

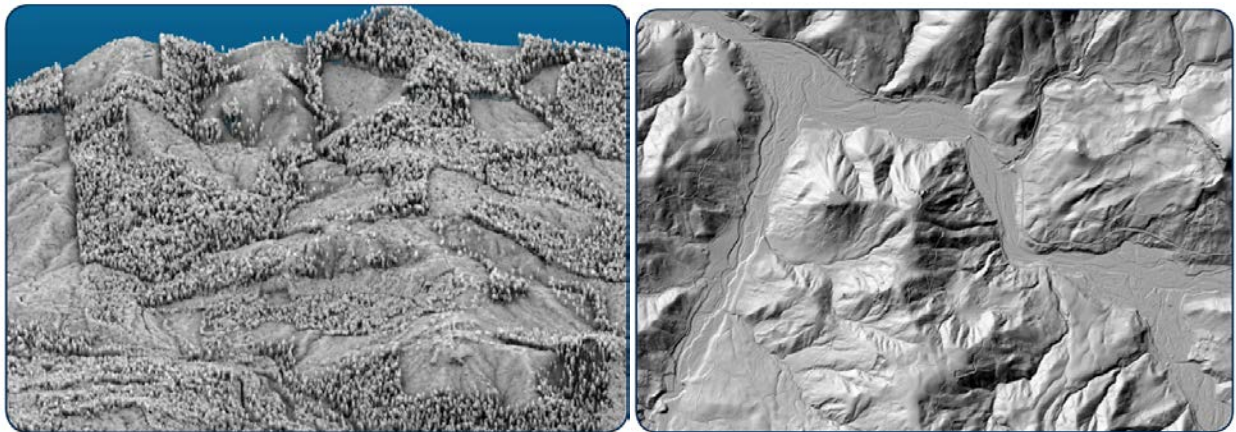
SMS Lidar Workflow

Background

The backbone of the SMS SRH-2D Software's capabilities is the mesh, which represents the surface over which water can flow. Generating the detailed mesh is the first portion of the 2D modeling process. The mesh surface can be created from either aerial LiDAR data or Digital Elevation Models (DEM) that can be procured from the following locations. Aerial imagery may also be downloaded to display with the elevation data for easier visualization.

Lidar data is a dense set of points, each with precise, 3D locations. Lidar can be collected aerially, statically, or on mobile platforms. Lidar can be used to create a surface, model, or raster of its features, but the point cloud itself is a collection of points measured from a platform with a laser. Lidar captures anything in its path, but cannot penetrate water, so the data is only good for areas surrounding water. Classification must be performed on Lidar to extract a dataset with only ground points (filtering out buildings, vegetation, etc.). See Appendix B for lidar file type information.

DEMs are usually created from lidar data, but can also be created from Structure from Motion (SfM) processing on sequential imagery from mobile or aerial platforms. The DEM is a raster format file containing a grid where each cell is a fixed size and holds the average elevation of the lidar data collected within that area. Some data sources don't provide the raw lidar data, but provide DEMs developed from lidar. DEMs provided in the ODOT GIS Archives come in Highest Hit and Bare Earth (see below). Highest Hit products show everything, while Bare Earth products are created only from lidar points classified as ground. The SMS software can read either lidar or DEM data. For DEM file type information, please see Appendix B.




Left: Highest Hit DEM; Right: Bare Earth DEM (OLC Lane County 2013)

LiDAR Resources

We recommend utilizing ODOT GIS Archive data first, and as a backup, consulting the Open Topography dataset. If those two resources don't have the data needed for a project, consult with your Region Survey Unit for additional data acquisition.

ODOT GIS Archives – Data: [\\xd6211x\](#) Index: <https://gis.odot.state.or.us/transgis/>

The best lidar data source is the ODOT GIS archive. The easiest way to find data is to turn on the Lidar Index layers in TransGIS which reside in the Boundaries category.

- 1) *Locating your project data.* Find your project area and turn on the Lidar Point Cloud Index layer. Use the  identify tool on the desired area, and on the information screen, look for the Delivery field. The Delivery Folder Name determines the lidar project folder and delivery number.
 - a) Use the Lidar Archive Index in Appendix C to find which numbered lidar archive the project is in. Open the “Data” path above, and open the corresponding lidar drive and project folder. Within the project folder, select the appropriate delivery folder from the Delivery number (DEL_1) in the TransGIS information dialogue. If there is no deliver number, look at the first 7 digits of the Ohio Code ID Number. Find the corresponding folder within the delivery folders (e.g. Ohio Code 44123A1311 would be in folder 44123A1 within Delivery 1).
 - i) Note that some project names are grouped under larger projects, so you may have to do some searching to find the project. For instance, PDX is under the METRO project delivery. The Lidar drives are *not* organized chronologically or by project, you *must* use the index in Appendix C.
- 2) *Locate project metadata: coordinate system, resolution, collection date.* Within the delivery folder you will find the “Data Report” folder and the data folders. Download (copy/paste) one of the reports (any report in the folder will work) to find important metadata: coordinate system information, point cloud resolution, and acquisition date.
 - a) The projection can usually be found in the first section that overviews the project. Look for a section about Deliverables. Consult Appendix A for projection information.

1.4 Data Format, Projection, and Units

Deliverables include point data in *.las v 1.1 and ascii format, 3-foot resolution bare ground model ESRI GRID, 3-foot resolution above ground surface ESRI GRID, 1.5-foot resolution intensity images in GeoTIFF format, Smoothed Best Estimate of Trajectory (5Hz frequency) information in ascii text format, and data report.

