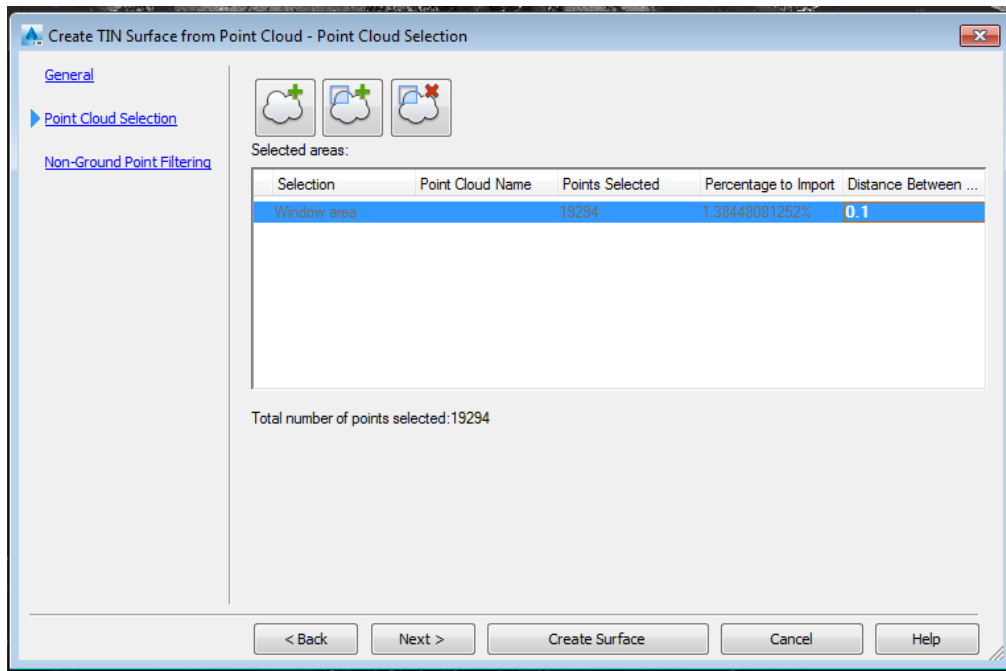
The steps to create a surface from a point cloud are:

- Choose “create surface from point cloud”

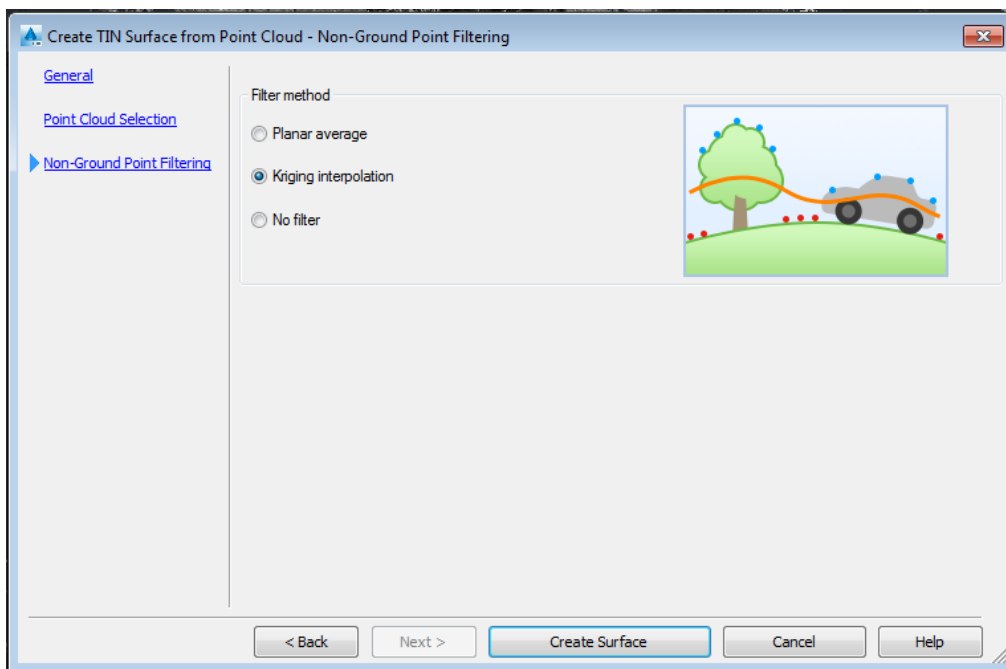


- Name and choose the surface style to apply
- Select area to create surface

- Change density of point cloud for surface creation



- Choose noise filtering (best for a ground terrain model is Kriging)



The benefits of this workflow are that any user can create a 3D terrain surface directly from a point cloud.

