Lidar Methodology for Verifying Broadband Internet Services Furnished over Wireless Networks in Pennsylvania

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Project Overview

- Commonwealth of PA has specific Broadband initiatives
  - Broadband internet access critical for economy
  - Pennsylvania maintains inventory of access
- Commonwealth has implemented Broadband oversight and funding
  - State Broadband Data and Development Program (SBDD)
    - Funded through ARRA of 2009
  - The Pennsylvania Act 183 of 2004
    - Managed by DCED and Governor's OA

Broadband Access Inventory

Pros

- Infrastructure in place to manage broadband resources
- Ongoing initiatives to obtain independent verification of assets

Cons

- Service Providers provide majority of data used to populate inventory
- Concern about accuracy of data reported

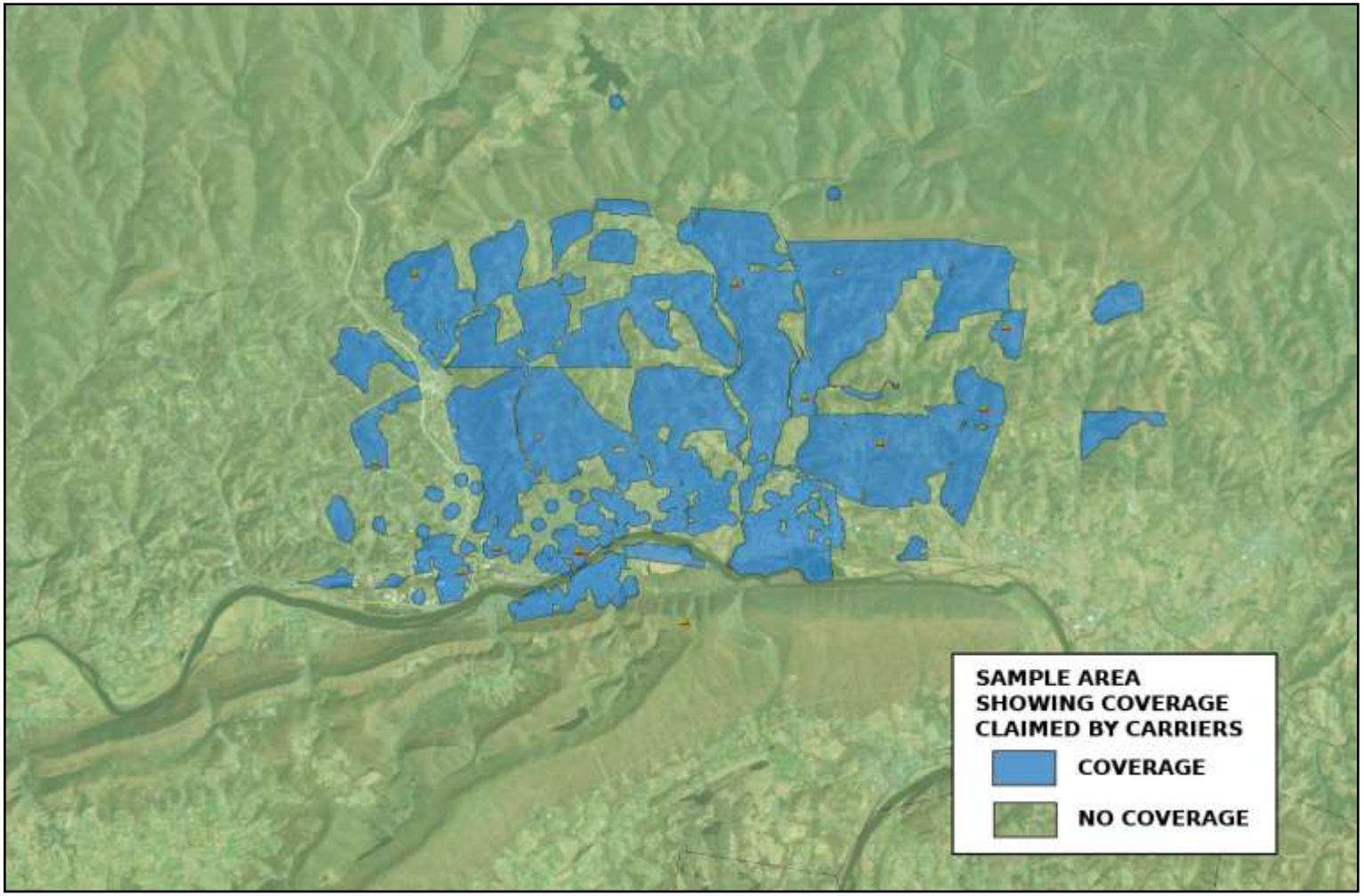
Key Challenges

- Service providers may be reticent to share data
- Implement credible application of Lidar data extraction methods to help create “independent” view of broadband access in PA
- Design efficient workflows so budget had enough time to process approximately 2 TB of data and allow room for re-running model, if needed

geographIT's Role in PA Broadband Verification

- Spring 2010 geographIT hired by Michael Baker Jr. Inc. to verify availability of broadband internet service furnished via wireless networks
- Simple Concept
  - Generate our own coverage map using independent data
  - Overlay new coverage on existing coverage provided by wireless carriers
  - Observe any differences

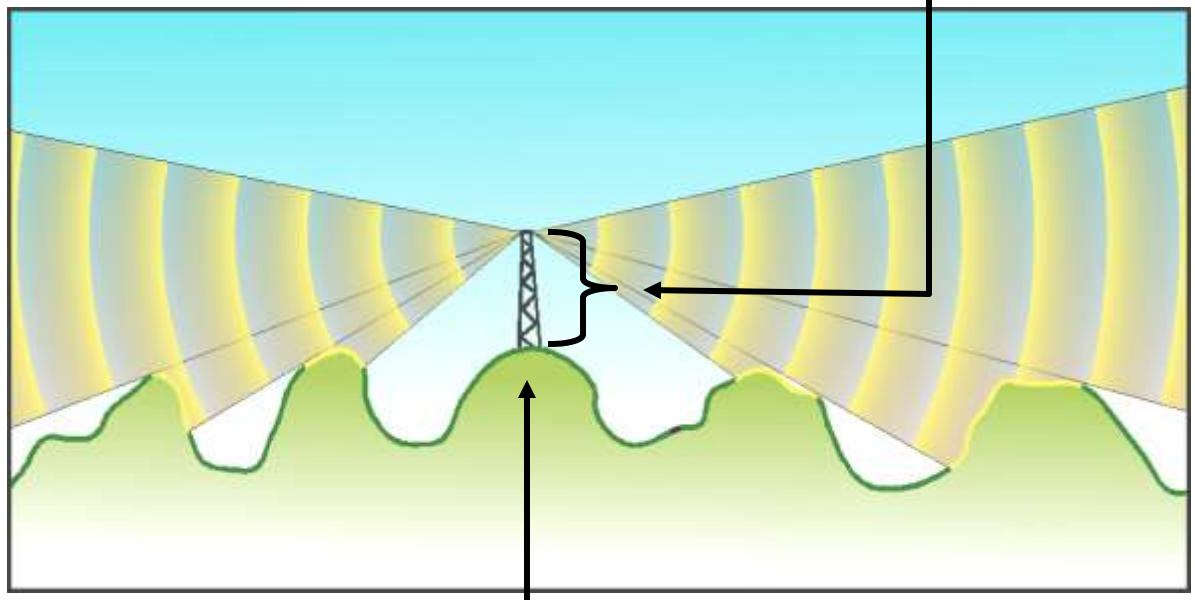
Broadband Coverage Reported by Wireless Carriers (2010)



Approach: Use Viewshed Analysis to Assess Areas in PA that Receive Wireless Tower Signals

Viewshed Analysis Requires:

3. Wireless Tower Elevations



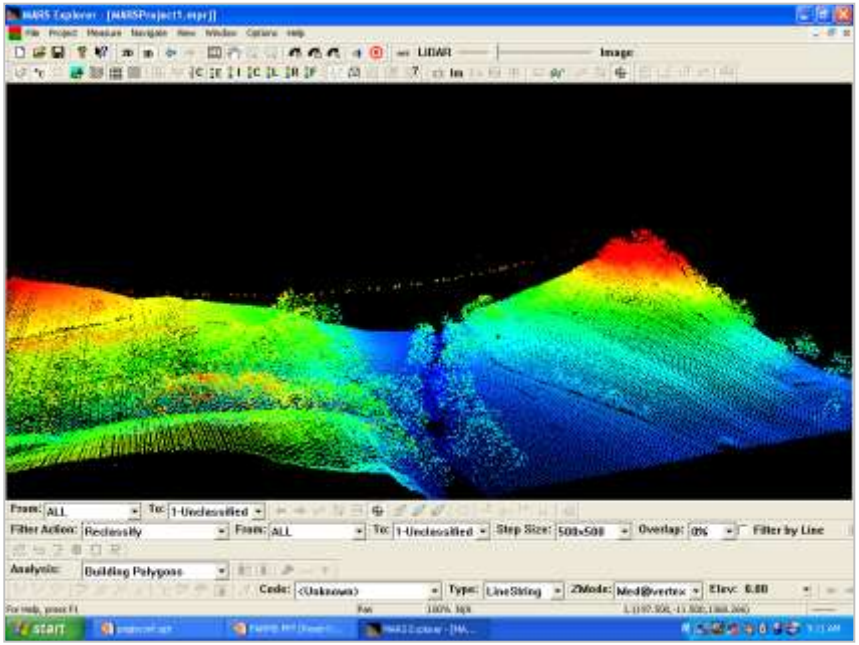
1. Terrain Surface

2. Wireless Tower Horizontal Locations

Viewshed = Line of Sight in All Directions

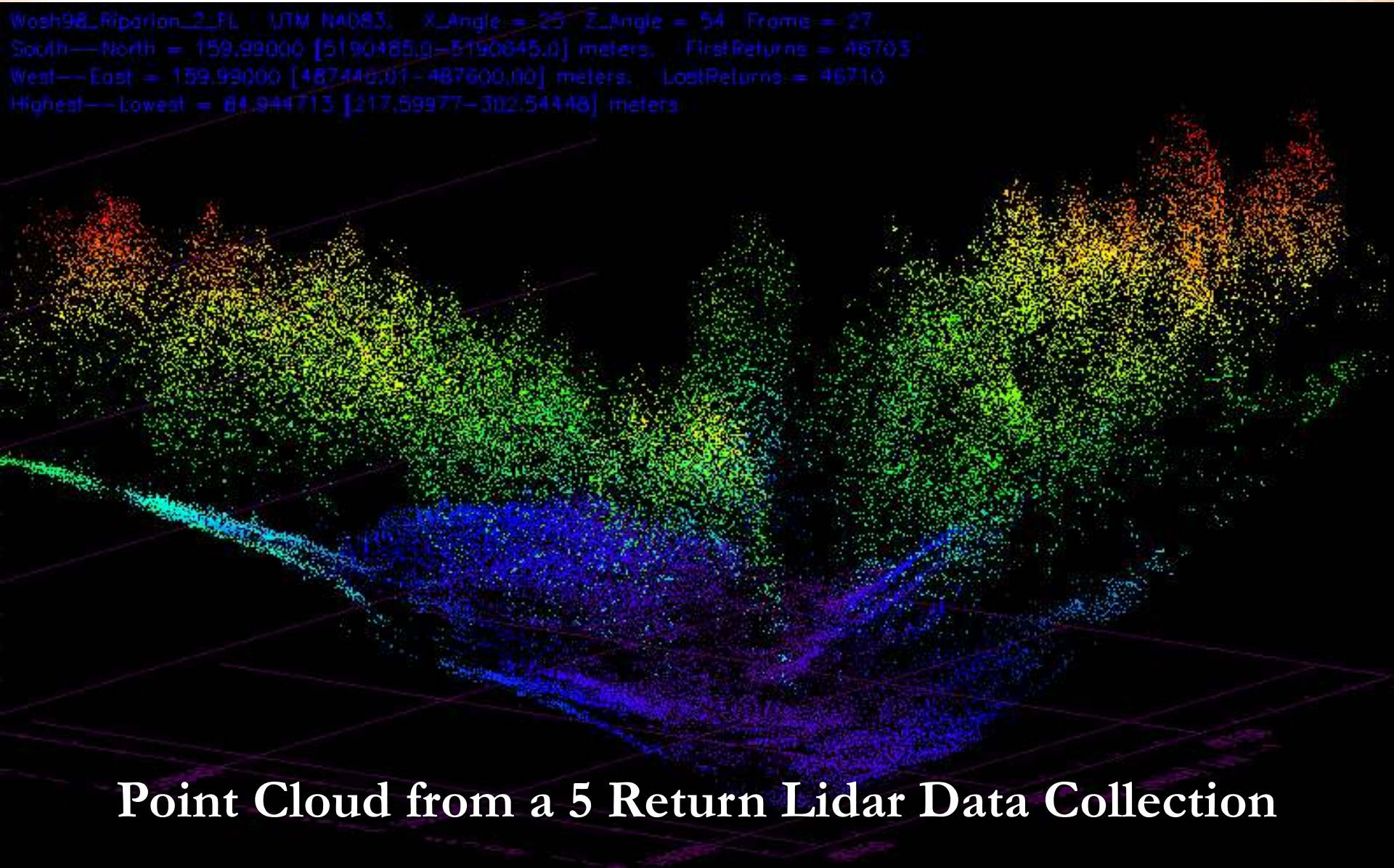
- Offers good approximation for how radio waves propagate in the wireless spectrum (1-2 Ghz)
- Inputs
  - Terrain Surface ……. PAMAP Lidar Data
  - Horizontal Locations of Towers……. Not available from Carriers, so State provided a dataset
  - Elevations of Towers …… Not Available from Carriers, so it was decided to attempt to extract them from PAMAP Lidar Data

