TLS Data Products & Analysis
C. Crosby, UNAVCO
Data volume – multi-GB per day of scanning

Scanner technology far outpaces most software available for data processing, management, and analysis.

Complex, multi-software workflows

Commercial ($$) software

*How do you get from 10s or 100s of millions of X,Y,Z points to science?*
9. What software do you use to process and/or analyze TLS data? Choose all that apply.

<table>
<thead>
<tr>
<th>Software</th>
<th>Response Percent</th>
<th>Response Count</th>
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<td>Cyclone</td>
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<td>Riscan</td>
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<td>TerraSolid</td>
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<td>Arc/GIS</td>
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<td>Matlab</td>
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<tr>
<td>Other (please specify)</td>
<td></td>
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Other:
- 3D Studio
- 3dReshaper
- AutoCad
- BCAL LiDAR Tools
- Blender
- CloudWorx
- Crusta
- ENVI
- FARO Scene
- GDAL
- GeoAnalysis Tools
- Geovisionary
- Global Mapper
- GMT
- GRASS
- IDL
- Kingdom Suite
- LASTools
- libLAS
- MapScenes
- MapTek I-SiTE Studio
- Meshlab
- MicroCad
- MicroStation
- MicroSurveyCAD
- OpenTopography DEM generator
- OpenVC
- Point Cloud Library (PCL)
- Points2Grid
- PointTools
- Python modules and custom tools
- RealityLinx
- Split-FX
- Surfer
- TerraModeler
- Trimble RealWorks
- UC Davis tools
- (LidarViewer, Crusta)
- “home grown software”
Point Cloud

• 3D “point cloud” of discrete locations derived from range and orientation of scanner for each laser pulse.

• XYZ position in cartesian coordinates plus associated point attributes: intensity, RGB, etc.

• 3D point clouds are the basis for subsequent analysis and used to create CAD or GIS models

• Typically ASCII XYZ + attributes or LAS
  – E57 = New standard under development, minimal adoption

• UNAVCO standard deliverable = merged, aligned, georeferenced point cloud in ASCII or LAS format.
**TLS Processing Workflow – Overview**

**Field data collection + data post-processing**

![Diagram](https://via.placeholder.com/150)

- Merged, aligned, georeferenced point cloud
- Data cleaning & thinning
  - Vegetation filtering & classification
  - Surface generation (DEM etc)
  - Raster data products & surfaces (DEM etc)
  - Analysis & science!
• Digital representation of topography / terrain
  – “Raster” format – a grid of squares or “pixels”
  – Continuous surface where Z (elevation) is estimated on a regular X,Y grid
  – “2.5D”

• Grid resolution is defined by the size in the horizontal dimension of the pixel
  – 1 meter DEM has pixels 1 m x 1m assigned a single elevation value.

Source: http://www.ncgia.ucsb.edu/giscc extra/e001/e001.html
• EarthScope lidar data

• Example from flat area with little or no vegetation. Ground sampled 5+ times per square meter

• How do we best fit a continuous surface to these points?

• Ultimately wish to represent irregularly sampled data on a regularized grid.
Interpolation Methods

- Inverse Distance Weighting (IDW)
- Natural Neighbors
- Kriging
- Splines
- TIN
  - linear
  - quintic
- ...

Isenburg, et al., 2006
Triangulated Irregular Network (TIN)

Inverse Distance Weighted (IDW)

Kriging

Regularized Spline with Tension and smoothing (RST)

Figure from Helena Mitasova (NCSU): http://skagit.meas.ncsu.edu/~helena/gmslab/index.html
Vegetation is a headache is geoscientists

- *Our noise is someone else’s signal*
- How to get good ground model? - Automated vs manual?
Typical approach ⇒ despike algorithm

Approach:

1. flag all points as ground

2. repeat:
   - build TIN (triangulated irregular network) of ground points
   - identify points that define strong positive curvatures
   - flag identified points as not-ground

3. Iterate until no or few points are flagged

Modified from: R. Hagerud, USGS
Start with mixed ground and canopy returns (e.g. last-return data), build TIN
Flag points that define spikes (strong convexities)
Rebuild TIN

R. Hagerud, USGS
Flag points that define spikes (strong convexities)
Rebuild TIN
Flag points that define spikes (strong convexities)
Rebuild TIN
Despike algorithm

Benefits:

• It works

• It’s automatic
  – Cheap(!)
  – All assumptions explicit

• It can preserve breaklines

• It appears to retain more ground points than other algorithms

R. Hagerud, USGS
Despike algorithm

Problems:
- Removes some corners
- Sensitive to negative blunders
- Computationally intensive
- Makes rough surfaces
  - Real? Measurement error? Misclassified vegetation?

Cross-section of highway cut

R. Hagerud, USGS
• Repeat TLS data (or TLS combined w/ ALS data) provide opportunity to explore topographic change and driving processes.

• Vertical change vs 3D displacements?
  – Depends on the geophysical process being studied.
  – Datasets must be well aligned – horizontal and vertical coordinates, datums, etc.
  – Signal must be larger than noise and error in datasets
Nissen et al., 2014, Coseismic fault zone deformation revealed with differential lidar: Examples from Japanese Mw ~7 intraplate earthquakes