The challenges with this workflow are:

- Lack of definition of hard edges (curbs, edges, etc.)
- Noisy surfaces. As the process relies on algorithms there will be areas with noise or spikes in the surface that will have to be manually edited.
- Heavy surfaces. As the surface is generated from a dense point cloud, the surface tends to be very dense on its own even with filtering and segmenting options chosen. This may slow down Civil3D when viewing in 3D or with certain surface visual styles (3D faces, dense contours, etc.)

Infraworks Surface Creation

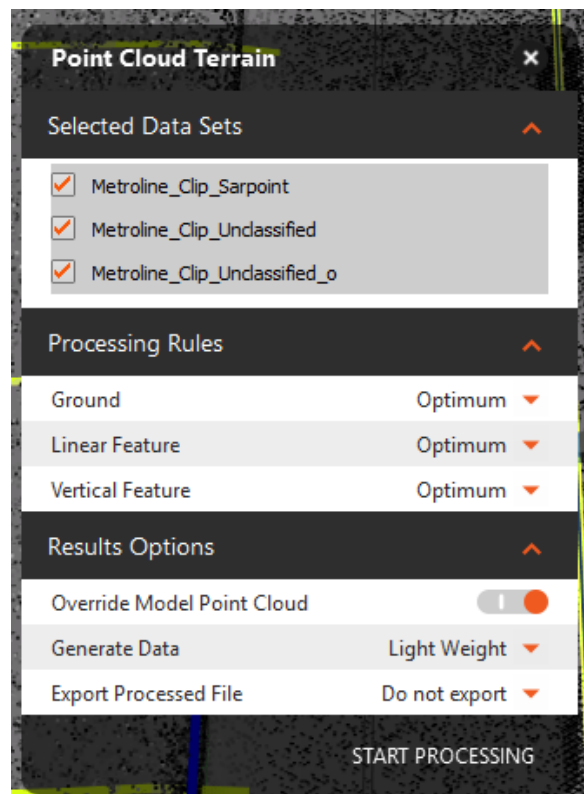
Autodesk has taken large strides in advancing the functionality of Infraworks, including the ability to classify and automatically extract features from point clouds. Infraworks is the ideal product for viewing point clouds as it is natively in 3D as are point clouds.

Here are the steps to work with point clouds in Infraworks:

- Once the point cloud data is imported and setup (map projection, scale, etc.), it is ready for the extraction workflow
- Choose the Point Cloud Terrain Generation tool



- This brings up the dialog with settings for extraction



- Settings can be customized as follows:
 - Selected datasets – can choose multiple point clouds if they exist
 - Processing Rules – Optimum setting is recommended
 - Ground – settings for “bare earth” ground surface extraction
 - Linear Feature – settings for linear features such as curbs and paint lines
 - Vertical Feature – setting for buildings, power poles, signs
 - Results Options
 - Override Model Point Cloud – as the point cloud file is being modified during this processing (filtered, classified, etc), there is the option to override the existing cloud with the edited one
 - Generate Data – option to generate a new point cloud file. All points, light weight, or key points.
 - Export Processed File – option to export the points to a new file. Options for all points, only ground points, or do not export.
- Start Processing. This process can take some time depending on computer speed, so go grab a coffee!! Or a nap!

Once the processing is complete, at this stage, the point cloud has been classified to segment the dataset into common features. Under the Point Cloud Style options, one can set up a style for Classification in order to see how the data was processed.

The coloring (as shown in the image below) is how the algorithms in Infraworks has been able to intelligently segment the data.