Lidar Data



- Vertical accuracy at 15 cm on discrete points
- Capable of collecting millions of points per hour
- Produces datasets with much greater density than traditional mapping
- Most systems capable of capturing multiple returns per pulse and/or intensity images
- Supported by rigorous QA/QC – Similar to traditional surveying practices and principles

Laser Beam Produces Multiple Returns, The "Point Cloud"



Point Cloud from a 5 Return Lidar Data Collection

Point Cloud stored in LAS Format

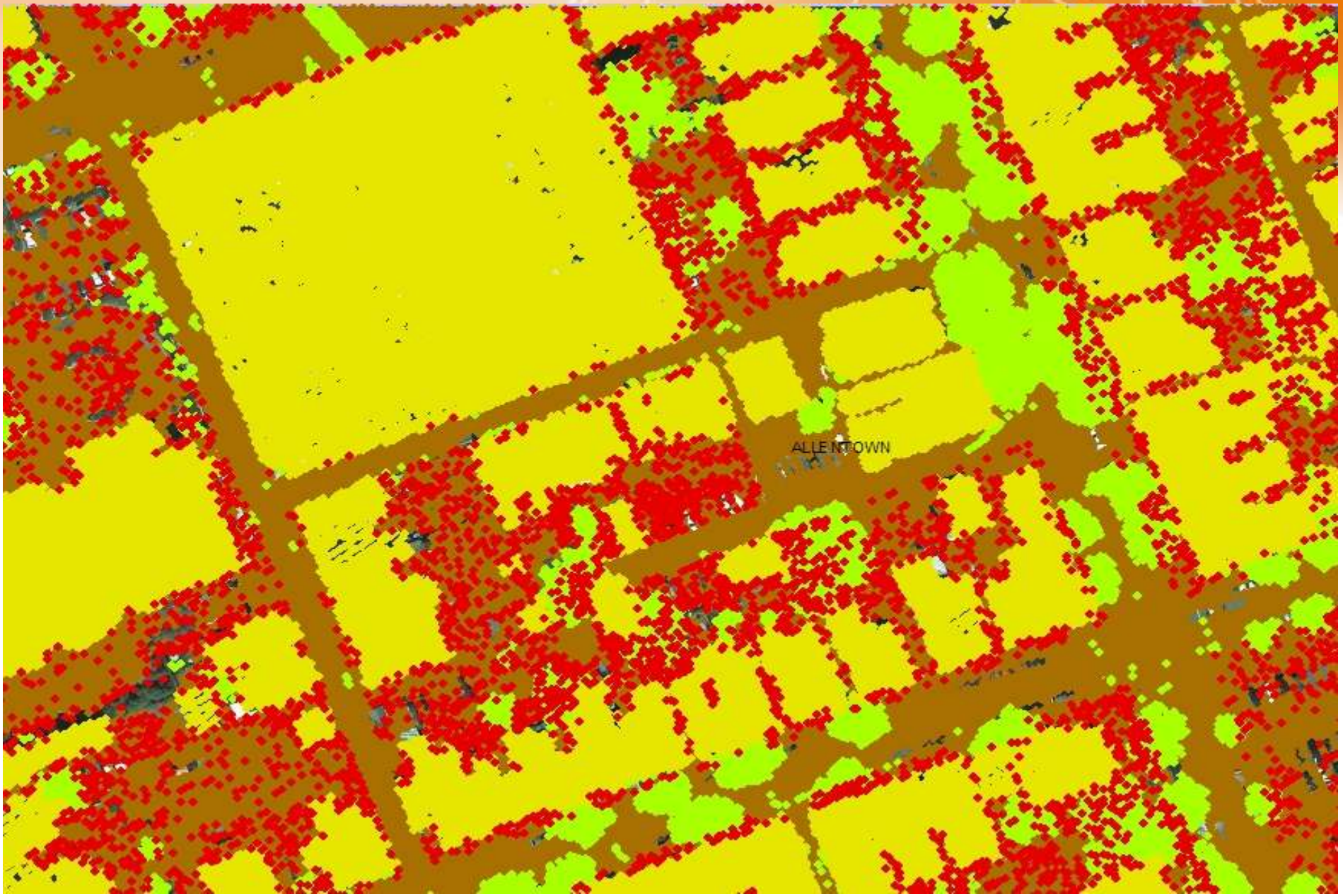
- LAS is binary data format developed in standards-based process by ASPRS
- www.lasformat.org
- LAS data fields include
  - Northing (Y)
  - Easting (X)
  - Elevation (Z)
  - Intensity (reflectance)
  - Return Number
  - Total Returns for Beam
  - Class

Point Classification Used for Viewshed

LAS Class fields

- **Class 1 (Default)** - a mixture of the remaining points after the ground classification. These would contain cars, buildings, parts of vegetation, etc.
- **Class 2 (Ground)** - points on the bare earth surface.
- **Class 12 (Non-Ground)** - points identified as first of many return or intermediate of many returns from the LIDAR pulse. Most likely vegetation returns or points identified to be not on the ground surface.
- **Class 8 (Model Key)** – a subset of Class 2 points that have been filtered using “educated thinning” process.
- **Class 9 (Hydro)** - points that fall within hydro features as well as are within ± 1.5’ of single line drains.
- **Class 14 (Bridge Decks)** - points that fall within bridge deck polygons captured during the break line compilation process.
- **Class 15 (Roads)** –points that fall within ± 1.5’ of road break lines.

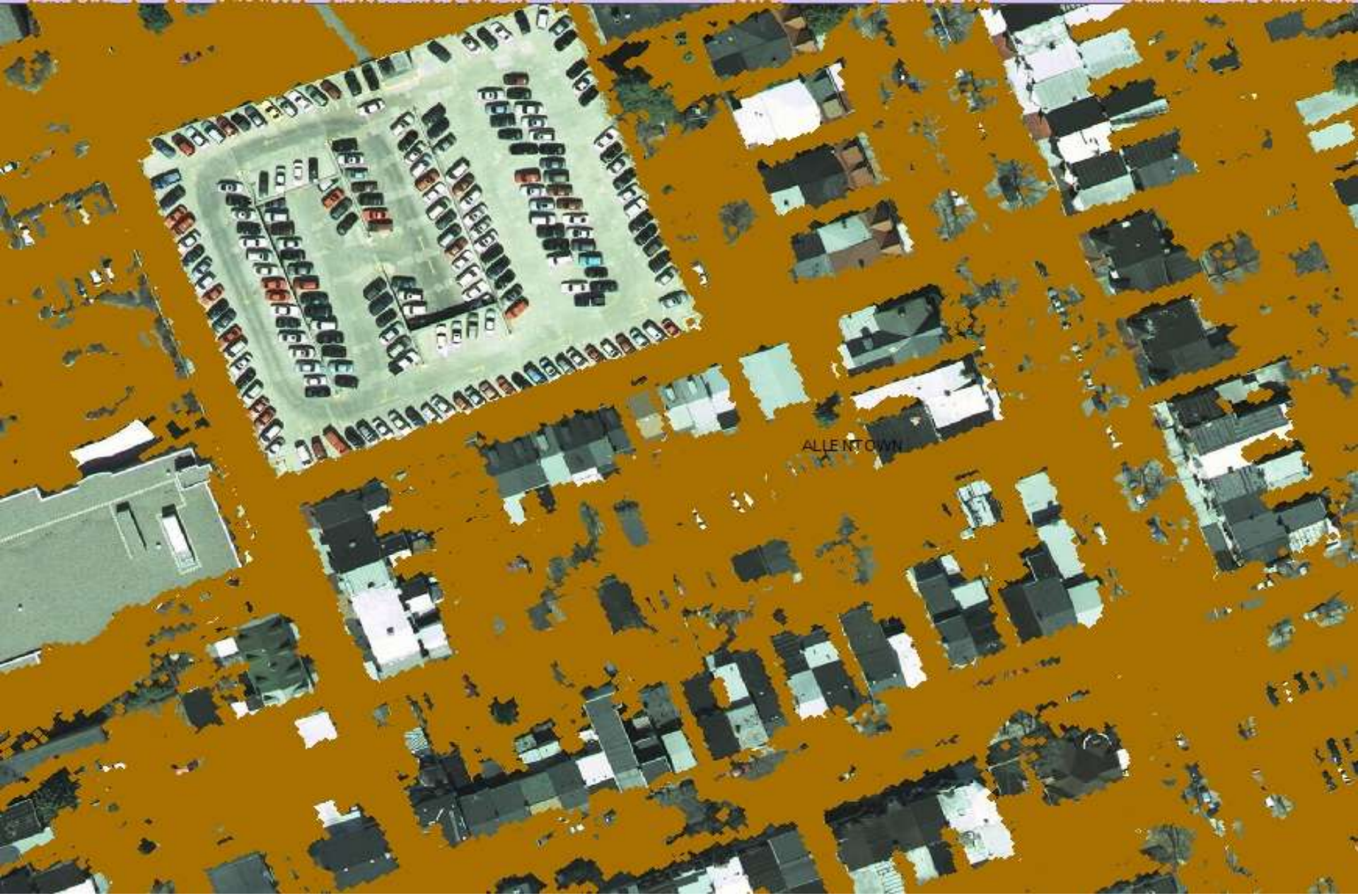
2005 LiDAR - City of Allentown, PA



LAS Data (All Points)

