Enhancing LiDAR in ArcGIS

Asset Systems Management-GIS Team
City of Portland Environmental Services
September 27th, 2019
Presentation Overview

- BES ASM Introductions
  - Mark Liebe, Engineering Supervisor
  - Kevin Ramey, GIS Technician III
  - Albert Tabino, GIS Technician III
  - Neil Revello, Engineering Technician II
  - Brent Freeman, Engineering Technician II
ASM-GIS History

• Established 1998
• Provides cartographic, spatial analysis, data management and other technical support for the City of Portland, Bureau of Environmental Services.
• Supports Asset Management, Modeling, Design and Construction to maintain 3,081 miles of collection lines, 50,386 manholes/structures and we support 7 watersheds to help manage stormwater within the Portland metropolitan area
• To Date: Completed nearly 10,000 requests for spatial data and mapping products
Portland and Topographic Watersheds
LiDAR Products

• Bare Earth Digital Elevation Model (DEM)
  • Flow tracing Auto Delineator
  • Stream Hydraulics and Hydrology
• Feature Height Model
• Slope
  • Emergency helicopter landing locations
• Landslide
• Supplemental elevations for surveyed areas
Bare Earth DEM with Hillshade
2014 Reclassified Products
History of LiDAR use in BES

• 2004-2005
  • Individual watershed specific LiDAR datasets
• 2007
  • Multiple flights merged to create single full classification dataset
• 2014
  • This data was minimally classified and we were unable to define bare earth to a resolution required for the model
• 2019 Upcoming
  • Higher resolution and improved classification
# LiDAR Specs

<table>
<thead>
<tr>
<th>Year</th>
<th>Point Density Requested</th>
<th>Ground Classification</th>
<th>Other Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Varied 1-8 pulses/square meter</td>
<td>Varied</td>
<td>Varied</td>
</tr>
<tr>
<td>2014</td>
<td>≥ 8 pulses/square meter</td>
<td><strong>Average 1.4 points/square meter</strong></td>
<td>ASPRS* 1, 2</td>
</tr>
<tr>
<td>2019</td>
<td>≥ 25 pulses/square meter</td>
<td>~ 90% points classified</td>
<td>ASPRS* 1-15</td>
</tr>
</tbody>
</table>

* American Society of Photogrammetry and Remote Sensing (ASPRS)
Making the Best out of a Bad Classification

This is your Digital Elevation Model?

YUP! You pour the data into this big LAS Dataset, then collect the DEM on the other side.

What if the DEM is wrong?

Just stir the pile until they start looking right.
Issue

- 2014 LIDAR Data had minimal classification of LIDAR points
- Can existing LIDAR data be reprocessed to improve accuracy and usefulness?
DEM Work Flow

- LAS Files
  - Reclassify LAS Points
  - Create Multipoint Feature Class
    - Create TIN
      - TIN to Raster
    - Multipoint to Terrain
    - Interpolation Tools
      - Point to Raster
      - Terrain to Raster
    - Create Terrain Dataset
    - Create LAS Dataset
      - LAS Dataset To Raster
  - Create LAS Dataset
  - Create Terrain Dataset
  - Interpolation Tools
    - LiDAR DEM
ArcGIS Pro - Classify LAS Ground Tool

- Notes:
  - Last return of LAS points with class code values of 0, 1, or 2 (Never Classified, Unassigned, or Ground) will be considered for reclassification as ground.
  - Locations with bridges/freeway on-ramps may be misclassified.
Tool Options - Ground Detection Methods

- Conservative
- Aggressive
- Standard
Tool Options - Reuse Existing Ground

• Not Checked (Reclassify Ground)
  • Existing ground points will be reclassified. Points that are not found to be a part of the ground will be re-assigned a class code value of 1, which represents unclassified points. This is the default.

• Checked (Reuse Ground)
  • Existing ground points will be accepted without scrutiny and contribute to the determination of unclassified points.
Tool Options - DEM Resolution

• Specifying a distance will result in only a subset of points being evaluated for classification as ground, thereby making the process faster. **Consider using this option when needing a faster method for generating a DEM surface.** The minimum distance is 0.3 meters, but the specified distance must be at least 1.5 times the average point spacing of the LIDAR data for this process to take effect.
2014 Reclassified Data

- What we used to reclassify the LAS points
  - Ground Detection Method – Standard
  - Reuse Existing Ground – Selected
  - DEM Resolution – Default (Highest Resolution)
Results: LAS Dataset Point Comparison