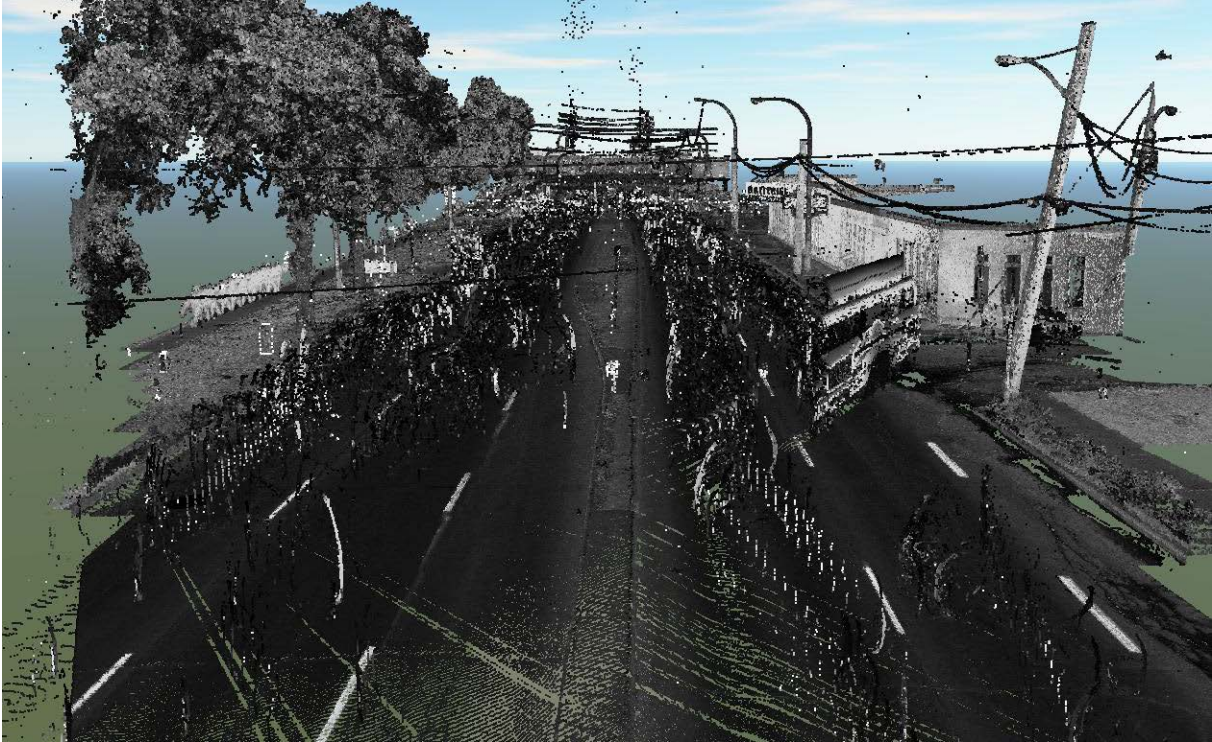


Figure 1 - Raw point cloud (intensity view)