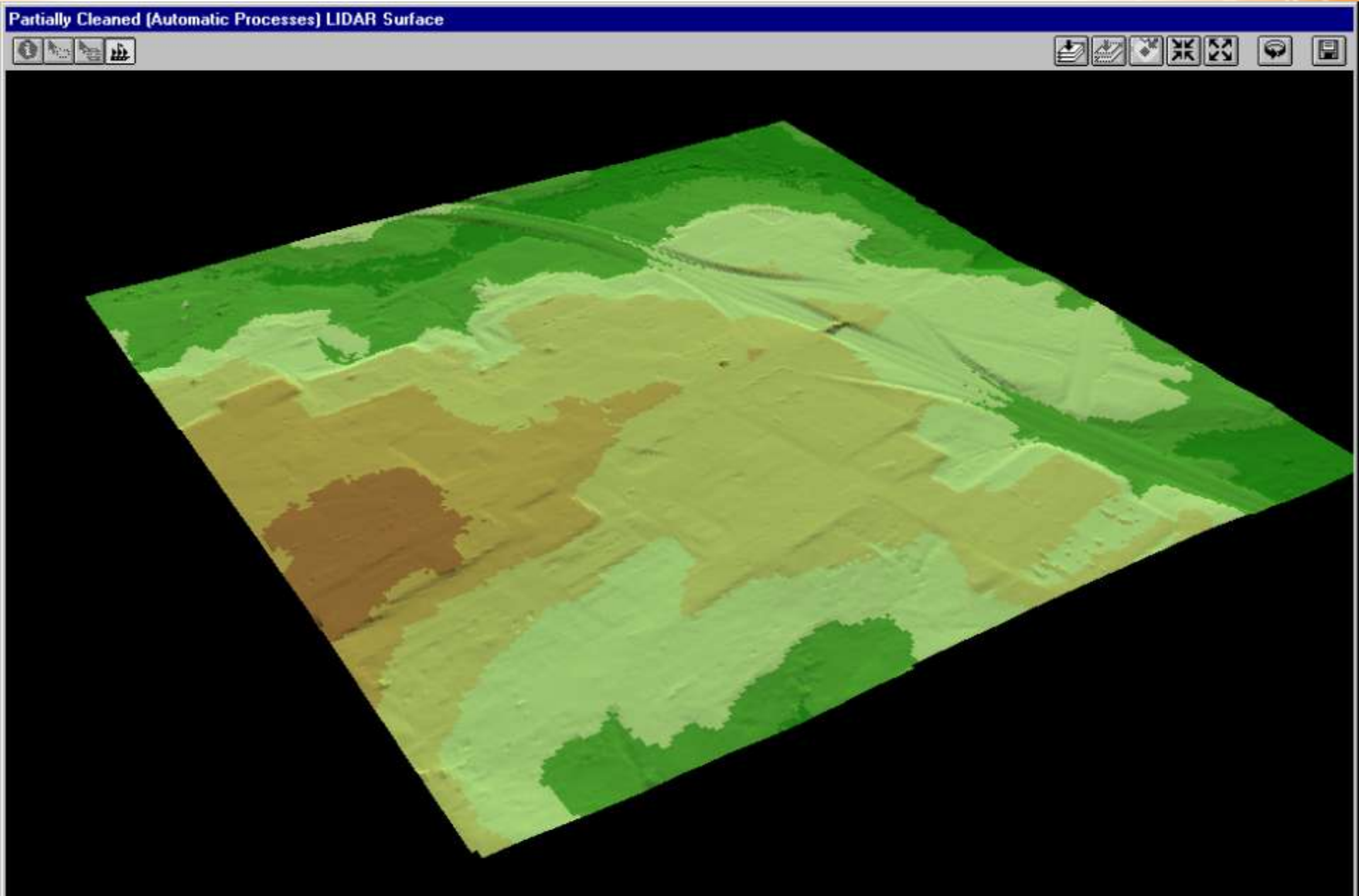
Removed Building Data

Removed Vegetation Data



Remaining: Bare Earth Data

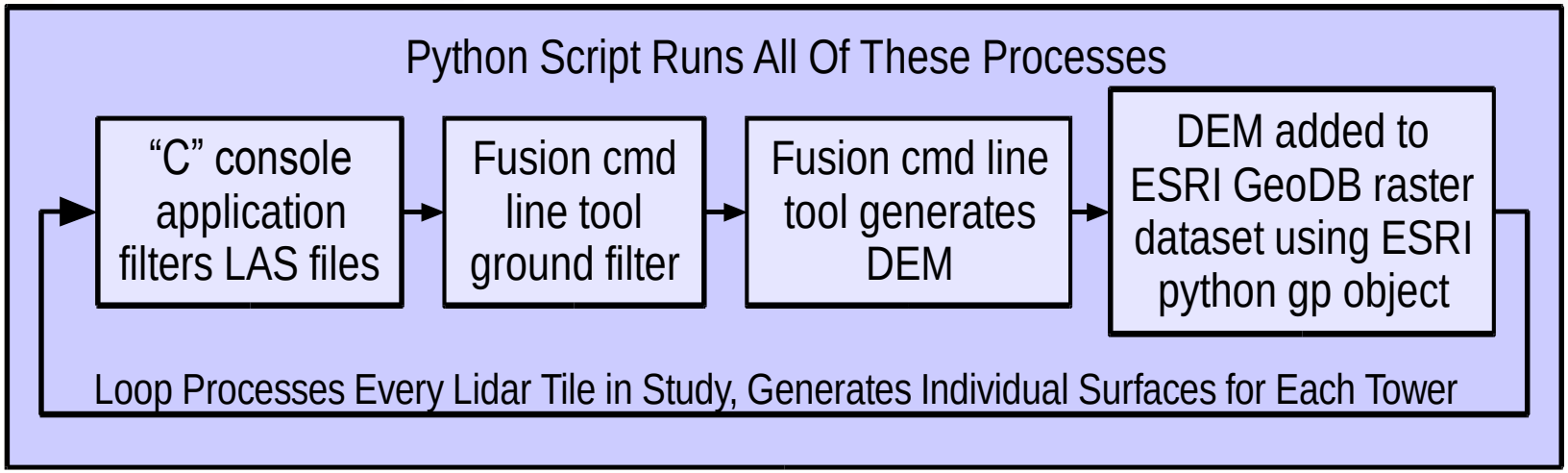
Bare Earth, Everything Else Removed



Tools for Mining LAS Data: Options

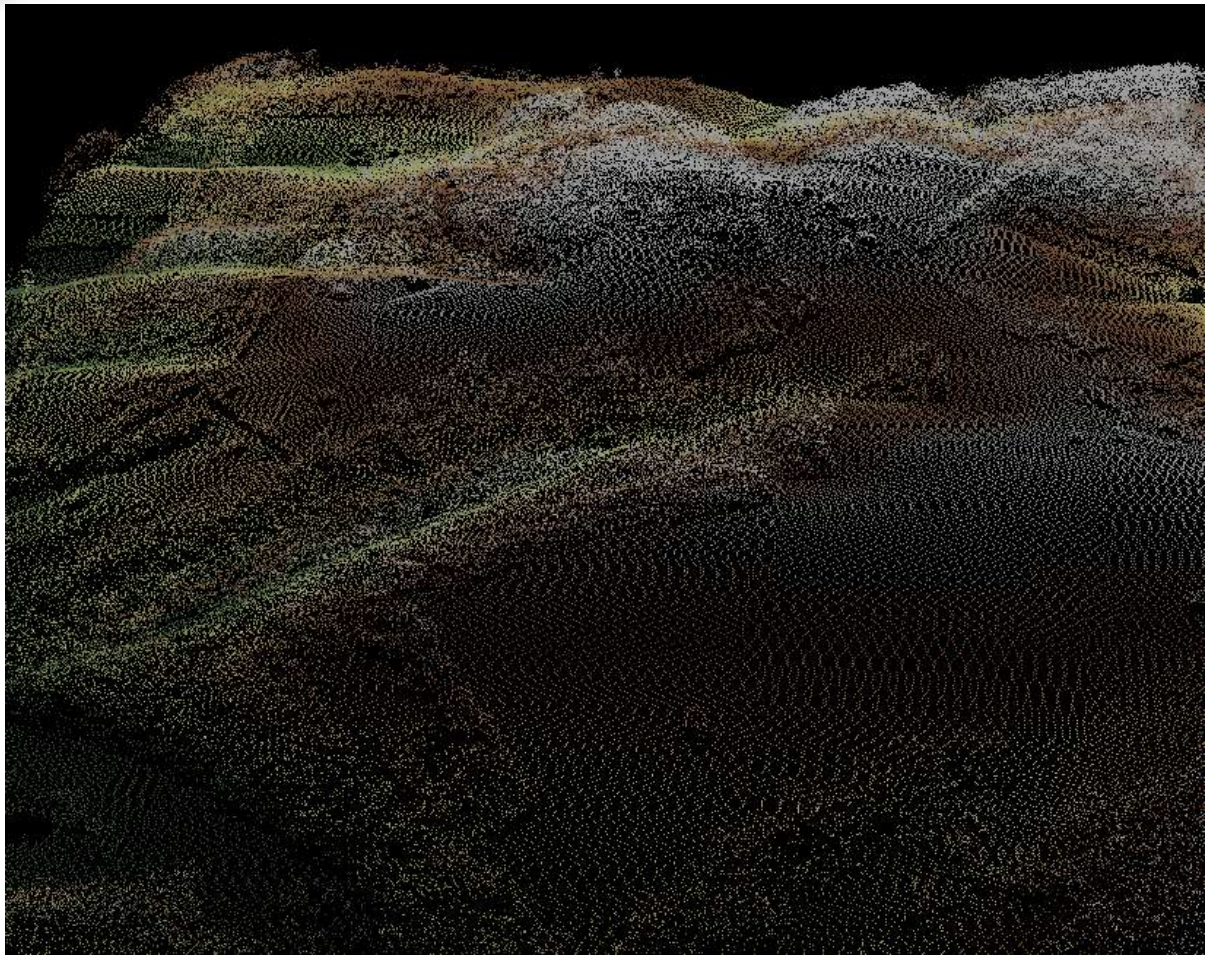
- Reviewed ESRI, USDOF Fusion, QT Modeler, Fugro, etc.
- Project Requirements:
  - Quickly filter the point cloud (LAS file) based on all of its fields.
  - Quickly produce DEM from filtered point cloud
  - Aggregate many DEMs into large surface rasters
  - Produce vectorized viewshed datasets from large surface rasters
  - Ability to process thousands of tiles within a reasonable timeframe

