Section 11: Point Clouds

Section Objective

Introduce users to point cloud collection methods such as LiDAR and photogrammetry methods. Users will learn about point clouds as a data format and a number of processing and editing methods.

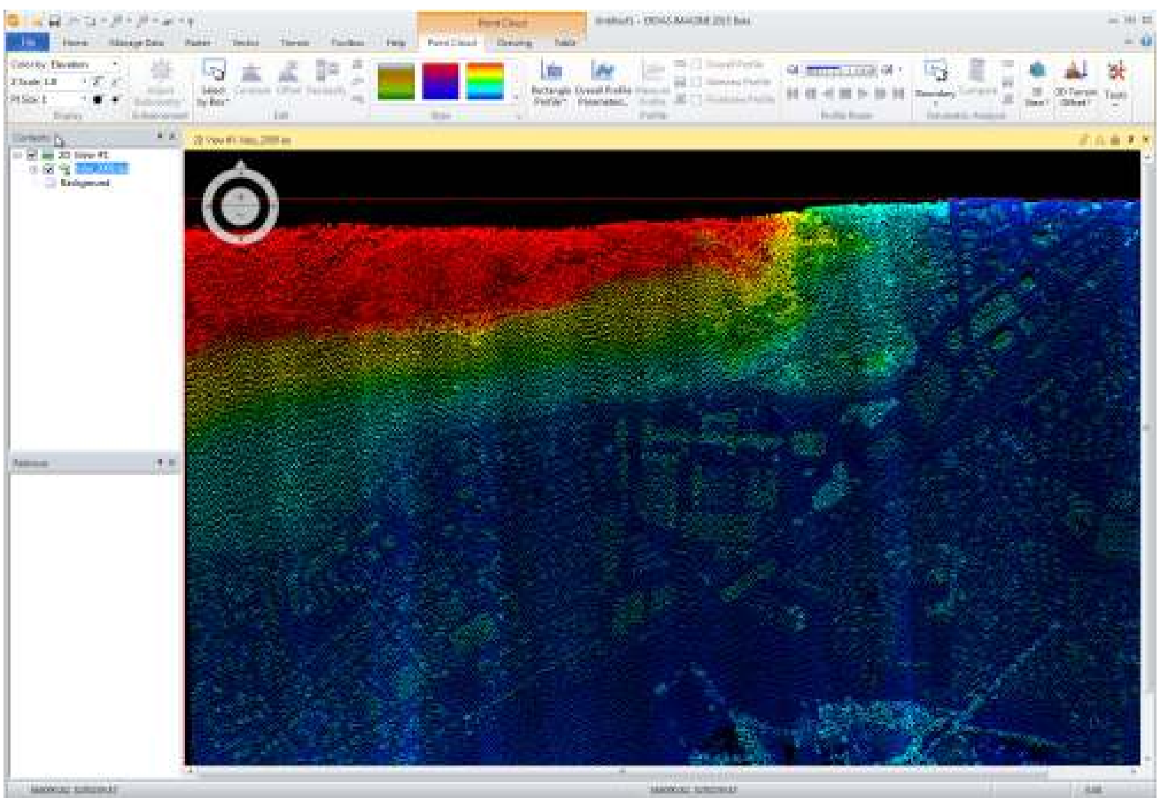
Point Clouds

Objective:

Students will gain an understanding of point cloud data through the use of the eWorkspace Students will use the 2D View in order to visualize point cloud data and to change the color scheme used to represent elevation in the data.

Task 1: Display Point Cloud Data in a 2D View

1. From the eWorkspace, click the **File** menu.
2. Select **Open > Point Cloud Layer** **.** The Select Layer to Add dialog displays. This dialog is used throughout ERDAS IMAGINE.
3. Ensure that **Files of Type** is set to the default **LAS as Point Cloud (*.las)**. The icon next to the drop-down to change the default file type.
4. Navigate to the course data directory and select **lidar_2008.las.**
5. Click **OK** and the point cloud displays in the **2D Viewer**.



The point cloud is shown with a blue-to-red maximal color slice. The lower elevations are displayed in blue shade and the higher elevations are displayed in shades of red.

6. To quickly display the Viewer options, right-click in 2D View #1 and select **Fit to Frame.**

You can also select Fit to Frame button in the Extent group on the Home tab.

7. To zoom in, cursor the cursor over the area you want to zoom in on and scroll the mouse wheel up.
8. To zoom out, scroll the mouse wheel down.
9. Use the **Interactive Zoom in** and **Interactive Zoom Out** tools to draw around the areas you want to view.

Additional Zooming tools are contained in the Zoom Tools menu. To access them, click the menu arrow and then select the tools you would like from the menu.

10. Click the **Previous Extent** button. This icon will step you backwards to the last zoom level. You may undo all the way to the original zoom level used when the point cloud was opened.
11. In the Viewer, hold the middle mouse button down and pan through the image.
12. Leave the dataset open in the 2D View for the next task.

Task 2: Change Color Slice

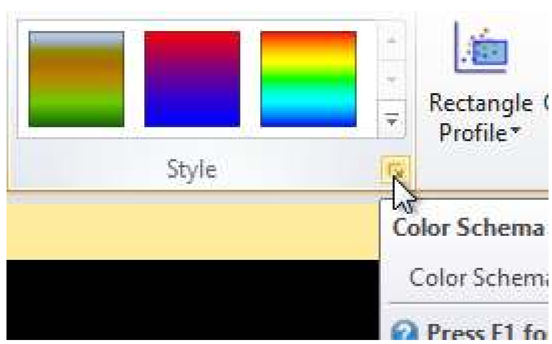
Students will gain an understanding of point cloud data through the use of the eWorkspace. Students will use the 2D View in order to visualize point cloud data and to change the colour scheme used to represent elevation in the data.

1. In the Scale group of the **Home** tab, type 1:1000 and press Enter.

   The data is still interpretable, but it is becoming difficult to see the point. We can increase the point size to help this interpretability.

2. Select the **Point Cloud** tab.
3. In the **Display** group click the **Point Size** button  .
4. In the **Point Size** menu, select **3.**
5. Click the **Fit to Frame** button on the **Home** tab to zoom to the data extent.
6. On the **Point Cloud** tab, click the **Earth Tones Style** button to use a different colour slice. The elevation values are coloured ranging from dark green for the lowest values through browns to greys for the highest values.

7. From the **Style** group click the **Color Schema** button.

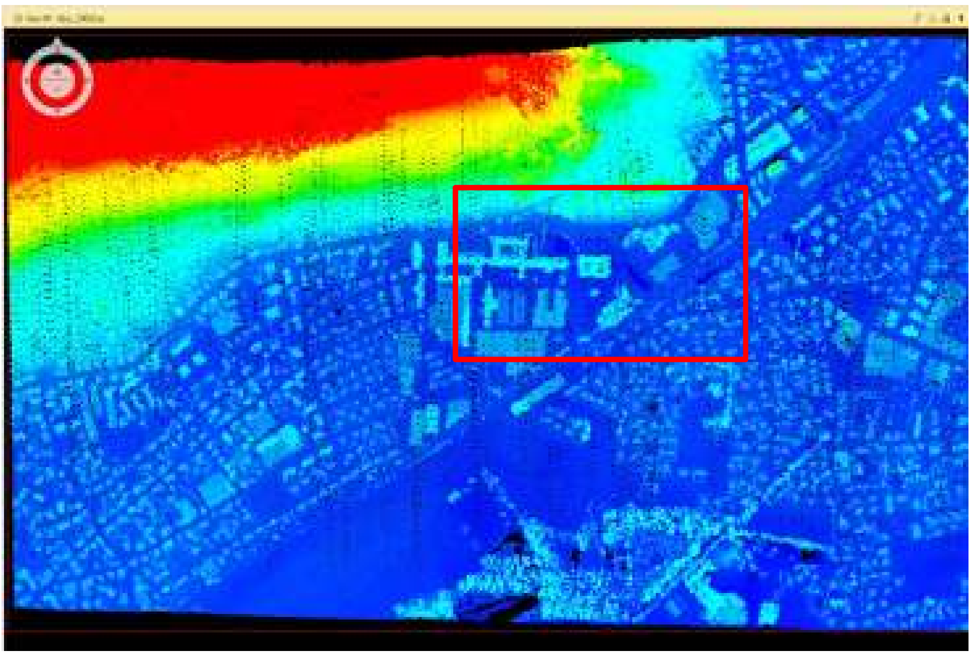


8. From within the Colour Schema Dialog box choose a **Min Elevation** colour and a **Max Elevation** colour.
9. Change the **Color Levels** to a lower number eg. **50**.
10. Click Apply to assess the results of the modified **Colour Schema**.
11. Reset the **Color Schema** back to the original rainbow.
12. Leave the dataset open in the 2D View for the next task.

