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Lesson 1 Lab Instructions (30 points)

In all the remote sensing courses, we assume that students have some familiarity and experience with GIS software, particularly some form of ArcGIS. Esri has added many new tools for viewing and manipulating lidar data in recent updates. The Lesson 1 Lab Activity is designed to give students a chance to become familiar with these ArcGIS features and will introduce LP360, the primary software that will be used for processing lidar data throughout the course.

Part 1: Introduction

ArcGIS Pro Familiarization

1. Just to ensure that everyone is starting out in GEOG 481 with a common basic mastery of ArcGIS Pro, you are asked to complete the introductory course: Getting Started with ArcGIS Pro. If you have completed this course in the past, you can retrieve your completion certification from the My Learning Activity dashboard on the Esri website to submit for credit.

Q1: Submit a screenshot of the completion certificate for Getting Started with ArcGIS Pro. (7 points)

Introduction to Lesson 1 Lab Activity

2. Watch Lesson 1 Lab Tutorial 1 in the Canvas lesson module.

Prepare Lesson 1 Data

3. Download the Lesson 1 Lab Data package from the Canvas lesson module.
   - Save Geog481_Lesson1Data.zip in your root folder, C:\Geog481.
4. In C:\Geog481, right click on Geog481_Lesson1Data.zip.
   - Use 7Zip > Extract Here to extract contents.
5. Navigate to C:\Geog481\LabDataRoot\Lessons
   - You should now have a Lesson 1 folder containing a total of 4 files and 3 folders.

Part 2: Adding and Managing Lidar Data (LP360 Training Exercise #0100)

Introduction to LP360

In each lesson, you will begin with tutorials based on the GeoCue LP360 Training Manual provided in the LP360 Resources module in Canvas. The manual is intended to be used in a week-long face-to-face training conducted by GeoCue staff. You may find the PDF manual helpful as a reference or opportunity for additional self-study; the Lab Tutorial videos and GEOG 481 Lab Instructions provided in Canvas provide the background needed to complete GEOG 481 lab exercises.

6. Familiarize yourself with the LP360 user interface by watching Lab Tutorial 2 in Canvas.

Davidson County Tutorial Dataset

The data used in the LP360 Training Exercises covers portions of Davidson County TN, including the City of Nashville. It is provided courtesy of the Nashville, TN office of the USDA Natural Resources Conservation Service, (NRCS).

The horizontal coordinate system is NAD83 (2011) Tennessee State Plane in units of US survey feet; the vertical datum is NAVD88 – Geoid 12B. It has been classified using the following scheme:

- Class 1 Processed, but Unclassified
- Class 2 Bare Earth Ground
- Class 7 Noise (low or high, manually identified)
- Class 9 Water
- Class 10 Buffered Ground, also known as Ignored Ground (Breakline Proximity)
- Class 11 Withheld

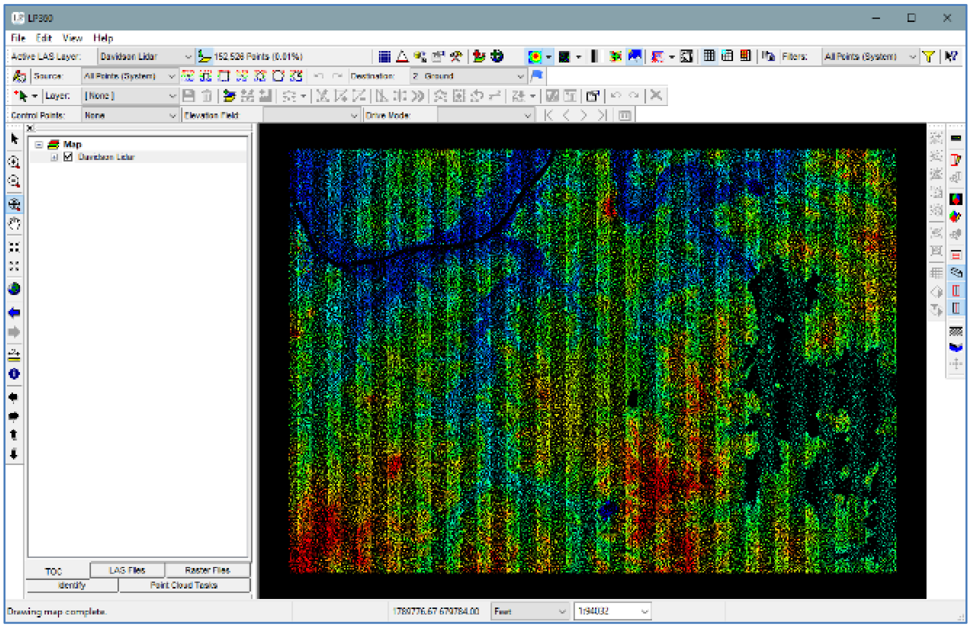
The Withheld class includes outliers, blunders, noise points, geometrically unreliable points near the extreme edge of the swath, and other points deemed unusable that are identified during pre-processing or though the ground classification algorithms

Load LAS Data

7. Open LP360.
8. Load all 99 LAS files in the \Data\Davidson\LAS\ folder as a single LAS Layer using the Add LAS/Raster/Feature Layer button on the main LP360 toolbar.
    - Open Setting: Open Read-Only
    - Load Setting: Load Files
    - Options
        - Uncheck Append to Compatible Layers
        - Check Pyramid
    - Click OK.

Creating pyramids takes a few minutes, but once they are created, you will not have to do it again, unless the files themselves are edited.

9. In Windows File Explorer, open the \Data\Davidson\LAS\ folder. Note that 99 new files ending in qvr have been created containing the pyramids.
10. In the LP360 Table of Contents (TOC) tab, right-click on LAS Layer 1 and change the name of the layer to Davidson Lidar.
11. In the LP360 toolbar, the following display modes should be set by default:
    - Legend Type: Elevation Gradient
    - Draw Mode: Points
    - Display Filter: All Points (System)
12. The display background color can be customized in the LP360 interface. Switching between dark and light background colors is helpful when highlighting certain characteristics and features of the lidar data.
13. Right-click on Map in the TOC and select Background Color.
    - Change the background color to black. Your display should resemble the figure below:



- Change the background color back to white.

14. Save the LP360 project as LabDataRoot> Lessons > Lesson1 > Davidson > Lesson1Part2.xml.

15. From the LP360 File menu, open Project Settings.
    - Set the project path to C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson.
    - Note the Map Spatial Reference System (SRS) by default is set to the SRS of the active LAS layer.
    - Close the project settings.

Add a Reference Layer

16. Using the Add WMS Layer button on the LP360 toolbar, add Bing Street as a basemap to provide some locational context for the dataset.

17. Click the Full Extent button on the Display and Navigation toolbar (by default appears as a vertical toolbar on the left of the application window and is similar in function and appearance to the classic ArcGIS navigation toolbar). In ArcGIS, this would zoom to the global extent of the basemap; LP360 ignores the extent of the basemap when calculating full extent.

18. LP360 allows you to load multiple WMS layers. Use the Add WMS Layer button to add Bing Aerial as an imagery basemap.

WMS basemaps are very convenient for locational context; however, as you learned if you took GEOG 480, you have little-to-no information about the positional accuracy or temporal currency of the basemap. Furthermore, WMS basemaps can be slow to refresh, depending on your internet speed.

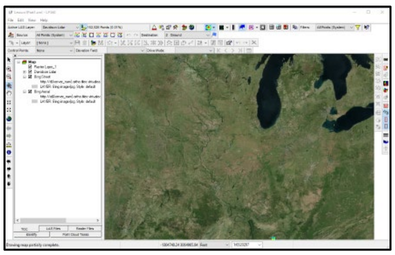
For the Davidson County project, we provided a 2014 countywide digital orthophoto mosaic from the USDA NAIP program to use as an image basemap.

19. Click on the Add Las/Raster/Feature Layer button on the LP360 toolbar.
    - Select the Raster tab

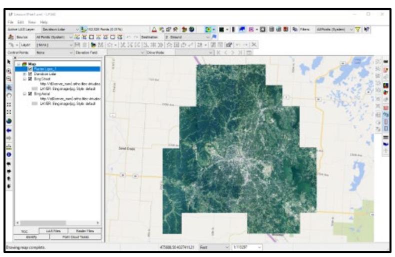
- Add C:\Geog481\LabDataRoot\Data\Davidson\Ortho\ortho_1-1_1n_s_tn037_2014_1.sid
  - Uncheck Append to Compatible Layers
  - Uncheck Pyramid
  - Examine the metadata displayed in the Add Files window.