Terrain Surface Workflow

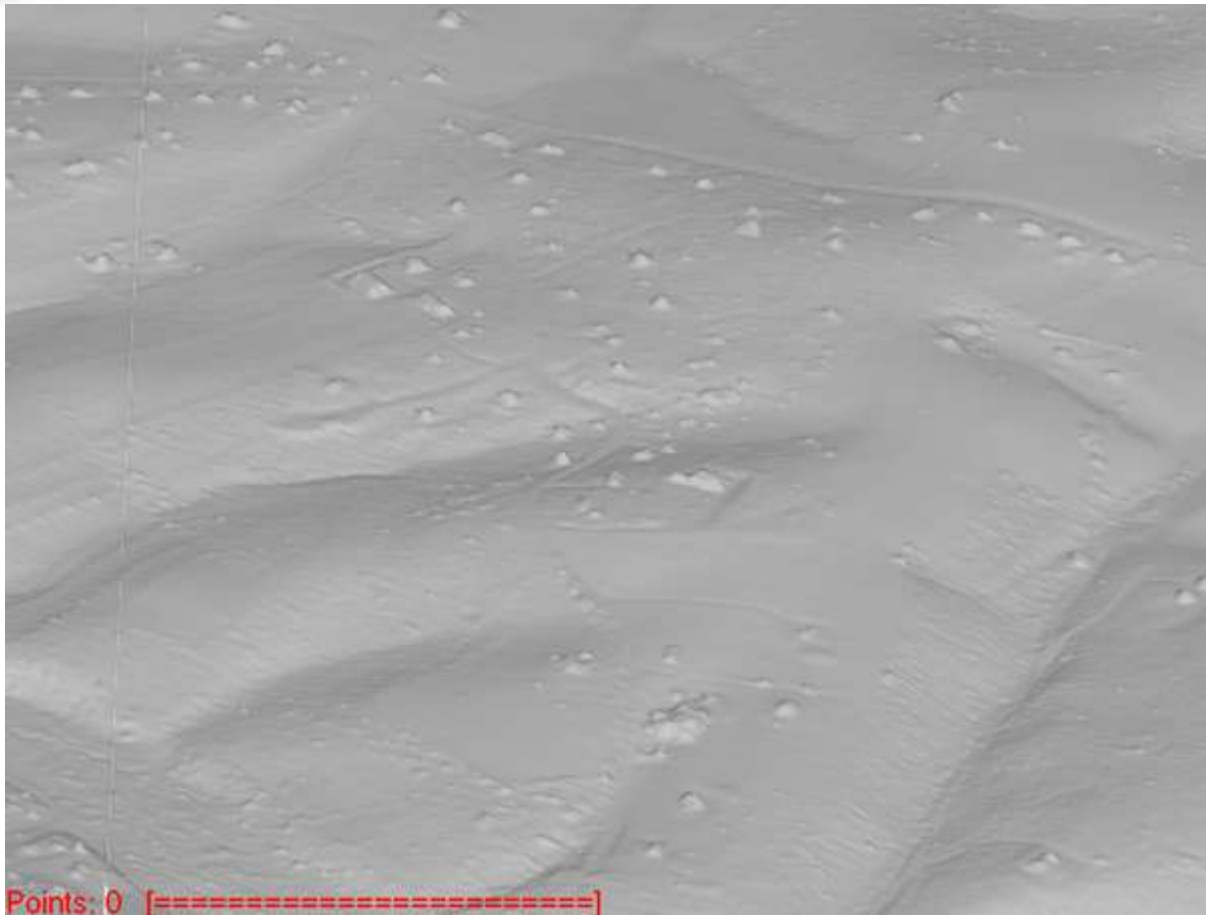


- ***Python*** chosen for scripting environment and tool integration
- Developed ***my own "C" filtering routine*** using LAS format documentation
- DEMs from the filtered point clouds were created using public domain ***Fusion*** software, maintained by US DOF
- ***ESRI*** tools were used to produce large aggregate surface rasters
- ***ESRI*** tools were used to generate vectorized viewshed datasets

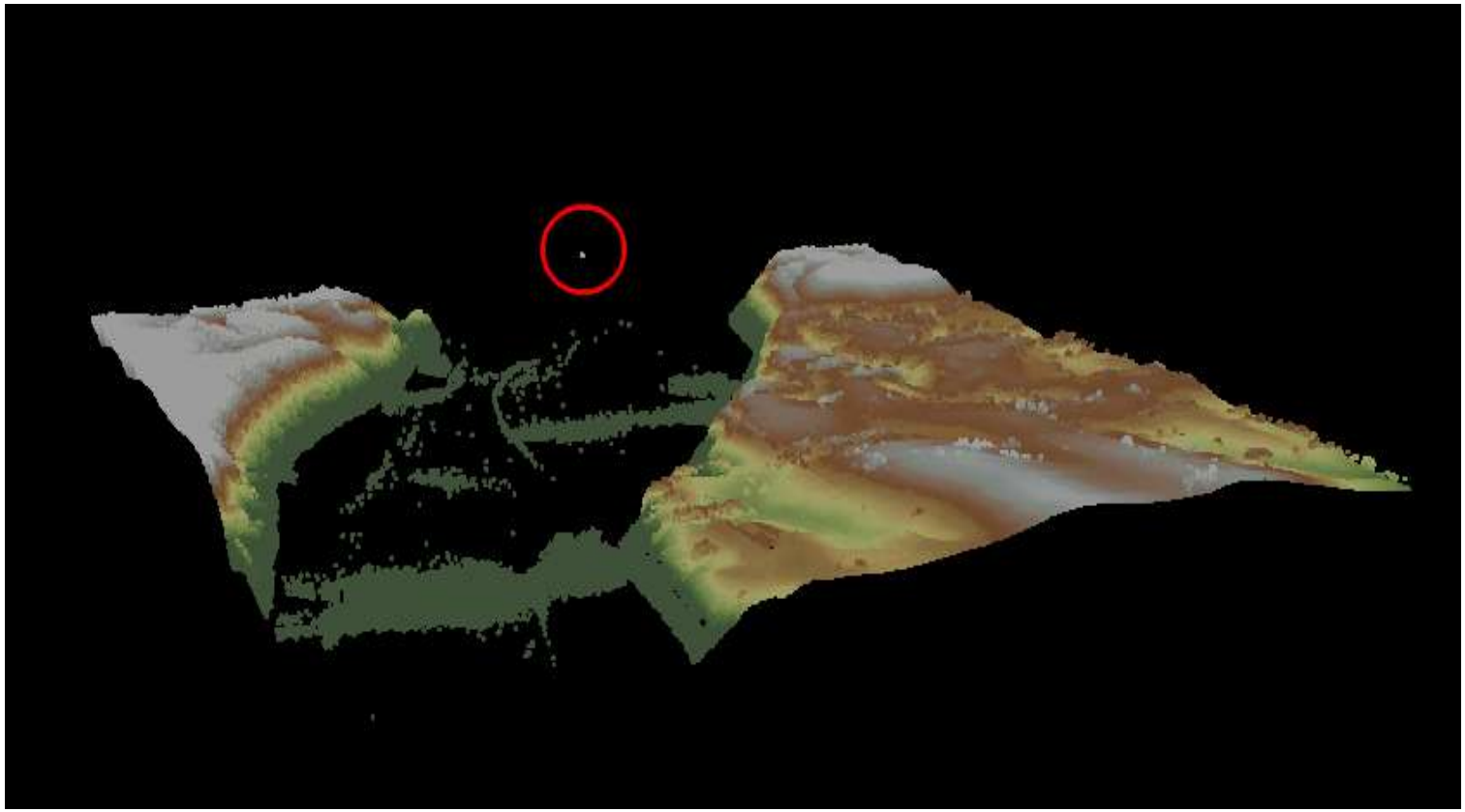
I Started with This…



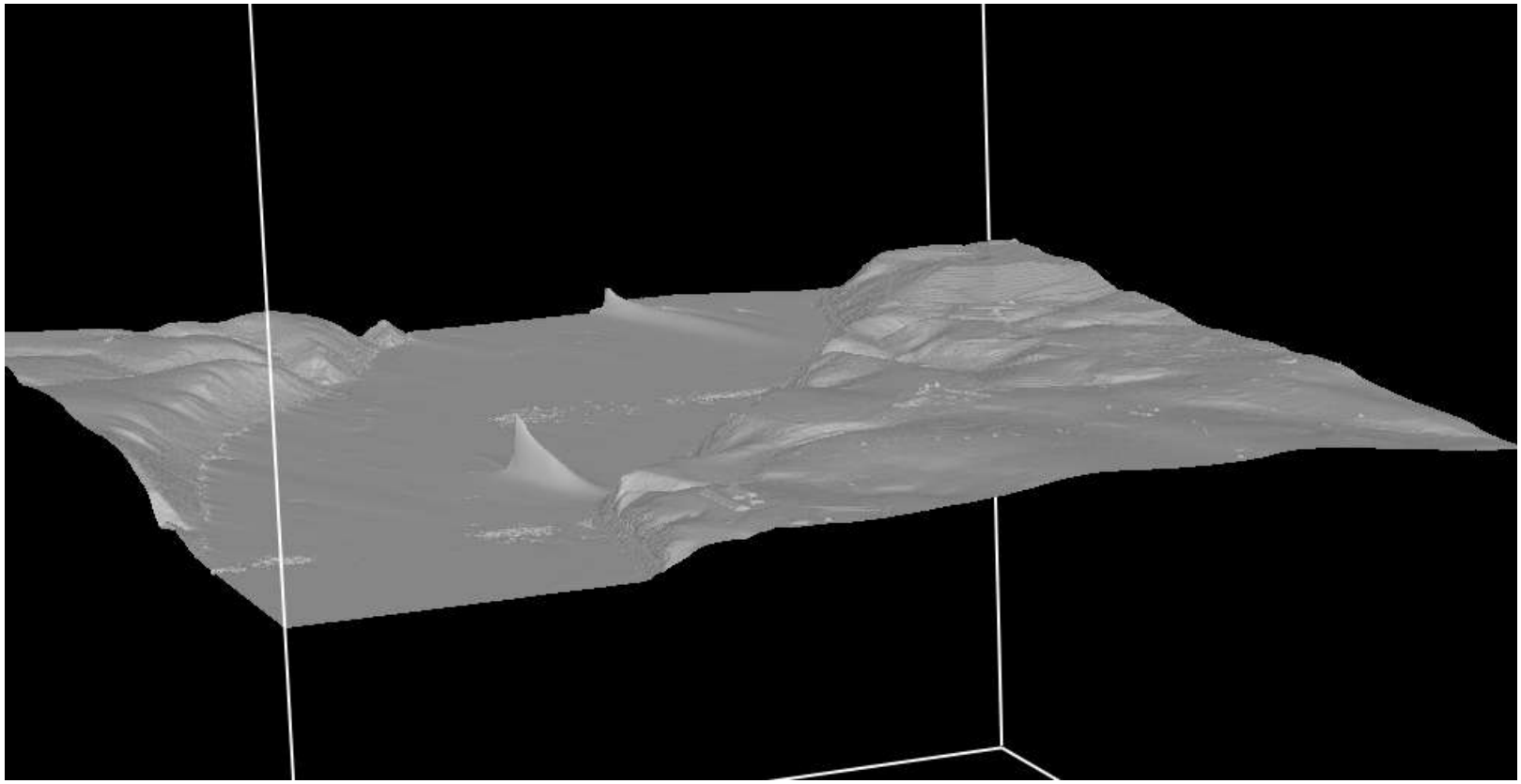
…and Ended Up with This



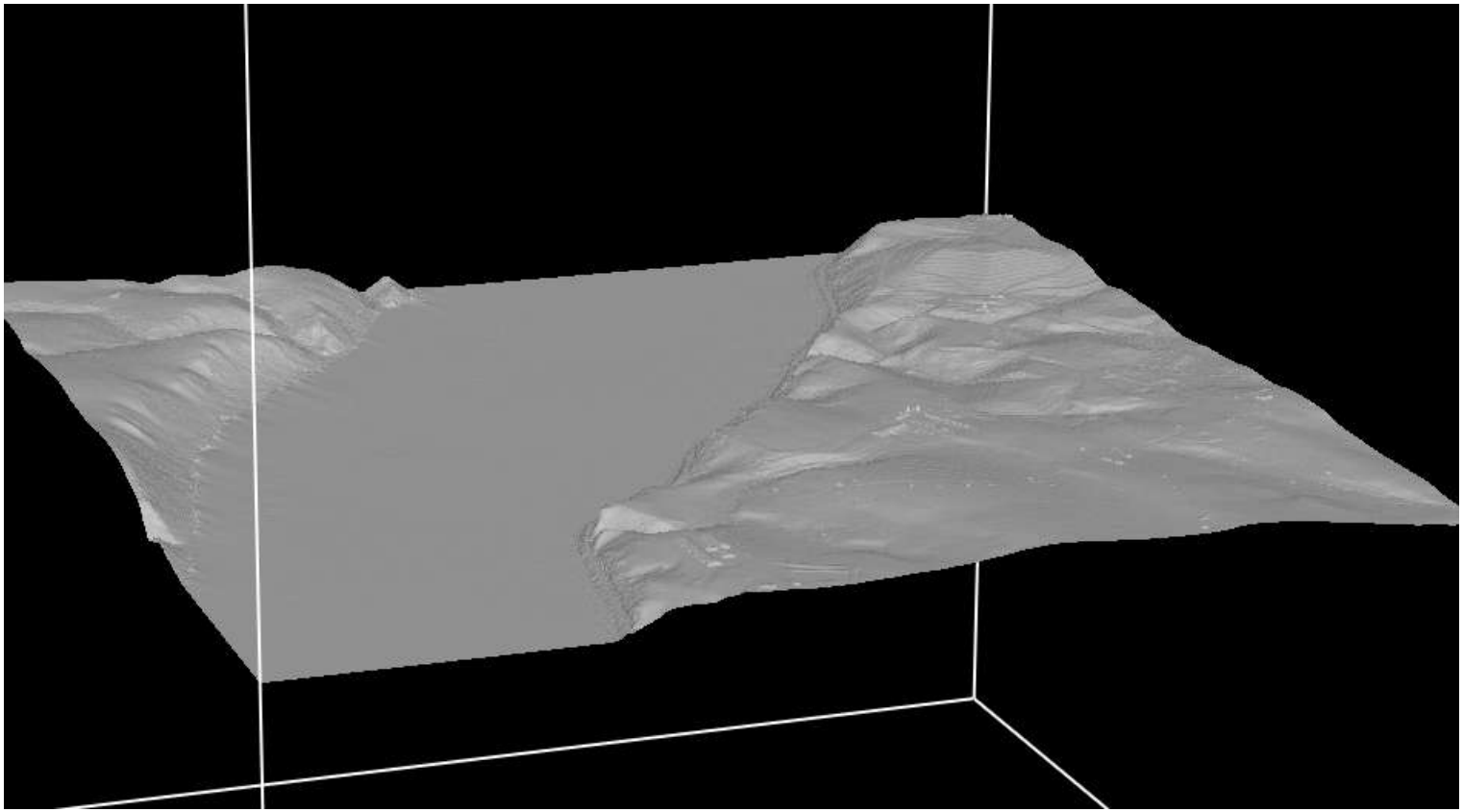
Lesson Learned: Birds in flight are often captured in LiDAR data.