Task 3: Viewing by Intensity and Returns

The nature of LiDAR data means that there are several different ways of looking at the data. In addition to elevation (or possible RGB encoding), LiDAR systems can also record the intensity of the light reflected back to the system, providing you with an additional way to understand the study area.

1. With **lidar_2008.las** open in the 2D view increase the point size to **3**, to improve visibility of the data.
2. Zoom in on the portion of the data highlighted in the image below.



Now we will display the LiDAR data as Intensity. This will colour the points based on the intensity of the pulse that was returned back to the sensor.

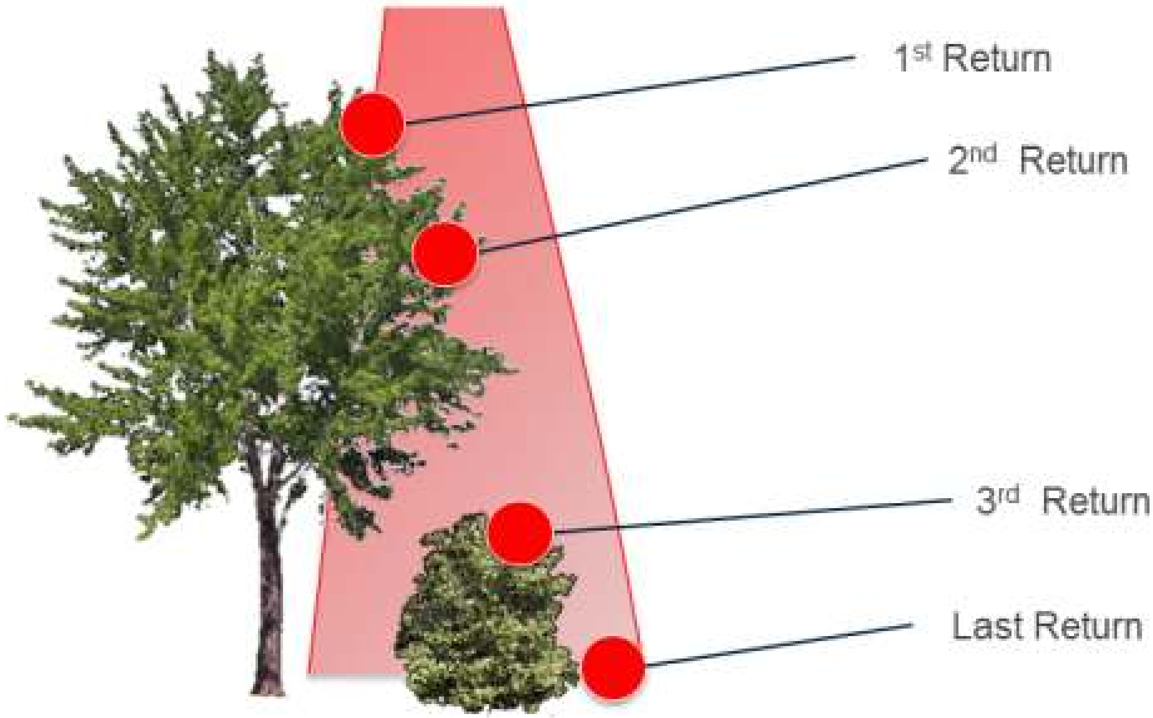
Many LiDAR sensors measure the whole waveform of the light reflected back to the sensor. This information can be encoded in the points as an Intensity value. This value rep-resents how much light was bounced back to the sensor and can be visually interpreted because it resembles a pan-chromatic image.

3. Select **Intensity** from the **Colour by** pulldown list on the Point Cloud tab.

If the point cloud displays as only black in the 2D view, open the Metadata from the Home Tab. Select Edit | *Compute Statistics. Click Yes to the attention box to Recompute the statstics. Remove the point cloud from the 2D View, and then RMB click* | *Open Point Cloud to open it again and display the new statistics. The Intensity Layer will now display.*

4. Examine the different features evident in the data.

   The nature LiDAR data means that it can have more than one return per pulse. For instance, a single pulse of light can be partially reflected by the top of a tree, a branch on the tree, a bush under the tree and the ground.



5. On the **Point Cloud** tab, select **Last/Int/First** from the **Colour by** pull-down menu

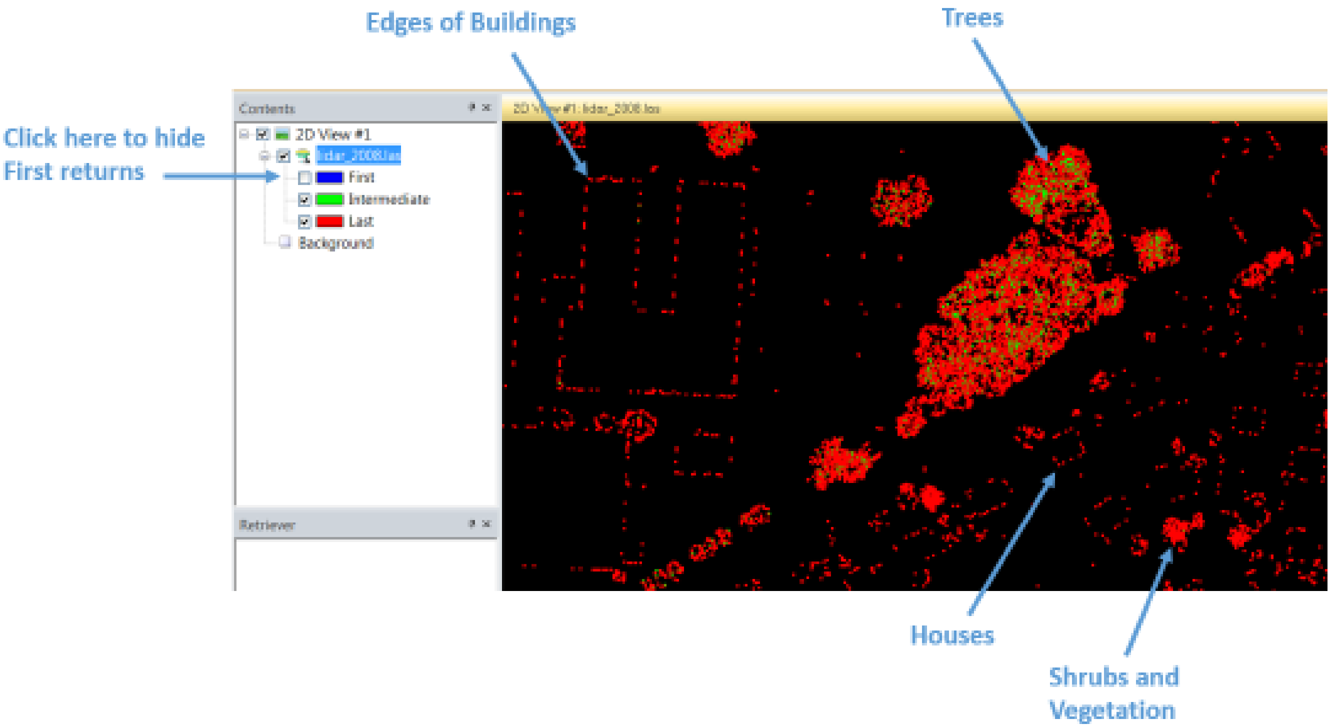
   This colours the points by their return, grouping them as first, intermediate and last returns. Single returns are considered First Returns.

First/Single returns indicate the tops of things: the roofs of building, tree canopies, power lines, or just bare earth.

Last returns indicate the bottoms of things: Bare earth under a tree, the ground beside a building, etc.

Intermediate returns occur when the pulse is reflected multiple times in the way down: branches of trees, understory in forests, beams in a power transmission tower, or girders in a building under construction.

6. Turn off the First returns by clicking the checkbox next to **First** in the **Contents** pane.



7. Note the features that you can see. You may want to toggle back and forth with the Intensity of encoding to get a better grasp of what you are seeing.

Why do the edges of buildings show up?

How can you identify trees using the Last/Int/First colouring scheme?

8. For more information on the returns, change the **Color by** option to **Returns.**
9. Hide the returns one by one by unchecking them in the Contents pane until only Return 4 is displayed.

What does Return 4 represent?

10. Toggle back and forth between the Colour representations we have used so far and see how different features are represented in LiDAR data.
11. Clear all data.