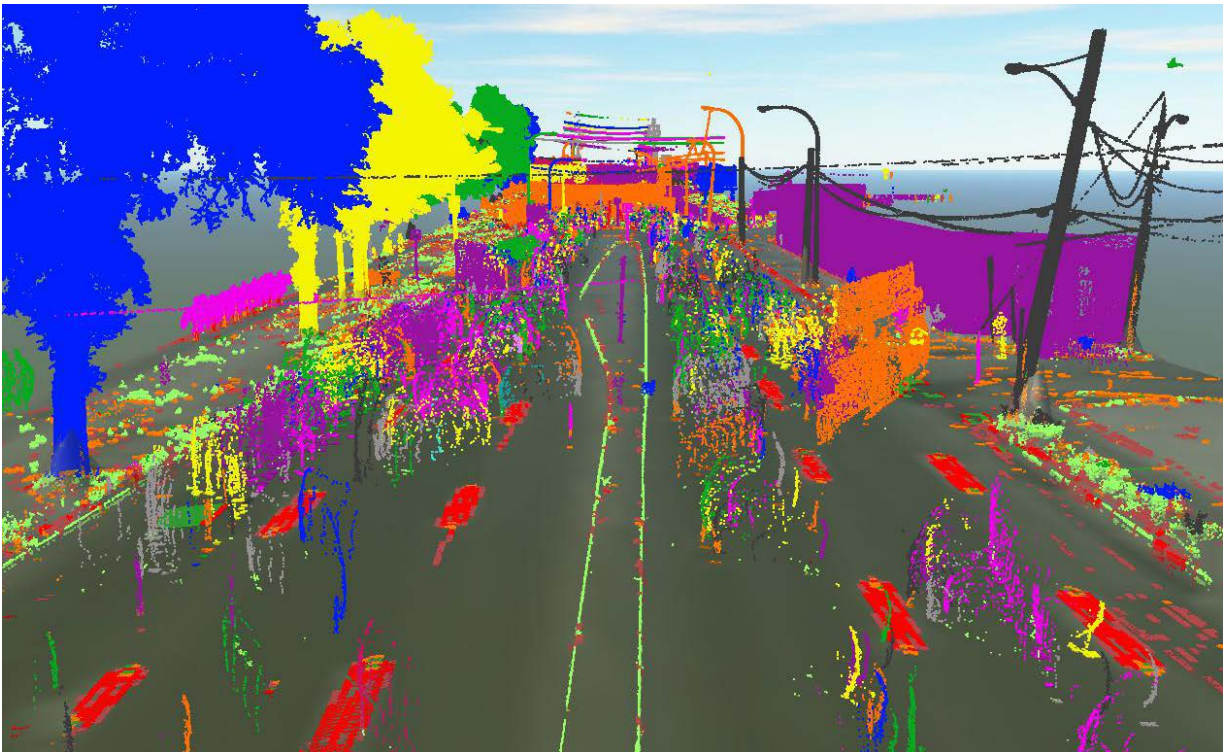


Figure 2 - Classified point cloud



Figure 3 - Terrain surface



Figure 4 - Terrain with image overlay



Figure 5 - Terrain with 3D modeled features

Linear Feature Extraction

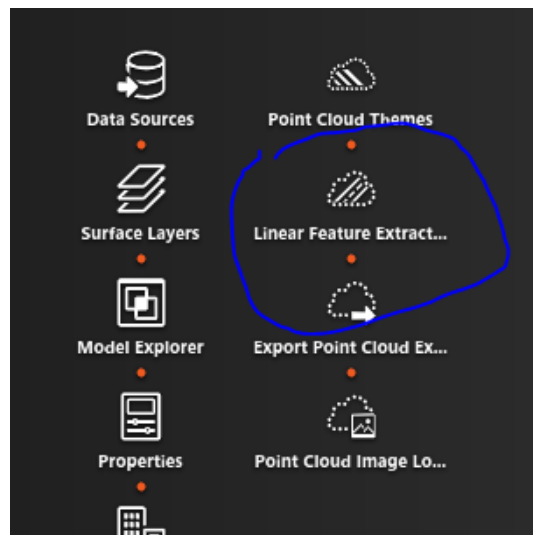
One of the most exciting new features of Infracore is the newer Linear Feature Extraction functionality that was added this past year. This type of extraction is essential for corridor projects, not only to extract features like paintlines, but to also create breaklines for enhanced and proper surface creation.

Two methods of Linear Feature Extraction exist in Infracore and will be discussed here.

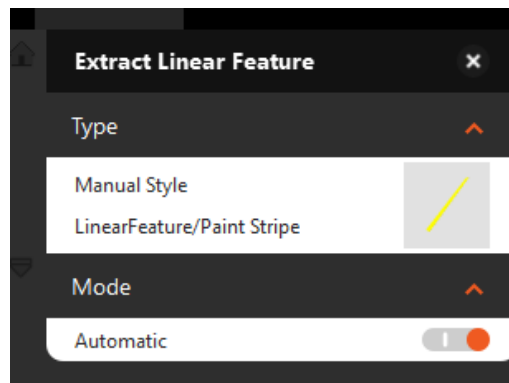
Automated Extraction

This method of extraction can be used for several types of linear extraction including paint lines and curb and gutter. The data does need to be very seamless (no gaps) in order for the extraction to work properly, otherwise there will be gaps in the extraction.

- Select the Linear Feature Extraction



- Choose the style of extraction you want to complete.



- Choose at least 2 points along the breakline / paintline to start the extraction.



- It will take a few seconds to run, then you will have an extracted 3D breakline with the style chosen

