UNIT 2: Data Types

TOPIC III: DEM & Elevation Data

SUMMARY

Using the experience you gained from previous readings and hands on training, you are going to work with data from Pennsylvania. In this assignment, you'll be downloading aerial photographs and LiDAR data from the PA Spatial Data Access website (http://www.pasda.psu.edu). You are going to compile and explore the LAS files using a LAS dataset. Then you are going to create a sample Digital Elevation Model (DEM) from the model key ground surface points then compare it with a downloaded DEM from the same website.

I. OBJECTIVE

The main objective of this assignment is to compile a series of raster and vector data for Pittsburgh (Pennsylvania) in a geodatabase. The following data is going to be used to accomplish this project:

- 2-Foot resolution aerial photographs
- 3.2-Foot (1-Meter) LiDAR DEMs
- Lidar LAS files
- Lidar generated contour lines
- Lidar generated breaklines

This exercise data is large and would need a high-speed internet for reasonable download time. Also, some of the exercise's processes might require a computer with a processor and memory resources capable of handling large amounts of data and the ability to display data in 3D.

II. PREPARING FOR THE EXERCISE

If you did not already do so, make sure to install a free zipping utility such as 7-Zip (https://www.7-zip.org/) on your computer. You'll be downloading, zipping and unzipping multiple files and folders in this exercise and future ones too, having a compression/zipping utility software would help tremendously in simplifying this task.

A. Organizing Exercise Folders

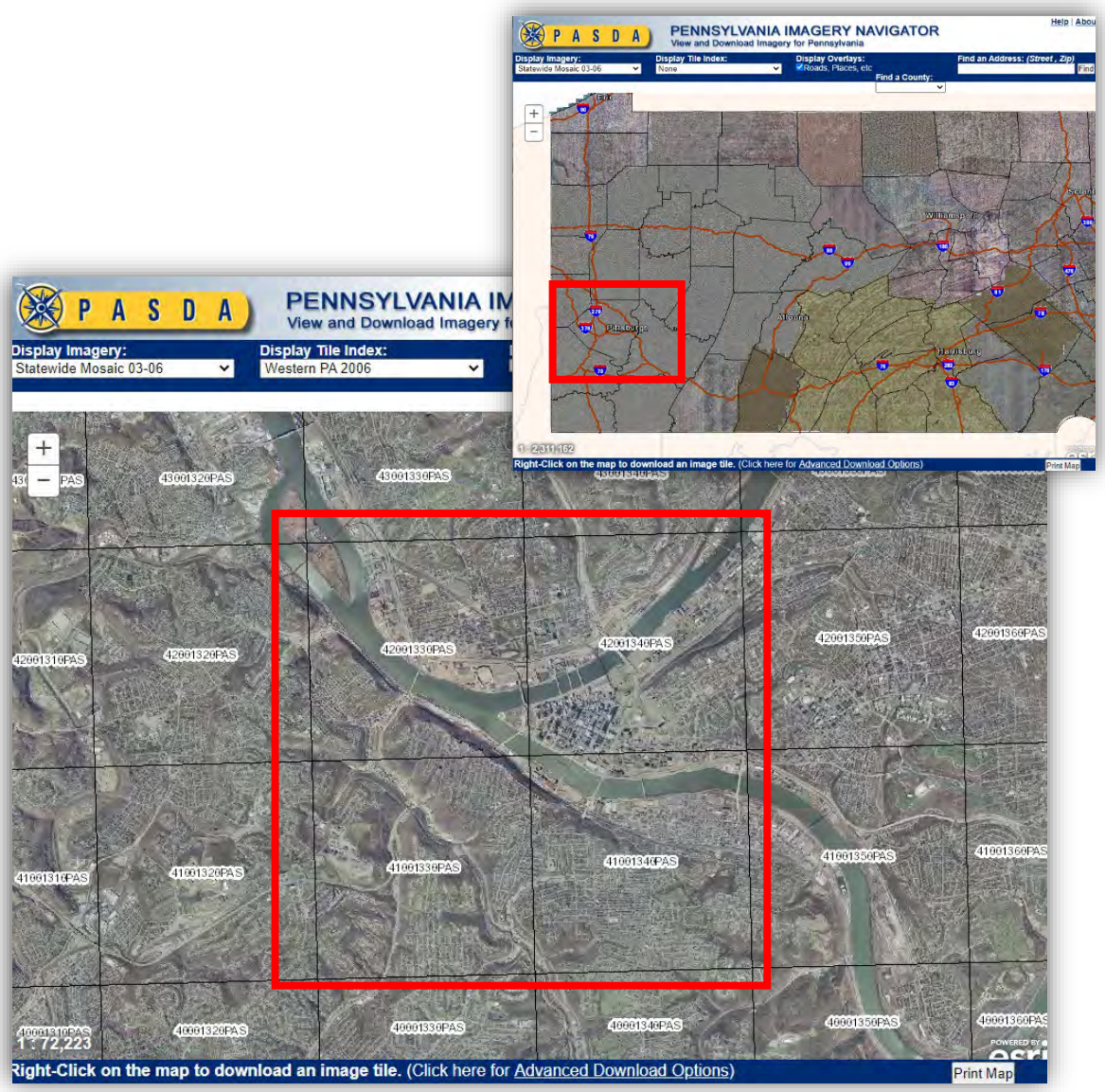
- In Windows *File Explorer* (Hold down the Windows key and click the E button once on the keyboard.
- Create a folder under your Desktop for the exercise: *Desktop >> ES460 >> U2TOPIC3*
- Create a subfolder under *U2TOPIC3* for data downloads, name it *DOWNLOADS* (*Desktop >> ES460\U2TOPIC3\DOWNLOADS*)
- Create another folder to store the downloaded LAS files call it *Desktop >> ES460\U2TOPIC3\DOWNLOADS\LAS* for future reference to the whole folder instead of pointing to one file at a time.