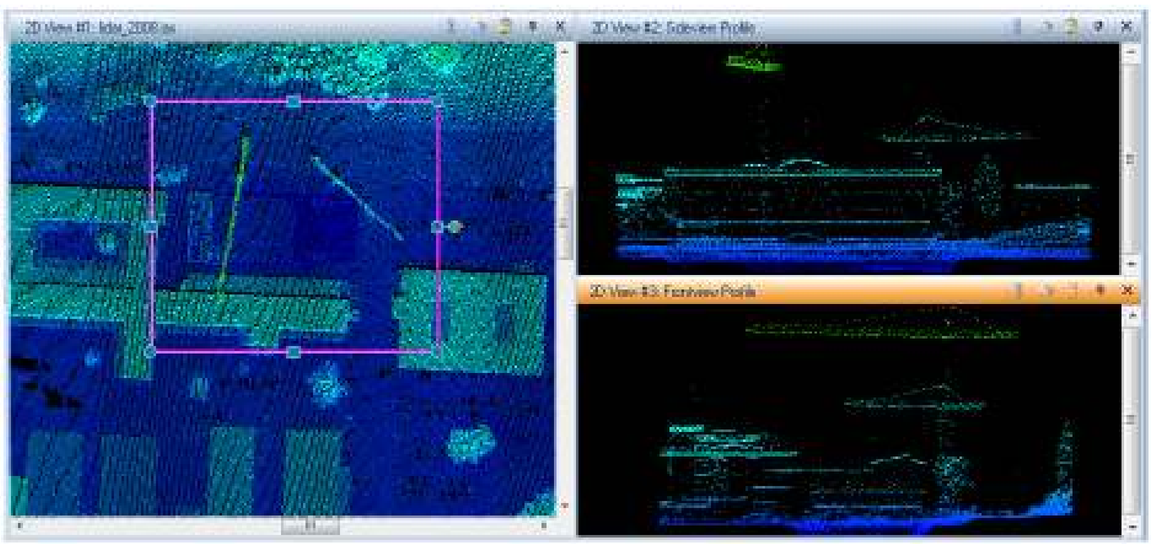
Task 4: Rectangular Profiles and Editing Points

Point cloud data is three-dimensional data; each point contains X, Y and Z information. Therefore we are not limited to only viewing the data in 2D planimetric views. ERDAS IMAGINE provides utilities that allow us to look at the data from several different angles at the same time.

1. In a 2D View open **lidar_2008.las**. Ensure the colour scheme is set to **Elevation**.
2. Open the Inquire Cursor (**Home** tab > **Information** group > **Inquire**) and enter the following coordinates.
    - **X: 546840**
    - **Y: 5250837**

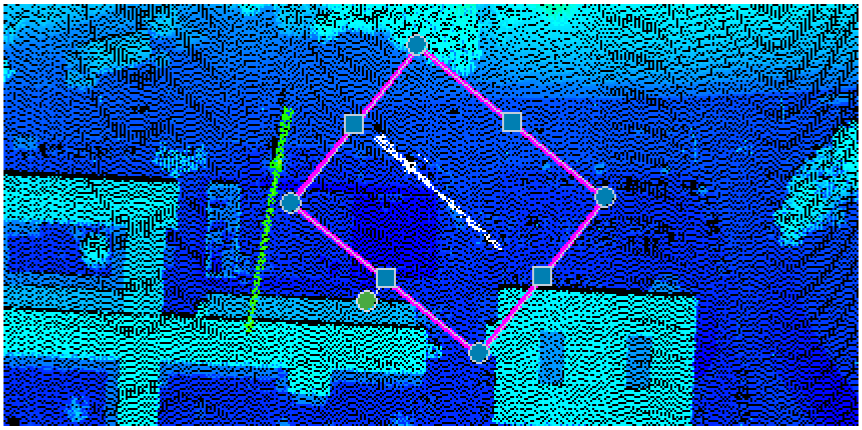
This point is in the middle of a construction zone. You should be able to see two tall, linear features.

3. Close the **Inquire Cursor.**
4. On the Point Cloud tab, click the  Rectangular Profile button.
5. In the 2D View, draw a box around the construction area, as seen below.



From the Profile Views, we can identify the two Linear features as construction cranes.

6. In the 2D View, grab the **green handle** on the Profile Box and rotate the box and change the Profile Views.



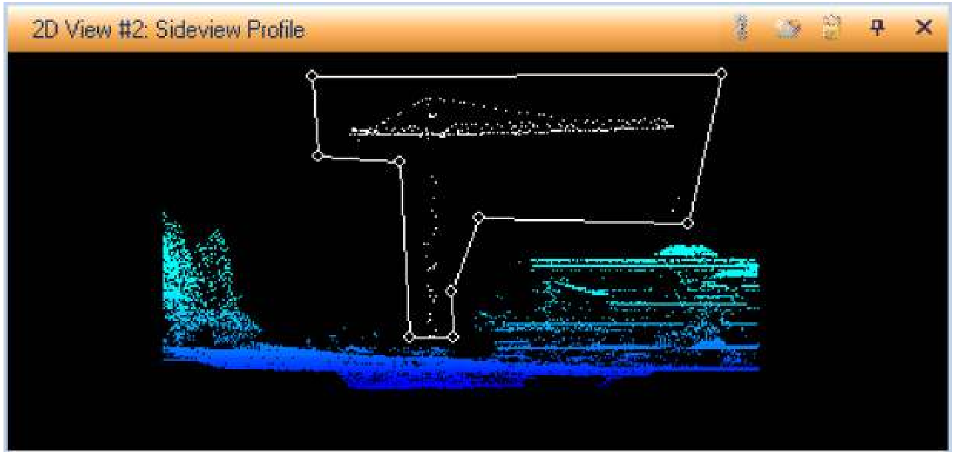
Each time you release the handle the profiles will update, showing the view from a new angle. The side of the box with the green handle defines the "Front" of the profile.

7. Drag the **Blue** handles to resize the area currently in the profile. Make sure that at least one profile view allows an unobstructed view of both the boom and the tower of the east-most (shorter) crane in the construction zone.
8. You can move the profile box by dragging one of the sides (not on a blue handle).

Now we will remove the crane from the data by deleting the points associated with it. It would be very difficult to only select the crane points in the 2D Planimetric View, however the Profiles provide a better view from which to select the points.

Note that the taller crane overlaps a portion of the building. We will need to select the crane points without selecting the building points.

9. Click on the bottom half of the **Select by Box** button and choose  **Select by Polygon** tool in the **Edit** group of the Point Cloud tab.
10. In the profile view with the unobstructed view of the cranes, digitize a polygon around the points representing the other crane. Click to add vertices and double-click to finish the polygon.
11. After you double-click to close the polygon, you can drag the polygon nodes around to reshape the selection to include all of the points.



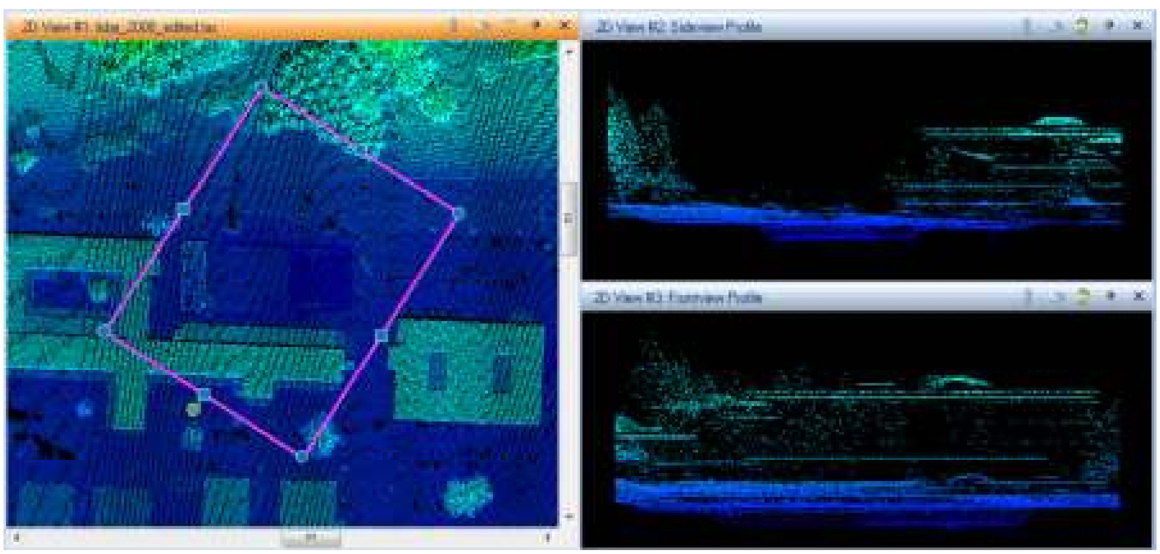
12. In the **Edit** group on the Point Cloud tab, click the **Delete** button .

13. Click **Undo**  bring the points backs.

14. Click **Redo**  to reverse the Undo action.

15. Resize and move the Profile Box to give an unobstructed view of the tall crane.

16. Use the tools above to remove the other crane from the data.



17. Click in the 2D View to make this the active window. Select **File > Save As > Top Layer As** and save the file as **lidar_2008_edited.las**.