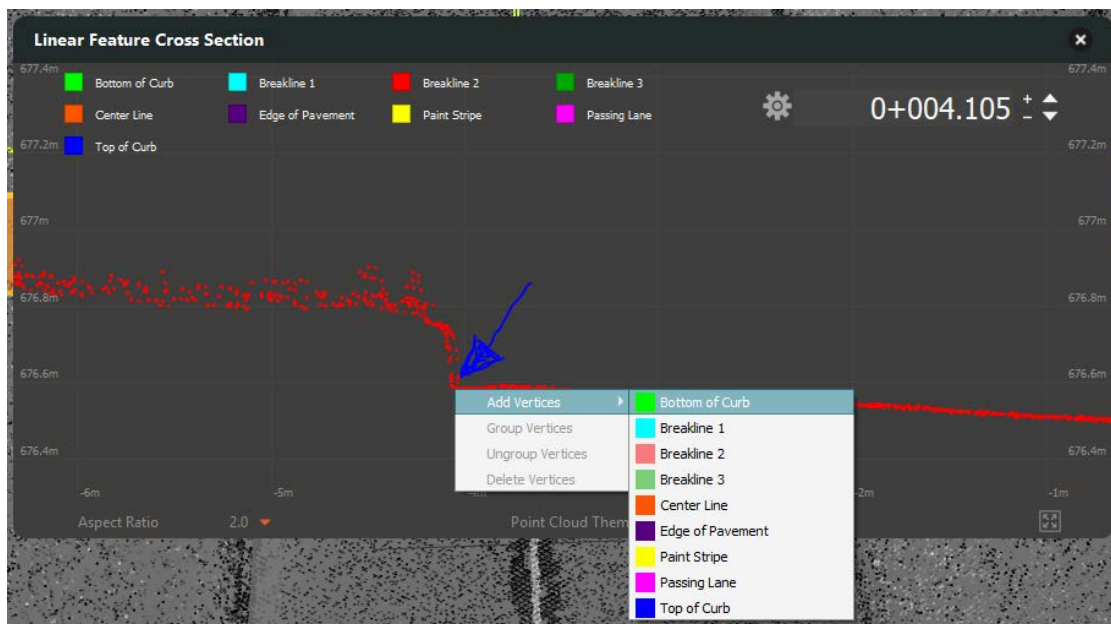
Some key tips with this are:

- Initial pick points – make sure the initial 2 points picked are of high quality and accurate. These will be used as the initial starting point to grow the extraction from there.
- Tangent sections – it is best to start the extraction on a tangent section and not a curve.
- Broken paintlines – be sure to pick the end of two adjacent paint segments as in the image above. This will ensure the extraction looks for a typical distance between the segments of the broken lines.
- Check the extraction!! – automation is great, but can be prone to errors. Checking the quality of the extraction is key

Cross Section View Extraction

The cross section view for extraction is one of the preferred methods for linear extraction from point clouds as it allows for quick and simple extraction and QA in one step. This functionality was added to Infraworks this year and continues to improve. Here are the steps to enter the extraction mode:

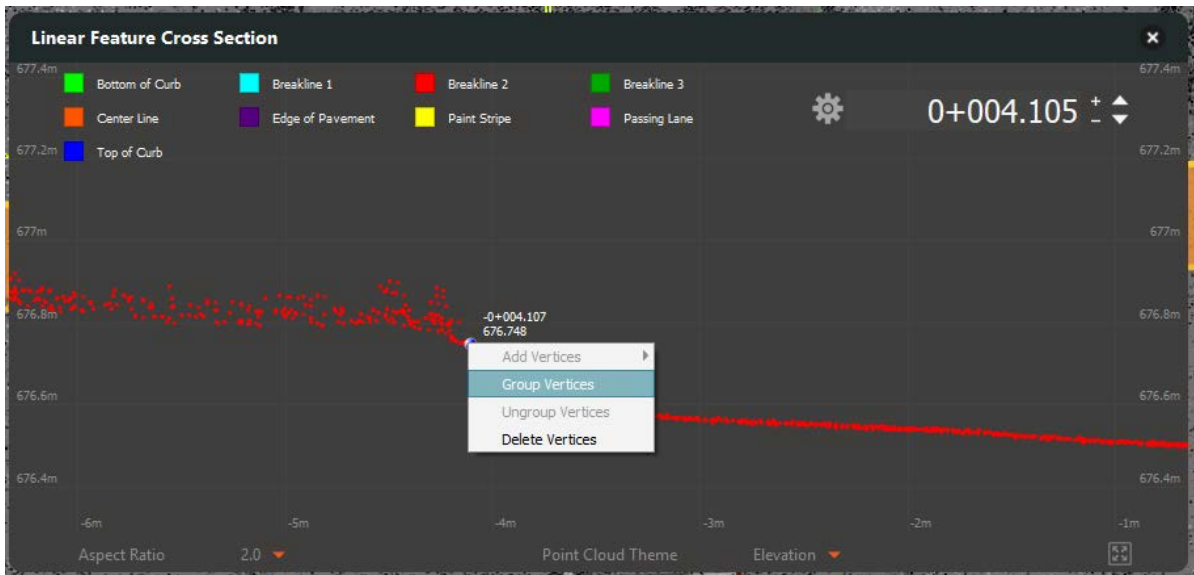
- Right click on a previously extracted line, then choose “Show Cross Section View”
 - Suggestion is to extract a paintline using the automatic extraction tools, then use this line as your main alignment
- This opens the cross section view with stationing based on the direction of the line
- Zoom to the location needing the extraction (ie. Curb and gutter)
- Hover over the location to mark, then right click to place the vertices needed