III. DOWNLOADING PAMAP AERIAL PHOTO TILES

All downloaded data should be stored and extracted (unzipped) in the *Desktop >> ES460\U2TOPIC3\DOWNLOADS* folder.

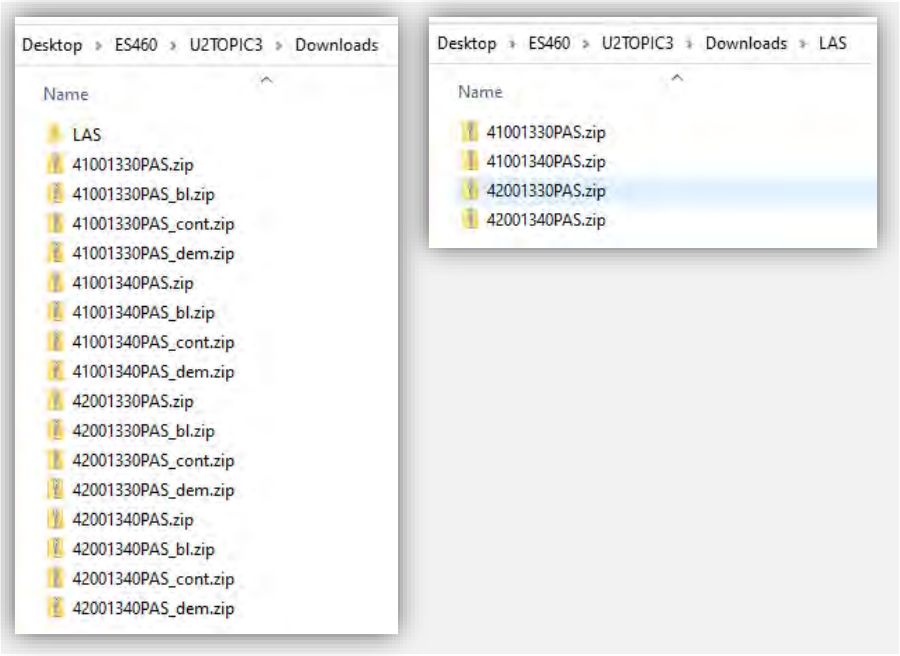
Use the PA Imagery Navigator website for all data downloads for this exercise (http://maps.psiee.psu.edu/ImageryNavigator/)