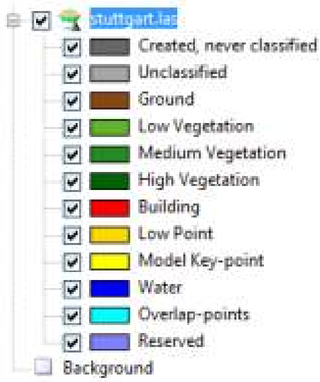
18. **Clear** the View. If prompted, do not save changes.

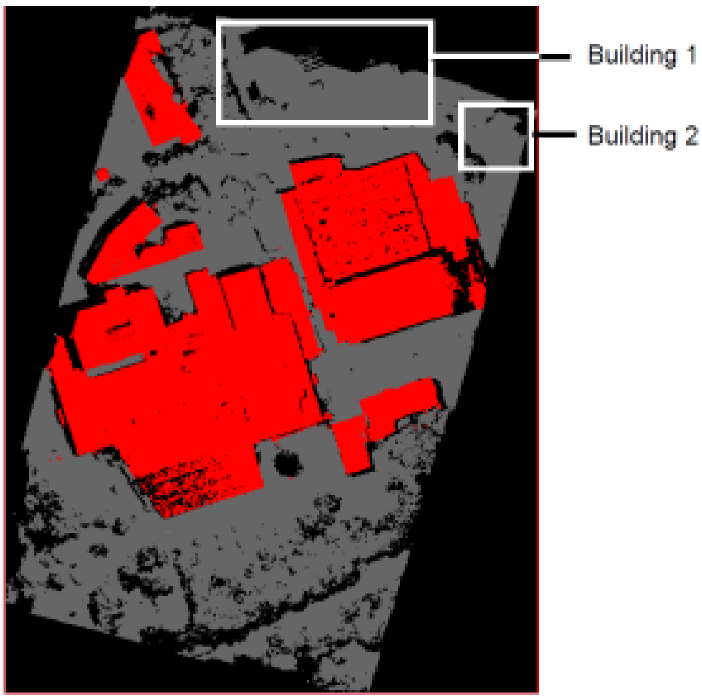
Task 5: Classifying and Filtering Point Clouds

Students will view a photogrammetric point cloud, select the points that represent a building and classify those points. Then they will filter the point cloud so that only the building points remain. This data is then ready for rasterization and conversion to a 3D vector

1. In a 2D View display **Stuttgart.las**
2. Change the Color by display method to **Classification**

The points are color coded based on the classes into which they have been gathered. The classes are specified in the LAS 1.3 Spec.





In this dataset, everything began as ***Created, never classified***. We have ben classifying the buildings, but have left two buildings as noted above.

3. To better see the buildings which have not been collected, change to **Color by RGB**.

We will now make changes directly to the LAS file, so we need to save the data as a new file, preserving the original as a backup.

4. Select **File > Save as > Top Layer as**. Navigate to your ouputs directory and name the new file ***Stuttgart_edited.las.***

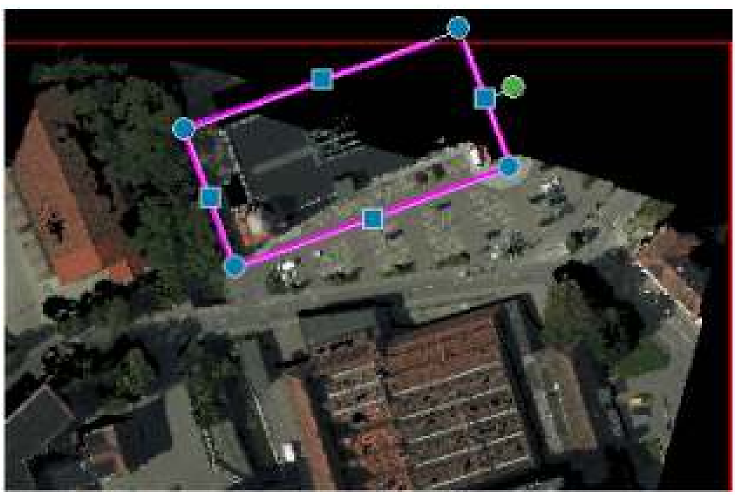
5. The new file is created and loaded in the View.

   Now we could begin digitizing the rooftops from the nadir 2D view, but this is elevation data! It is much easier to grab the points in the Profile views.

6. On the Point Cloud tab, click the Rectangular Profile button.

7. In the 2D View, draw a box around Building 1. Use the green handle to rotate the box and the Blue handles to resize the box.

You will want to make sure that you stay relatively close to the buliding, making sure no trees or other obstructions are blocking the face of the building.

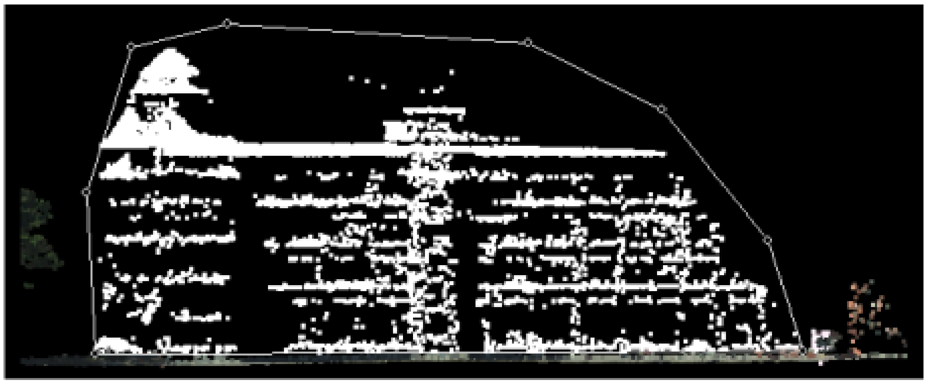


8. In the profile that displays the side of the building facing the parking lot, the long side of the box, note that there are trees on one side and a car on the other side of the building.

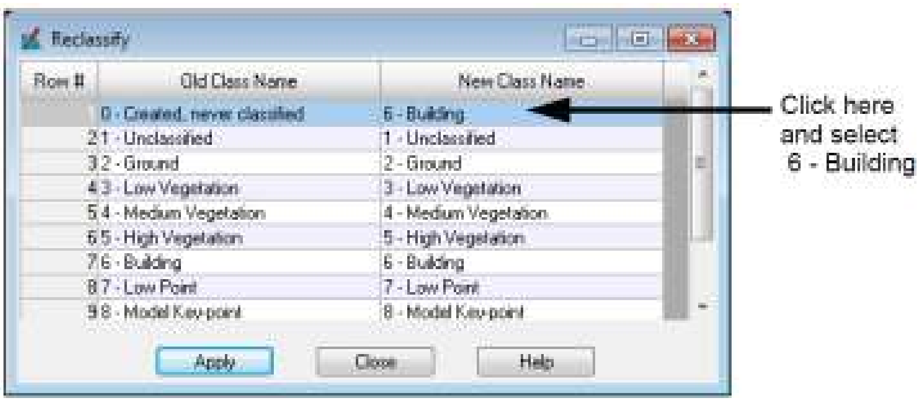
9. Change the Selection mode to **Select by Polygon.**

10. Digitize a polygon that selects the building points but excludes the tree branches, car and ground points.

You don't have to get all of the points at once. You can classify the building in pieces if you want.



11. In the Edit group on the Point Cloud tab, click **Reclassify**  **.**



12. In the **Row 1,** click **0-Created, never classified** in the **New Class Name** column.

13. Select ***6 – Buildings*** from the popup list of Classes.

    This will take any point which currently in the "Created, never classified" class and re-label it as "Building".

14. Click **Apply** on the Reclassify dialog.

15. To see the point which have been reclassified, change to **Color by Classification**.

16. You may need to click **Select**  on the Home tab, (also on the Quick Access bar) in order to cancel the Select by Polygon mode and see the changes to Building 1.

17. Move and resize the profile box to display **Building 2.**

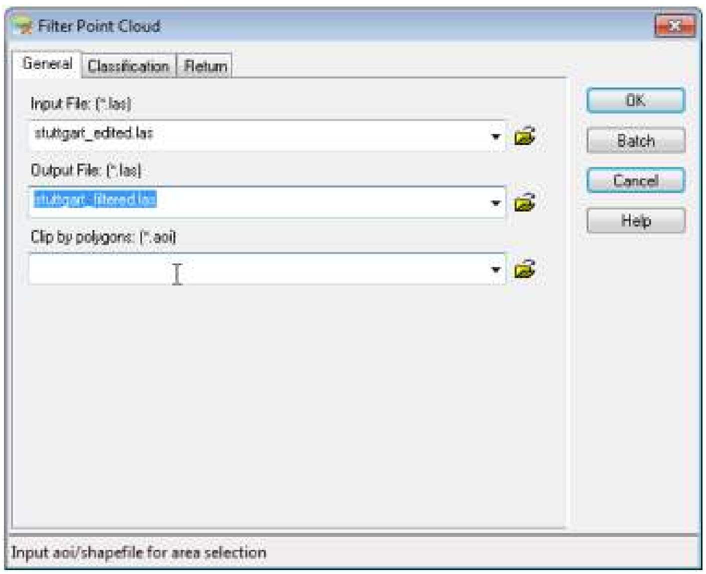
Note that Building 2 sits on a slope, so you will need to be careful when digitizing the polygon.

