

Aerial LiDAR

A brief primer on Aerial LiDAR prepared for the
Town of Chatham Zoning Board of Appeals

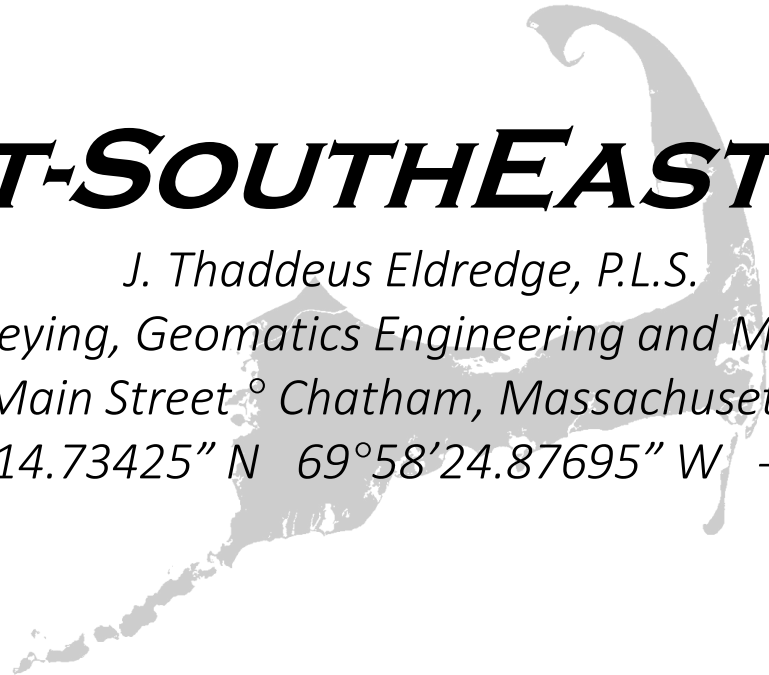
EAST-SOUTHEAST, LLC

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1038 Main Street ° Chatham, Massachusetts 02633

41°41'14.73425" N 69°58'24.87695" W -10.019 M



LiDAR

- Light Detection And Ranging
- Laser Radar
- Laser Scanning



- The lasers are not visible so this is not some exciting laser light show.

Phodar

- 3-d data obtained from photogrammetry with a similar output as LiDAR.
- Usually from a drone but could be from a camera or cell phone camera.