- In the PA Imagery Navigator, Zoom in to Pittsburgh (South West corner of PA)
- Zoom in more till you have the window almost centered on the three rivers intersection (Allegheny, Monongahela, and Ohio), it is located almost at the center of Allegheny County (Where Pittsburgh falls). Also turn off the Roads, Places, etc. (Display Overlays), and show the 2006>Western PA Tile Index (Display Tile Index:)



- The designated tiles for download are:
    - 42001330PAS;
    - 42001340PAS;
    - 41001330PAS; and,
    - 41001340PAS

  You may need to zoom in more in order to display the tile labels.
- Start the tile data download by right-clicking on each of the four tiles, the *PASDA Download Links* window will pop up. Save the downloaded files in the *Downloads* folder you created earlier on the *Desktop >> ES460\U2TOPICIII\DOWNLOADS*
- For the Aerial Photographs, select the "*'06*" tab and download the *JPG2000* format (last column) since it represents one of the smallest file size downloads (about 16-17 MB per tile). If you would like to see the difference in file size compared to an uncompressed TIFF format, click on the download of the TIFF file and explore how large is the file (about 247 MB).
- For the Lidar data (*DEM, Contours, and Breaklines*), click on the "*Lidar, Topo*" tab from the *PASDA Download Links* window and repeat right-clicking on each of the designated tiles to Download the *DEM, Contours,* and *Breaklines* for each of the given tiles.
- Repeat the same steps for the LAS files, saving them in the *LAS* folder on the *Desktop >> ES460\U2TOPICIII\DOWNLOADS\LAS* folder. Be careful since the zip LAS files have the same name as the Aerial Photographs', watch for duplicate file naming and do not overwrite previous downloads.
- A total of 20 zip files should be downloaded.
- Unzip the downloaded files inside their corresponding folders.
- If you have 7-Zip installed, you may select all of the zip files located in a folder, right-click, and select "Extract Here"
- After making sure that every file is unzipped properly, you may delete all ZIP files in order to free up some disk space.

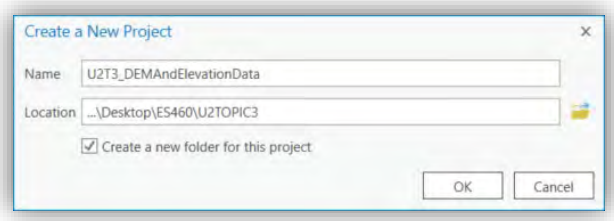


- The total *U2TOPICIII\DOWNLOADS* folder size will be approximately **790MB** after extracting and deleting the zip files.

IV. SETTING UP ARCGIS PRO

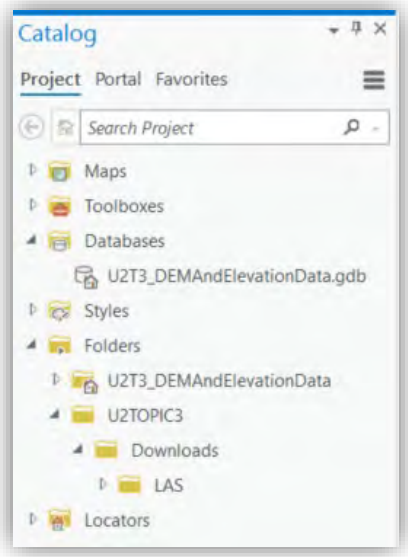
A. Creating a New ArcGIS Pro Project

- Start ArcGIS Pro
- Under *New* click on *Map*
- Name the project *U2T3_DEMAndElevationData* and change the *Location* to be under *Desktop >> ES460 >> U2TOPIC3*
- Check the box next to "*Create a new folder for this project*"
- Click *OK*
- A new project will be created and a map with a basemap will be displayed.