18. Repeat the previous steps to reclassify Building 2.
19. **Save** you changes to ***Stuttgart_edited.las***.
20. **Close** only the **Profile** Views.

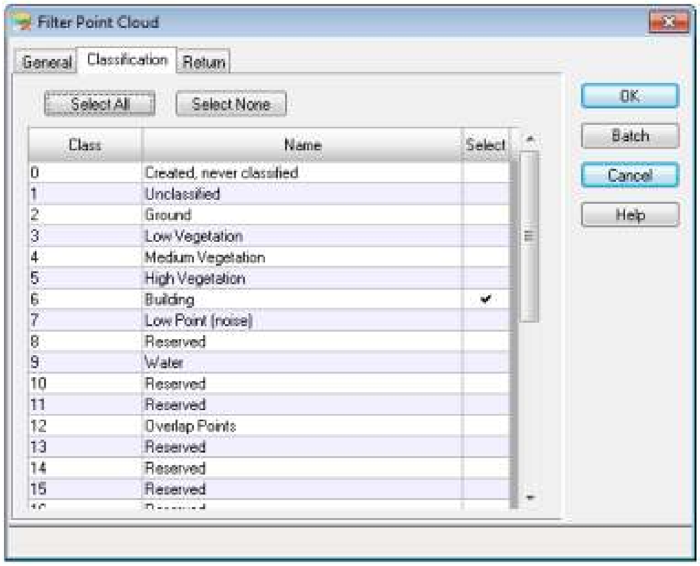
We will now filter the Point Cloud by a Class.

Filtering allows you to select the point you would like to include in a new file. You can filter by class, return or both. We will be creating an output LAS file that only contains our buildings.

21. Ensure that ***Stuttgart_edited.las*** is displayed in the 2D View with the reclassification changes.
22. From the Tools group on the Point Cloud tab, select **Filter** **.**



23. Select ***stuttgart_edited.las*** as the **Input File.**
24. Enter ***Stuttgart_filtered.las*** as the **Output File.**
25. On the **Classification** tab, place a check in the **Select** column for the **Building** class.



26. Click **OK** on the Filter Point Cloud dialog.

27. **Clear** the **2D View**.

28. From your Outputs folder, open ***Stuttgart_filtered.las.*** Click Yes to have the software create the Level of Detail (LOD) for you.

29. Change the **Color by** to **RGB**.

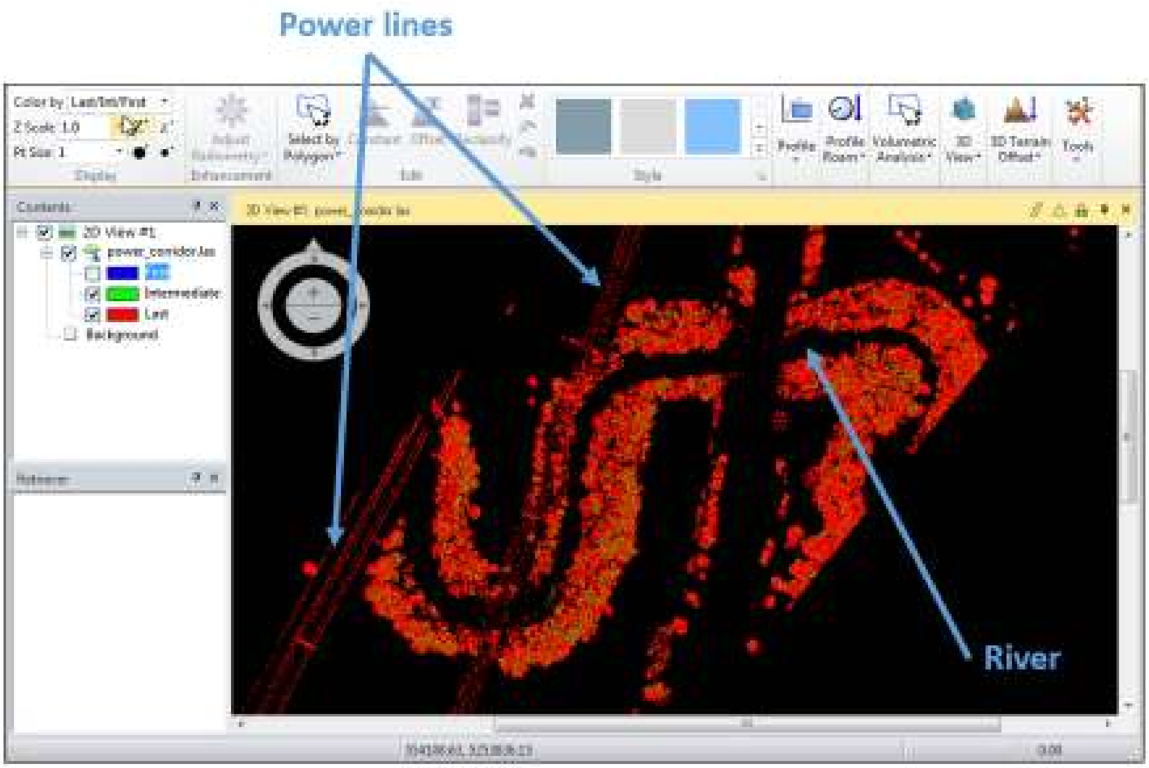
30. Examine how well you did you your classification. If any cars or tree branches appear in the file, select them and **delete**  them.

31. Clear all views.

Task 6: Linear Profile View and Mensuration

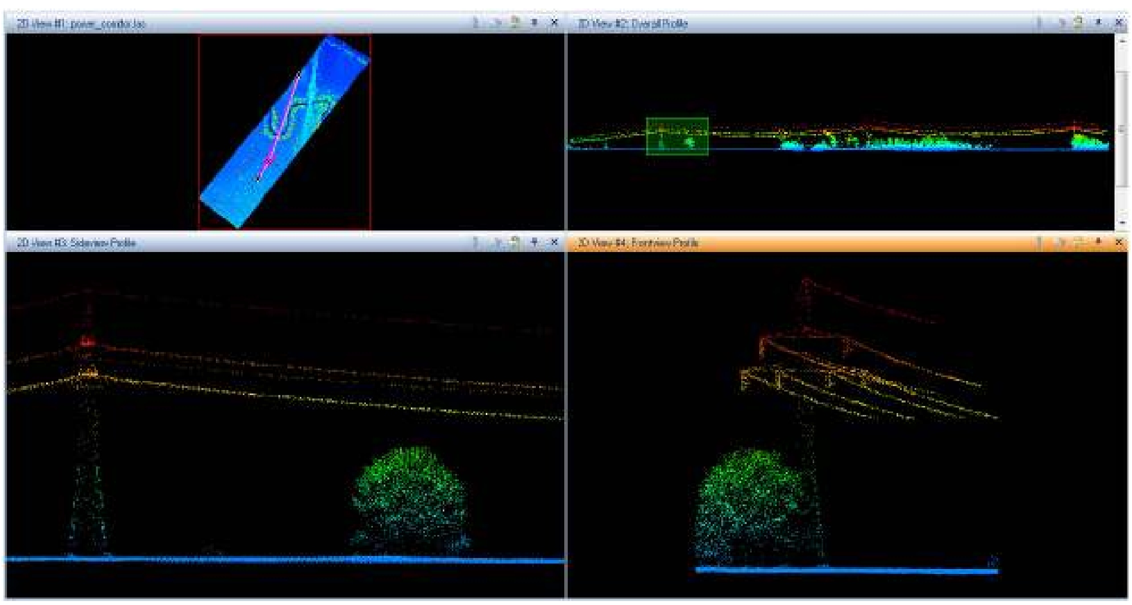
Students will view a LiDAR dataset of a powerline corridor and learn to use a linear profile tool to roam down the corridor and identify locations where vegetation is beginning to obstruct the power corridor. They will also use the mensuration tools to measure the height and location of these obstructions. One common use of LiDAR data is to locate place where vegetation is encroaching on power lines. In this take we will load a LAS file of apower line corridor and view a linear profile aloong the power line.

1. In a 2D View display **power_corridor.las.**
2. To most easily identify where the power lines are change the **Colour by** option to **Last/Int/First** and deselect the **First** return.