Q2: True or False: The orthophoto basemap is in the same coordinate system as the LAS layer. (1 point)

20. Click OK to add the raster to the LP360 project as Raster Layer_1.
21. Move Raster Layer_1 to the top of the TOC.
22. Zoom to full extent.



23. Zoom to the extent of Raster Layer_1.

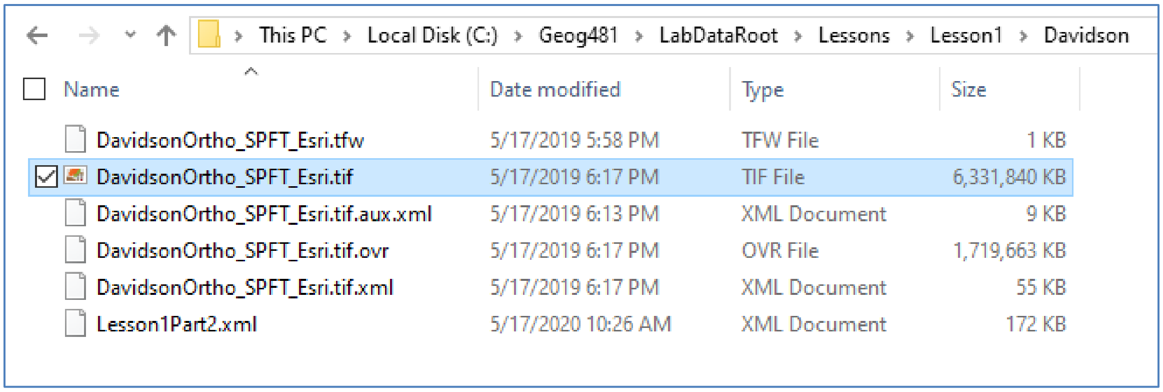


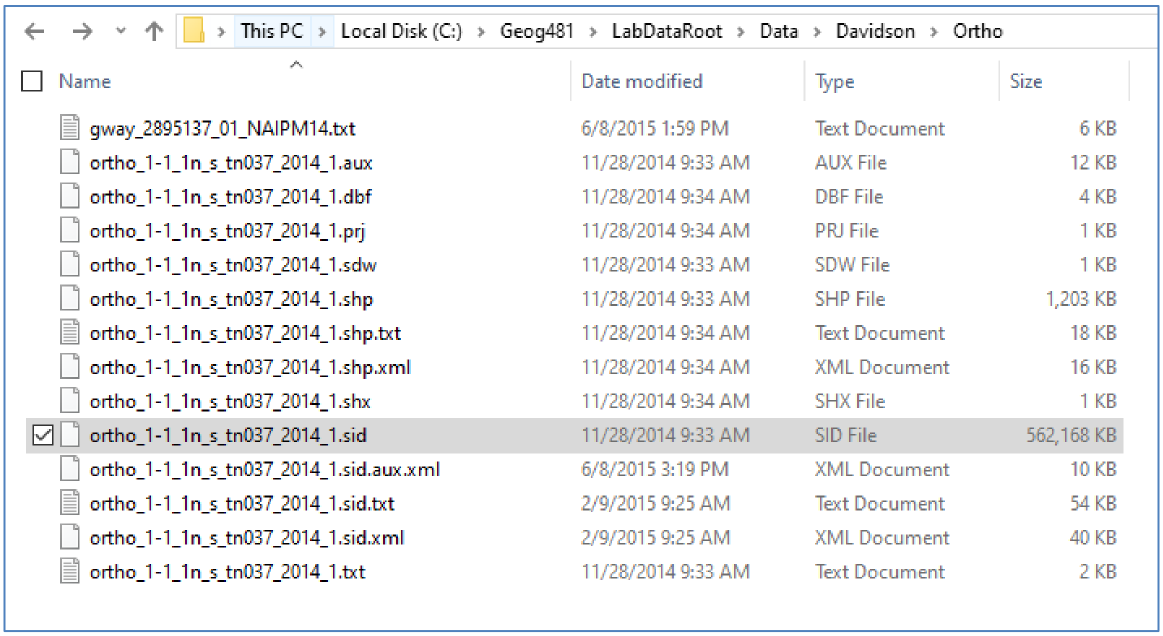
LP360 does not (yet) support on-the-fly projection, so the image coordinates are interpreted as Tennessee State Plane regardless of the image dataset SRS, and the orthophoto is displayed somewhere in Wisconsin.

24. Remove Raster_Layer_1 from the LP360 project.

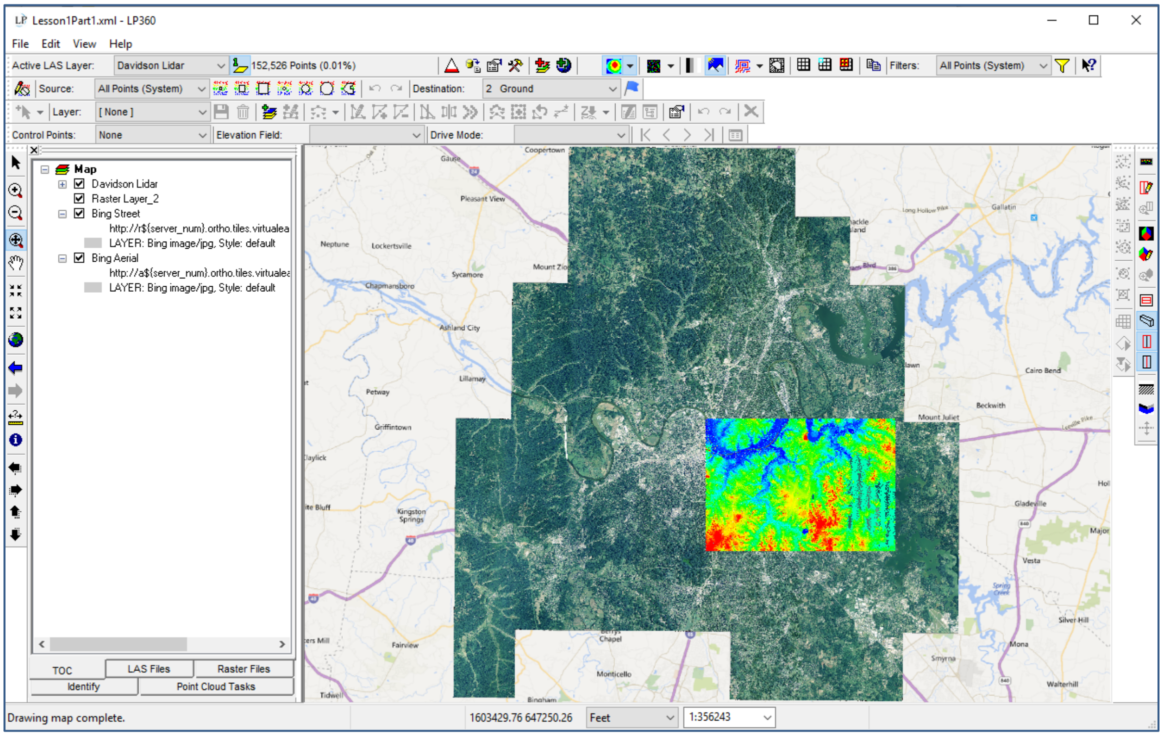
This is a very typical problem that you are likely to encounter in your own work, so we have included this in the lab as a "teachable moment." To use the imagery in LP360, you would have to project the image into the LP360 project SRS, which can be done using LP360 tools we will introduce later in the course.

You could also, as we did below for the purpose of demonstration, use ArcGIS Pro to project the image from UTM to State Plane; however, this image happens to be a highly compressed dataset in MrSID format. The SID file is about 500 MB, but in order to project, it will have to be uncompressed. ArcGIS and LP360 both can do this, but neither can recompress the result back into MrSID format, as this is a proprietary function requiring a license from the company that owns the MrSID format. The resulting image dataset projected to Tennessee State Plane Feet is over 6 GB.