- ODF AOIs are delivered in Oregon Lambert, EPSG 2992, with horizontal units in International Feet and vertical units in US Survey Feet, in the NAD83/NAVD88 datum (Geoid 03).
- All other AOIs are delivered in Oregon State Plane North, with horizontal units in International Feet and vertical units in US Survey Feet, in the NAD83 HARN/NAVD88 datum (Geoid 03).

- b) The point cloud resolution (density) can also be found in the overview section. Look for a section on Resolution. DOGAMI specifies that data must have a resolution of ≥ 8 points per square meter.

1.3 Accuracy and Resolution

	Total Pulse Density	Ground Pulse Density
2007 ODF Data Acquisition Processing Complete	7.71 points per square meter 0.72 points per square foot	0.71 points per square meter 0.07 points per square foot
2007 DoGAMI Data Acquisition Processing Complete	6.90 points per square meter 0.64 points per square foot	1.28 points per square meter 0.12 points per square foot
2008 DoGAMI Data Acquisition Processed to Date	7.74 points per square meter 0.72 points per square foot	0.53 points per square meter 0.05 points per square foot

- c) The lidar acquisition date can usually be found in the Acquisition Specifics section.

2.1.1 Acquisition Specifics per Delivery Area

Delivery Area 1 - Portland: These data were collected between March 16 - April 15, 2007, with both the Leica ALS50 and the Optech 3100 LiDAR systems, as shown in Figure 2.4.

Delivery Area 2 - ODF: These data were collected between April 27 - May 11, 2007 with the Leica ALS50 LiDAR System.

Delivery Area 3 - Upper Sandy River: These data were collected between May 18-19, 2007 with the Leica ALS50 LiDAR System.

Delivery Area 4 - Collawash: These data were collected on June 14, 2007 with the Leica ALS50 LiDAR System.

Delivery Area 5 - Lower Sandy River: These data were collected September 29 - October 7, 2007 with the Leica ALS50 LiDAR System.



- 3) *Download lidar data.* Use the identify tool on the Lidar Point Cloud Index layer to get the Ohio Code ID Number for the project area. The POINTS folder contains lidar data, sometimes in two formats: all points and ground only. Download (copy/paste) ground only LAS files. If no ground only points exist, download all points and contact Geometronics to help classify the data to get ground only points.
- 4) In addition to lidar, the bare earth raster data may be useful. The bare earth raster is a DEM made only from lidar classified as ground points. Find the bare earth Ohio Code file name in TransGIS using the Lidar Imagery Index layer and navigate to the Raster folder within the project delivery folder. Download (copy/paste) the entire corresponding bare earth folder. Open the large ADF file from the folder into SMS.

OpenTopography – <http://opentopo.sdsc.edu/datasets> (does not work in Internet Explorer)

Topography allows users to define an area of interest, as well as a subset of the data (e.g. “ground returns only”), and then download the results of this query in ASCII or LAS point cloud formats. The system can also generate geomorphic metrics such as hillshades and slope maps.



- 1) Open the web link above. Zoom in to Oregon and find project location.

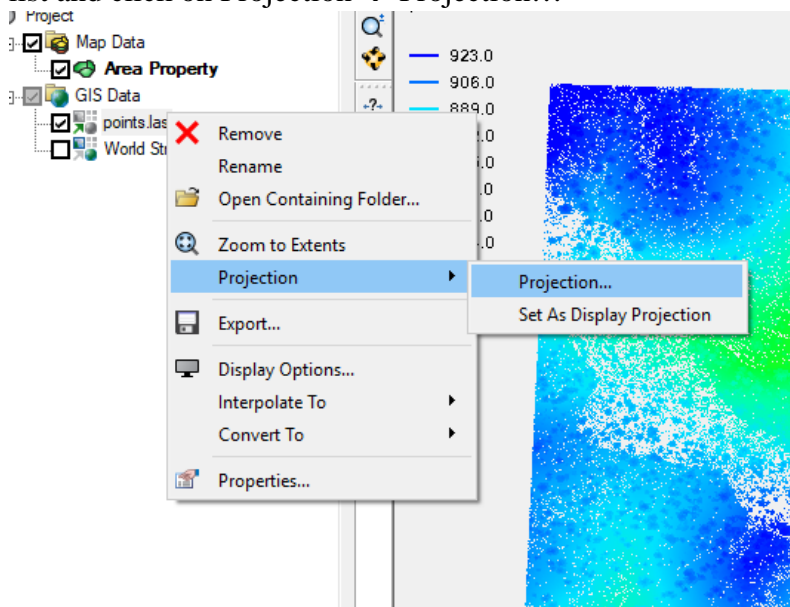


- 2) Click  and create a selection around your area of interest.
- 3) Scroll down to below the map to the RESULTS section. All results are point clouds available for download. Click  to read project information.