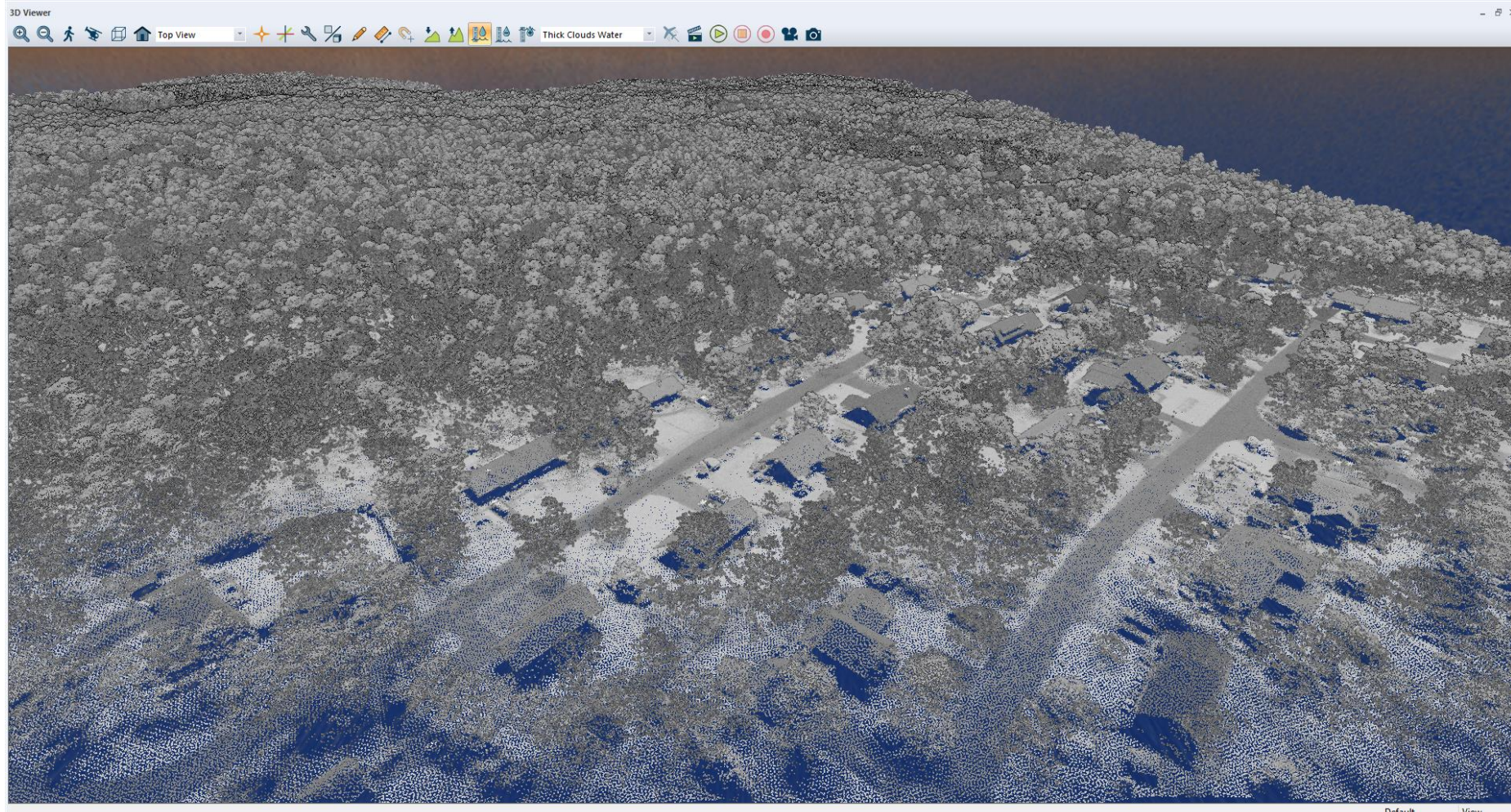
Flavors of LiDAR and Phodar

- Handheld LiDAR (a)
- Handheld Phodar (Camera) (b)
- Terrestrial Static (c)
- Terrestrial Mobile (d)
- Drone LiDAR (e)
- Drone Phodar (f)
- **Aerial LiDAR (Aircraft) (g)**



LiDAR

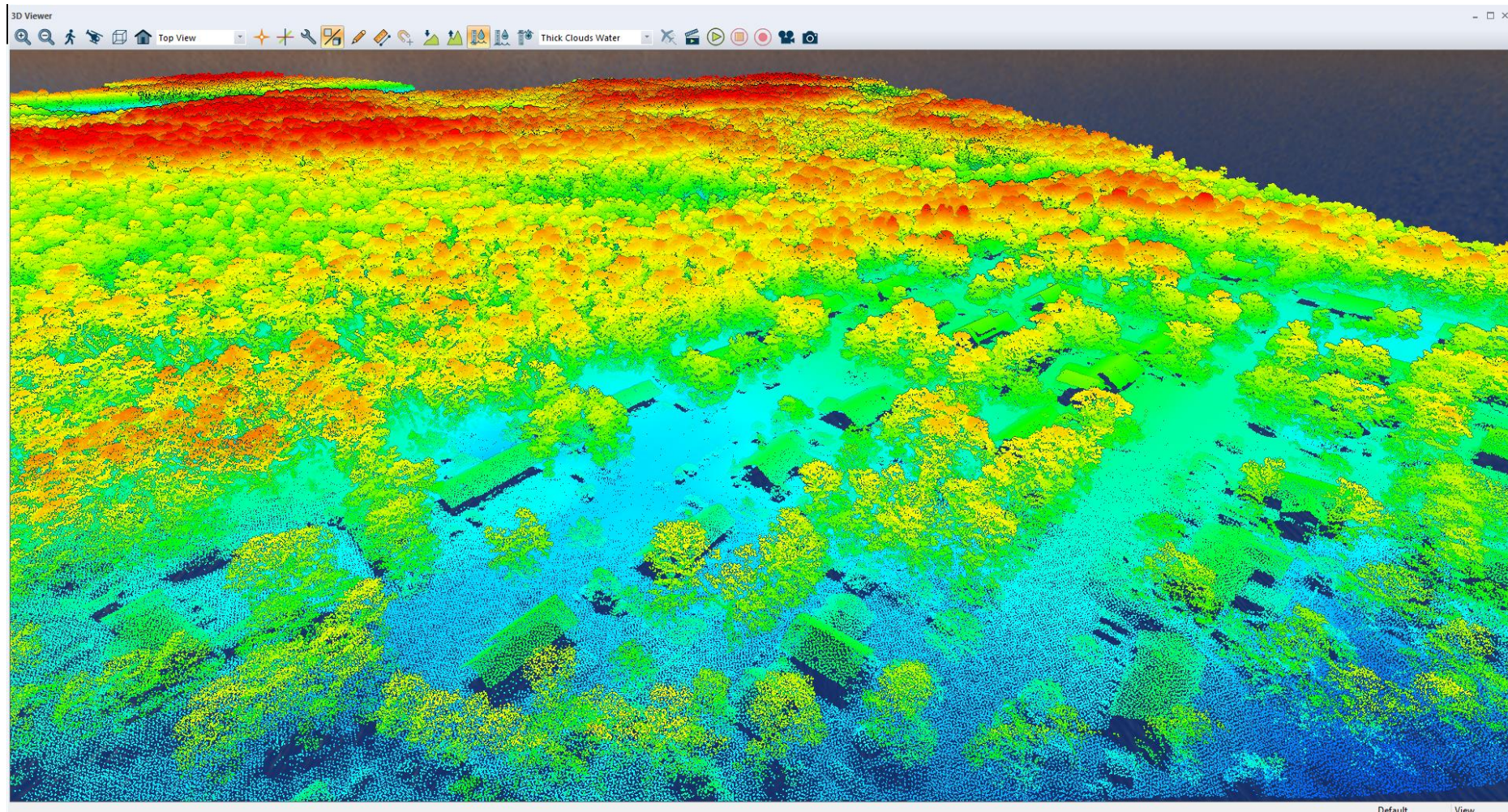
- First dataset is a mass called a Point Cloud – 3d bitmap.
- Most scanners return the reflectivity of the object scanned. This is a point attribute called Intensity as shown below. It's like a black and white imagery but a little different.