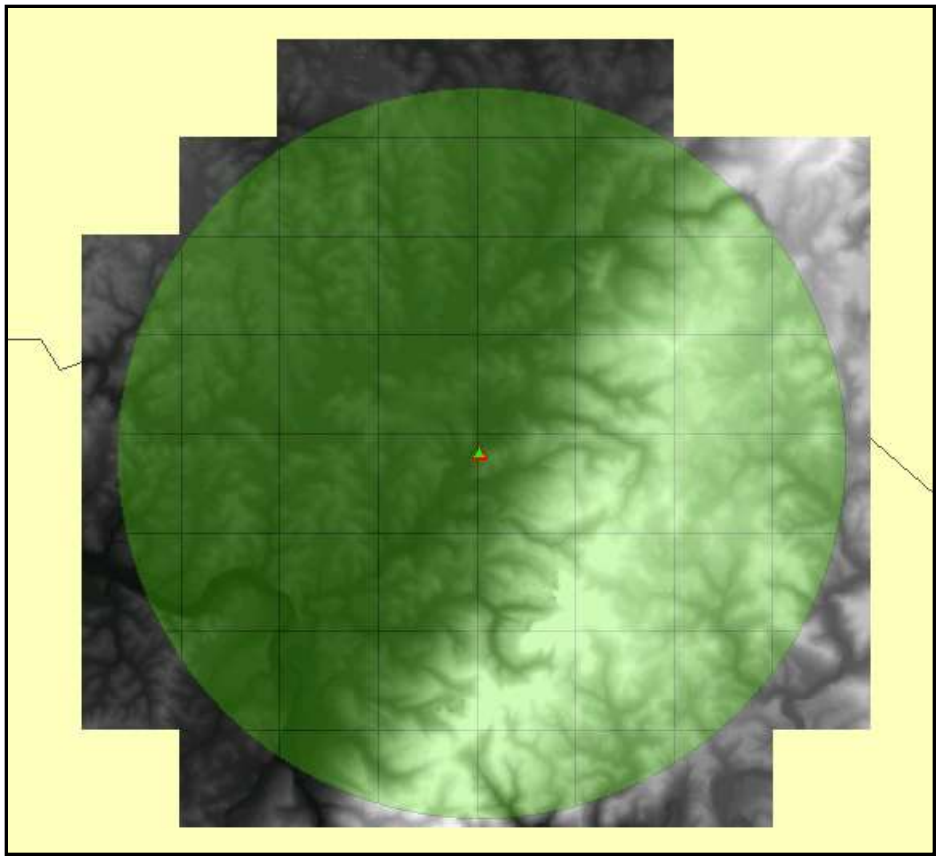
Lesson Learned: Fusion makes “tents” out of birds flying over water



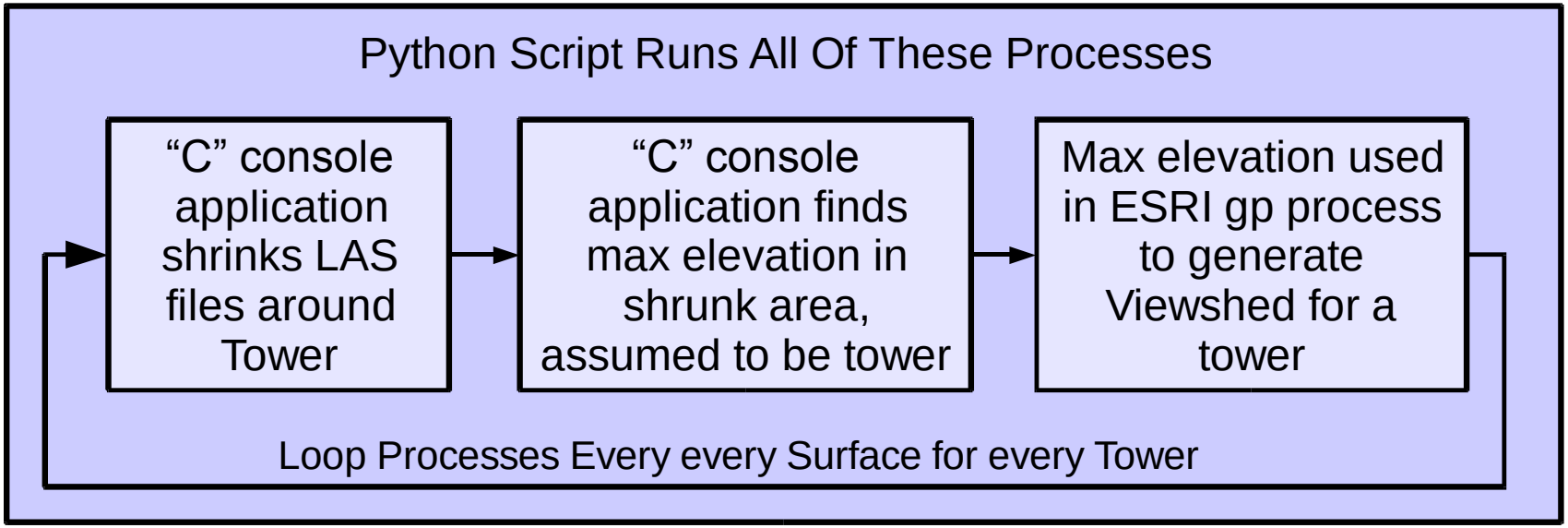
Lesson Learned: Use NHD to clip “Non Water” points above water bodies



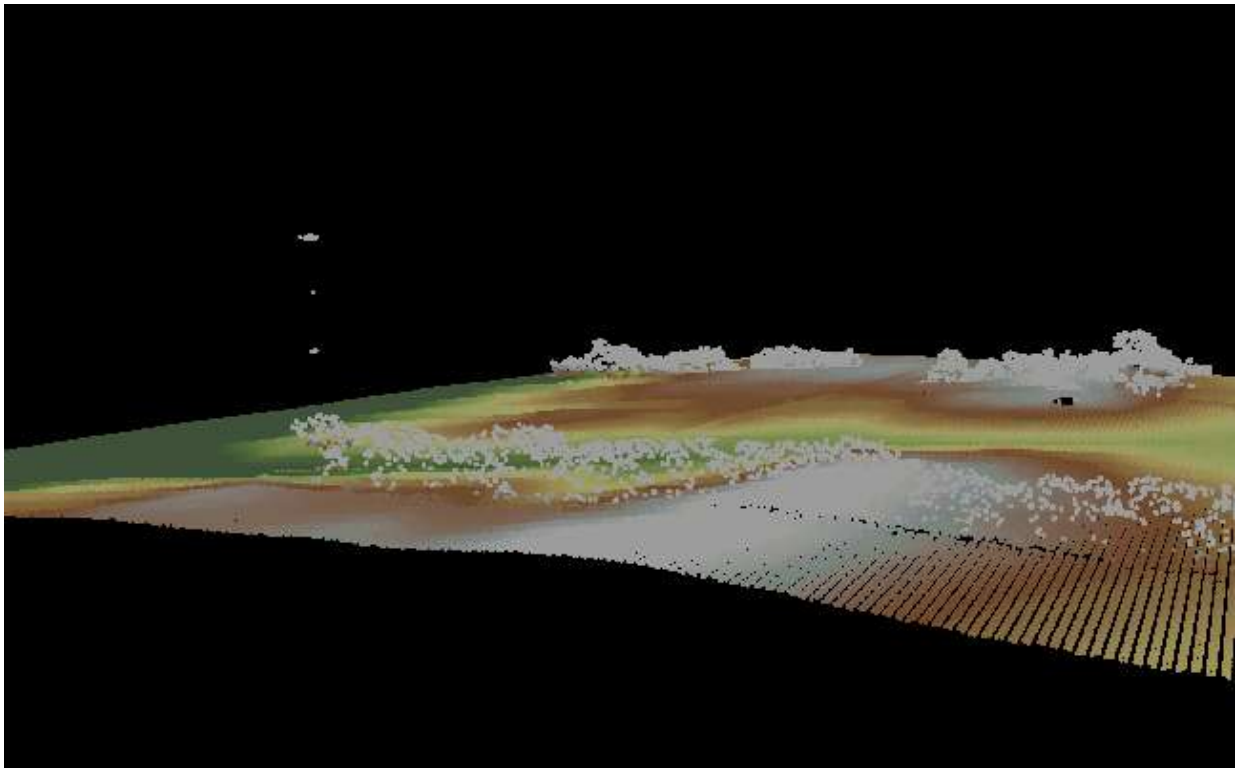
Aggregate DEM from LiDAR Tiles within Transmission Range of a Tower