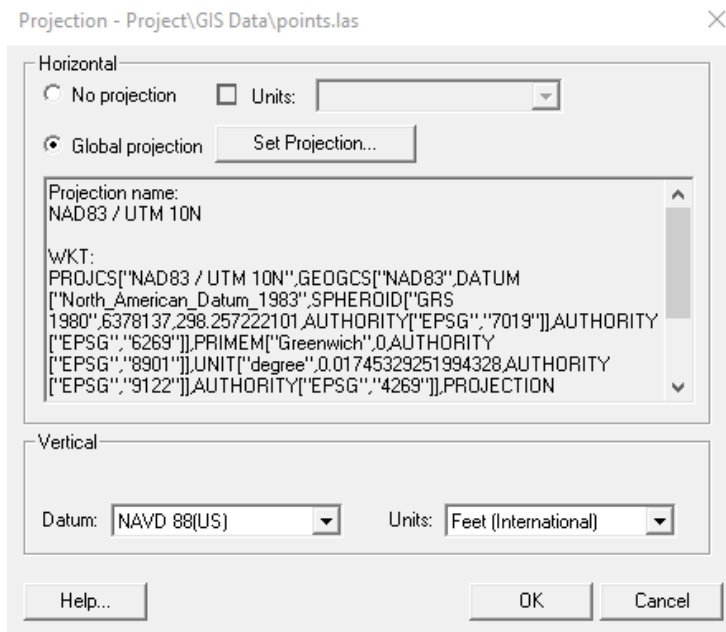
- 4) To download lidar data, select Point Cloud Bulk Download. If other data products are listed, you could download those as well. If not, the site will create a DEM (scroll down for options).

Processing Steps

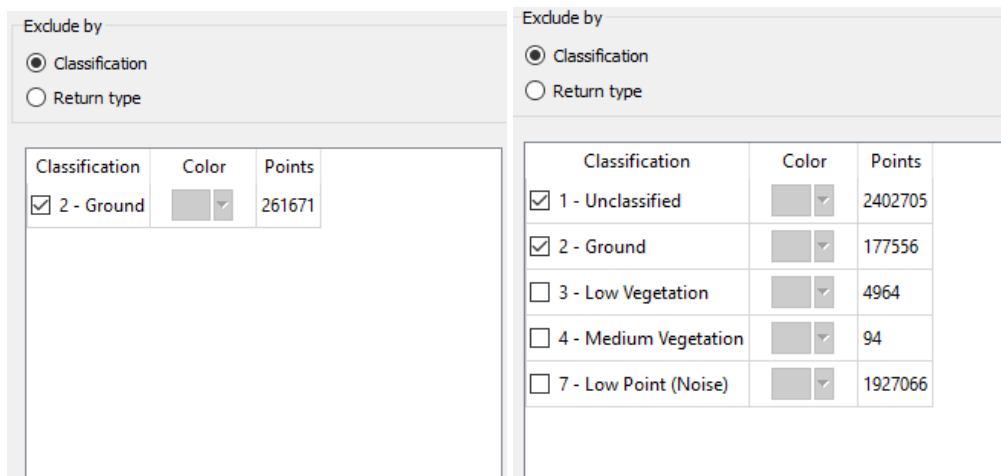
- 1) Once the LiDAR, DEM, and/or imagery for the project is secured, open the SMS software. Save  the project and name accordingly.
- 2) Import elevation data: lidar or DEM either by dragging data into SMS map view window or by clicking Open . For information on importing field survey data, see Appendix D.
 - a) In general, the steps for compiling terrain data are as follows:
 - i) Import and trim primary terrain data (i.e. Lidar or photogrammetric data)
 - ii) Merge/Convert terrain data to scatter data (to merge multiple datasets, highlight and convert all to scatter at once)
 - iii) Import data from other sources (topographic surveys, channel cross section surveys)
 - iv) Merge all datasets and review
 - v) Add breaklines where needed to force correct triangulation
- 3) Set the Display Projection by selecting *Display* → *Display Projection*. The Display Projection will be used to bring all the data together by projecting on the fly, even if each data source originated with differing projections. Check with your region survey group to find out which projection to use for your specific project.
 - i) **Please see Appendix A for details on projections**
 - ii) To find the OCRS zones: Set Projection → Projected Coordinate Systems → State Systems → Oregon → OCRS xxxx NAD 1983(Feet Intl)
- 4) Set/confirm the projection of the data you imported. Right click on the data file in the layer list and click on Projection → Projection...



- a) Usually files will contain projection information, but always check the projection after importing to confirm it matches the metadata.
- b) Select the appropriate horizontal coordinate system and vertical datum for the dataset based on the Data Report using the Set Projection button. Always check that the units match.