Hawksnest,
East Harwich

Visualization

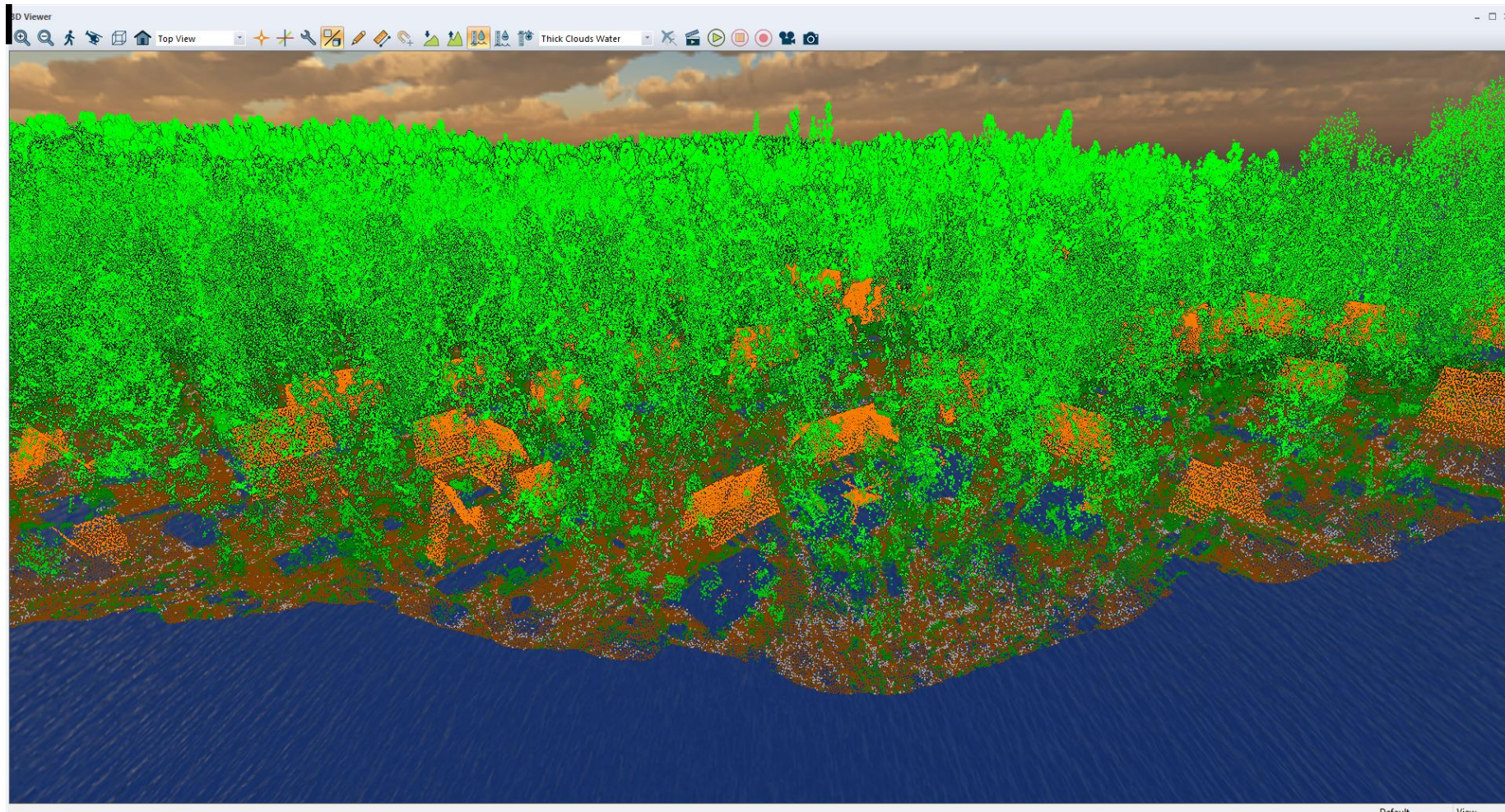
- This is based on elevation – blue is low, red is high and the colors in between represent the elevations in between.



Hawksnest,
East Harwich

Classification

- One method to sort and view the data.
- Computer algorithms and human verification add another attribute to each point.
- Orange = Buildings, Green = Low, Medium, Tall Vegetation, Brown = Ground
- Because the data is all digital, one can exaggerate the vertical as shown below:



Hawksnest,
East Harwich

Lidar exposes the remnants of an overgrown ancient civilization in the Amazon

Devin Coldewey @techcrunch / 3:14 PM EDT • May 27, 2022

Comment

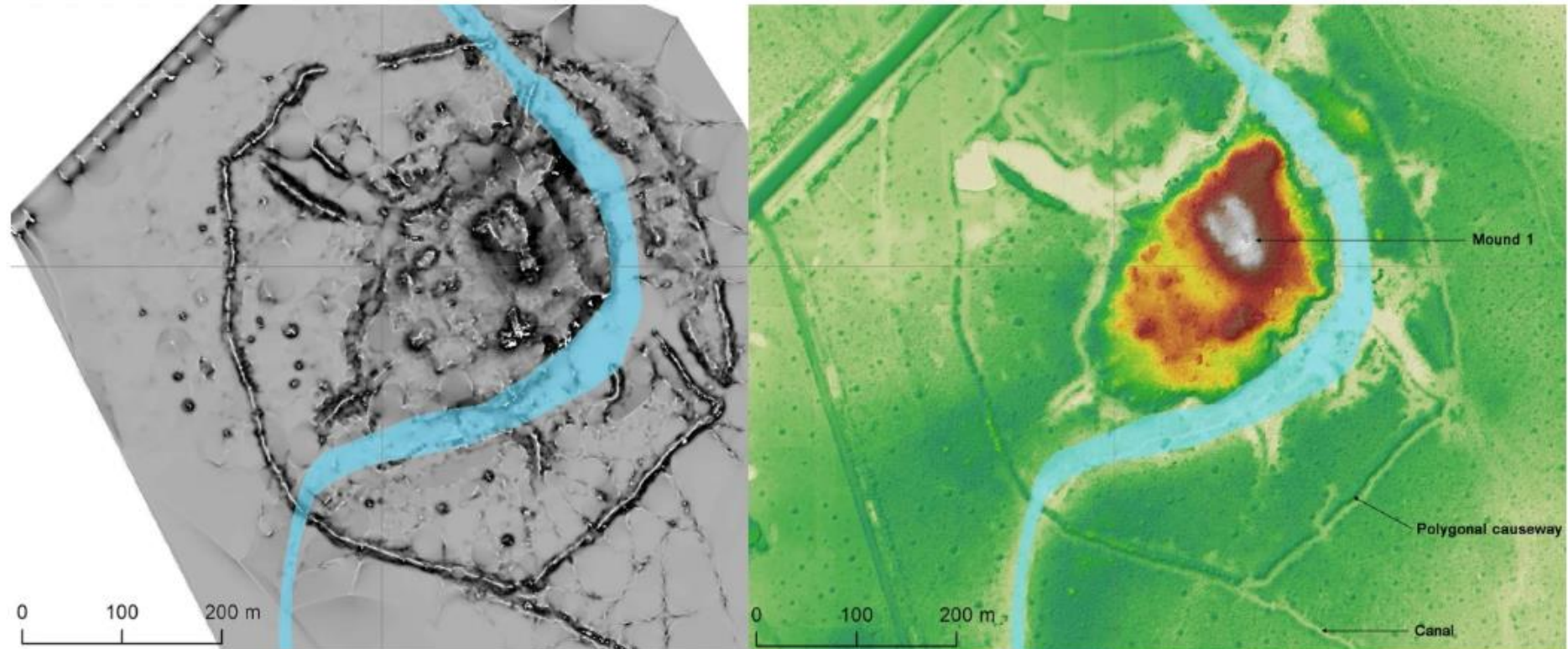


Image Credits: Prümers et al.

- LiDAR –
Surface
Modeling
- Multiple ancient structures that are not easily observable have been rediscovered with LiDAR surface modeling.

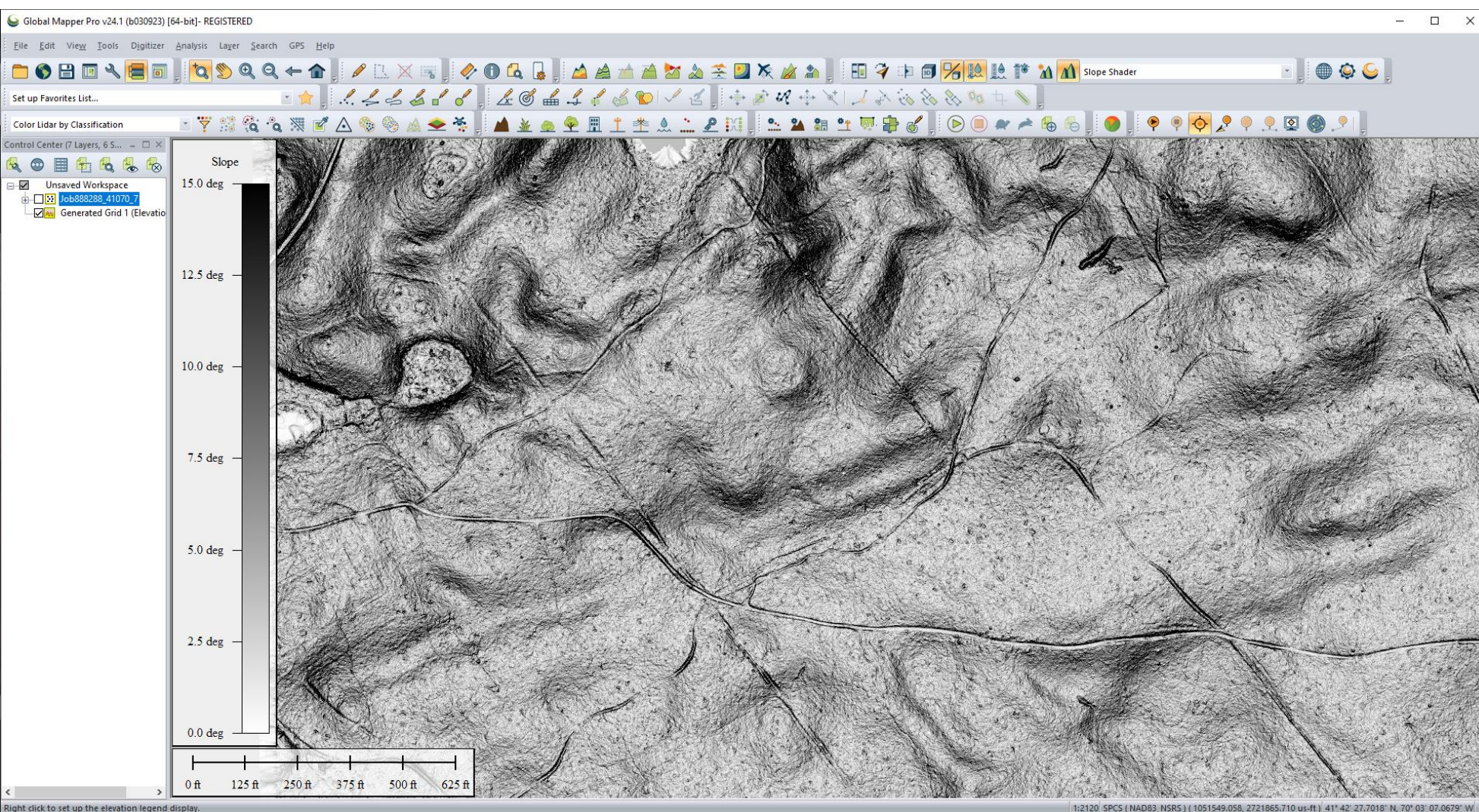
It's Friday and the world is falling apart, so let's just take a short mental health break with some interesting news out of the field of archaeology, where tech is enabling some fascinating new discoveries. [A new lidar-powered analysis](#) of land in the Amazon basin has provided evidence of a previously unknown urban center of “mind blowing” complexity.