B. Making Folder Connections

- In ArcGIS Pro, in the Catalog Pane, Right-click on *Folders* and click on *Add Folder Connection* then select the *Desktop >> ES460\U2TOPOC3* folder and click OK.
- The new folder connection will show with the Project's main folder.
- Expand all of the folder connections, your folder structure should look similar to the figure.



V. ASSEMBLING THE DATA IN THE PROJECT

A. Previewing the Downloaded Data

Start by exploring the data you just downloaded. You may drag the following and drop them onto the Map:

- aerial photographs (41001330PAS.jp2, 41001340PAS.jp2, 42001330PAS.jp2, and 42001340PAS.jp2);
- DEMs (41001330PAS_dem.tif, 41001340PAS_dem.tif, 42001330PAS_dem.tif, and 42001340PAS_dem.tif);
- Contours (41001330PAS_cont.shp, 41001340PAS_ cont.shp, 42001330PAS_ cont.shp, and 42001340PAS_ cont.shp); and,
- Breaklines (41001330PAS_bl.shp, 41001340PAS_ bl.shp, 42001330PAS_ bl.shp, and 42001340PAS_ bl.shp)

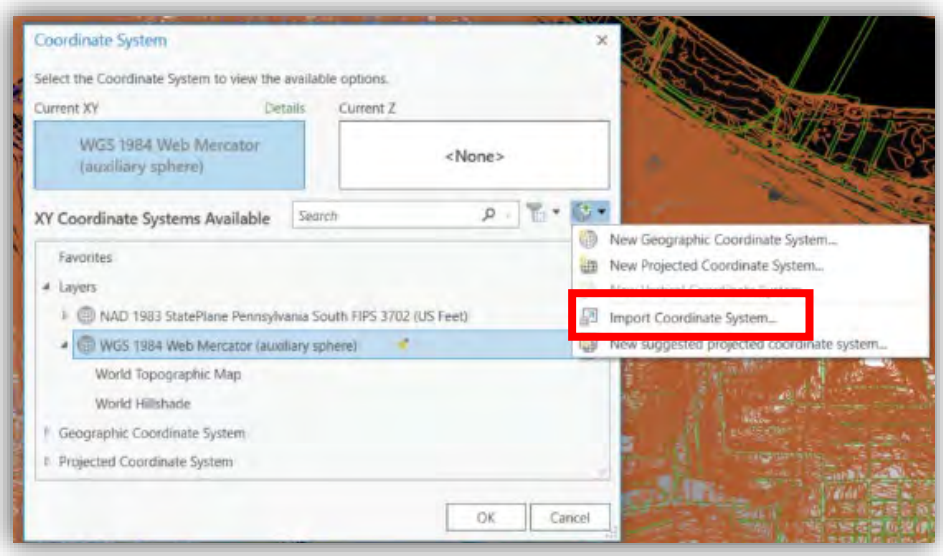
Change each layer's symbology, and view the corresponding attribute tables. You may explore grouping the layers in order to make it easier to view and manipulate in the *Contents* Pane:

- Select multiple Aerial Photos, for example, (Click on the first aerial photo in the Contents pane, hold down the Ctrl key, and click one the second, third and fourth aerial photo)
- While selected, right-click one of them and select *Group*.
- Group layers can be turned on or off for all containing layers in one step.