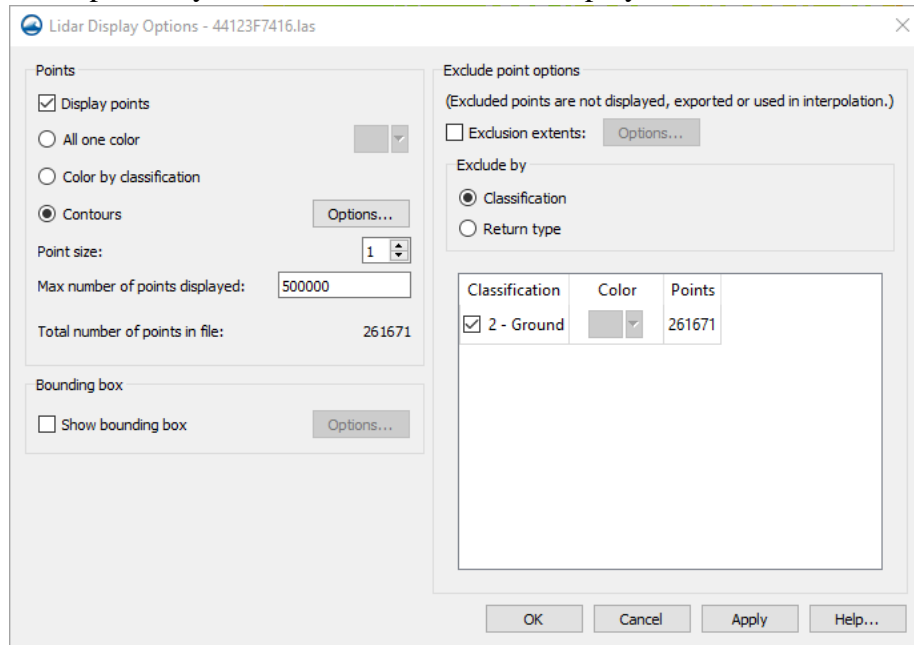


- 5) Change the way the lidar is displayed by right clicking on the lidar file and clicking Display Options
 - a) Choose options for viewing certain classifications (i.e. Ground/Bare Earth/Vegetation)
 - i) Classification must be performed on the lidar prior to import (Contact Geometronics if you need lidar classified)
 - ii) To know if the data has been classified, upload to SMS, then open the Display Options. On the right side of the window under Classification are all the classifications present in that dataset. A ground only dataset will list only one classification: Ground. An All Points dataset will list multiple classifications, and an unclassified dataset will show none.











- iii) The classification checkbox selection affects which points are used in any further interpolation of the data (mesh creation). For example, you wouldn't want to include vegetation in the mesh.
- b) Set the number of lidar points displayed to see all the data as well as the size of points
 - i) The number of points displayed setting will NOT affect the number of points used to interpolate the data, it is only a display setting.
 - ii) Recommended display settings are shown below:

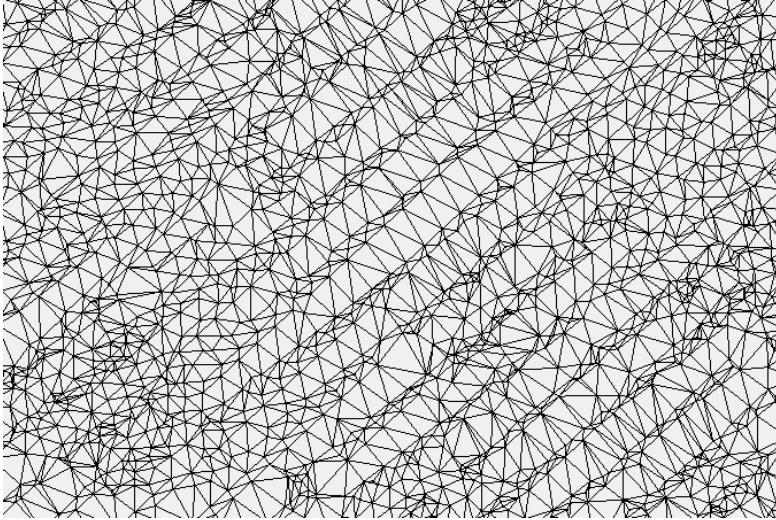
Color points by Contours, Point size = 1, Displayed Points = 500,000



Optional Steps (skip to Step 10 if satisfied with displayed data)

- 6) Upload a base map for site visualization if desired. If project imagery is available, import that instead.
 - a) Click Add Online Maps  or File → Add Online Maps...
 - b) Select desired map: e.g. imagery or streets
 - i) Base maps are downloaded from the internet and may be blocked by the ODOT firewall
- 7) Edit the lidar data if desired. **Optional edits** include:
 - a) *Trimming by View window* (later you will be able to trim out individual points)
 - i) Switch to Plan View 
 - ii) Zoom in to your desired area of interest
 - iii) Open Display Options and check Exclusion extents and then Options
 - iv) Select X/Y and then Update to get the X/Y max/min from the current view
 - v) Only these extents will be used in any further processing
 - vi) If desired, export the trimmed LAS
 - b) *Converting Lidar to Raster Format* (if you prefer a DEM for viewing)
 - i) Right click the lidar file and choose Interpolate to Raster

- (1) This can also be done with multiple lidar files; select all files in the catalog and then right click and choose Interpolate to Raster.
 - ii) Select a cell size: this should not be smaller than the default, as that will not be true to the density of the data. The cell numbers will change automatically.
- 8) *Trim Raster*. If project imagery or large rasters were imported, you may want to trim the images down to the project area to minimize processing time.
- a) First, the projection of the raster being edited must be set as the display projection. Right click on raster, go to *Projection...* → Set as Display Projection
 - b) Activate the Map Module  and select Create Feature Arc 
 - c) Draw a closed figure around your area of interest to the extent you want to trim your raster
 - d) While the feature arc is still selected, go to *Feature Objects* → Build Polygons
 - e) Use the Select Polygon  tool to select the polygon
 - f) Right click on the raster to be trimmed and select *Convert To* → Trimmed Raster
 - g) In the Save As window, give your trimmed raster a name.
- 9) *Display DEM data in 3D* rather than a 2D image
- a) click Display Options 
 - b) Select GIS from the list on the left.
 - c) In the *Raster* section, select *Display as 3D points*
- 10) Create 2D Scatters from all datasets
- a) Right click the file and select Convert to 2D Scatter
- 11) Edit the Scatter before continuing
- a) Turn off all layers other than the scatter to be edited
 - b) If needed, change the display setting for the scatter to color by elevation by clicking Display → Display Options, and selecting Use Contour Color Scheme
 - c) Use the Rotate  tool to zoom in to the points you'd like to delete
 - d) Use the Select  tool to select points, then press the Delete key, then Yes to the prompt
 - e) Continue editing the Scatter until satisfied
- 12) Merge all scatter datasets together before creating a mesh.
- a) Select one Scatter, then go to *Scatter/Merge Sets*
 - b) Check the box under Merge for each dataset to be merged, name the set, and click OK.
- 13) Create a Mesh from the combined scatter
- a) Right click on the scatter and select Convert Scatter → 2D Mesh
 - b) The resulting mesh should look like the following