UNH Stone Walls

- The University of New Hampshire has a program to define all of the stone walls in their state using aerial LiDAR.

The screenshot displays the 'NH Stone Wall Mapper' web application. The browser address bar shows the URL: `nhdes.maps.arcgis.com/apps/webappviewer/index.html?id=f4d57ec1a6b8414190ca066245...`. The application header includes the title 'NH Stone Wall Mapper' and navigation links for 'NH GRANIT', 'NH Department of Environmental Services', 'Progress to Date', and 'Help'. A search bar at the top right contains the text 'Go to address or point (e.g. -70.5)'. The main interface is split into two panels. The left panel, titled 'Smart Editor', contains a 'NH Stone Walls' feature template with a 'Stone Wall, unverified' entry. Below this is a form with a checked checkbox for 'Use preset values (new features only)'. The form includes input fields for 'User Name' and 'User Email', and a dropdown menu for 'Feature Mapping Source' currently set to 'LiDAR Hillshade'. The right panel shows an aerial LiDAR map of a rural area with numerous pink lines representing stone walls. Labels on the map include 'Center Conway', 'Conway Lake', and 'Snow Brook'. A vertical line on the right side of the map indicates the border between 'NEW HAMPSHIRE' and 'MAINE'. The bottom of the map shows a scale bar, coordinates (-71.090 43.942 Degrees), and the Esri logo with the text 'POWERED BY esri' and 'All rights reserved'.

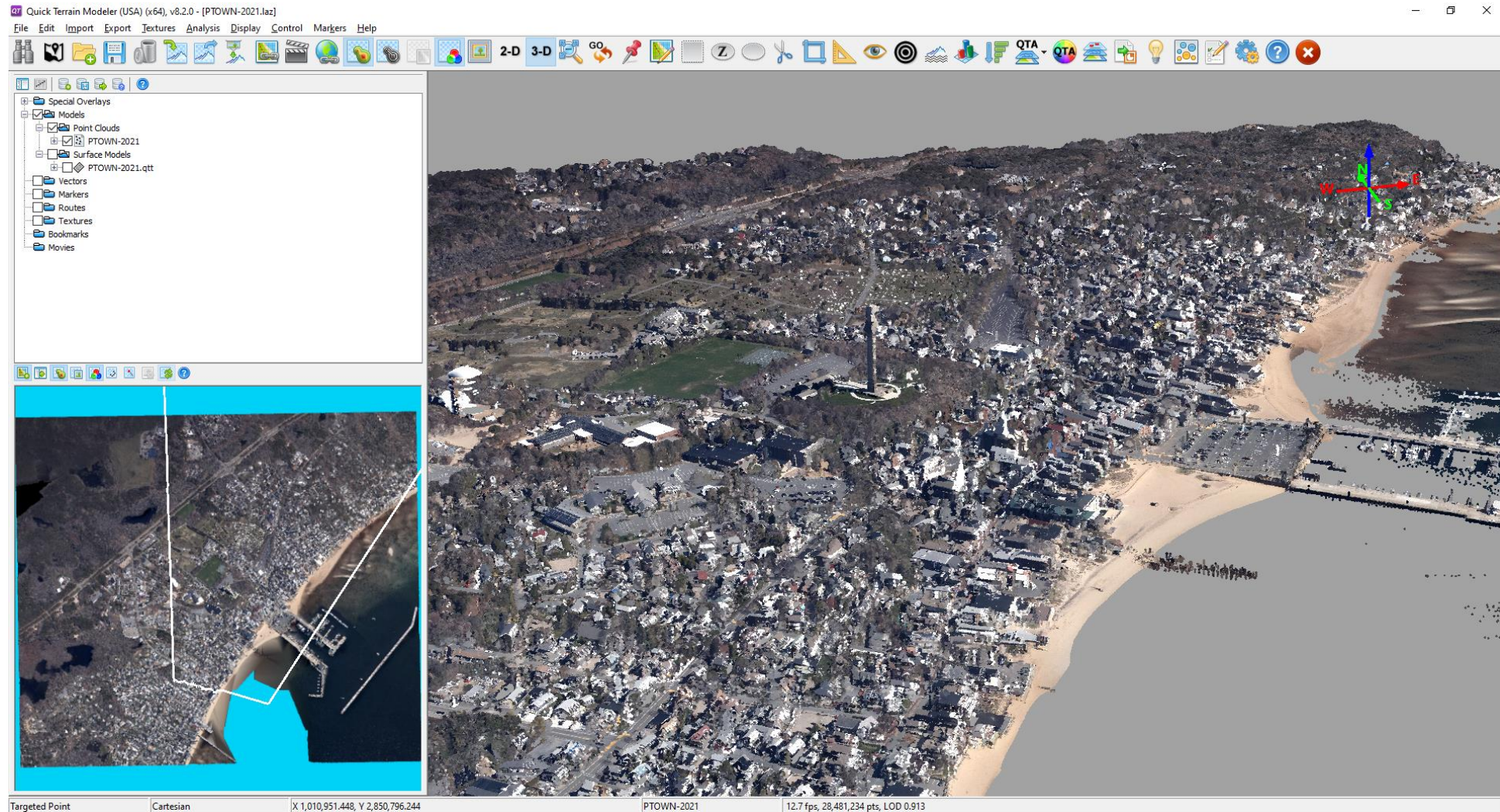
We don't have ancient cities or ancient stone walls south of Route 6.