3. Change back and forth from **Intensity** view until you become familiar with data.
4. On the Quick Access toolbar, click **Fit to Frame** to zoom to the extent of the data.
5. In the Profile group on the Point Cloud toolbar, click the bottom half of the **Rectangular Profile** command and select **Polyline Profile** .
6. In the 2D View, **digitize** a polyline along the power line where it crosses the river. **Click** to add vertices and **double-click to** finish digitizing. Do not worry too much about getting the line perfect right now.

7. Once you have digitized the line, change the **Colour by** back to **Elevation** and select **Blue to Red** color scheme.



8. In the Profile Roam group, click **Play** begin roaming down the polyline.

As you roam along the polyline, note that the green box in the Overall Profile indicates where the current viewing location is.

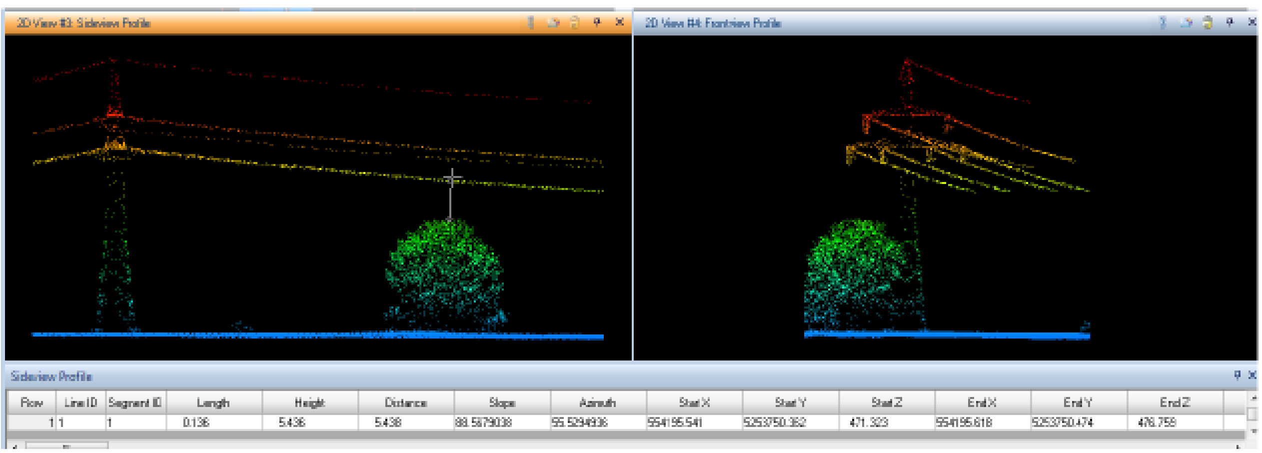
9. Use the thumbwheel to increase and decrease the roam speed.

10. Watch the Frontview and Sideview profiles. When a tree enters the View, click
Pause .

11. Select the Sideview profile by clicking on its title bar.

12. Activate the **Measure Profile** tool by clicking the button.

Note that in the image below it is easier to clearly distinguish where the tree is in relation to the powerline in the Sideview profile. Therefore we will measure in the Sideview profile. Your view may differ; take the measurements in the view that provides the most clear view of the tree and powerline.



13. In the Profile that gives the best view of the tree and powerline, mea-sure the distance between the tree and the powerline by **clicking** on the edge of the tree and then **double-clicking** on the powerline. \

The measure tool records the Length (in X direction) and Height (in Y direction) as well as the Distance (the actual length of the digitized line). In addition, it records the X, Y, and Z coordinates of the start and end of the measurement line.

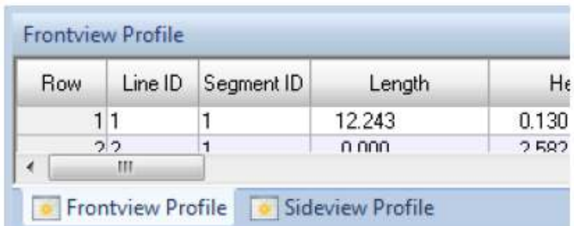
14. Get rid of the digitized line line (while keeping its measurements) by clicking the button in the **Profile** group.

15. Continue roaming down the polyline, pausing the roam to measure a few more trees that are encroaching on the power corridor. Use the Profile that provides the best view of the data.

It is important to note that sometimes the vegetation can encroach from the side of the powerline. In those cases, measure in a horizontal direction.

The Measure Profile saves the measurements into two sep-arate tables. All measurements taken in the Frontview pro-file are saved in the Frontview Profile table. All measurements taken in the Sideview are stored in its corre-sponding table.

16. When you have collected a few measurements, select the **Frontview Profile** table at the bottom of the eWorkspace.



17. In the Profile group, click the **Save Measurement** button . Name the file **frontview_meas.txt.**

18. Select the **Sideview Profile** table. Click the **Save Measurement** button. Name the file **sideview_meas.txt.**

19. This file can be viewed in a text editor, like the one included with ERDAS IMAGINE. Select **File > View > View Text File** and click on the **Recent** button.

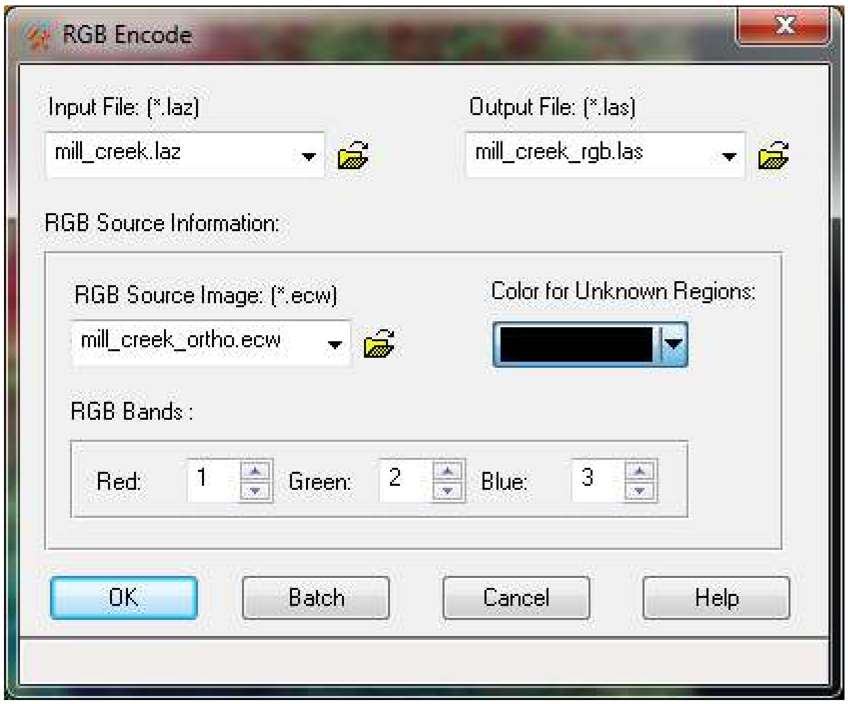
20. Select **frontview_meas.txt** from the list of recent files and click **OK.**

21. Clear all views and close all open dialogs.

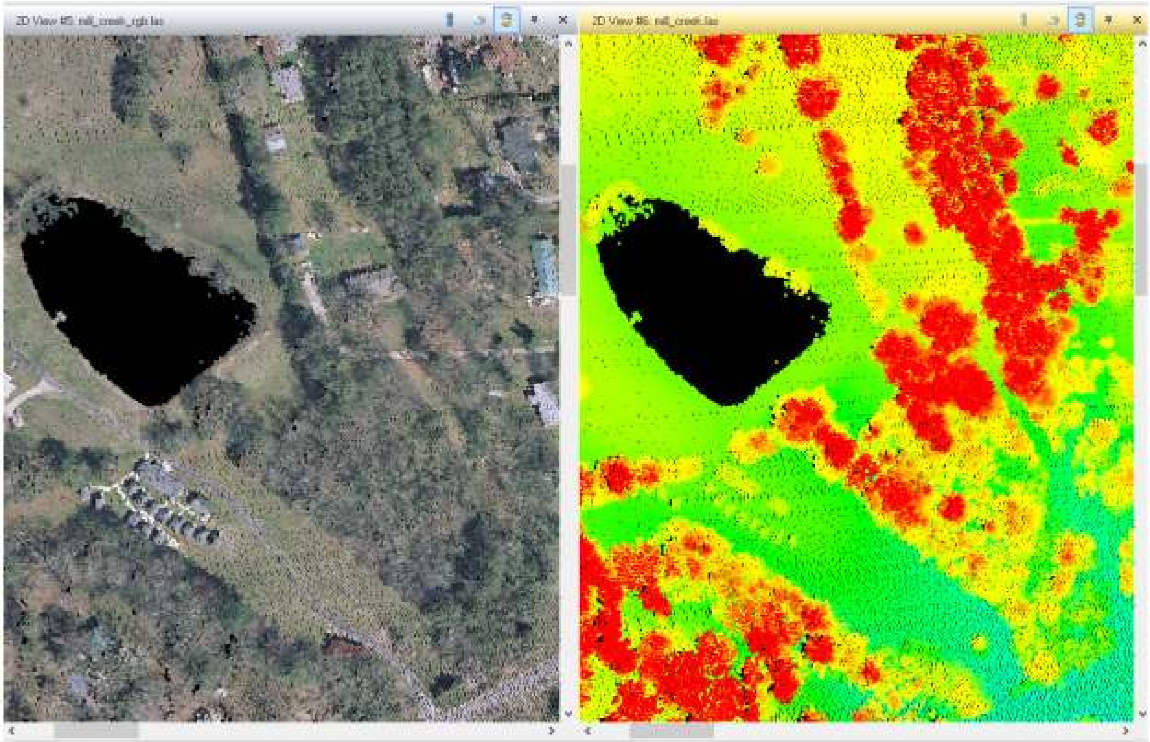
Task 7: RGB Encoding a Point Cloud

In a LAS or LAZ file, you can include an RGB value for each point in the cloud. This means that if you have a corresponding image for your point cloud data, you can transfer the RGB value from the image to each point in the point cloud.