This PC > Local Disk (C:) > Geog481 > LabDataRoot > Lessons > Lesson1 > Davidson
Name | Date modified | Type | Size
DavidsonOrtho_SPFT_Esri.tfw | 5/17/2019 5:58 PM | TFW File | 1 KB
DavidsonOrtho_SPFT_Esri.tif | 5/17/2019 6:17 PM | TIF File | 6,331,840 KB
DavidsonOrtho_SPFT_Esri.tif.aux.xml | 5/17/2019 6:13 PM | XML Document | 9 KB
DavidsonOrtho_SPFT_Esri.tif.ovr | 5/17/2019 6:17 PM | OVR File | 1,719,663 KB
DavidsonOrtho_SPFT_Esri.tif.xml | 5/17/2019 6:17 PM | XML Document | 55 KB
Lesson1Part2.xml | 5/17/2020 10:26 AM | XML Document | 172 KB


This PC > Local Disk (C:) > Geog481 > LabDataRoot > Data > Davidson > Ortho
Name | Date modified | Type | Size
gway_2895137_01_NAIPM14.txt | 6/8/2015 1:59 PM | Text Document | 6 KB
ortho_1-1_1n_s_tn037_2014_1.aux | 11/28/2014 9:33 AM | AUX File | 12 KB
ortho_1-1_1n_s_tn037_2014_1.dbf | 11/28/2014 9:34 AM | DBF File | 4 KB
ortho_1-1_1n_s_tn037_2014_1.prj | 11/28/2014 9:34 AM | PRJ File | 1 KB
ortho_1-1_1n_s_tn037_2014_1.sdw | 11/28/2014 9:33 AM | SDW File | 1 KB
ortho_1-1_1n_s_tn037_2014_1.shp | 11/28/2014 9:33 AM | SHP File | 1,203 KB
ortho_1-1_1n_s_tn037_2014_1.shp.txt | 11/28/2014 9:34 AM | Text Document | 18 KB
ortho_1-1_1n_s_tn037_2014_1.shp.xml | 11/28/2014 9:34 AM | XML Document | 16 KB
ortho_1-1_1n_s_tn037_2014_1.shx | 11/28/2014 9:34 AM | SHX File | 1 KB
ortho_1-1_1n_s_tn037_2014_1.sid | 11/28/2014 9:33 AM | SID File | 562,168 KB
ortho_1-1_1n_s_tn037_2014_1.sid.aux.xml | 6/8/2015 3:19 PM | XML Document | 10 KB
ortho_1-1_1n_s_tn037_2014_1.sid.txt | 2/9/2015 9:25 AM | Text Document | 54 KB
ortho_1-1_1n_s_tn037_2014_1.sid.xml | 2/9/2015 9:25 AM | XML Document | 40 KB
ortho_1-1_1n_s_tn037_2014_1.txt | 11/28/2014 9:33 AM | Text Document | 2 KB

Here is the projected image displayed in LP360, overlaid with the LAS layer.



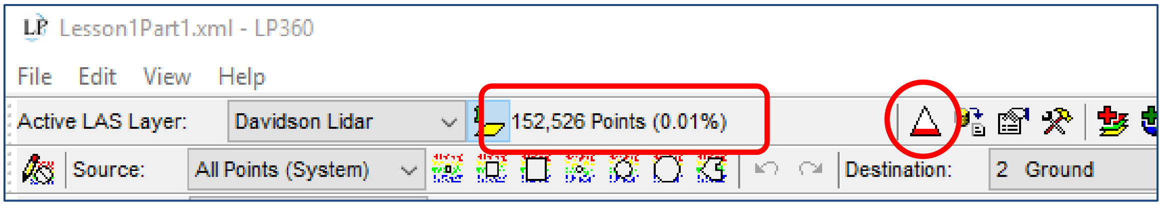
It is up to you to decide to whether use the WMS layer or project the image yourself in ArcGIS Pro. Either will suffice for the purpose of the lab exercises. In a project of your own, you would want to consider pros and cons depending on the role the imagery plays in your analysis.

25. With the reference image of your choice loaded in the LP360 project, zoom to full extent. The "extent of Full Extent" will depend on which background image you have chosen.
    - If you use Bing Aerial, Full Extent will be the extent of the lidar layer.
    - If you use a projected version of DavidsonOrtho, the Full Extent will be the extent of the ortho layer.

Q3: Create a screenshot showing the entire Davidson Lidar layer overlaid on the either the Bing Aerial or projected Davidson orthophoto at full extent. Your screenshot should show the entire LP360 application window including the TOC. (1 point)

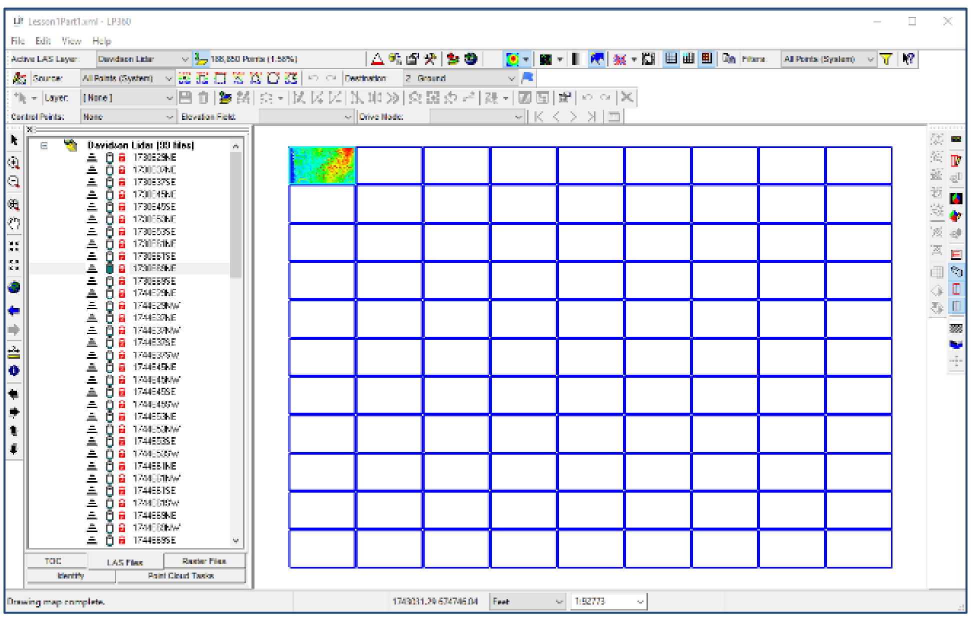
26. Turn off the reference image layer to speed navigation and display for the rest of the exercise.
27. Save the LP360 project as C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\Lesson1Part2.xml.

By default, LP360 displays only a fraction of the lidar point cloud based on the amount of RAM you have on your computer. The percentage of points displayed is shown on the LP360 toolbar. The number you see will likely differ; I have 32 GB of RAM on the laptop used to create the screenshot below.



For general display and navigation, reduced resolution is effective. There are cases when you will need to see 100% of the lidar points.

28. At full extent, Force 100% resolution by clicking on the button circled above in the LP360 toolbar.
    - You should see only a very small portion of the project area filled with lidar data, and the message in the toolbar should change to (OVF) meaning memory overflow.
29. Turn off 100% resolution by clicking the button again.
30. Turn on the LAS Display Boundaries.
31. Use Select and Load LAS Files Graphically to select the tile in the upper-left corner, 1730669NE.



32. Note the change in the number and percentage of points displayed in the message area of the LP360 toolbar.
33. Zoom to a small area within this tile and force 100% resolution. Adjust the zoom level until you can display 100% of the points without an overflow.

Q4: Create a screenshot showing a portion of tile 1730669NE at 100% resolution. Your screenshot should show the entire LP360 application window including message area in the LP360 toolbar showing the number and percentage of points displayed. (1 point)

34. The display legend should still be set to ElevationGradient.
35. Open Live View and select the Elevation tab.
    - Click on Symbology

Q5: In the default Elevation Gradient legend, the highest elevations are: (1 point)

A. Blue

B. Green

C. Yellow

D. Red

36. Still in Live View > Elevation > Symbology, change the Gradient selection to grayscale.

- Click Apply
- Open the legend for the lidar layer in the LP360 TOC. Notice that the Elevation legend is really only a “conceptual” icon. It does not relate to the actual active legend symbology. You must refer to Live View for this type of information.