We do have roads (ancient and recent), paths, ridges, ditches, remnants of old farmed areas and other deviations in the surface model that can be seen. This is Hawksnest State Park in Harwich where many of the original boundaries can be seen in the form of ditches, ridges and roads.

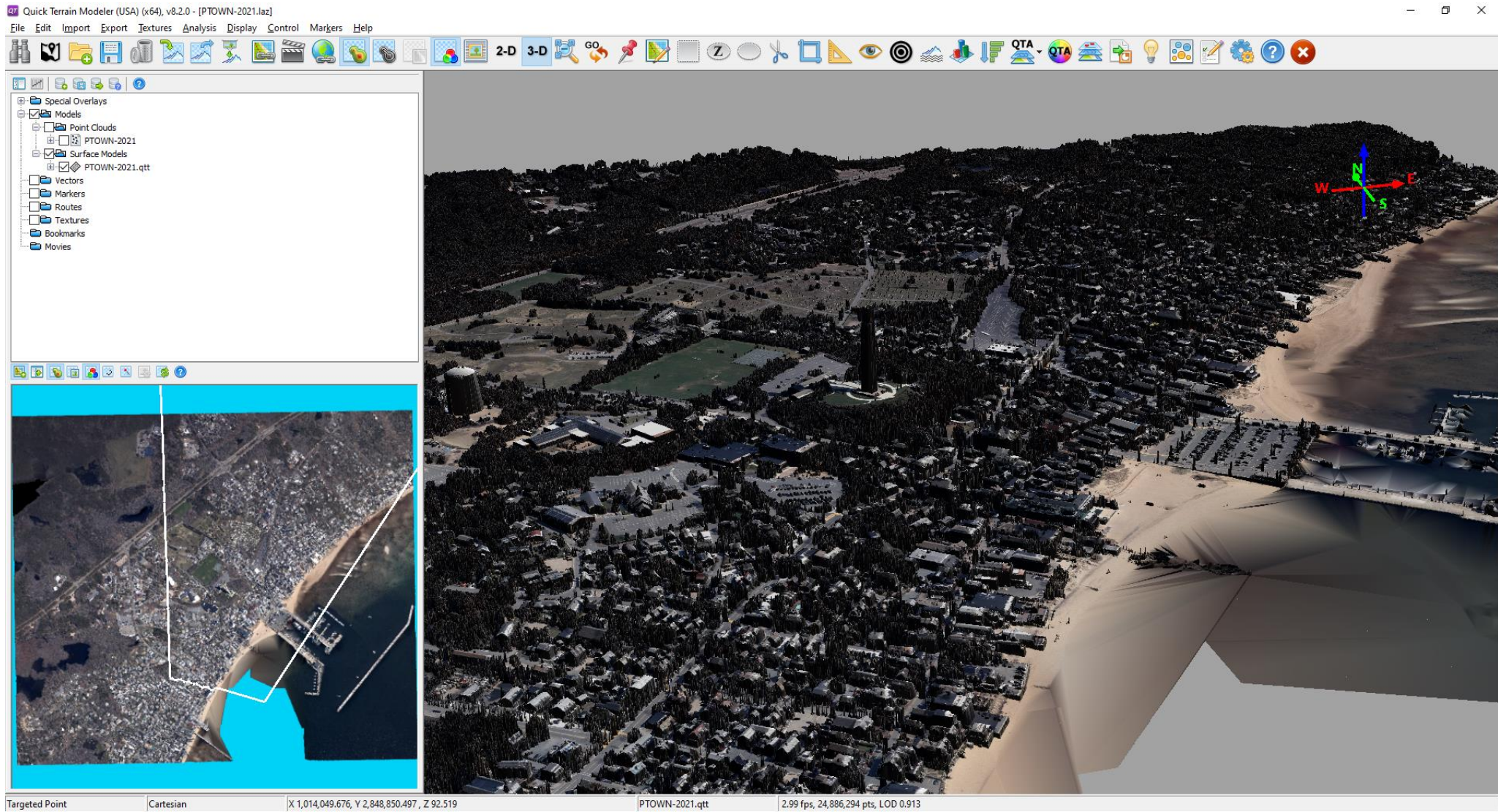
Colorized Point Cloud

2021 USGS LiDAR
2022 USGS Imagery
Colorized Point Cloud



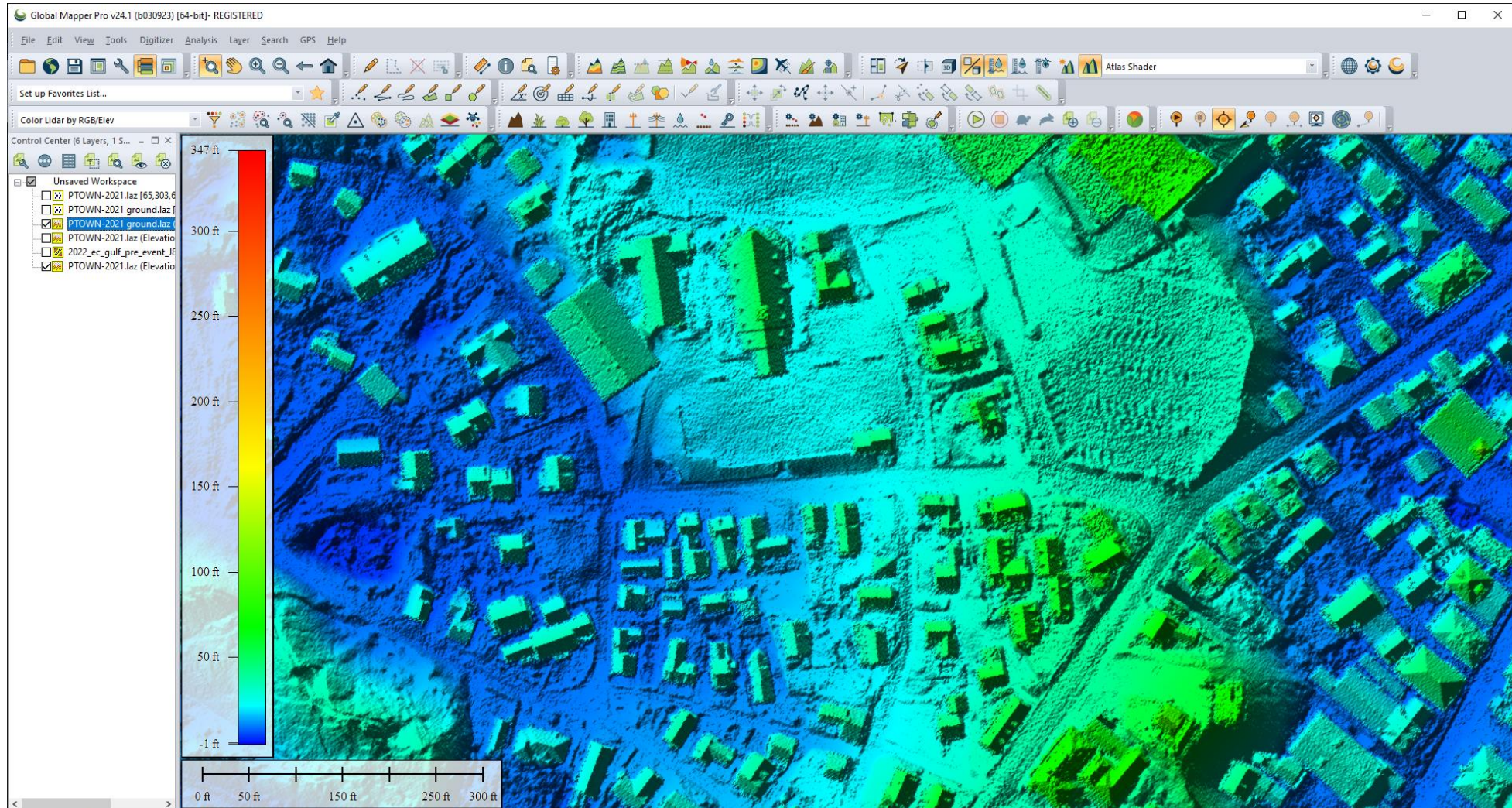
Colorized Surface Model

2021 USGS LiDAR
2022 USGS Imagery
Colorized Surface Model



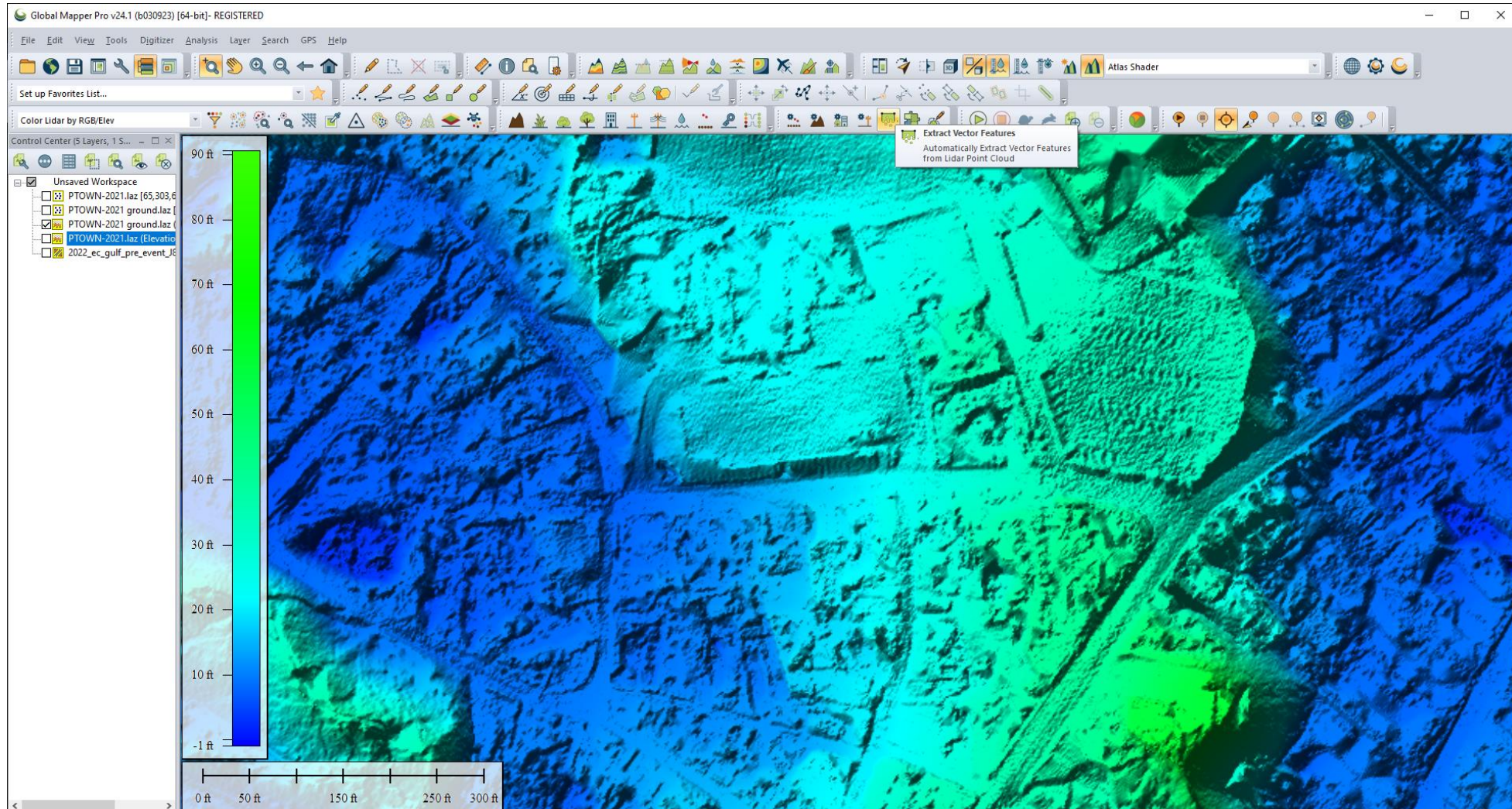
Volumes of Buildings

- Take a surface model that includes only the ground and the buildings.



Volumes of Ground

- Take a surface model based only on the ground points. It fakes in under the buildings based on the elevations around the perimeter of the building.



Volumes

- Compare the volumes of the two surfaces (A-B)

Measure Volume Between Surfaces

Layer Selection: Volume Bounds

Select Elevation Layer to Subtract From

- PTOWN-2021 ground.laz (Elevation Values)
- PTOWN-2021.laz (Elevation Values) bld + ground

Select Elevation Layer to Subtract

- PTOWN-2021 ground.laz (Elevation Values)
- PTOWN-2021.laz (Elevation Values) bld + ground

Volume Units: cubic feet

Drag a Box to Select Export Bounds

Hold down the SHIFT key when dragging to select a square box

Zoom In Zoom Out

Volumetric Calculations