1. Display **mill_creek.laz** in a 2D View.
2. On the Point Cloud tab, expand the **Tools** group.
3. Click on the **RGB Encode** button.



4. Ensure that **mill_creek.laz** is entered as the **Input** File.
5. Enter **mill_creek_rgb.las** as the **Output** file.
6. Select **mill_creek_ortho.ecw** as the **RGB Source** image.
7. Change the **Color for Unknown Regions** to **Black.**
8. Click **OK** to run the RGB Encode process.
9. When the process finishes, display **mill_creek_rgb.las** in a 2D View.



You can also insert explanatory paragraphs.

10. With the view containing the new RGB LAS file selected, select **RGB** from the **Colour by** pull-down list (located in the Display ground on the Point Cloud tab.)
11. Assess the resulting RGB Encoded point cloud.
12. Clear all Views.

Task 8: View Photogrammetric Point Cloud in RGB

Now we willl look at a photogrammetrically-derived point cloud. This method of creating a point cloud used four 10 cm aerial photographs. The imagery was trianulated with IMAGINE Photogrammetry and the Imagestation Semi-Global Matching (SGM) algorithm was used to create a 10cm post spaced point cloud.

1. Select **File > Open > Point Cloud Layer.** Browse to your input directory and select **quarry.las.** Click **OK.**

   Why does the point cloud only contain First Returns?

2. Zoom in on the data and notice how dense the data is compared to the LiDAR point clouds in the previous exercises.
3. On the Point Cloud tab, in the Display group, change the **Color by** to **Intensity**.

   Why is the entire dataset grey?

> *Point Clouds which have been created in ImageStation and LPS are RGB encoded at creation so they can be viewed in True Colour.*

4. On the Point Cloud tab, in the Display Group, change **Colour by** to **RGB.**
5. Zoom and pan around the data and see how closely it resembles an orthophoto.
6. Leave ***quarry.las*** open for the next task.

Task 9: View Point Cloud in 3D

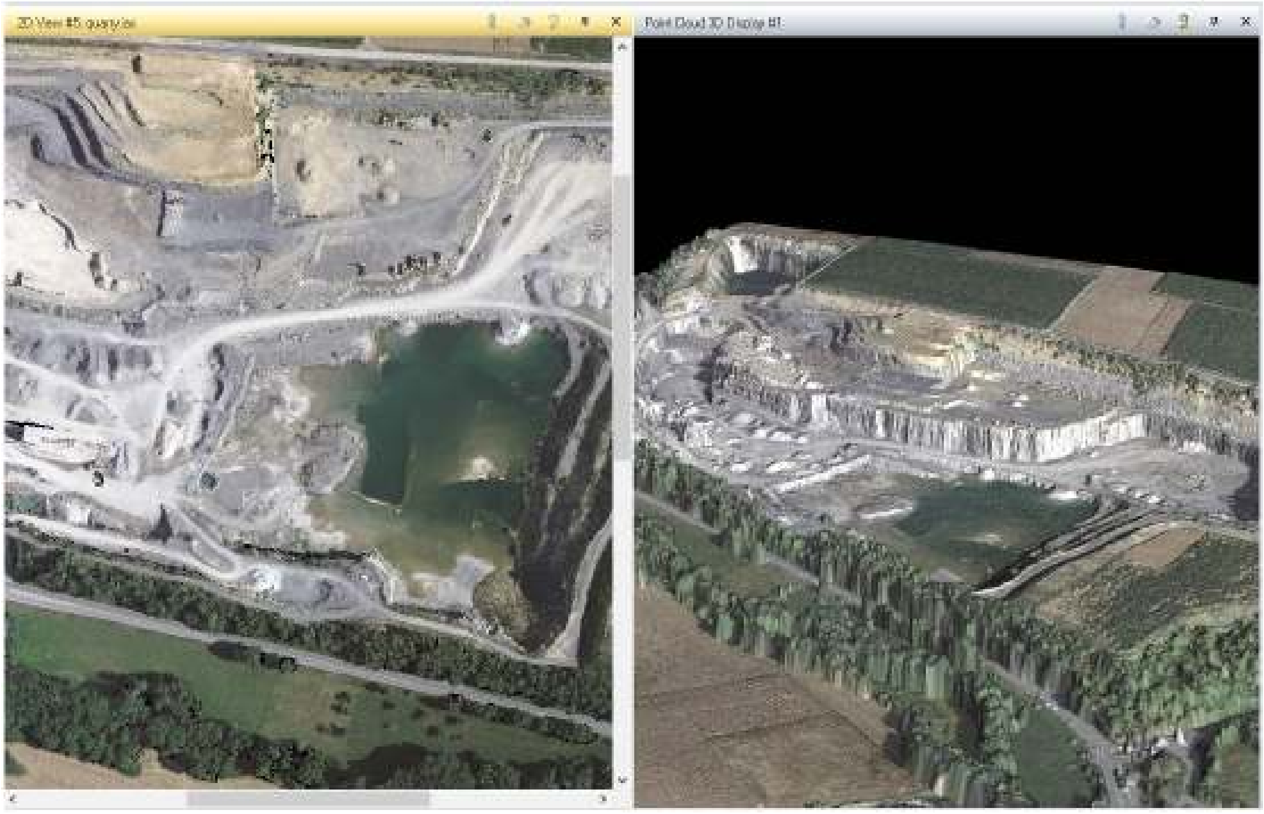
Because an RGB-encoded point cloud contains the information of an image with every point in its real-world X, Y and Z position, it can be thought of as “True Ortho”.

1. And In the 3D View group, click **Show 3D**  **.**
2. The point cloud comes in zoomed to the data extent. To zoom in, use the mouse scroll wheel to scroll away from you.
3. Now, using the left mouse button, pan up to the quarry at the north end of the dataset.
4.

Navigation	Mouse Command
Zoom in	Scroll wheel up Right-button drag up
Zoom out	Scroll wheel down Right-button drag down
Pan	Left-button drag
Tilt	Middle mouse button drag up/down Ctrl + scroll up/down Ctrl + right button drag up/down
Rotate	Middle mouse button drag left/right Shift + scroll up/down Shift + right button up/down

5. Click and hold down the middle mouse button/scroll wheel. Move the mouse forward and backward to tilt the point cloud. Move the mouse left and right to rotate.
6. Continue roaming, zooming, tilting and rotating around the quarry in the 3D view.
7. In the 3D View group on the Point Cloud tab, click on the bottom half of the Point Mode and select **Triangle Mode**  **.**

In the 3D View, the view updates to convert the point to “TINned” triangles, creating a more solid view.



8. Tilt and rotate the 3D View to explore the scene.
9. Close the 3D View and clear the 2D View.

Task 10: Viewing Point Clouds as Relief

Sudents will view the Point Cloud data as a raster image. This will allow visualization as a shaded relief, which allows you to simulate the position of the sun to better understand the topography of the region. Students will also create a Painted Relief Image with a colored level slice Overlay. By knowing the topography of a geographic region and the position of the sun, it is possible to create an image which represents the amount of light reflected to a position directly above the scene.

1. Select **File > Open > Raster Layer**. Change the Files of Type to **LAS to Raster (.las)**.
2. In the Select Layer to Add dialog, select ***lidar_2008.las***. The software creates a rasterized version of the LAS file.
3. On the Raster Options tab, change the **Display As** to **Relief** and click **OK.**
4. On the **Relief** tab, Move the Sun Aspect circle around the diagram to change the sun angle and the shadows in the Relief image.
5. Roam and Zoom about the image, getting used to seeing this data in a new way.
6. When you find a Sun Position that you like make a note of it here.