- Mark all the vertices needed in the view. Use the “gear icon” to change the settings for the section view including spacing along the alignment and thickness



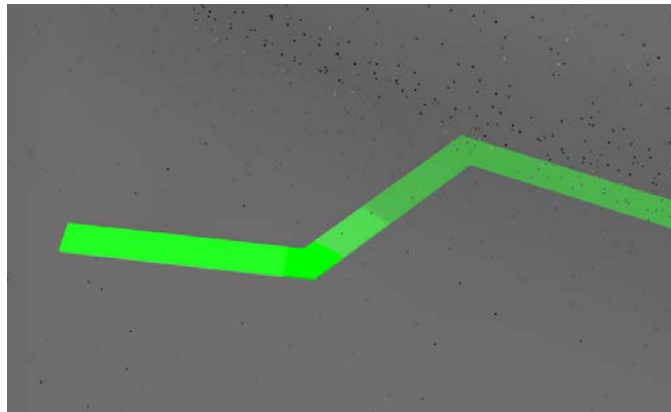
- For some extraction, you may want to keep a consistent extraction between the breaklines (such as for curb and gutter), so there is the option to “Group” vertices which will hold the spacing between the vertices. This way when one of the vertices is moved, the others part of the group will move with it. Select the vertices to group with the shift key, the right click to group.



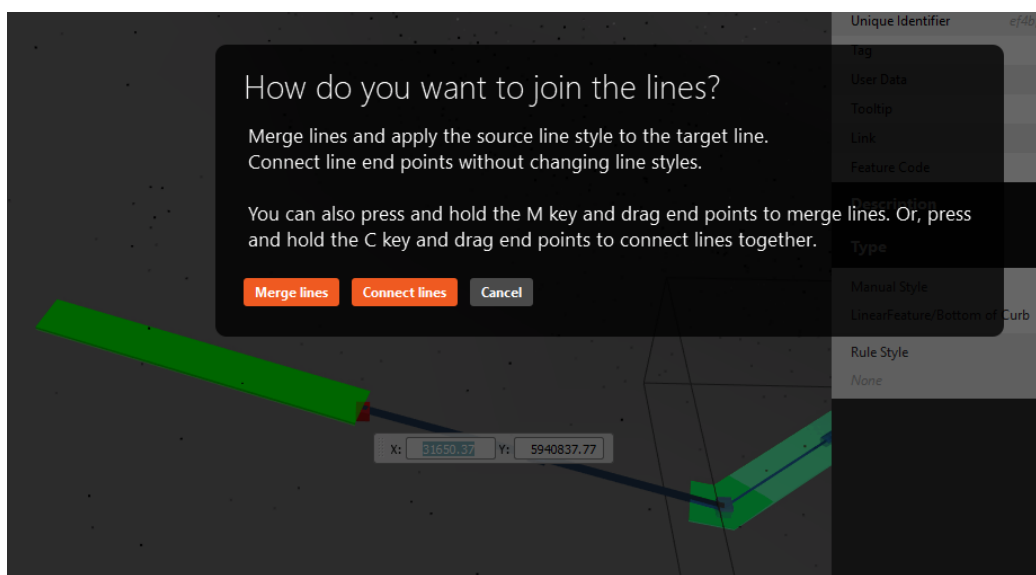
Editing Extracted Linework

Infraworks now has a limited set of tools for editing the extracted linework. Here are a few tips:

- Surface Opacity – in order to better visualize the linework, increase the surface opacity. Often the linework may be drawn slightly below the surface that was extracted and won't be visible
- Selecting Lines – the line may be visible to see (with the surface opacity turned on), but it can't be selected. This is because the line is slightly under the surface. The view has to be orbited to see under the terrain in order to select the line. This can be seen in the image below where the brighter green is above the terrain, and faded when below.