Q6: In the greyscale Elevation Gradient legend, the highest elevations are: (1 point)

A. Black

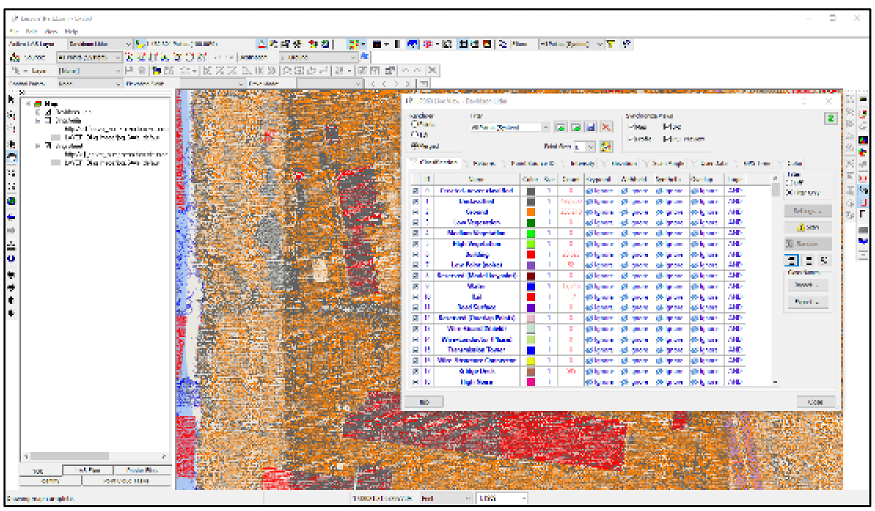
B. White

C. Light Grey

D. Dark Grey

37. Keep Live View open but change the display legend to Classification.

- Select the Classification tab in Live View



38. Note that on the Classification tab in Live View, there is a Count column displaying the total number of points in each class for the entire LAS layer (loaded and unloaded files).

- Click Scan to update the point counts for the entire LAS layer

Q7: Approximately how many points are classified as Water in this LAS Layer? (1 point)

A. 1,000

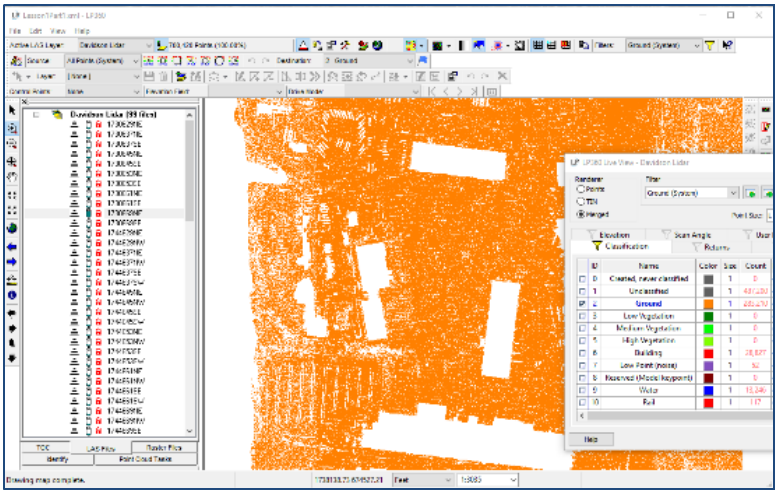
B. 13,000

C. 118,000

D. 1,200,000

E. 20,200,000

39. In Live View, change Filter to Ground (System).
    - Ground points are in Class 2 and are Orange by default.



40. Change the display filter to Canopy (System) and force 100% resolution.

Q8: How many lidar points are classified as canopy in the LAS Layer? (1 point)

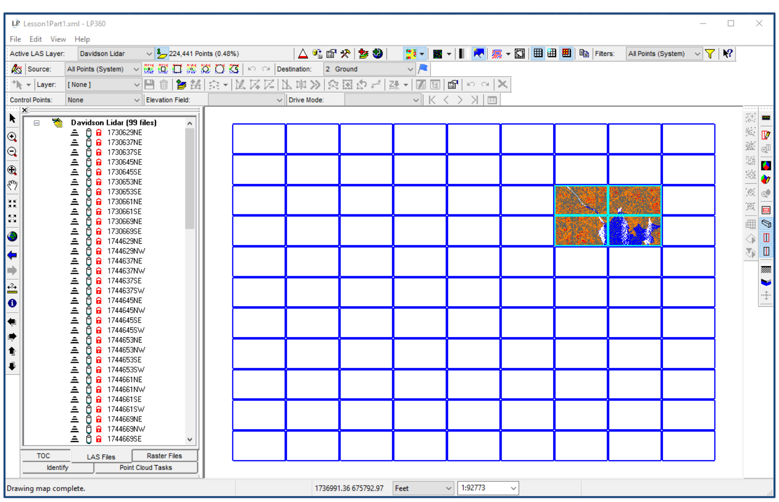
A. 125,000

B. 69,500

C. 25,000

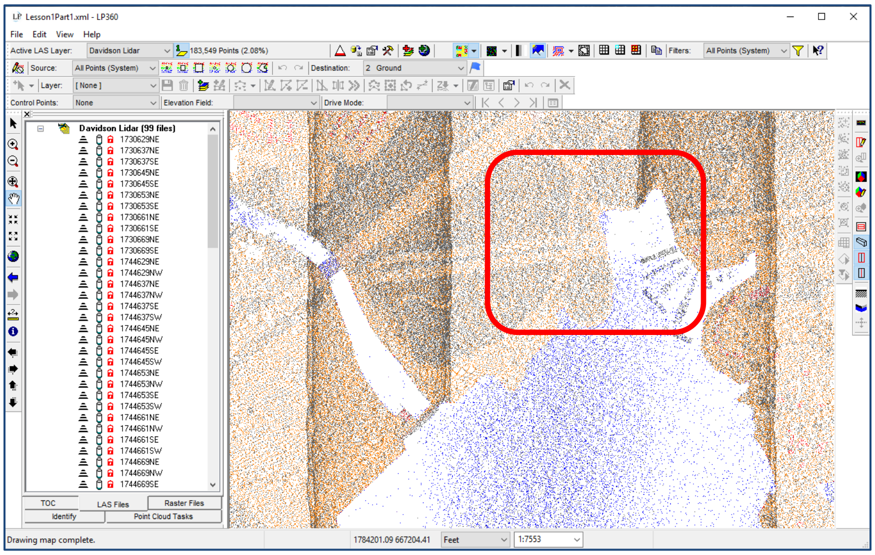
D. 0

41. Turn off 100% resolution and change the display filter back to All Points.
42. In the LAS Files tab, right-click on the Davidson Lidar layer.
    - Clear the current selection
    - Load all LAS files
43. Zoom to full extent.
44. Select and Load the four tiles encompassing the J. Percy Priest Dam, as shown below.



45. Zoom to the selected files.

46. Locate the marina in the upper-right quadrant northeast of the dam



47. Zoom into the marina until you can display 100% of the lidar points.

Q9: Observe the distribution of lidar points on the water in the area around the marina, comparing the surrounding ground. Is it noticeably different and if so, why? (1 point)

A. There is no noticeable difference.

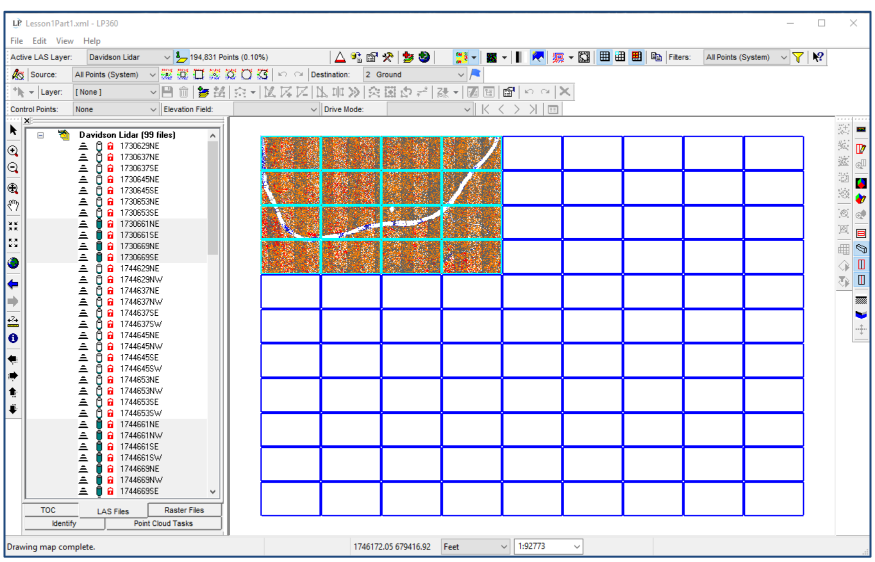
B. Boats in the marina cause multipath.