Total Volume Between Surfaces: 180449.84 cubic feet

Cut Volume: 104.48608 cubic feet
Cut 2D Surface Area: 7127.3 sq ft
Cut 3D Surface Area: -

Fill Volume: 180345.35 cubic feet
Fill 2D Surface Area: 17581 sq ft
Fill 3D Surface Area: -

LAYER_COMPARE: PTOWN-2021 ground.laz (Elevation Values)
LAYER_BASE: PTOWN-2021.laz (Elevation Values) bld + ground
REPORT_TIME: 7/23/2023 4:01:19 PM
AVG_Z_DELTA: -7.2946 ft
MAX_Z_DELTA: 0.3473 ft
MIN_Z_DELTA: -35.4843 ft

The measurements have also been copied to the clipboard for your convenience.

OK Cancel Help

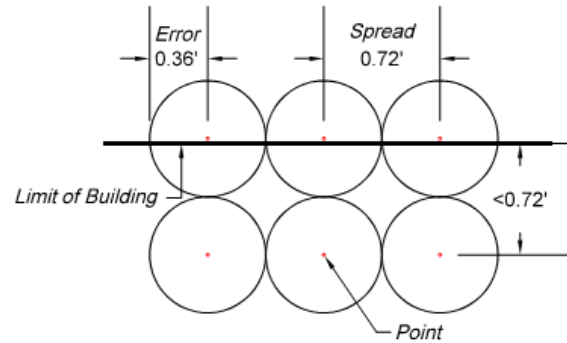
PTOWN-HACKS Provincetown Guide

Images may be subject to copyright

Google Earth

Imagery Date: 10/2019 42°03'04.40" N 70°11'25.43" W elev 30 ft eye alt 27 ft

How close can we compute?



We take a homogenous group of points in that they are equidistant and the regular pattern is aligned with an edge of a building. We provide two extreme scenarios:

1. The points fall within a minimal distance of the edge of the building. For ease we will call this dimension 0.
2. One string of points fall just outside of the building, then the next row falls just under 0.72'. For ease we will call this 0.72'.

The horizontal error is disregarded since it would follow a normal distribution and compensate to null.

Building w/o overhangs		Area	Low			Percentage
20	40	800 S.F.	18.56	38.56	715 S.F.	89.4%