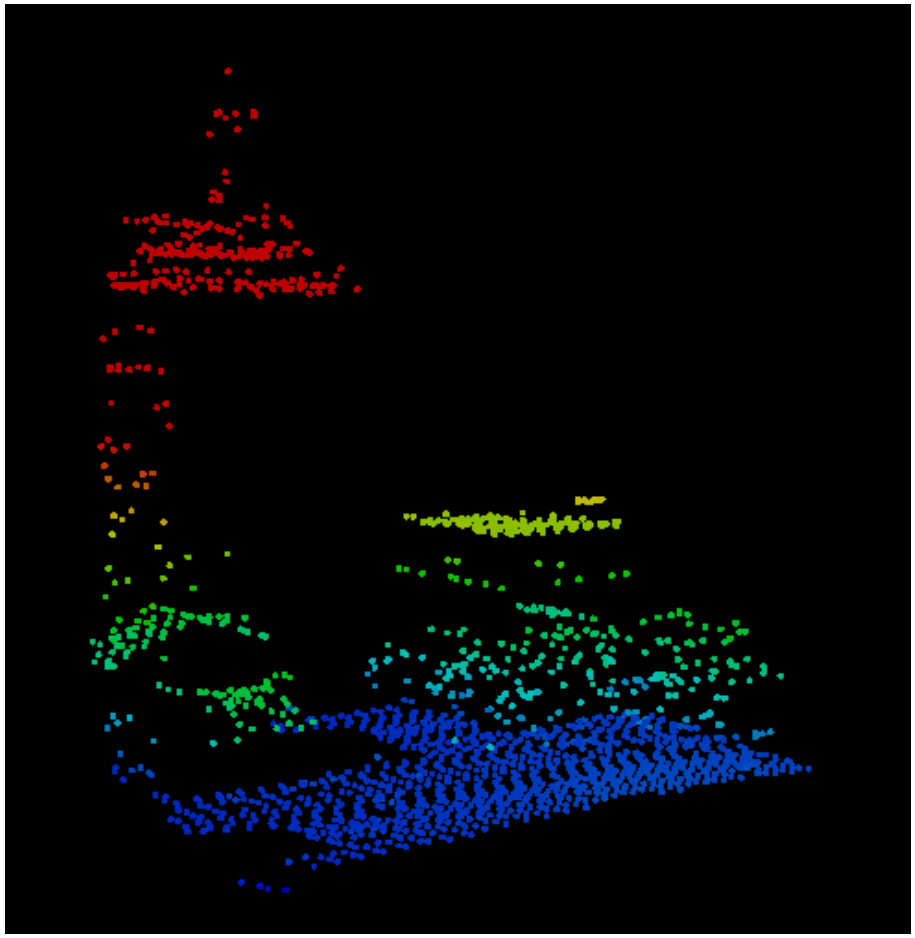
Viewshed Workflow



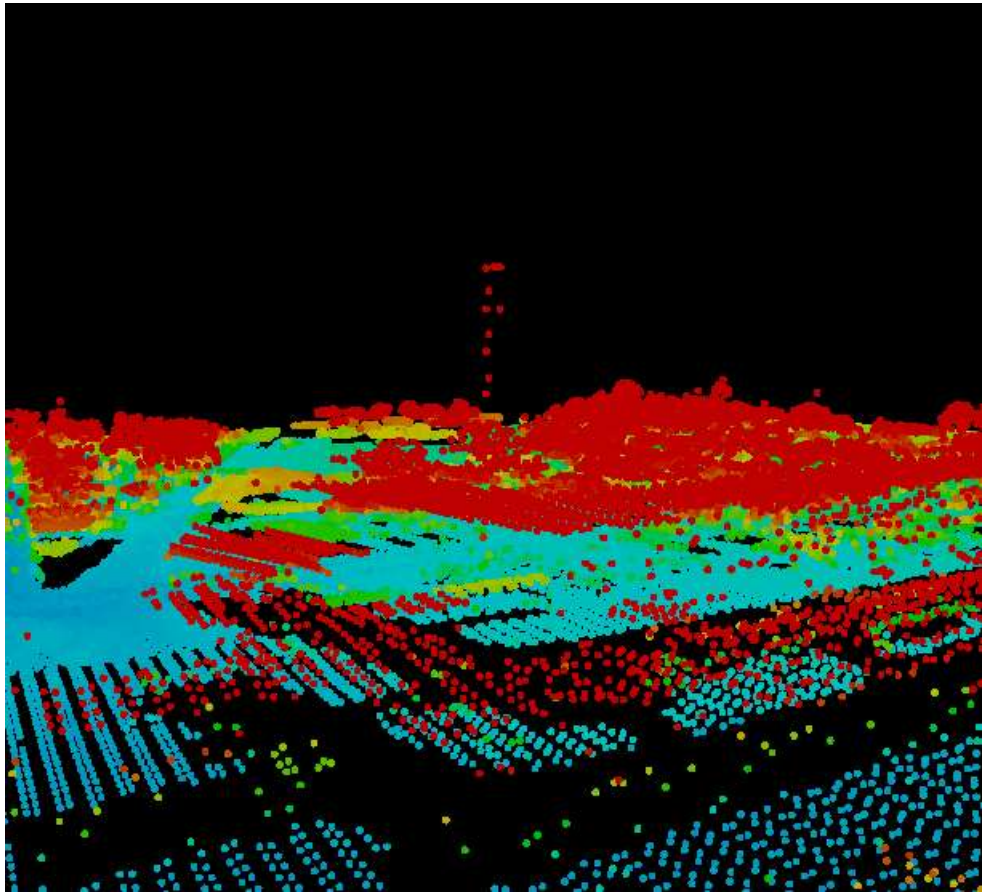
Seeing is Believing: Are Towers / Antennas Visible in LiDAR Data?