C. Lidar is strongly absorbed by water depending on the angle of incidence of the lidar pulse.

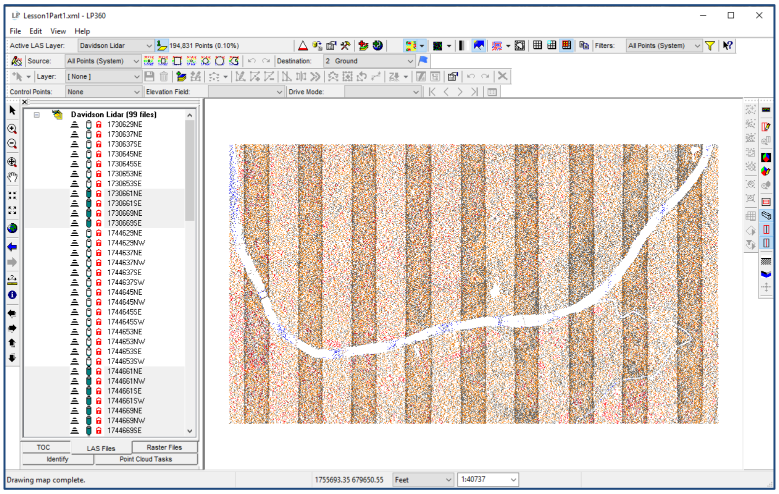
D. No lidar is recorded where the sunlight is being reflected off the water.

48. Clear selected tiles and zoom back to the full extent of the lidar dataset.

49. Load 16 tiles in the NW corner of the project area (4 rows x 4 columns) as shown below.



50. Zoom to the extent of the loaded tiles and turn off display of the file boundaries.



51. Change the draw type to TIN and use the display filter to show only the ground points using an Elevation legend. You may note some edge effects in the corners, particularly where there is water, because the TIN algorithm runs out of valid ground points to use to create a surface. Change the display filter to All Points to see the difference.

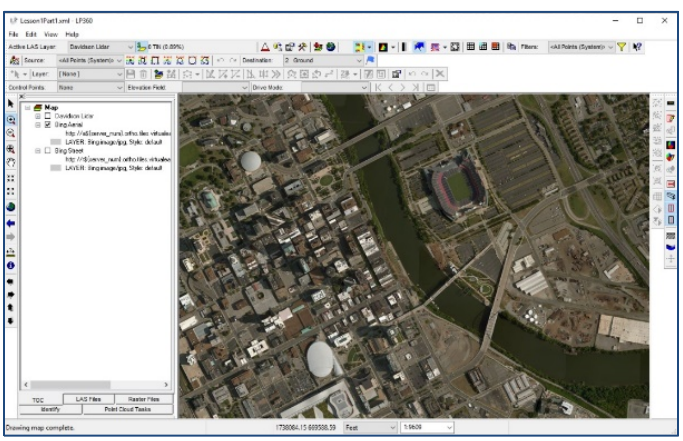
52. Locate Toggle Hillshading on the LP360 toolbar. It is toggled on by default. Toggle off. Notice the flatter appearance of the TIN.

53. With Toggle Hillshading OFF, change the display filter to Ground. Without hilshading, the TIN is a solid color and not at all informative. In general, TINs are most effectively displayed with hillshading turned on.

54. Toggle Hillshading ON and leave it on for the rest of this course.

Q10: Create a screenshot of the 16-tile area, displayed as a hillshaded Ground TIN with an Elevation Gradient legend. (1 point)

55. Using either a WMS layer or orthophoto as a locational reference, zoom to an area on the west side of the project, including the football stadium (Nissan Stadium) on the east side of the river, several bridges crossing the river and a portion of downtown on the west side of the river.



56. Select and load the one LAS tile that covers this area, 1730661NE and zoom to this tile.

57. With a draw type of Points, set the legend to Classification and the display filter to All Points. Turn off the reference image so you can see the lidar points displayed on a solid background.

58. Using Live View, turn off only Class 9 water. Note that some points in the river are removed, but not all. The classification is apparently not 100% accurate in this dataset. You will learn more about classification accuracy and realistic product expectations later in the course. For now, suffice it to say that this is not unusual, even in professionally processed datasets.

59. Change the draw type to TIN and toggle the water on and off using Live View. Even with water points removed from the TIN, the water surface on the river is not flat. You will learn more about flattening of water bodies in Lesson 6.

60. Save the project and close LP360.

Part 3: Importing (Converting) ASCII Files to LAS Format (LP360 Training Exercise #0110)

The lidar data used for this exercise was obtained from the former USGS CLICK website. The location is on Coronado Island along the southern coast of California, about 2 miles southwest of downtown San Diego and features the legendary Hotel del Coronado. Two datasets are provided; one from October 24, 2003 and the other from September 28, 2004.

In this exercise, you will convert ASCII text files from the 2004 dataset to LAS using to the Import ASCII wizard in LP360.

61. Watch Lesson 1 Lab Tutorial 3.

62. Locate the datasets in C:\Geog481\LabDataRoot\Lessons\Lesson1\Scripps\ASCII.

Both datasets set came with the first and last return points coordinates and attributes listed on the same record (row). Two imports will be required to ulitimately create a LAS file containing both the first and last returns. The first line of each text file contains column headings, described in the table below.

Column #	Heading	Description
1	GPSTime	the GPS time the point was recorded
2	XFR	Universal Transverse Mercator (UTM) NAD83 Zone 11 Eastings coordinate of the first return point
3	YFR	Universal Transverse Mercator (UTM) NAD83 Zone 11 Northings coordinate of the first return point
4	ZFR	Z coordinate for the first return point in meters
5	XLR	Universal Transverse Mercator (UTM) NAD83 Zone 11 Eastings coordinate of the last return point
6	YLR	Universal Transverse Mercator (UTM) NAD83 Zone 11 Northings coordinate of the last return point
7	ZLR	Z coordinate for the last return point in meters
8	IntFR	the intensity value of the first return point
9	IntLR	intensity value of the last return point
10	PointID	integer value representing the year the flight was flown
11	RetNum	return number of the first return point
12	RetNum2	return number of the last return point
13	NumRet	the number of returns in the Laser pulse

63. Find the spatial reference information in the html metadata file for the 2004 dataset.

64. Open LP360 with a new project.

65. Open Project Settings.
    - Set the Project Path to C:\Geog481\LabDataRoot\Lessons\Lesson1\Scripps.
    - Set the Project SRS based on the project metadata.
        - Search the metadata file to find the proper geoid model for the vertical datum designation.
    - Select Map Spatial Reference System to Use Project SRS.