30	50	1500 S.F.	28.56	48.56	1387 S.F.	92.4%
40	80	3200 S.F.	38.56	78.56	3029 S.F.	94.7%
Building w/ 6" overhangs on lengths.						
20	41	800 S.F.	18.56	39.56	734 S.F.	91.8%
30	51	1500 S.F.	28.56	49.56	1415 S.F.	94.3%
40	81	3200 S.F.	38.56	79.56	3067 S.F.	95.9%
Building w/ 12" overhangs on lengths.						
20	42	800 S.F.	18.56	40.56	753 S.F.	94.1%
30	52	1500 S.F.	28.56	50.56	1444 S.F.	96.2%
40	82	3200 S.F.	38.56	80.56	3106 S.F.	97.1%

The best case scenario is the measurements are pretty close to perfect. The worst case scenario is somewhere above 90% depending on the size of the structure.

The horizontal and vertical errors are disregarded as they would follow a normal distribution and given the large enough sample set will average out to the desired point. So we review the maximum recorded distance based on the spread. If the returned point is about 0.72' from the edge of the building then the area will decrease and thus the computed volume will decrease.

All buildings have overhangs and the LiDAR acquires eaves, gutters, drip edges and other projections. The distribution of points will be closer that the extremes so as a rule of thumb these volumes will typically be better than 95% with a \pm of 5%.

95% \pm 5%

There is quite a bit more, but we have to save something for another day.



Provincetown
Monument,
Provincetown,
MA
Ground Surface
with Points for
non ground
objects.