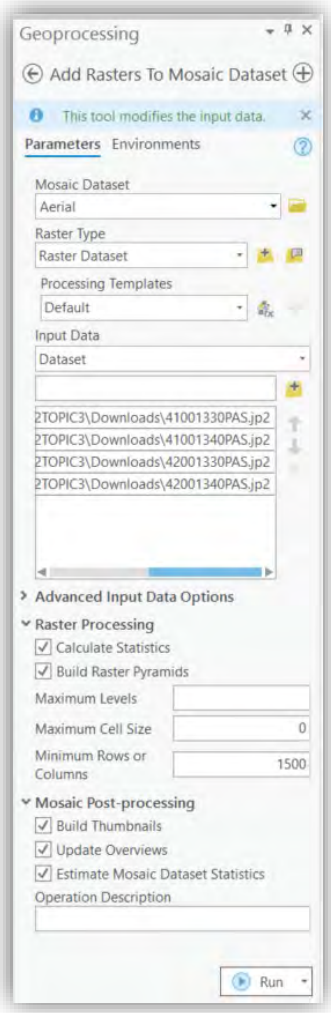
B. Handling Raster Data

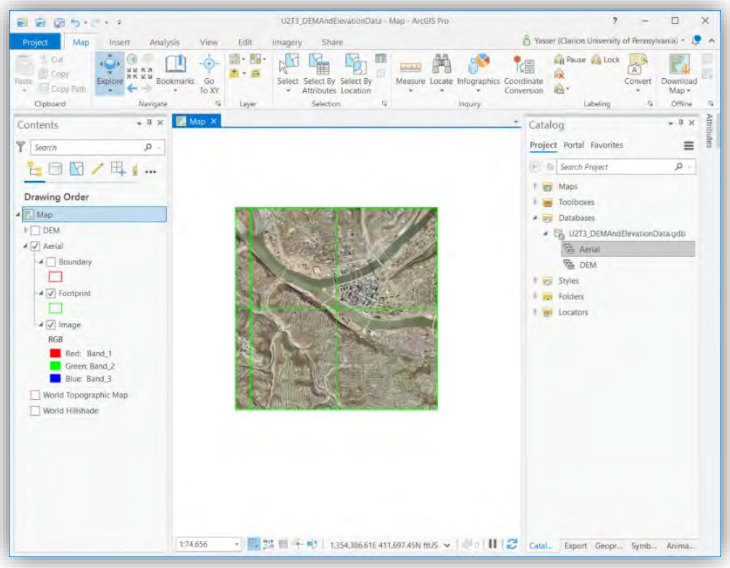
Two raster data types exist: Aerial photographs (jp2) and the Digital Elevation Models (DEM) (tif). You are required to create two raster Mosaic Datasets one for each of them. The Mosaic Dataset would assemble those four individual tiles into one entity. It does NOT store the original files inside the geodatabase, instead it creates pointers (or references) to the location of the individual files wherever they are stored on disk (e.g. *Desktop >> ES460\U2TOPOC3\DOWNLOADS*).

- All Mosaic Datasets should be stored inside the Project's Database (*Catalog* pane >> *Databases >> U2T3_DEMAndElevationData.gdb*)
- Create two Mosaic Datasets, one for the Aerial Photographs (***AERIAL***) and the other for the DEMs (***DEM***)
- Remember that the coordinate system for the current data will always be in *State Plane, Pennsylvania North (NAD83)* and the units are always going to be in *US Feet* (*NAD_1983_StatePlane_Pennsylvania_South_FIPS_3702_Feet*).
- When prompted to choose a coordinate system always chose to ***Import Coordinate System…*** from one of the aerial photo tiles (e.g. *41001330.jp2*).



- Add the corresponding rasters to each of the designated Mosaic Datasets (right click the Dataset >> *Add Rasters…*). Build the necessary pyramids for both mosaics, calculate statistics, and build/update overviews. An example of the *Add Rasters to Mosaic Dataset* geoprocessing tool for the Aerial Photographs is shown in the figure.
- Clear the *Contents* by selecting all layers and removing them;
- Check the correctness of the mosaic creation by adding the *Mosaic Datasets* to the *Map* and previewing the result. For the aerial photos, all 4 frames of the available tiles should be displayed. Same thing for the DEMs. Below is a sample of how the result for the aerial photo mosaic dataset should look like:

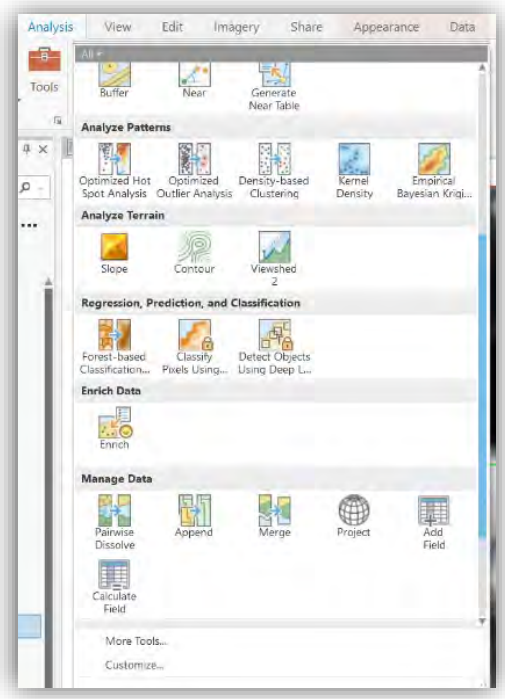




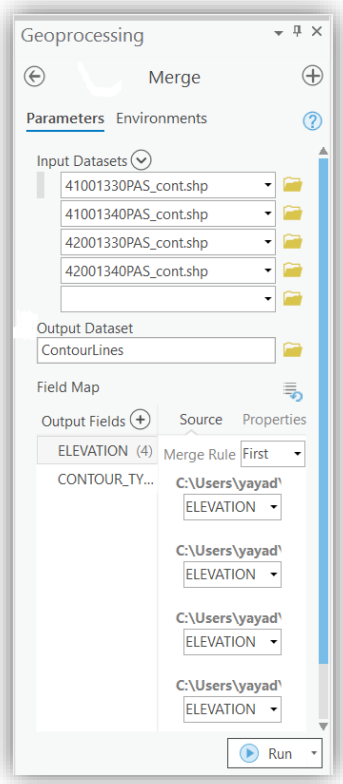
C. Handling Vector Data

Creating a Feature Dataset is the best way to store feature classes sharing the same coordinate systems.

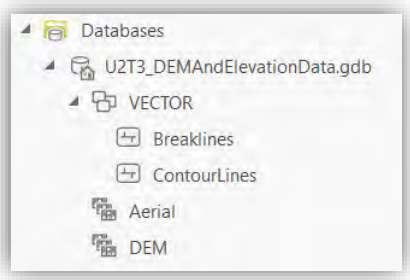
- Create a feature dataset name it ***VECTOR*** under the Project's Database (Catalog pane >> Databases >> U2T3_DEMAndElevationData.gdb)
- When prompted to choose a coordinate system always chose to ***Import Coordinate System…*** from one of the aerial photo tiles (e.g. *41001330.jp2*). You may use the *NAVD88* as the vertical datum (check the *Spatial_Reference_Information* section of the Lidar metadata from *http://www.pasda.psu.edu/uci/FullMetadataDisplay.aspx?file=pamap_lidar_LAS.xml)*.
- Since we have downloaded 4 different tiles of each of the *Contours* and the *Breaklines*, the best method to import those vector data into the dataset would be to use the "*Merge*" tool (*Analysis* tab >> *Tools* group >> *Manage Data* section >> *Merge*).



- Input all 4 contour line tiles shapefiles (you may use the ctrl key to select multiple files, and name the output ***ContourLines***, place it inside the ***VECTOR*** dataset. Accept all other defaults. The final Merge dialog should look as follows:

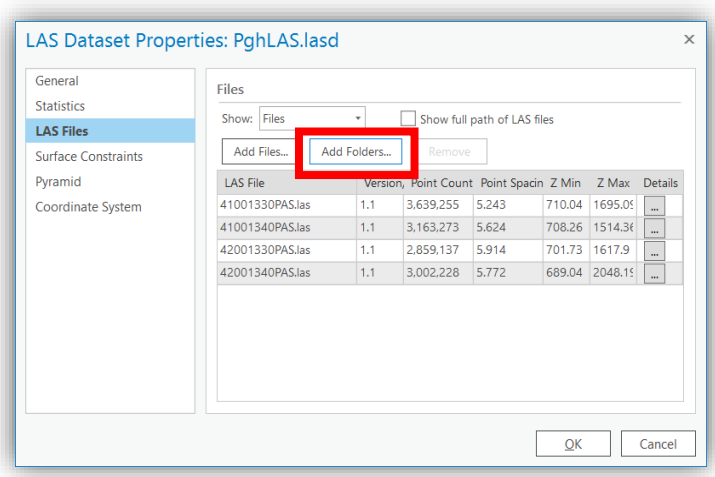


- Repeat the same steps for the *Breaklines*. Save the output as ***Breaklines*** inside the ***VECTOR*** dataset.
- By the end of this step your geodatabase should look like the following figure

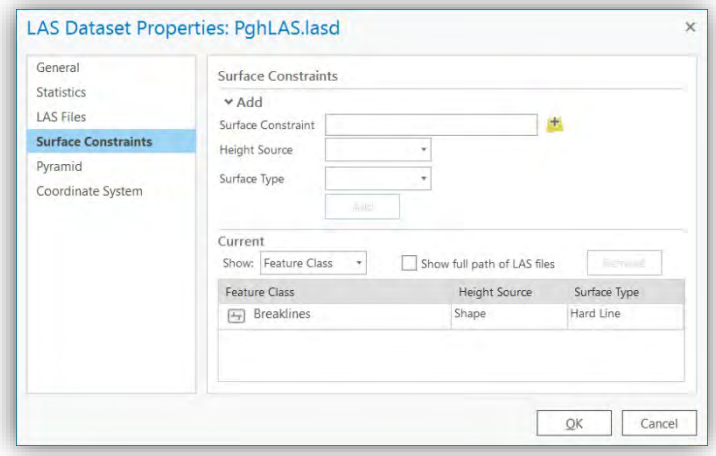


D. Handling LAS files

- Using your experience from the past training, readings and presented video, create a LAS dataset in the Project's folder (*Desktop >> ES460\U2TOPICIII\U2T3_DEMAndElevationData*), name it ***PghLAS*:**
  - In the *Catalog* pane, expand the *Folders.*
  - Right-click on *U2T3_DEMAndElevationData* project home folder and select *New >> LAS Dataset*
  - Rename it to *PghLAS*
- By right-clicking on the newly created LAS dataset and selecting *Properties,* go to the *LAS Files* section and add the LAS files to the *PghLAS* dataset either using the *Add Files* individually (previously downloaded and located inside the *Desktop >> ES460\U2TOPICIII\DOWNLOADS*\LAS folder), or by simply adding the whole *LAS* folder (*Add Folders…* option)



- Now you'll add the breaklines as surface constraints to the LAS dataset:
  - Under *Surface Constraints* section, click Add
  - Click the yellow icon next to the *Surface Constraint* field and pick the *Breaklines* located under the *VECTORS* feature dataset inside the Project's database.



- Under the *General* section, check the box of "*Store relative path names to data sources*"
- Update Statistics if not already calculated.
- Click *OK*.

E. Previewing the Compiled Data

- If not already done, start adding the data we complied earlier in the following order:
  - ***PghLAS.lasd*** LAS dataset
  - ***Breaklines*** feature class (*VECOTRS >> Breaklines*)
  - ***ContourLines*** feature class (*VECTORS >> ContourLines*)
  - ***Aerial*** raster mosaic dataset
  - ***DEM*** raster mosaic dataset

  Organize the layers in the table of contents so that you have the aerial image at the bottom, followed by the DEM, Contours, Breaklines, then the LAS dataset at the top.
- You might need to turn off most of those layers then turn them on individually to preview the data.
- In order to view the LAS dataset's contents, you may need to zoom in more than usual in order for the points to appear.