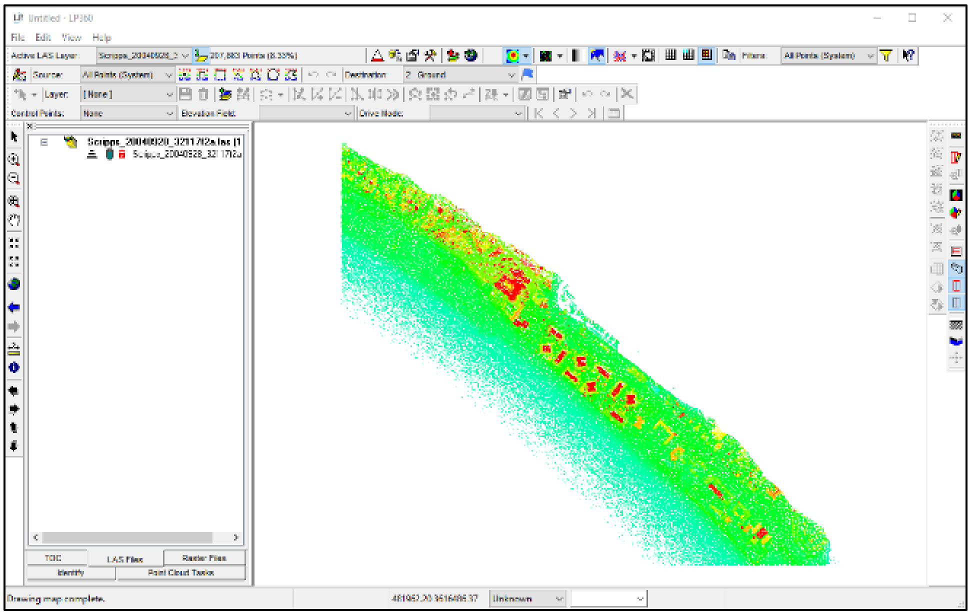
66. Save the LP360 project as C:\Geog481\LabDataRoot\Lessons\Lesson1\Scripps\Lesson1Part3.xml.

Q11: Create a screenshot of the fully populated Project Settings dialog. Expand the window vertically so all the SRS information is visible. (1 point)

67. Following the steps outlined below, use the LP360 Import ASCII wizard to create a first-return-only LAS 1.2 file from the 2004 Scripps dataset.
    - Step 1
        - Output format: LAS
        - Add Scripps_20040928_32117f2a.txt
        - Select output folder C:\Geog481\LabDataRoot\Lessons\Lesson1\Scripps.
        - Click Next
    - Step 2
        - Delimited
        - Start import at line 2 to skip column headings
        - Click Next
    - Step 3
        - Delimiter: comma
        - Check to see that fields are separated properly in the Preview pane
        - Click Next
    - Step 4
        - Assign Fields
            - GPS Time: Column 1 (GPSTime)
            - X/Easting: Column 2 (XFR)
            - Y/Northing: Column 3 (YFR)
            - Z/Elevation: Column 4 (ZFR)
            - Intensity: Column 8 (IntFR)
            - Return Number: Column 11 (RetNum)
            - Number of Returns: Column 13 (NumRet)
        - LAS File Version: Version 1.2
        - Force all points to classification: 0 – Created, never classified

- Click Finish.

68. The imported file loads into LP360 automatically and should match the figure below.



69. Using the LP360 Display options and Live View, verify that all the points in the imported LAS file are:
    - First Returns (cyan when viewed by Return Combination)
    - Class 0: Unclassified (grey when viewed by Classification)
70. LP360 created the name "Scripps_20040928_32117f2a.las" for the LAS file from the name of the input text file. We want to make a second LAS file from the same input text file, so we need to rename the first file. In order to rename, we will have to remove the file from LP360.
71. From the TOC, remove the lidar layer.
72. Save the project.
73. Close LP360.
74. In Windows File Explorer:
    - Rename the LAS file to Scripps_2004_First.las
    - Delete the .qvr file
75. On your own, repeat the steps above to create a last-return-only LAS 1.2 file from the 2004 Scripps ASCII dataset.
76. Using the LP360 Display options and Live View, verify that all the points in the imported LAS file are:
    - Last Returns (yellow when viewed by Return Combination)
    - Class 0: Unclassified (grey when viewed by Classification)
77. From the TOC, remove the lidar layer.
78. Save the project.
79. Close LP360.

80. In Windows File Explorer:
    - Rename the LAS file to Scripps_2004_Last.las
    - Delete the .qvr file
81. Open Lesson1Part3.xml with LP360.
82. Add the two imported LAS files as a new lidar layer.
    - Open Read-Only
    - Load Files
    - Pyramid
83. Rename lidar layer to Scripps_2004.
84. To verify that the files are correctly georeferenced, add the USGS Imagery Topo WMS as a locational reference.
85. Save the LP360 project as C:\Geog481\LabDataRoot\Lessons\Lesson1\Scripps\Lesson1Part3.xml.
86. Open Live View > Returns to verify that you have the same number of points (415,460) in both the Return 1 of 2 and Return 2 of 2 blocks.

If you think about it for a moment, having exactly the same number of 1^{st} and 2^{nd} returns in a dataset seems "fishy". This dataset, as is the case with almost every lidar dataset, should have single returns in areas of bare ground and on hard above-ground objects, such as buildings. The fact that there are an equal number of 1^{st} and 2^{nd} returns in this dataset is an artifact of the ASCII data representation. But it did serve to demonstrate the import process.

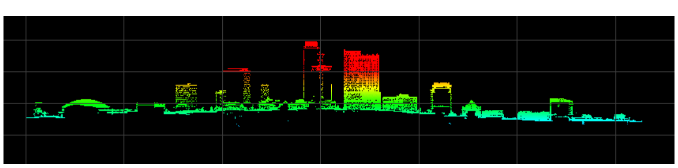
87. Zoom to full extent.

Q12: Create a screenshot of the lidar layer as a Last Return TIN with Elevation Gradient legend overlaid on the USGS Imagery Topo at full extent to show that it is correctly georeferenced. (1 point)

88. Save the Lesson1Part3 project and close LP360.

Part 4: Using the Profile Window (LP360 Training Exercise #0120)

89. Watch Lesson 1 Lab Tutorial 4.
90. Open Lesson1Part2.xml with LP360.
91. Save as Lesson1Part4.xml in the same folder.
92. Use Bing Street as the background reference layer.
93. Locate Nashville Municipal Auditorium at the corner of Gay Street and 5^{th} Ave N in Nashville. It is a distinctive round building with a dome roof on the west edge of the project area.
94. Select and load the lidar tile that contains the auditorium, 1730661NE.
95. Use the profile tool to create a cross-section through the lidar data that encompasses this building and the next 8 - 10 buildings along 5^{th} Ave in a southeasterly direction.
96. Adjust the profile window display to capture the entire scene horizontally and vertically.



97. Set the legend in the Profile Window to Classification. Note that while ground seems to be correctly classified (orange), there are many points that are clearly on buildings that are not in the building class (red). It is not particularly unusual to see incomplete or only partially correct point classification in the “above ground” point cloud.

Q13: Upload the screenshot of the Profile Window with a Classification legend. (1 point)

Q14: Using 470 feet as the elevation of the ground around the Auditorium, what is the approximate height above ground of the Auditorium dome at the highest point? (1 point)

A. 90 feet

B. 245 feet

C. 565 feet

D. 645 feet

98. Use Live View to increase the point size to 3 in the profile window.

99. You should see some points (purple) that appear to be below the ground. We’ll talk about the reason for that later in the course.

Q15: In which class are the below ground points? Hint: You can use the Identify tool from the Display and Navigation toolbar to query points in the Profile window. (1 point)

A. Class 0

B. Class 1

C. Class 7

D. Class 10

E. None of the above

100. Save Lesson1Part4.xml and close LP360.

Part 5: Using the 3D Window (LP360 Training Exercise #0130)

101. Watch Lesson 1 Lab Tutorial 5.

102. Save Lesson1Part4.xml again as Lesson1Part5.xml in the same folder.

103. Open Lesson1Part5.xml in LP360.

104. Locate the Nissan football stadium across the river from the Municipal Auditorium.

105. Use the 3D window to create a visualization of the stadium as:

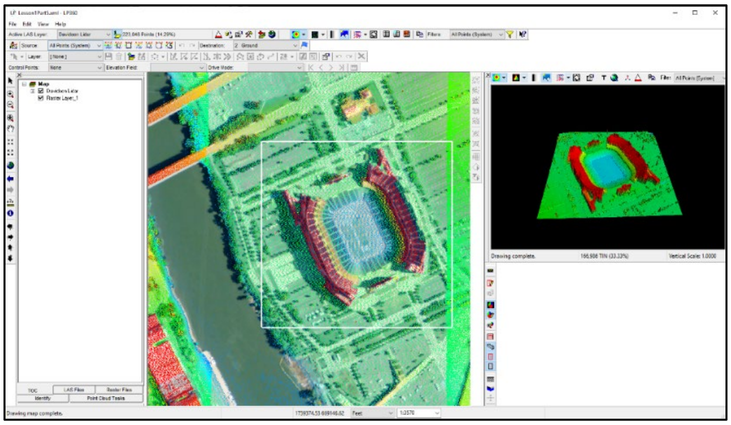
- TIN with hillshading
- elevation legend
- rotated so that the stadium in the 3D window is being viewed from the Auditorium.