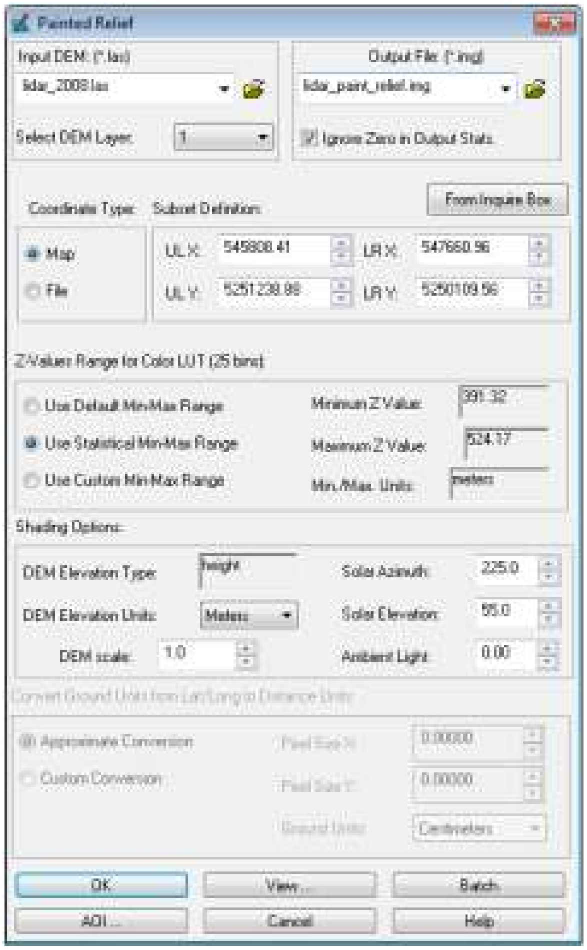
Solar Azimuth	**Solar Elevation**

***What features are visible in the relief image that weren't apparent in the point cloud*?**

Task 11: Creating a Painted Relief Image from a LAS Dataset

There are two methods for creating a painted relief with color. The first method is an automated process which uses a default color ramp.

1. From the eWorkslpace click **Terrain >** **Painted Relief.** The Painted Relief dialog box appears.

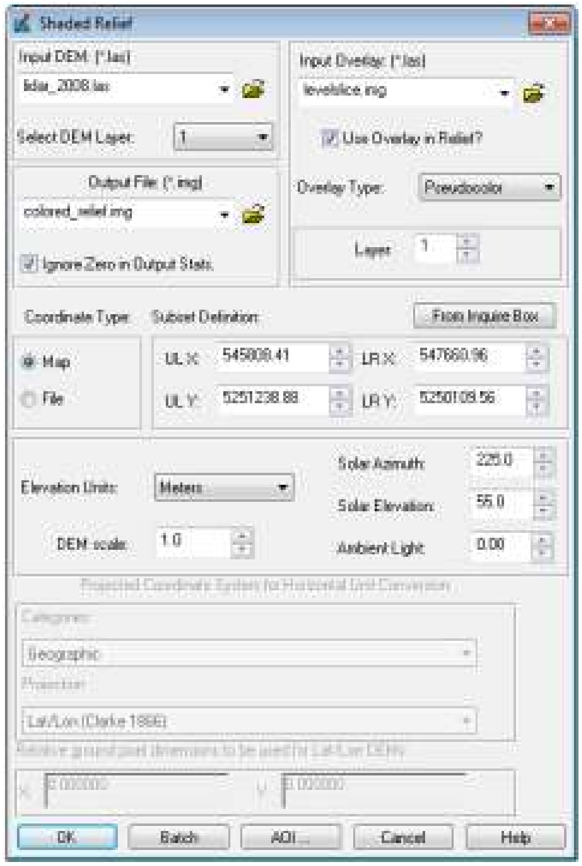


2. Use ***lidar_2008.las*** for the input and name the Output File: ***lidar_paint_relief.img***
3. For the Z-Values Ranges for Color LUT, click the **Use Statistical Min-Max Range** radio button.
4. Change the **Solar Azimuth** and Solar Elevation to the settings you wrote down in the previous task.
5. Click **OK** to begin the process.
6. Open the file in a View.

Task 12: Shaded Relief with Level Slice Overlay

The second method allows you to use a customize color ramp image created in IMAGINE (the Level Slice function) or any raster overlay on the shaded relief.

1. From the eWorkspace, click **Terrain** tab > **Shaded Relief**. The Shaded Relief dialog displays.



2. Use ***lidar_2008.las*** as the Input DEM and enable the **Use Overlay in Relief** checkbox.
3. Browse to your input directory and use ***levelslice.img*** as the Input Overlay and ensure the **Overlay Type** is set to **Pseudocolor.**
4. Set the **Solar Azimmuth** and Solar Elevation to the settings you identify in Task 1, then name the Output file ***colored_relief.img*** and click **OK.**
5. Display and assess ***colored_relief.img*** in a 2D View.
6. **Clear** all open View and close dialogs.

Task 13: Point Cloud compression LAS to LAZ or HPC

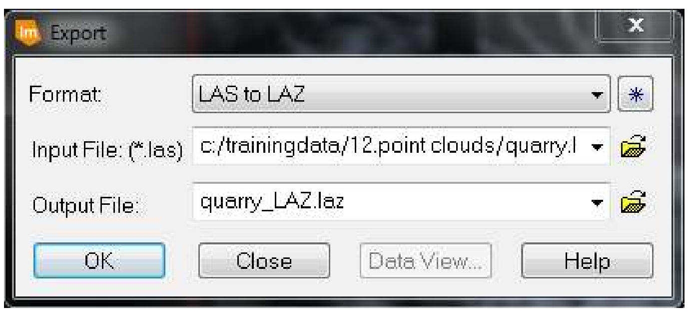
One weakness of the LAS format is file size. This task will look at two compressed point cloud formats, LAZ and HPC.

1. Go to **File > Open > Point Cloud Layer**
2. Navigate to and open ***quarry.las***
3. Open a file explorer window and navigate to the location of ***quarry.las***
4. **RMB** on ***quarry.las*** select **Properties**.

What is the file size in Megabytes of this LAS dataset?

____

5. Go back to the file in ERDAS IMAGINE.
6. Go to **Manage Data** tab and click **Export Data.**
7. From the **Format** drop-down list select **LAS to LAZ**.
8. Set ***quarry.las*** as the Input File.
9. Name the Output File ***quarry_LAZ.laz***



10. Click **OK** to run the process in the Export dialog box

11. Click **OK** again on the second dialog box. Note if we wanted to compress a large number of LAS files to LAZ we could use the batch process available here.
12. When the Export LAS process has completed, close the Export dialog box.
13. Open ***quarry_LAZ.laz*** in the 2D View.
14.

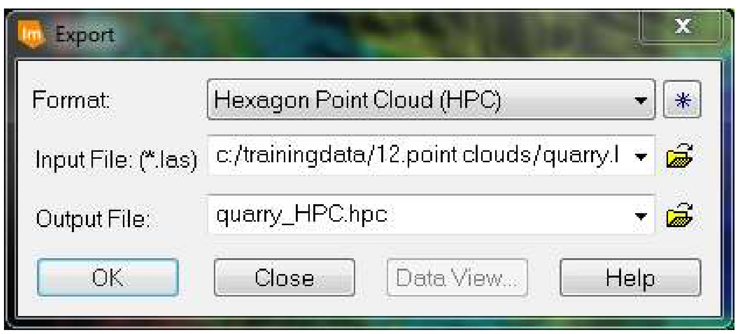
IMAGINE will build the Level of Detail (LOD) file for the LAZ file, this may take a few minutes.

15. Open ***quarry_LAZ.laz*** in a second 2D View.
16. Compare the two datasets (LAS and LAZ) side by side. Can you see any visual differences?
17. Open a file explorer window and navigate to the location of ***quarry_LAZ.laz***.
18. RMB on the data and select **Properties.**

What is the file size in Megabytes of this LAZ dataset?

We will now convert the original ***quarry.las*** to **HPC** format.

19. Ensure ***quarry.las*** is selected in **2D view #1.**
20. Go to **Manage Data** tab and click **Export Data.**
21. From the Format drop-down list select **Hexagon Point Cloud (HPC)**
22. Select ***quarry.las*** as the Input file.
23. Name the Output File ***quarry_HPC.hpc***.
24. Click **OK** on the Export dialog.



25. On the Convert Point Cloud to HPC dialog box, leave the resolution as 0.020 meters.
26. Click **OK** to run the process.
27. Close the Export dialog box.
28. When the process is complete open ***quarry_HPC.hpc*** in a new (third) 2D View.
29. Compare the new dataset with those already open.
30. Can you see any visual differences?
31. Open a file explorer window and navigate to the location of ***quarry_HPC.hpc***
32. RMB on the dataset and select **Properties.**

What is the file size in Megabytes of this LAZ dataset?