- Total Points in LASD - 12,977,208,659

<table>
<thead>
<tr>
<th>Class Code</th>
<th>Original</th>
<th>Reclassified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Unclassified</td>
<td>11,736,180,707</td>
<td>9,106,179,709</td>
</tr>
<tr>
<td>2-Ground</td>
<td>1,241,027,952</td>
<td>3,871,028,950</td>
</tr>
</tbody>
</table>

Percent Ground

- 9.56
- 29.83

~ 3 x more ground points
Point Cloud Comparison

Before

After
Accuracy

Absolute Elevation Difference Frequency Distribution (Benchmark - DEM)
Results: DEM Comparison

- Two locations to show differences in DEMs
- Rotates view between 2007, 2014 Original and 2014 Reclassified DEMs

*Note* - 2014 Aerial Photos
Issues
Better
Contours - Derived LiDAR Product Example
Contour Product - Workflow History

Contours - Platform - Workflow

• 2007 LiDAR Mashup Datasets & Bathymetry
  Generated with ArcMap 9.x & LP360 add-on
Contours - Platform - Workflow

- 2007 LiDAR Mashup Datasets & Bathymetry
- 2015 2014 LiDAR Data – Regional, Watershed, City Limits

Generated with ArcMap 10.x, automated with Python
Optimized with FME and ArcMap 10.x
Contour Product - Workflow History

Contours - Platform - Workflow

- 2007 LiDAR Mashup Datasets & Bathymetry
- 2015 2014 LiDAR Data – Regional, Watershed, City Limits
- 2018 2014 Reclassified LiDAR City Boundary

Generated and Optimized by City-Wide Contour Workflow
ArcMap 10.x, ArcGIS Pro 1.x, & FME
City-Wide Contouring Workflow

Optimization with FME

1' Bare Earth DEM → Generate Contours → Snapper Transformer → LineCombiner Transformer → CurveFitter Transformer → Editing Generalize → Editing Smoothing → Intermediate 2' Contour Dataset

Data Cleanup and Classification

Intermediate 2' Contour Dataset → Artifact Removal → Water and Shoreline Correction → Contour Classification → 2' Contour Dataset
Contours - Platform - Workflow

- 2007 LiDAR Mashup Datasets & Bathymetry
- 2015 2014 LiDAR Data – Regional, Watershed, City Limits
- 2018 2014 Reclassified LiDAR City Boundary
- 2019 2014 Reclassified LiDAR Watershed Boundary

Generated and Optimized by Watershed Contour Workflow
ArcGIS Pro 2.41
Contour Test Area

Raw Contours

Smoothed Contours
Watershed Contouring Workflow

1. **DEM Conditioning and Generalization**
   - **LiDAR 3' DEM**
   - Watershed’s with Waterbodies Removed
   - Convert DEM Elevations to Integer
   - Extract DEM Contour Area's

2. **Generate Contours**
   - **Westside**
     - Contour Extracted DEM Area
     - Exporting Contours with shape_length ≥ 30
     - Contour Smoothing Smooth Line
   - **Eastside**
     - Contour Extracted DEM Area
     - Exporting Contours with shape_length ≥ 30
     - Contour Smoothing Smooth Line
   - **Islands**
     - Contour Extracted DEM Area
     - Exporting Contours with shape_length ≥ 30
     - Contour Smoothing Smooth Line

3. **Merge Contour Areas**

4. **Contour Classification**
Watershed Contours Areas
Watershed Contouring Workflow

- **DEM Conditioning and Generalization**: Convert DEM Elevations to Integer → Extract DEM Contour Area's → Watershed's with Waterbodies Removed

- **Generate Contours**
  - **Westside**
    - Contour Extracted DEM Area → Exporting Contours with shape_length ≥ 30 → Contour Smoothing Smooth Line
  - **Eastside**
    - Contour Extracted DEM Area → Exporting Contours with shape_length ≥ 30 → Contour Smoothing Smooth Line
  - **Islands**
    - Contour Extracted DEM Area → Exporting Contours with shape_length ≥ 30 → Contour Smoothing Smooth Line

- **Merge Contour Areas** → **Contour Classification**
Watershed Contouring Workflow

DEM Conditioning and Generalization

- LiDAR 3' DEM
  - Watershed's with Waterbodies Removed
  - Convert DEM Elevations to Integer
  - Extract DEM Contour Area's

Generate Contours

- Westside
  - Contour
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- Islands
  - Contour
    - Extracted DEM Area
  - Exporting Contours with shape_length ≥ 30
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    - Smooth Line

Merge Contour Areas

Contour Classification
Final Watershed Contours 2019
2019 Watershed Contours