Q16: Create a screenshot of the LP360 application window including the 3D view showing Nissan Stadium as a hillshaded TIN with elevation legend viewed from the Auditorium. (1 point)

LP360 has the capability to fuse an image with the lidar data to display a colorized point cloud. In order to do this, you will need a locally saved ortho image in the project SRS.

106. If you projected the Davidson orthophoto on your own in Part 2, load it in your project. If not, download this small snippet of the ortho to use for GIS Fusion; save and unzip in C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson.

107. Use the Add Raster Layer button on the LP360 toolbar to add the orthophoto to the LP360 project. It should be added as Raster Layer_1.



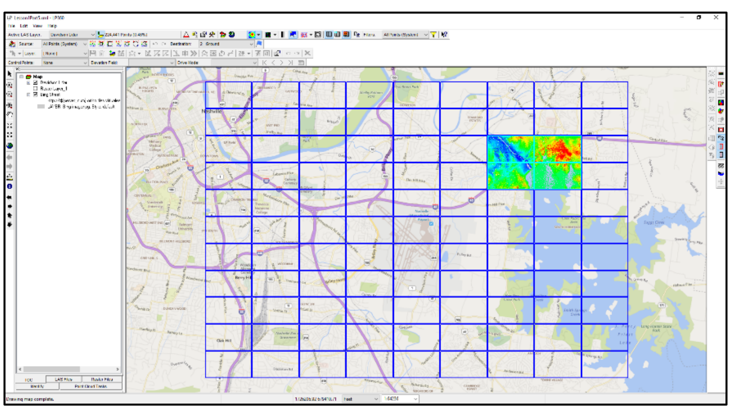
108. In the 3D viewer toolbar, select Viewer Properties.
    - Select Symbology > GIS Fusion
        - Set Color Source: Raster Layer_1
    - Click OK to save.
109. In the 3D viewer toolbar, change the legend to Display by GIS Fusion.
110. Change the draw type to Points.
111. In Live View, set the point size in all views back to "L."

Q17: Create a screenshot of the 3D viewer showing Nissan Stadium as a colorized 3D point cloud. (1 point)

112. Save the project and close LP360.

Part 6: Using the 3D Window (LP360 Training Exercise #0140)

113. Watch Lesson 1 Lab Tutorial 6.
114. Save a copy of Lesson1Part5.xml as Lesson1Part6.xml and open in LP360.
115. If you reprojected and have the large county orthophoto loaded, leave it in the project. If you loaded the small image of the stadium, remove it from the project.
116. Select and Load the 4 LAS files that include the J. Percy Priest Dam, as shown below.

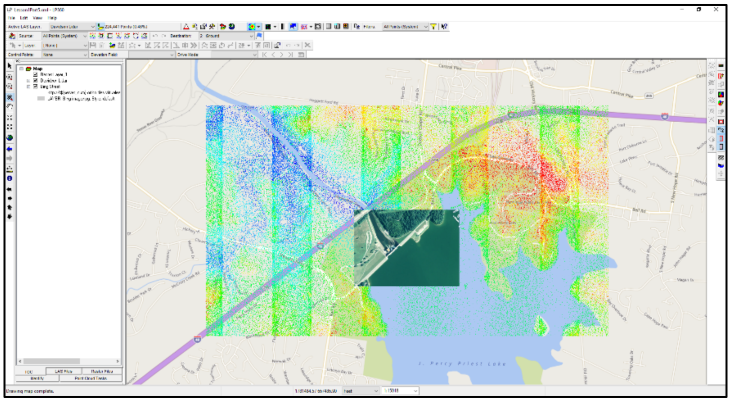


117. If you do not have the large county orthophoto loaded, download this image of the area around the dam to use for GIS Fusion; save and unzip in C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson. Load it as Raster Layer_1.

118. Drag Raster Layer_1 to the top of the TOC.

119. Zoom to the loaded tiles.

120. Turn off display of the LAS file boundaries.



121. Open the Profile Window and draw a profile across the dam, from SW to NE, just wide enough to include the dam structure.

122. Turn off display of the orthophoto image in the TOC.

123. In Live View, turn off synchronization for all views, except Map. This will allow you to use different draw types, filters, and legends in each window.

124. Display the lidar data in the Map view as a Ground TIN (change the draw type and use one of the system display filters to accomplish this) with an Elevation Gradient legend.

125. Apply a Classification legend to All Points in the profile view to answer the following questions.

Q18: What is the approximate elevation of the water surface behind the dam as indicated by the lidar data in the profile view?

A. 350 feet

B. 420 feet

C. 485 feet

D. 533 feet

Q19: How is the dam structure classified in the lidar point cloud? (1 point)

A. Ground

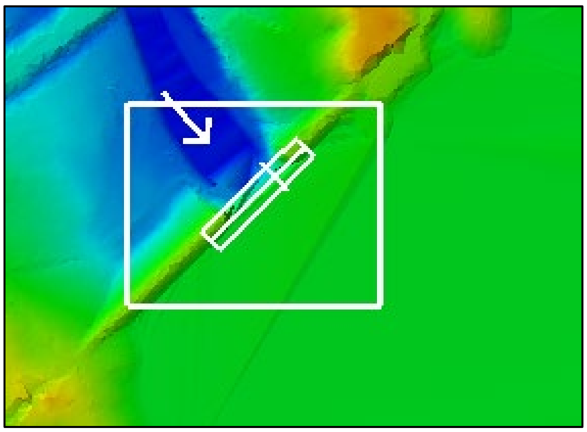
B. Water

C. Building

D. Canopy

E. Unclassified

126. Open the 3D Viewer and draw a 3D extent around the dam as shown below. Rotate the point cloud to view in 3D from the NW, as indicated below.



127. Click on the Draw Profile in 3D View button to see the location of the profile relative to the 3D point cloud. Toggle off once you have seen it.

128. In the 3D view, create a colorized point cloud of the dam, as seen from the NW, using the orthophoto as the color source.

Q20: Create a screenshot of the entire LP360 application window including 1) 2D map view, Ground points only with an Elevation Gradient legend; 2) Profile view using All Points showing the dam structure with a Classification legend, 3) 3D view using All Points showing the dam structure seen from the NW as a colorized point cloud. (1 point)

129. Save the Lesson1Part6 LP360 project.

Part 7: Creating Derivative Lidar Products (LP360 Training Exercise #0170)

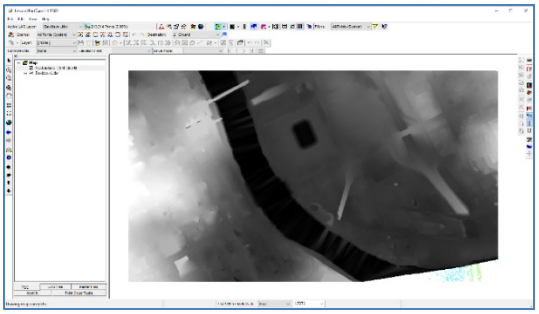
The LP360 Export Wizard is a powerful and versatile tool for creating lidar-derived products in a variety of point-based and raster formats. We won't explore all the capabilities of the Export Wizard at this time, but we do want to introduce it now and we will be using the more advanced capabilities later in the course.

In this exercise, you are going to use the LP360 Export Wizard to create four derivative products that are frequently used in GIS analyses:

- A raster bare-earth DEM (elevation of ground points only)
- A raster first-return DSM (elevation of all lidar first-returns regardless of classification)
- A raster nDSM (normalized Digital Surface Model) which contains height above ground of the first returns, rather than elevation. The nDSM is produced by subtracting the DEM from the DSM.
- A raster building height model that is a nDSM that contains heights of buildings above ground and is flat everywhere else.