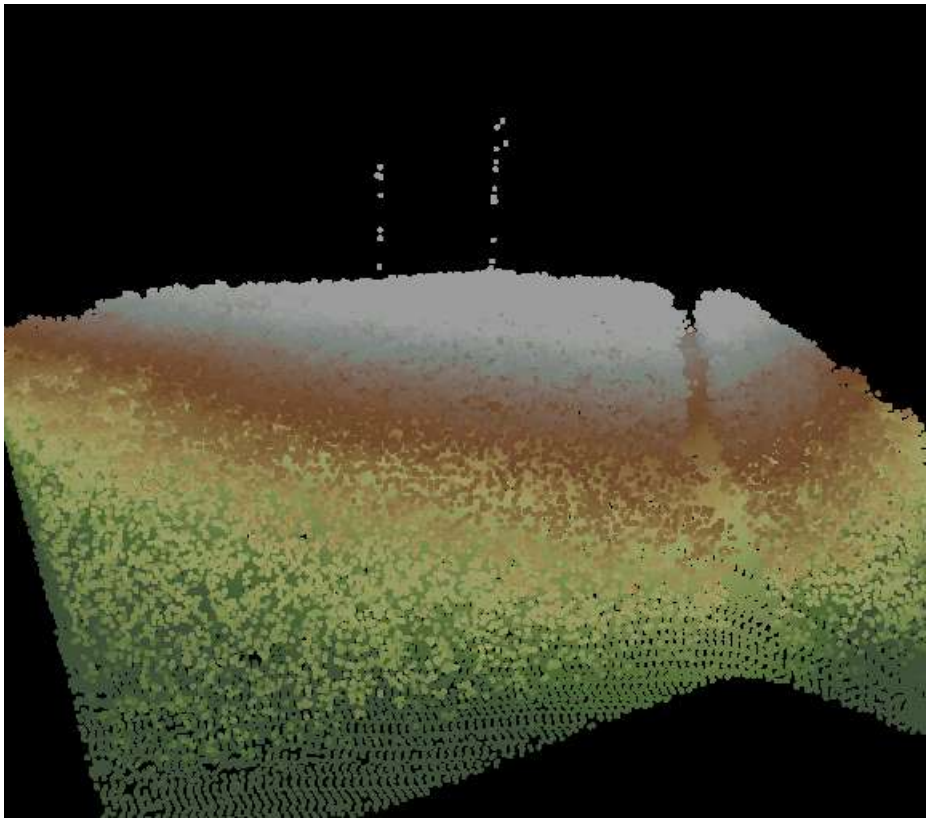
Antenna on top of Building



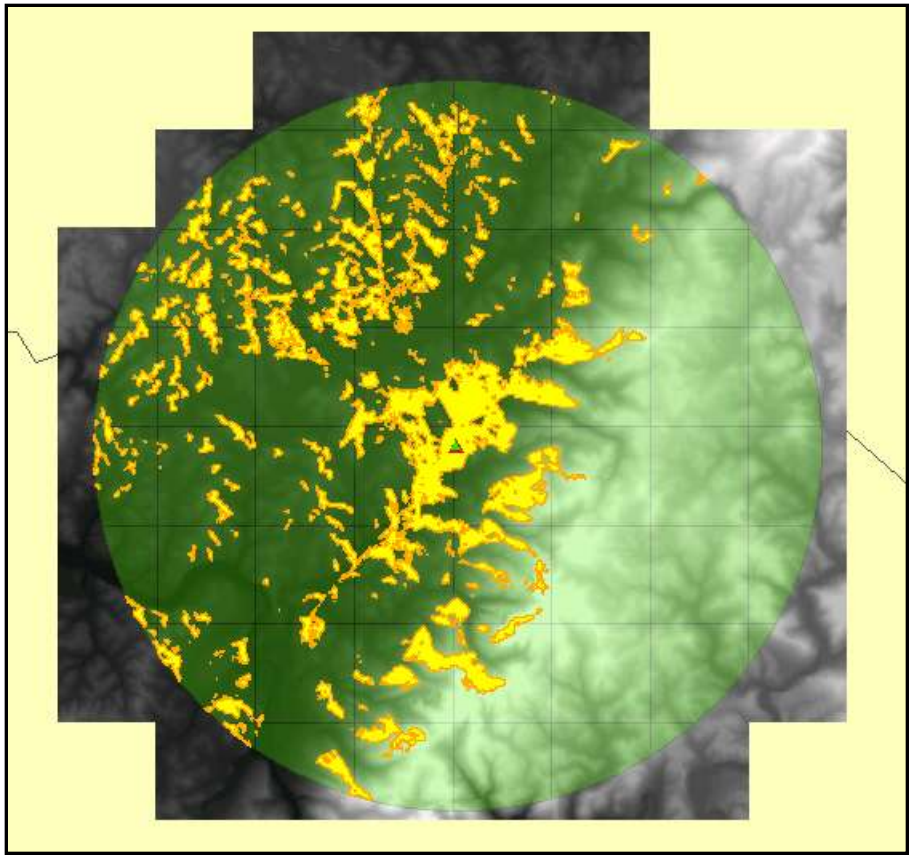
Another Tower



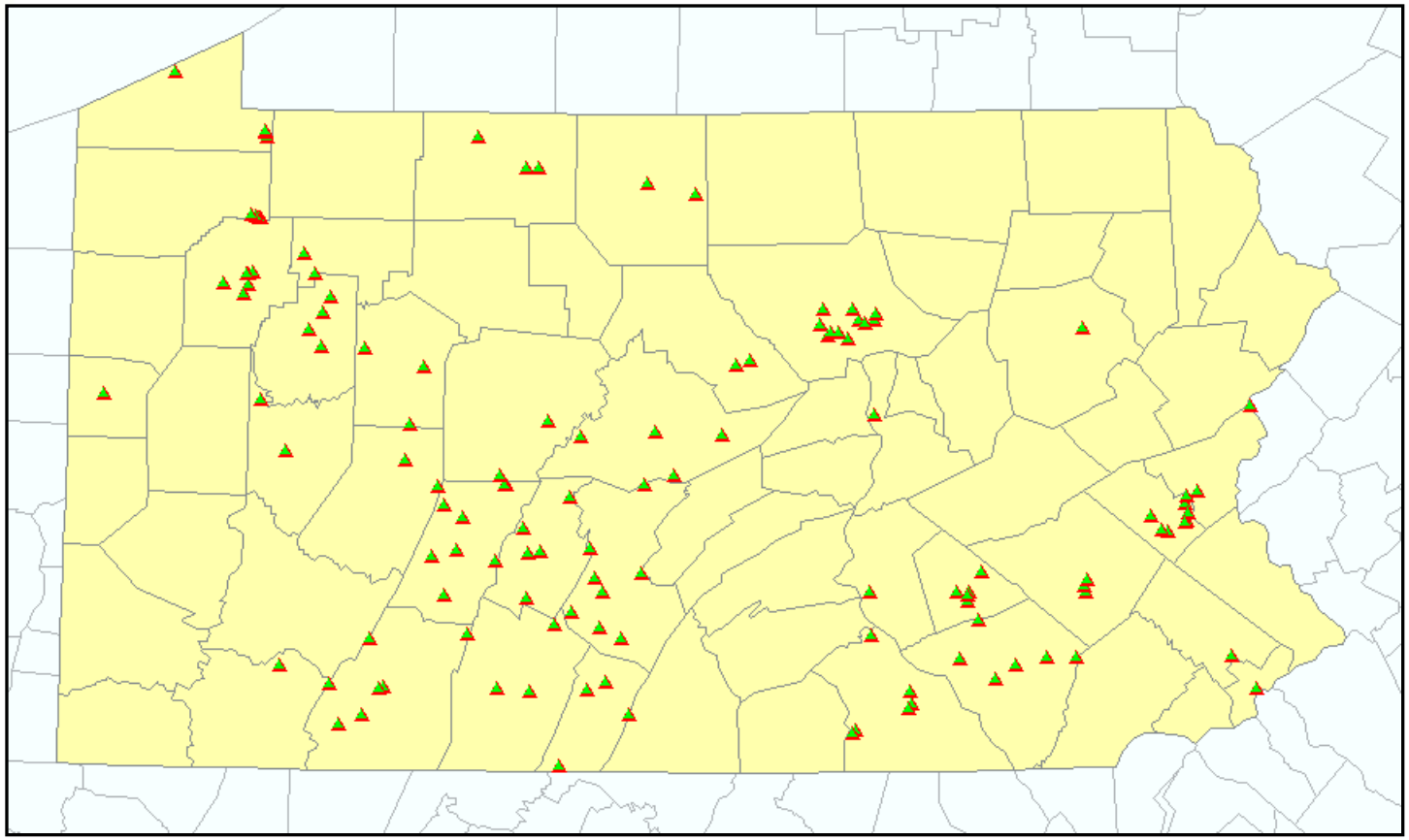
More Towers



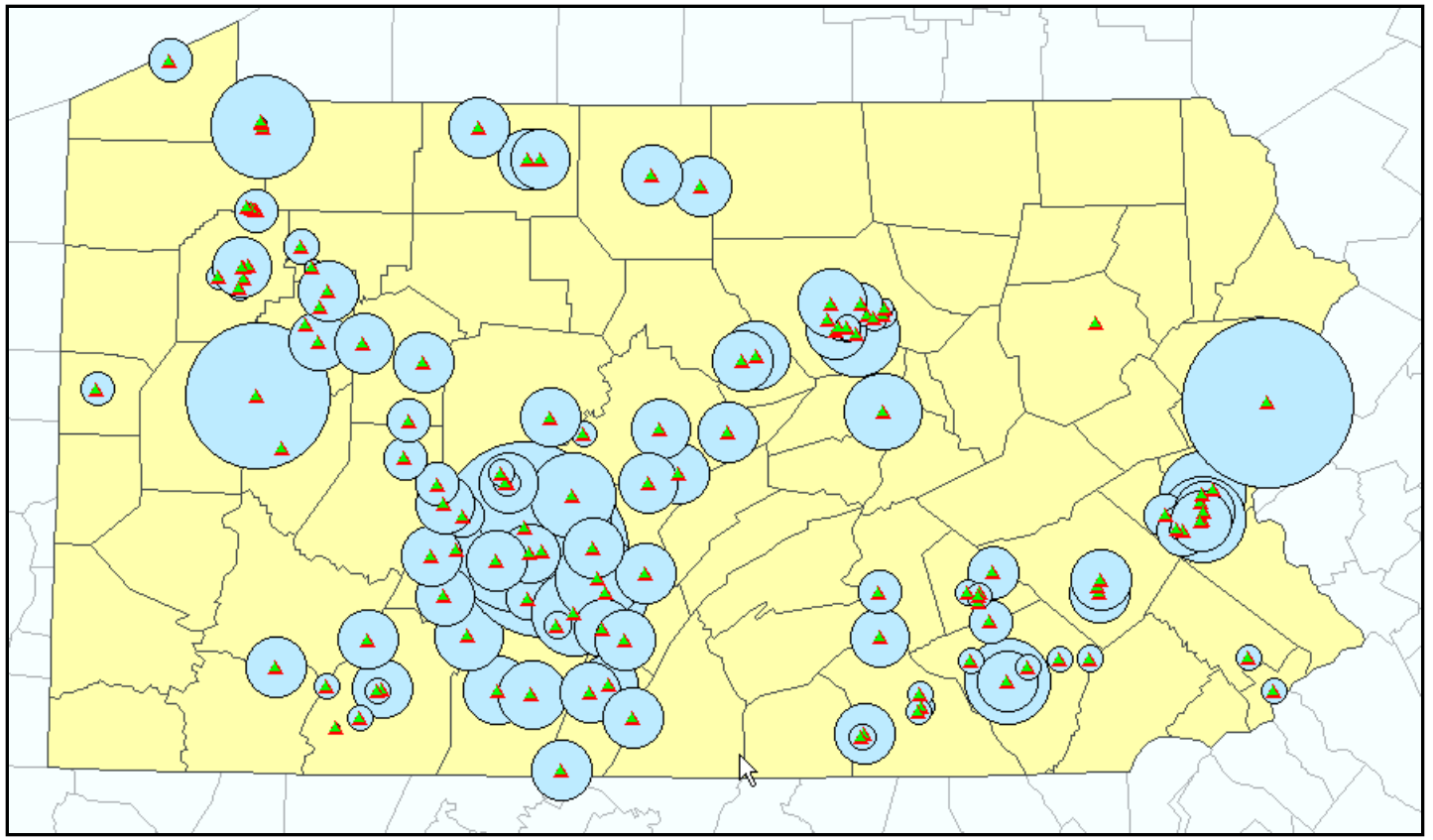
Terrain Surface (DEM) + Tower = Viewshed



125 Towers Provided by State



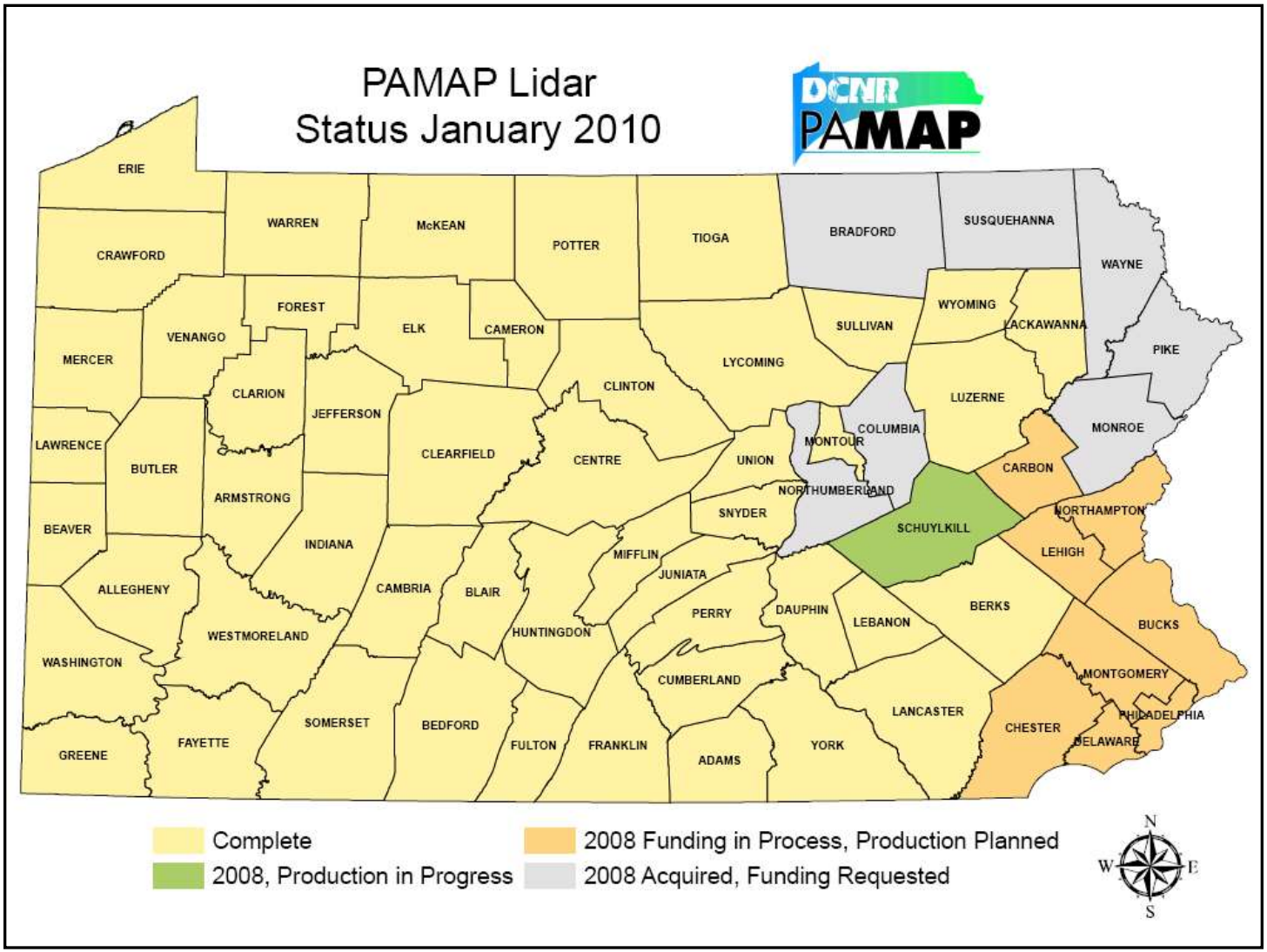
123 Wireless Towers with Transmission Ranges



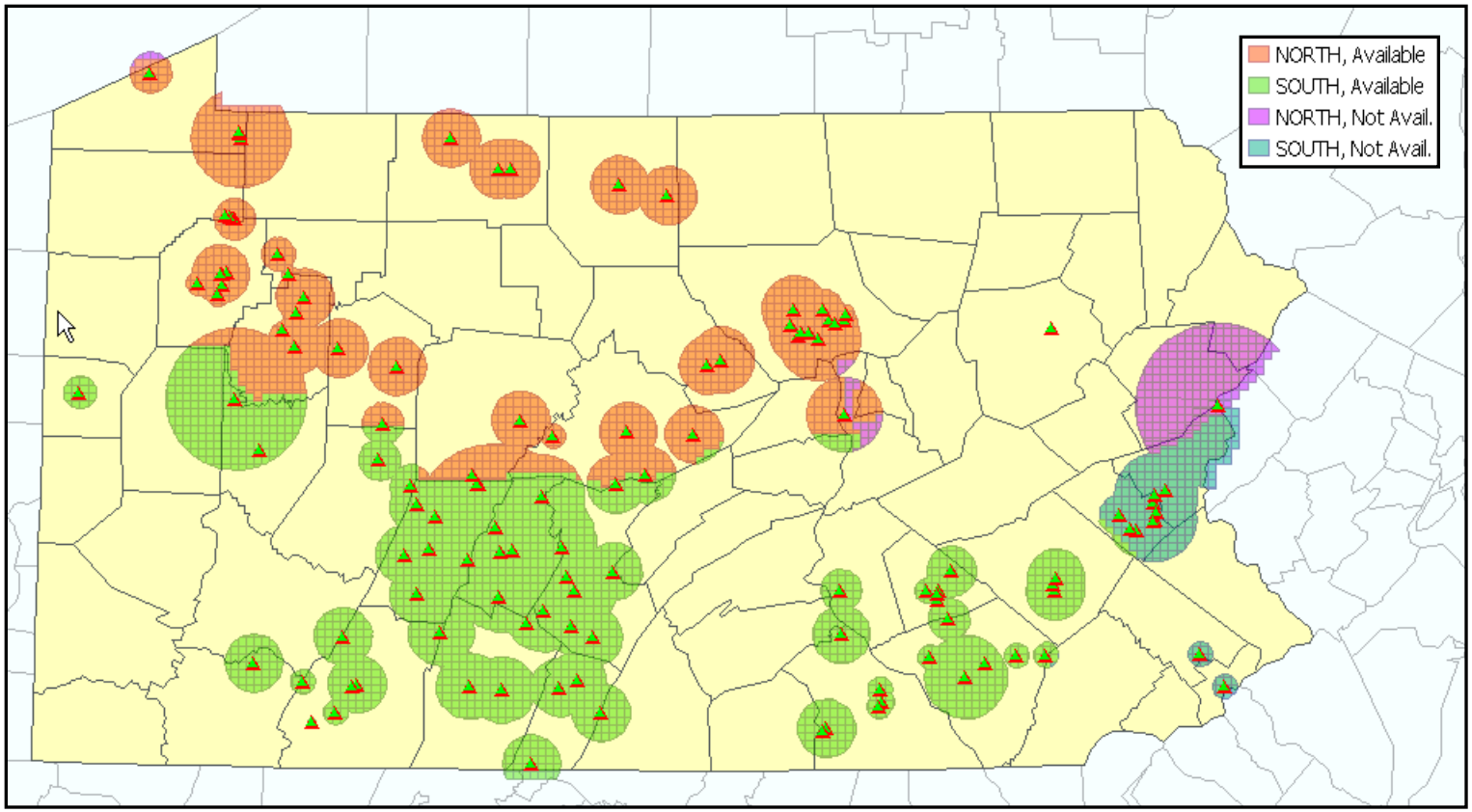
Wireless Tower Data: 50% locations verified via Lidar/Google Maps and 50% were not “found” in imagery or Lidar