c) Make sure to save the mesh. File → Save Mesh

Appendix

A. Coordinate Systems

When downloading and importing data, especially when bringing in multiple datasets, it is important that all datasets are displayed in the same coordinate system. Horizontal coordinate systems can be either geographic (latitude/longitude) or projected (northing/easting). Latitude and longitude are angles from the center of the Earth to a point on the surface. Northings and Eastings result from the Earth's round surface being projected onto a 2D (flat) surface.

When multiple datasets involving elevation are being compared, vertical datums become even more important. In the bottom portion of the Projection dialogues are the vertical datum settings. Any data with elevations included should be set to the appropriate datum. If all data came from the same source, the automatic "Local" datum will suffice. If not, make sure to select the appropriate vertical datum based on any metadata you have access to. Right now, the only two options in SMS are NAVD88 (most common) and NGVD29. For ODOT GIS Archive data, the vertical datum is listed in the report file (see below).

1.3 Data Format, Projection, and Units

Deliverables include point data in *.las v 1.1 and ascii format, 3-foot resolution bare ground model ESRI GRID, 3-foot resolution above ground surface ESRI GRID, 1.5-foot resolution intensity images in GeoTIFF format, Smoothed Best Estimate of Trajectory (5Hz frequency) information in ascii text format, and data report.

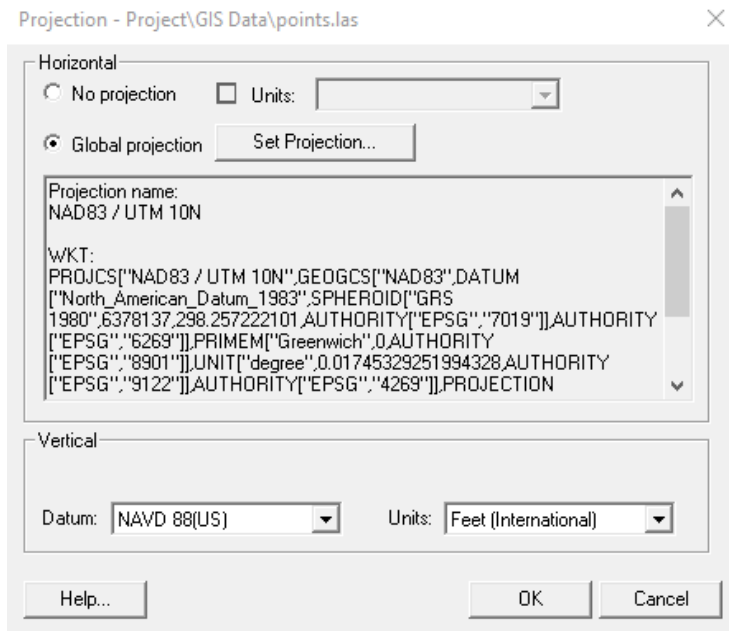
- ODF AOIs are delivered in Oregon Lambert, EPSG 1992, with horizontal units in International Feet and vertical units in US Survey Feet, in the NAD83/NAVD88 datum (Geoid 03).
- All other AOIs are delivered in Oregon Lambert, with horizontal units in International Feet and vertical units in US Survey Feet, in the NAD83 HARN/NAVD88 datum (Geoid 03).

Before starting a project, a projection should be selected based on project history, future deliverables, and customers. Many ODOT projects utilize the Oregon Coordinate Reference System (OCRS) which is a set of low distortion projections that cover the state of Oregon. The SMS software has "Project on the fly" ability, so if datasets different native coordinate systems, they will be reprojected for display in the software, as long as their native systems are known and set correctly. The first imported dataset's coordinate system sets the display coordinate system, unless you set a different display coordinate system.