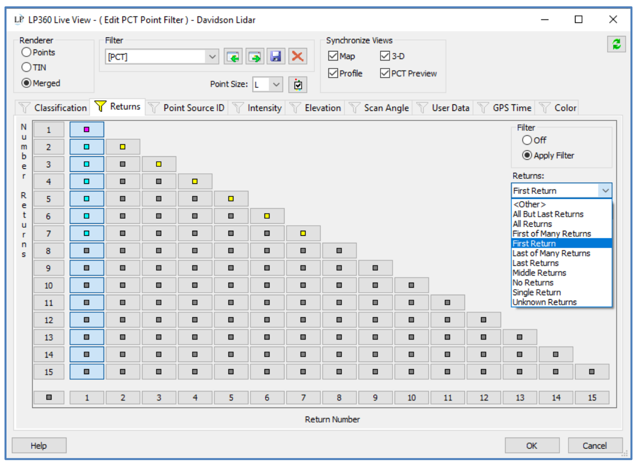
130. Watch Lesson 1 Lab Tutorial 7, which is a video produced by GeoCue.
131. Make a copy of the Lesson1Part2 LP360 project and save it as Lesson1Part7.xml in the same folder.
132. Select and load the single LAS file, 1730661NE, in the downtown area. This is the same file containing the stadium used earlier in this lab exercise.
133. Remove the two WMS layers to speed navigation and display.
134. On the LAS Files tab, right-click on the layer name to bring up a context menu for the layer.
    - Click Invert Selection to select the 98 unloaded files
    - Click Remove Selected Files to remove all but the file of interest from the project
135. Zoom to full extent.
136. Save the project.
137. Open the Export Wizard from the LP360 toolbar.
    - Step 1
        - Export Type: Surface
        - Source Points:
            - Classification tab
                - Class 2 Only
        - Surface Method: TIN
        - Cell Edge Length: 10 Map Units (feet)
        - Surface Attribute to Export: Elevation
        - Export Format: GeoTIFF
    - Step 2
        - Export Extent: Extent of Active Lidar Layer
    - Step 3
        - Export File: C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\P7DEM
            - LP360 will add the .tif extension
        - Check Insert Output to Map
    - Click Finish

The correct result is shown below. The DEM is displayed in greyscale, with black being the lowest elevation and white being the highest elevations. Note the area of no data in the SE corner where there is water; the surface algorithm ran out of valid ground points to use in this area.



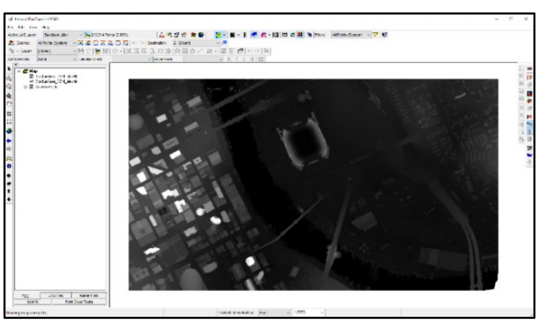
138. Create a DSM using the same method and settings, with the following changes:

- Source points:
  - Classification tab: turn on all classes
  - Returns tab: select First Returns



  - Export File: C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\P7DSM
    - LP360 will add the .tif extension

The correct result is shown below. Note that there is more coverage in the SE corner now because there are first returns in that area.



The nDSM is simply a new raster creating by subtracting DSM – DEM. LP360 has no equivalent to ArcGIS Raster Calculator, but you can produce a difference surface using the Export Wizard.

The most potentially confusing aspect of this step is being clear on how the DEM and DSM are defined:

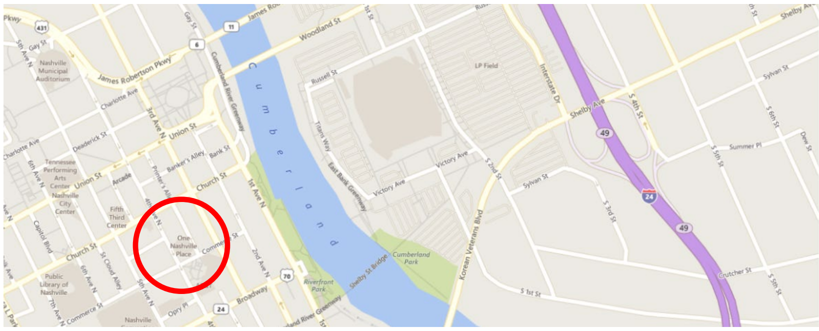
- Source Points is the Ground DEM.
- Top Layer is the First Return DSM

139. Open the Export Wizard from the LP360 toolbar.
    - Step 1
        - Export Type: Surface
        - Source Points:
            - Classification tab
                - Class 2 Only
            - Returns tab
                - All Returns
        - Surface Method: TIN
        - Cell Edge Length: 10 Map Units (feet)
        - Surface Attribute to Export: Elev Difference
        - Export Format: Binary Raster
        - Top Layer: Davidson Lidar
        - Top Filter:
            - Classifications: All
            - Return Combinations: First Return
    - Step 2
        - Export Extent: Extent of Active Lidar Layer
    - Step 3
        - Export File: C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\P7nDSM
        - LP360 will add the extension .flt for a binary raster
        - Check Insert Output to Map

Q21: Create a screenshot of the entire LP360 application window, showing the greyscale nDSM at full extent. (1 point)

140. Now, on your own, create another nDSM showing only the heights of buildings above the ground and heights of 0 feet everywhere else. THINK CAREFULLY about how to set this up to get the desired result. *The nDSM should not contain any negative heights and it should not contain any vegetation or other above ground points. Only building heights above ground where there are buildings, and a 0 height value where there are no buildings*.
    - The bottom layer source points will be the same: all returns, ground class only.
    - The top layer should be 1st returns but consider which classifications to use to get heights of buildings where there are buildings, and heights of 0 where there are no buildings. You have to supply the ground height where there is open ground or you will be subtracting the ground elevations in the DEM from a value of 0 in the DSM.
    - Save the output as C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\Buildings

141. Add Bing Streets WMS for locational reference. Find the building called One Nashville Place at the corner of 4th Ave N and Commerce Street.



142. Use the Identify button on the LP360 navigation toolbar to query raster values.

Q22: What is the approximate height of the building called One Nashville Place, on the corner of 4th Ave N and Commerce Street? (1 point)

- **A. 150 feet**
- **B. 225 feet**
- **C. 330 feet**
- **D. 400 feet**

LP360 has limited options for raster symbology compared to ArcGIS. You can display the resulting raster into ArcGIS Pro to make a more interesting graphic.

143. Save Lesson1Part7.xml and close LP360.

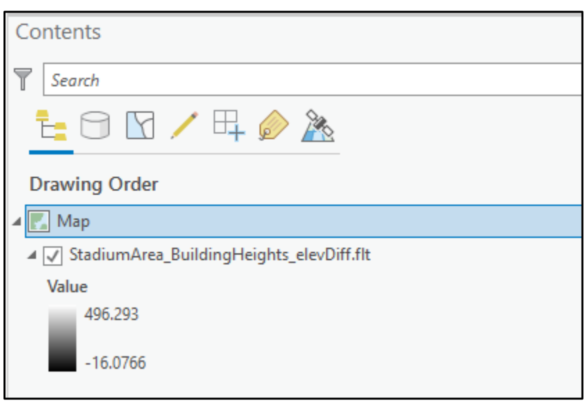
144. Open ArcGIS Pro with a new, blank map.

- Create a project called Lesson1Part7 in C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson

145. Set the map coordinate system to NAD83 (2011) Tennessee State Plane (US Feet)

146. Add C:\Geog481\LabDataRoot\Lessons\Lesson1\Davidson\Buildings

You may notice, as shown below, that there are some negative elevations present.



You can use ArcGIS raster symbology to isolate the pixels that contain negative values. You will find that they are relatively few in number, and they are mainly in the river. This is because the ground DEM has not been hydroflattened, a process we will discuss later in the course. For the purpose of this exercise, they can be ignored. We will come back to fix this after learning how to hydroflatten surface models in Lesson 6.

147. Create a hillshade of the building height raster using default settings in ArcGIS Pro.

Q23: Create a screenshot of the entire ArcGIS Pro application window, showing the hillshade created from the building height model at full extent. (1 point)

148. Save the project and close ArcGIS.

Q24: What was the single most interesting thing you learned in this lab? What was the single most difficult or confusing task to complete? (1 point)