- Splitting linework – you can't split at the node of a line, only along the line itself. Right click on the line to access the split command
- Joining linework – grab one of the nodes and drag to the end of another line and it will automatically snap. You then have the option to Merge or Connect
 - Merge: joins lines and changes the style to the source line
 - Connect: joins lines without changing the styles

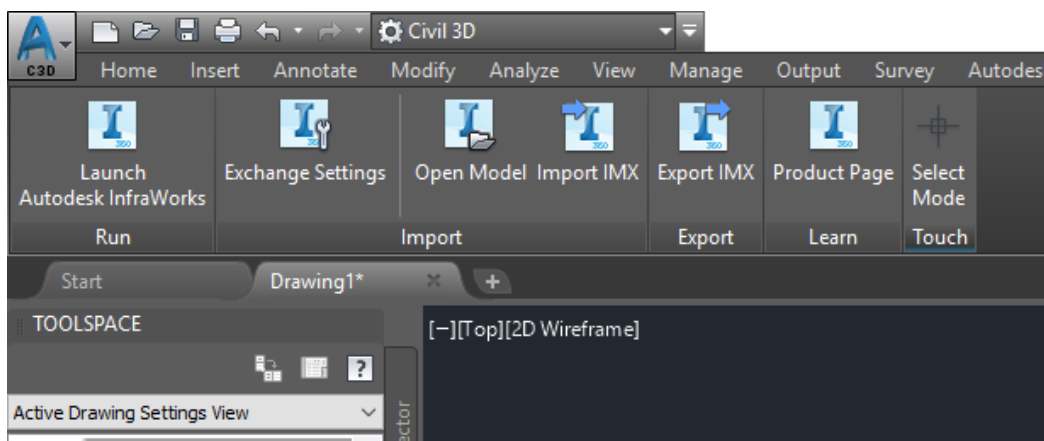


Exchange of features between InfraWorks and Civil3D

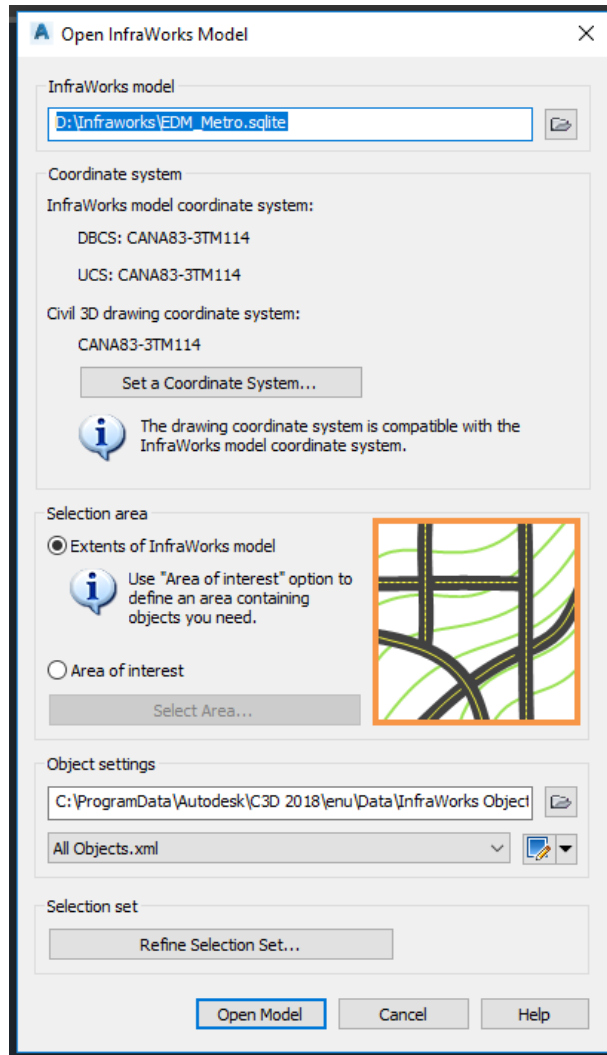
As the majority of the point cloud extraction tools are built in InfraWorks, it is necessary to exchange data between it and Civil3D. It isn't as easy as it should be, but getting better for sharing of information that was extracted (ie. Linework, terrain, etc.). For the purposes of this discussion, it will only show the process to exchange extracted features and not design objects.

Terrain

In Civil 3D, you can exchange terrain data in multiple ways.