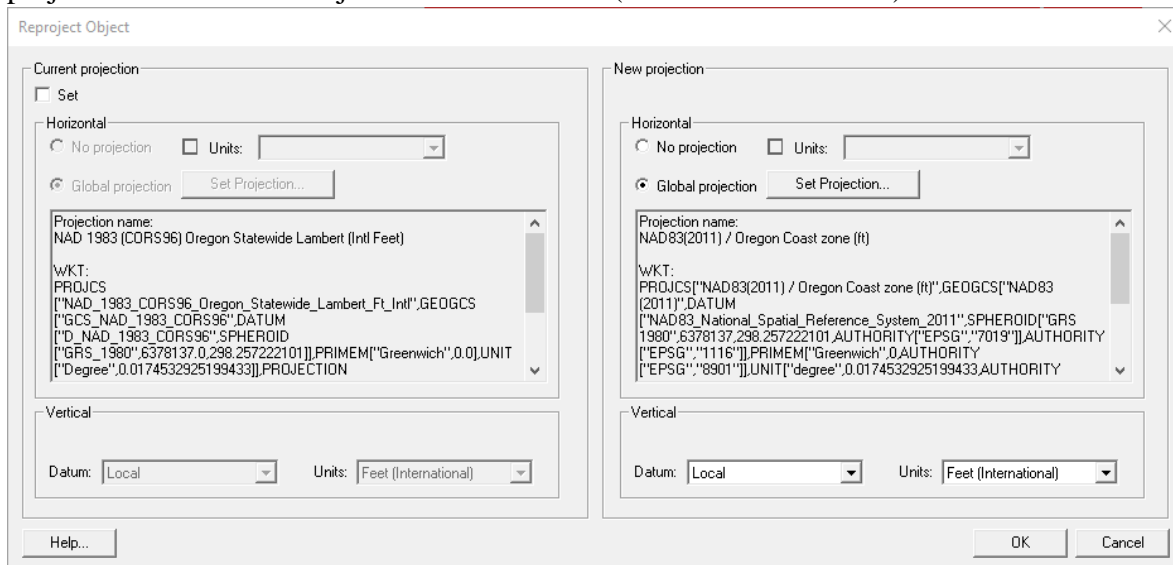
Oftentimes, TIFF raster images come with TIFF World files, which assign the image to be located at the correct coordinates. If the image isn't accompanied by a PRJ projection file, the projection may still need to be assigned. When importing a raster, the software will return an alert if projection information is needed. Projection information can be found in the data source's metadata (report file). If needed, set the projection (see Processing Step 3). After setting, the SMS software will export and then import a version of the TIFF with the projection information written to it.

After importing your data, check the coordinates. If using an OCRS zone, consult the OCRS Handbook or Zone Maps on the [ODOT Engineering Automation webpage](#). Locate the project area on the map of the zone you would like to work with, and compare the coordinates to the bottom of the viewer (Easting, Northing). If unsure of which coordinate zone to select, contact your region survey group or use the OCRS Projection Zone tool on the [Geometronics Toolkit](#).

The display projection can be changed using the Display menu → Display Projection



Note that in order to edit a dataset, its coordinate system must be permanently the same as the Display Projection. To permanently reproject a dataset (must be converted to 2D scatter first), right click and select *Reproject...* Do not change the current projection, simply select the display projection under New Projection and click OK (see screenshot below).



B. File Types

Typical LiDAR File Types

- LAS (Lidar Data Exchange File)
 - Industry-standard binary format for storing lidar data
 - Each point contains the following information
 - X,Y,Z coordinates
 - Classification
 - Intensity of returned pulse
 - RGB value (from imagery)
 - Scan angle (from nadir)
- LAZ (Zipped LAS)
 - Open source format with optimized compression
- CSV (Comma Separated Value)

Typical DEM (raster) File Types

- TIFF (Tagged Image File Format)
 - Format for storing raster graphics
 - Can be accompanied by a TFW (World File) for location information
- JPEG (Joint Photographic Experts Group)
 - Lossy graphics file with compressed image format

Typical Field Survey File Types

- XYZ
 - Plain text file usually containing point number, then X, Y, Z coordinates
- DTM
 - Microstation-specific file containing surface data
- XML
 - CAD surface data file that works in SMS
- TIN
 - Esri-specific vector storage format containing elevation data. Must be exported as LandXML for use in SMS

Typical GIS/CAD File Types

- SHP
 - Shapefile format developed by Esri, can contain any type of vector data
- DGN
 - Design CAD file specific to Microstation
- DWG
 - Design CAD file specific to AutoCAD

C. Lidar Archive Index

From ODOT Lidar Data Access and Resources Version 3 (2018)

Drive	Delivery/folder	Used	Free	Drive Size	Capacity
\\xd6211x\Lidar_1		3777.5	4224.1	8001.56	47%
	Baker Pass	116.0			
	Camp Creek	295.0			
	Christmas Valley	29.0			
	CVO Crater Lake	287.0			
	Glass_Buttes	140.0			
	Grande Ronde Basin	330.0			
	Metro	1125.0			
	OLC_Clackamole	276.0			
	OLC_EAGLE_POINT_2010	198.0			
	Willamette 1	45.4			
	Willamette 10	156.4			
	Willamette 11	109.7			
	Willamette 12	114.2			
	Willamette 13	250.0			
	Willamette 14	159.8			
	Willamette 15	285.0			
	Willamette 16	206.4			
	Willamette 17	165.0			
	Willamette 2	87.8			
	Willamette 3	127.3			
	Willamette 4	185.2			
	Willamette 5	188.2			
	Willamette 6	203.1			
	Willamette 7	158.9			
	Willamette 8	207.7			
	Willamette 9	186.4			
	Ontario_2008	208.0			
	OPRD	33.0			
	OR Military	20.0			
	Paulina Marsh	120.0			
	Pine Creek	160.0			
	Rogue Valley	353.0			
	Summer Lake	47.0			

Drive	Delivery/folder	Used	Free	Drive Size	Capacity
\\xd6211x\Lidar_2		3823.7	4177.9	8001.56	48%
	Klamath BOR	400.5			
	Klamath 1	46.2			
	Klamath 2	38.2			
	Klamath 3	57.2			
	Klamath 4	63.5			
	Klamath 5	43.2			
	Klamath 6	49.4			
	Lower Columbia 2005	7.2			
	ODF	31.1			
	ODOT_GrassValley	314.8			
	OLC_CLACKAMOLE_2013	469.3			
	OLC_SCAPPOSE_2013	50.6			
	OLC_YAMBO_2010	1105.0			
	Umatilla 1	142.9			
	Umatilla 2	284.2			
	USACE_Columbia River	1418.6			