Age of data could be factor

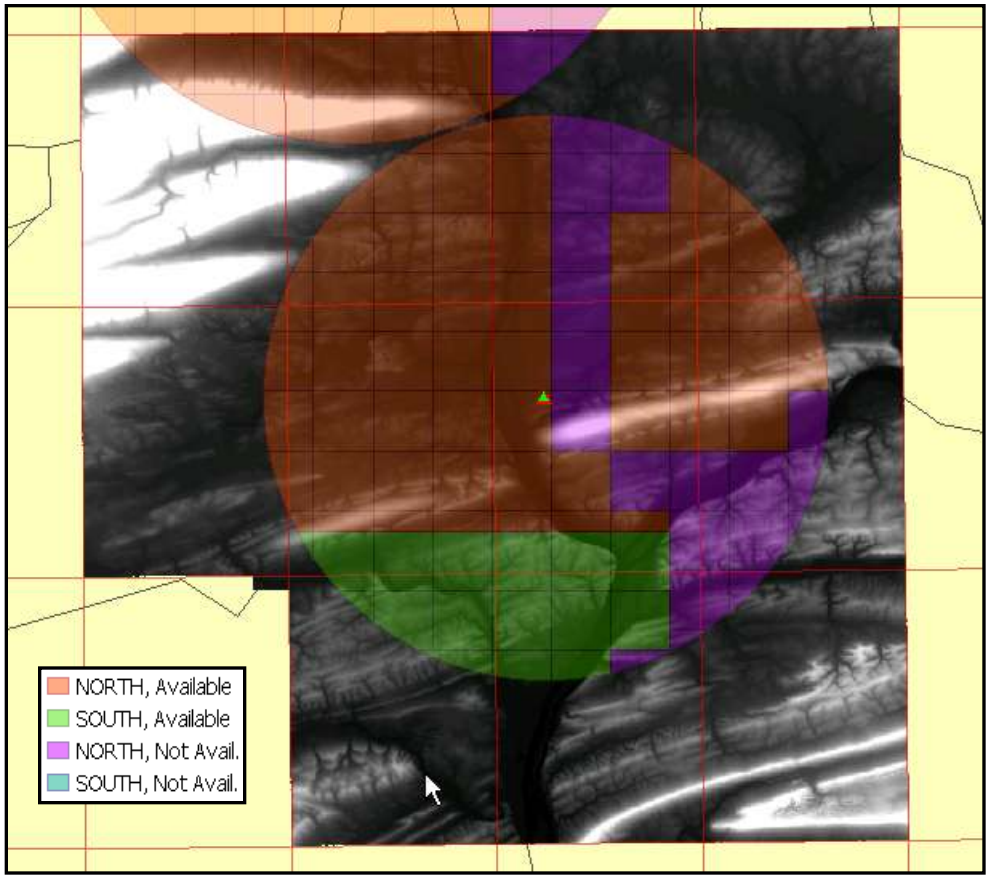
LiDAR Data Was Not Complete For All Counties in PA



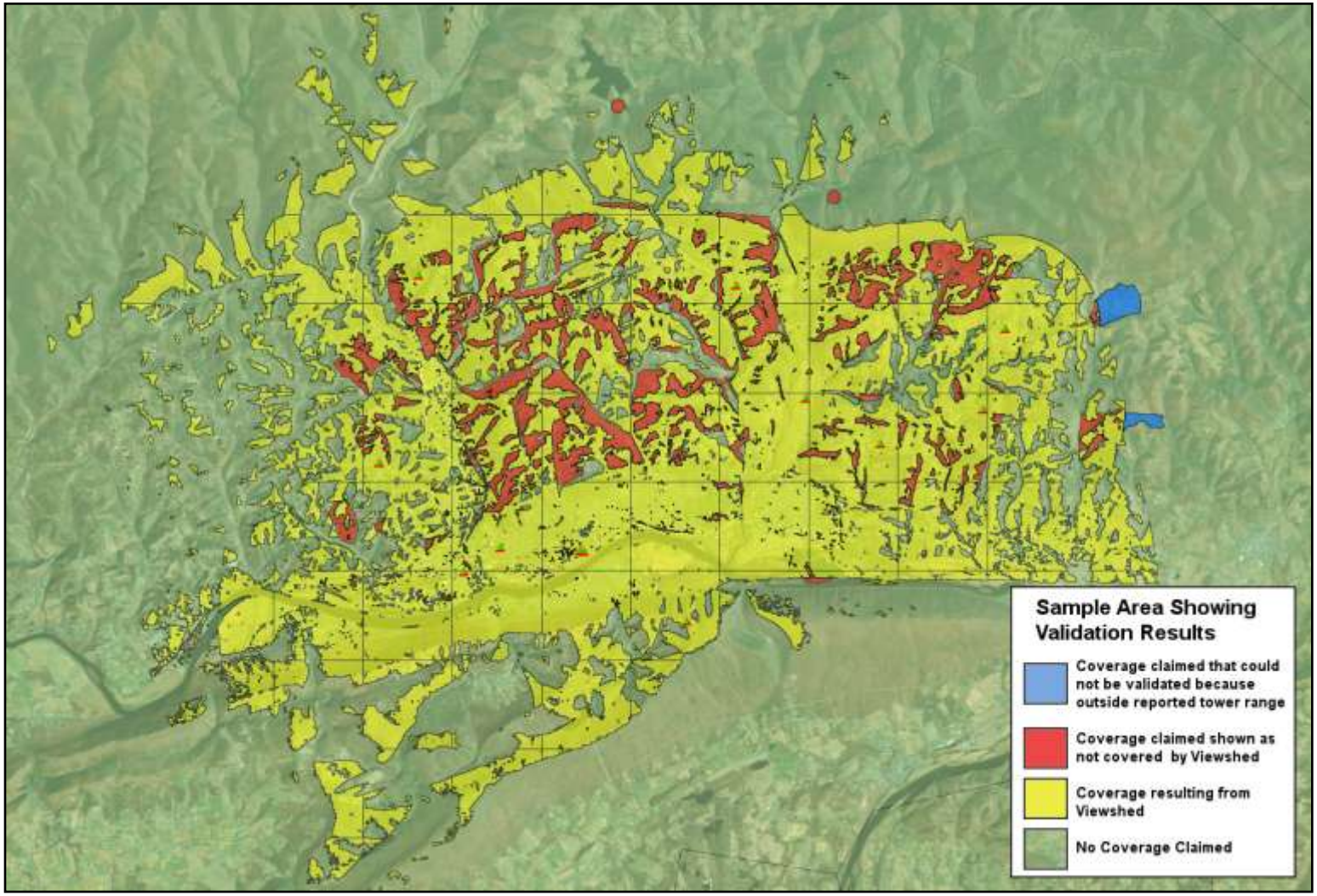
3400 LiDAR Tiles within Range of Towers



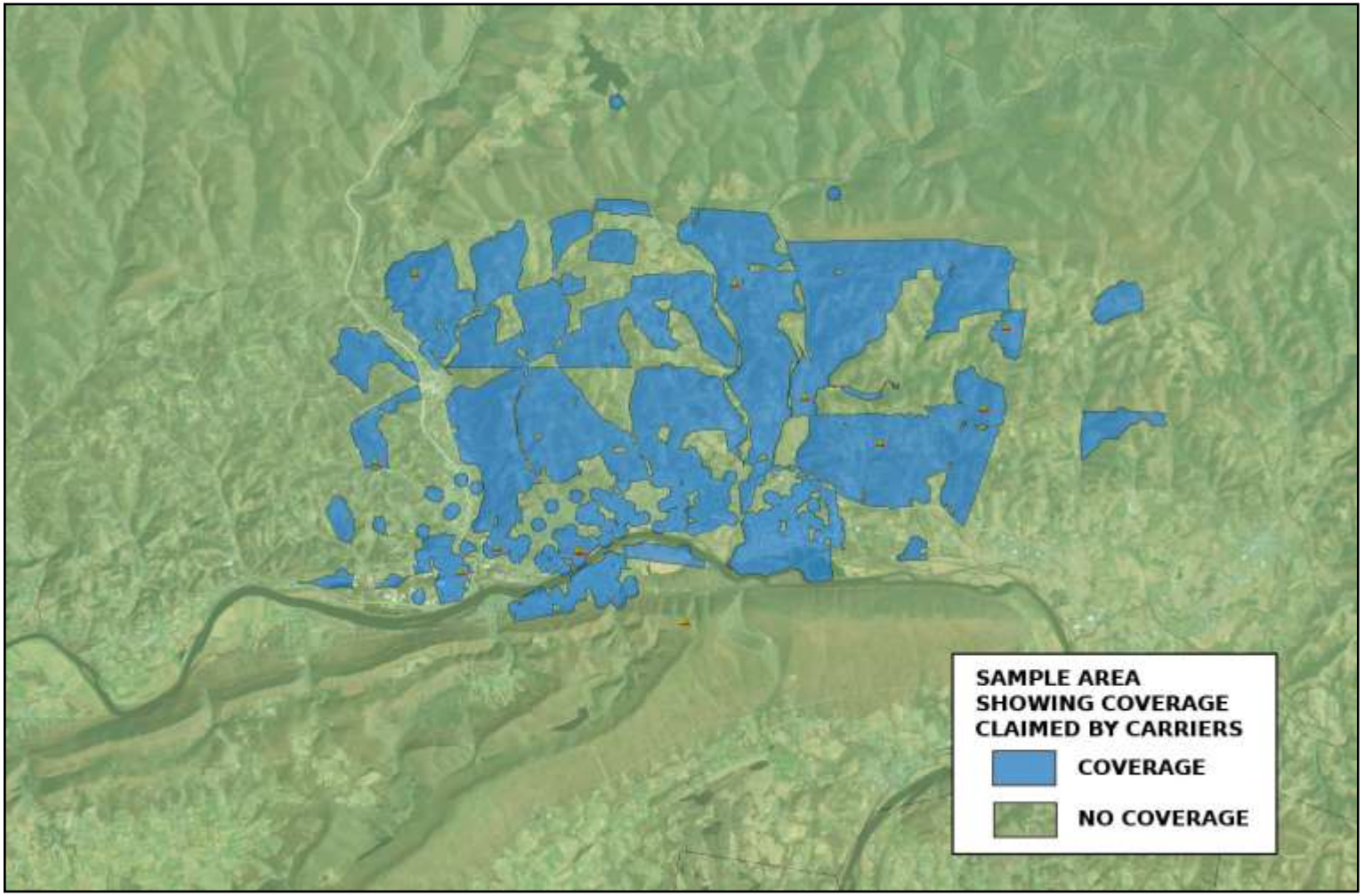
Holes in Available Lidar Tiles Were Covered with USGS 10 and 30 meter DEMs



End Result


Sample Area Showing Validation Results
Coverage claimed that could not be validated because outside reported tower range
Coverage claimed shown as not covered by Viewshed
Coverage resulting from Viewshed
No Coverage Claimed

Broadband Coverage Reported by Wireless Carriers (2010)



Thank you!

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