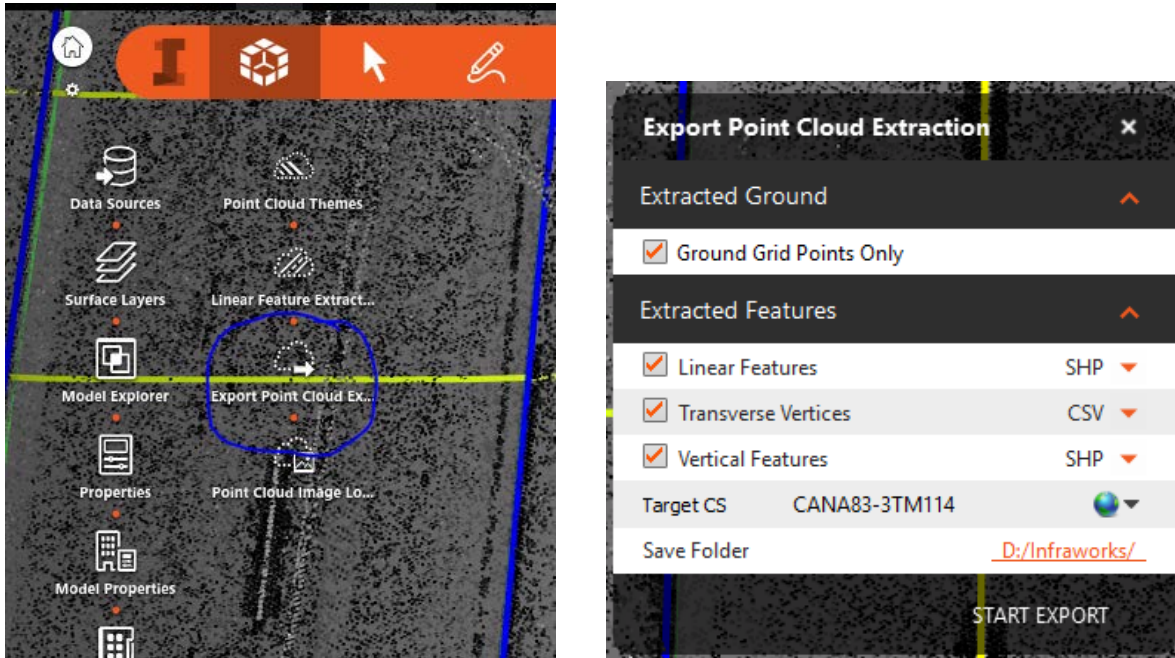


- Export IMX from Infraworks containing the surface. This creates an external file that can be imported into Civil3D from the ribbon using the “Import IMX” command
- Create surface directly from the point cloud. As the ground points can be exported to a Recap format from Infraworks, you can generate the terrain surface from that file (as per the earlier section in the handout).
- Open Model from Infraworks directly. Using the “Open Model” command the sqlite project file can be opened directly. Using the settings in the import, you can choose how the import is handled (change the object settings options. For basic terrain import, nothing needs be changed in the settings).



Linear Features

The linear features from Infracworks can only be exported by SHP format. Using the “Export Point Cloud Extraction” option, you can choose what to export.



In Civil 3D, use the “MapImport Command” to import the SHP file which contains the 3D breaklines. These can then be added to your Civil3D surface as breaklines.

Challenges with Data Exchange

Some of the challenges with the exchange are the following:

- Coordinate system information. Infracworks is a very spatial project that heavily relies on coordinate systems for data management. When exchanging to Civil3D, careful attention needs to be given to the coordinate settings of the drawing to ensure data is exchanged correctly.
- Large datasets are derived from the point cloud in Infracworks. The terrain model that is generated can be handled quite easily in Infracworks, but Civil3D can still struggle with large datasets, particularly surfaces.
- Exported linear feature data from Infracworks is only done by shapefile. These can be awkward to use if you aren't familiar with the MAP3D tools.

Best practices for terrain from point clouds in Civil3D

As shown in the previous sections, there are many methods that can be used to generate a surface from a point cloud in Infracore and in Civil3D, and they can all yield different results. Point clouds are very dense datasets, which makes it even more challenging to use in Civil3D because of their size. The more data that gets imported and used in the surface definition, the heavier and more challenging it is to use it efficiently in Civil 3D.

The key consideration for using the data in Civil 3D is to limit the amount of information that is imported to make the surface more lightweight. **Smart data management is critical!!**

Our preferred method to get a usable surface in Civil 3D from Infracore is the following:

- Export the Ground Grid Points from Infracore. This will only export the point identified as ground points to an RCS point cloud format.
- Edit the RCS file in Recap to trim the erroneous points from the perimeter of the dataset. If other points are visibly noisy, remove them as well.
- In Civil 3D, import the filtered RCS file.
- Select point cloud in Civil 3D, then “Create Surface From Point Cloud”
 - Changes spacing settings to a larger value (30cm)
- Import SHP file of linear extracted features from Infracore
 - Add to surface definition as Breaklines
- Run Simplify Surface Command to remove 85 – 90% of points