- Start exploring the LAS dataset by tweaking the layer's properties; this is going to be computing extensive, so, I recommend that you turn off all other layers in the table of contents and work only with the *PghLAS* layer.
- While the *PghLAS* layer is selected in the *Contents* pane, select the *Appearance* tab >> and click on the arrow under *Symboloby*
- Under *Symbolize your layer using a surface* section, select *Slope*
- Change the points to display only the Ground data by clicking on *LAS Points* under *Appearance >> Filters* group and selecting *Ground*. This will display the ground's surface slopes of the area instead of using all points available from the LAS files.
- You may also change the *Display Limit* under the *Appearance* tab >> *Point Thinning* group >> *Display Limit*. Increase to 5,000,000.
- Changing the *Full Resolution* (*Appearance* tab >> *Point Thinning* group >> *Full Resolution*), would result in more or less calculation time and finer or coarser data representation. Set it to 24,000, so it won't display the full data if zoomed in more than that (time consuming).

VI. CREATING A DEM AND AN INTENSITY RASTER

For help and explanation about this part please make sure to watch the video: Lidar in ArcGIS: An Introduction, available on Esri Training. Also, refer to the following links:

- *https://pro.arcgis.com/en/pro-app/latest/help/analysis/raster-functions/las-dataset-to-raster-function.htm*
- *https://pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/las-dataset-to-raster.htm*

A. Creating Intensity raster

- Using all Classes of the *PghLAS* las layer:
  - Make sure that the *PghLAS.lasd* layer is selected in the *Contents;*
  - In the *Appearance* tab >> *Filters* group, click on the arrow of *LAS Points* >> select *All Points*
- Create an intensity map using the *LAS Dataset to Raster (Conversion)* tool from the *Analysis* tab >> *Tools,* Search for "*Las Dataset to Raster*"; Change the *Value Field* to *Intensity*
- Save the intensity raster inside the project's database: ***PghLAS_Intensity***

B. Creating DEM raster

- Using only the ground class of the *PghLAS* las layer:
  - Make sure that the *PghLAS.lasd* layer is selected in the *Contents;*

  - In the *Appearance* tab >> *Filters* group, click on the arrow of *LAS Points* >> select *Ground*
- Create a DEM map using the *LAS Dataset to Raster (Conversion)* tool from the *Analysis* tab >> *Tools,* Search for "*Las Dataset to Raster*", change the *Value Field* to *Elevation*
- Save the intensity raster inside the project's database: ***PghLAS_DEM***

VII. COMPRESSING AND SUBMITTING THE GEODATABASE

- Open Windows File Explorer (Windows Key + E) and navigate to the exercise folder ***Desktop >> ES460\U2TOPIC3***
- Right click on the project's folder ***U2T3_DEMAndElevationData*** and select 7-Zip >> Add to ***U2T3_DEMAndElevationData.zip***
- A compressed ZIP file is created. The file size should be around 68Mb.
- Upload this zipped file (***U2T3_DEMAndElevationData.zip***) to the corresponding Assignment on D2L (*U2TOPICIII: DEM and Surface Data*)

VIII. GRADING RUBRIC (TOTAL 70 POINTS)

- One Dataset with the correct coordinate system created (**5 points**)
- Feature classes (contours and breaklines) were properly saved inside the dataset
  - Breaklines and ContourLines tiles were successfully merged into the corresponding feature classes (**10 points**)
- Raster Mosaic Datasets created with the proper coordinate system and the proper rasters added
  - AERIAL (**7.5 points**)
  - DEM (**7.5 points**)
- LAS dataset was properly created (**5 points**)
  - LAS files properly loaded to the dataset, statistics present, surface constraints and other properties properly set (**15 points**)
- Intensity raster was properly created for all classes and stored inside the geodatabase (**10 points**)
- DEM raster was properly created for the ground and the model key classes and stored inside the geodatabase (**10 points**)