\\xd6211x\Lidar_3		4408.2	3593.4	8001.56	55%
	OLC_UPPER_ROGUE2015	4408.2			

\\xd6211x\Lidar_4		5193.0	2808.6	8001.56	65%
	OLC_BIG_WINDY_2015	1044.9			
	OLC_MCKENZIE_RIVER_2016	608.8			
	OLC_MILTON-FREEWATER_2016	341.5			
	OLC_UPPER_UMPQUA_2015	5193.0			

\\xd6211x\Lidar_5		7290.4	711.16	8001.56	91%
	ODF	131.0			
	OLC_CANYON_CREEK_2016	400.8			
	OLC_FOUR_RIVERS_2014	1500.0			
	OLC_HARNEY_BASIN_2014	858.0			
	OLC_LOWER_MALHUER_2015	327.6			
	OLC_MF_WILAMETTE_BATHY_2015	229.1			
	OLC_MIDDLE FORK WILLAMETTE BATHY 2015	411.5			
	OLC_PANTHER_CREEK_2015	37.5			
	OLC_SF_CROOKED_RIVER_BATHY_2015	5.6			
	OLC_WASCO_2015	3074.7			
	OLC_YAKIMA_BENTON_2015	314.6			

Drive	Delivery\folder	Used	Free	Drive Size	Capacity
\\xd6211x\Lidar_6		3930.0	70.75	4000.75	98%
	OLC_CROOKED_OCHOCO_2014	272.2			
	OLC_LANE_COUNTY_2013	2212.2			
	OLC_SOUTH_WARNER_2014	987.8			
	OLC_UMATILLA_YST_2014	457.8			
\\xd6211x\Lidar_7		3261.2	739.55	4000.75	82%
	CVO_NEWBERRY_CRATER	506.2			
	Deschutes 1	36.5			
	Deschutes 10	119.0			
	Deschutes 11	384.0			
	Deschutes 12	266.7			
	Deschutes 13	485.0			
	Deschutes 14	144.0			
	Deschutes 15	355.0			
	Deschutes 16	217.0			
	Deschutes 2	118.0			
	Deschutes 3_5	322.0			
	Deschutes 4	272.0			
	Deschutes 6	93.0			
	Deschutes 7	229.0			
	Deschutes 8	176.0			
	Deschutes 9	44.0			
\\xd6211x\Lidar_8		1547.0	2453.8	4000.75	39%
	North Coast (NCST)	1568.0			
	OLC_BLM_FIRES_2013	686.0			
	South Coast 1	988.0			
	South Coast 2	559.0			
\\xd6211x\Lidar_9		2762.7	237.85	3000.55	92%
	2007_Catherine_Willow_Lostine_Creeks_UTM_11	220.1			
	2011_Catherine_Creek_UTM_11	6.5			
	ODF_Clatsop	130.1			
	OLC_CENTRAL COAST_2012	1486.7			
	OLC_CVO_NEWBERRY2	919.3			
\\xd6211x\Lidar_10		2906.0	94.55	3000.55	97%
	MAHLUER_RIVER_2008	97.1			
	OLC_ROGUE_2012	2808.9			

Drive	Delivery\folder	Used	Free	Full Size	Capacity
	\\xd6211x\Lidar_11	2906.2	94.35	3000.55	97%
	2012_FallCreek_MiddleFork	71.5			
	OLC_BURNS_2011	68.5			
	OLC_GREEN_PETER_2012	398.5			
	OLC_KENO_2012	304.7			
	OLC_OCHOCO_2011	343.7			
	OLC_OCHOCO_WEST_2013	526.1			
	OLC_TILLAMOOK_YAMHILL_2012	367.8			
	OLC_UNION_BAKER_2012	730.9			
	Umpqua_JeffCoe_LIDAR	94.5			
	\\xd6211x\Lidar_12	2914.3	86.25	3000.55	97%
	ODF_NW_OR_2015	114.1			
	OLC_WALLOWA_2015	429.2			
	OLC_METRO_2014	2371.0			
	\\xd6211x\Archive	312.7	2687.9	3000.55	10%
	USGS	118.0			
	Lower Nehalem	12.5			
	Yaquina_LIDAR_2005	68.2			
	OR_DEM_10M.gdb	10.2			
	SpragueRiver_2004	103.8			

D. Importing Survey Data

To import field survey data, the horizontal coordinate system and vertical datum need to be known.

- 1) File → Open
- 2) Select the TXT or CSV that contains the survey data and click Open. The File Import Wizard will open
- 3) Depending on the format of the survey data, select the appropriate import options.
 - a. Select Delimited, then choose the delimiter (tab, space, or comma).
 - b. Then select which row to start importing. If the file has a header, start import at row 2.
 - c. See typical settings below. Make sure the preview shows correct column allocation before clicking continuing.

File Import Wizard - Step 1 of 2

File import options

Set the column delimiters:

Delimited Fixed Width

Space Tab Semicolon

Comma Other: Text qualifier: "

Treat consecutive delimiters as one Skip Leading Delimiters

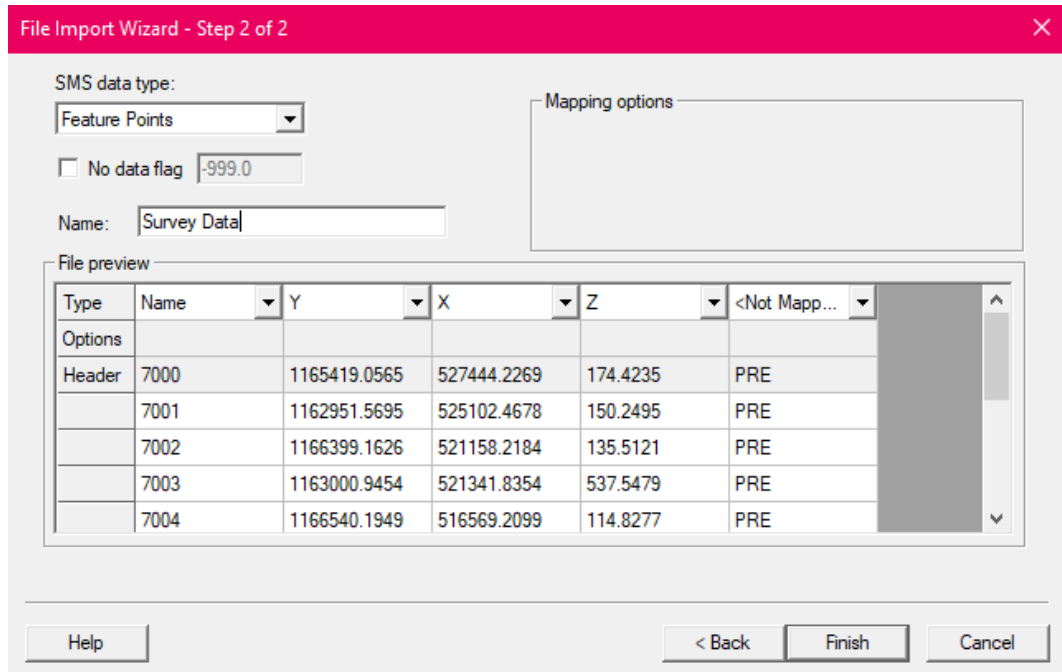
Start import at row: Heading row

File preview

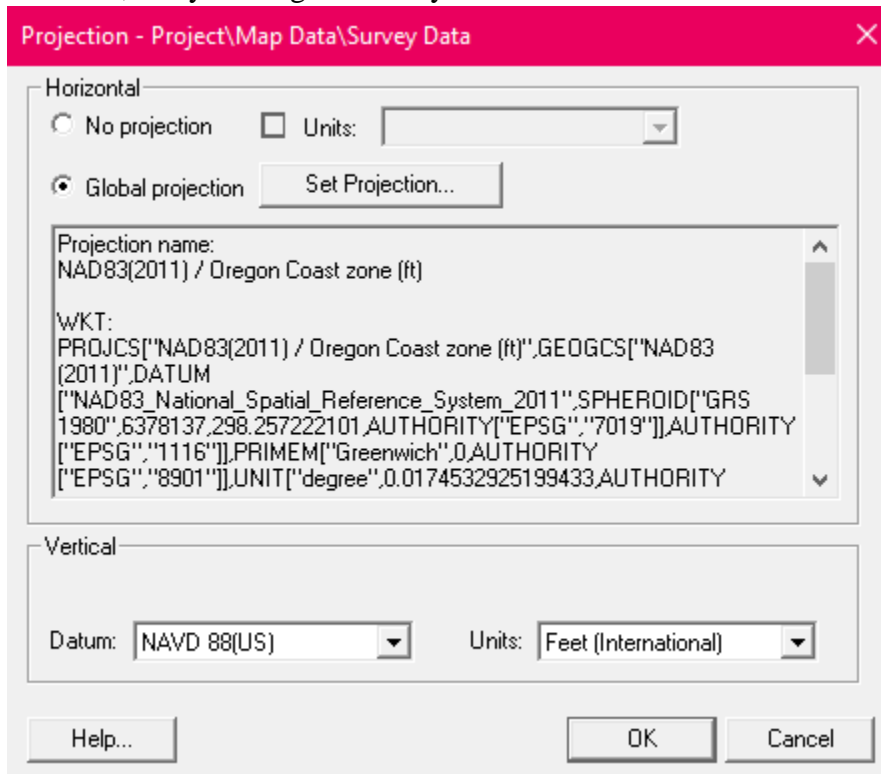
1	Point Id	Northing	Easting	Ortho. Height	Code
2	7000	1165419.0565	527444.2269	174.4235	PRE
3	7001	1162951.5695	525102.4678	150.2495	PRE
4	7002	1166399.1626	521158.2184	135.5121	PRE
5	7003	1163000.9454	521341.8354	537.5479	PRE

Help < Back Next > Cancel

- 4) Next, associate each column with its data type.
 - a. Set SMS Data Type to Feature Points
 - b. Rename the file if desired (i.e. Survey Data) in the Name field
 - c. Select the appropriate value for each column. If data has Northing then Easting, make sure columns are Y then X.
 - d. See settings below. When satisfied, click Finish.



- 5) A dialogue box will tell you to set the projection information for the survey data.
- 6) Select the data's projection. Make sure to select the correct **vertical datum AND units**. If unsure, ask your Region Survey Unit.



- 7) To change the point symbol and label the points, select the file and go to Display → Display Options