

# **Scene-specific collection planning for a Geiger-mode lidar system with georeferenced scanning**

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# What is Scene Specific Collection Planning?

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Determining how to operate the sensor in the most efficient way based on the characteristics and content of the particular area of interest.

## Why is it important?

Efficient lidar collection planning balances the cost of overcollection (flight time and processing time) with quality of product (point density, spatial resolution, and signal-to-noise ratio) required to meet customer needs.

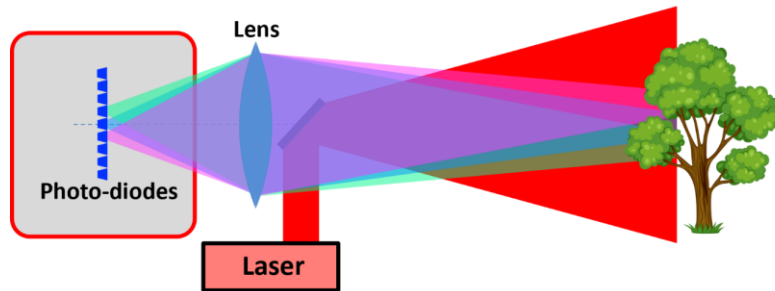
## What are some important scene characteristics?

- Surface reflectivity (different materials)
- Scene complexity (obscuration from buildings and foliage)
- Shape and size of the area of interest

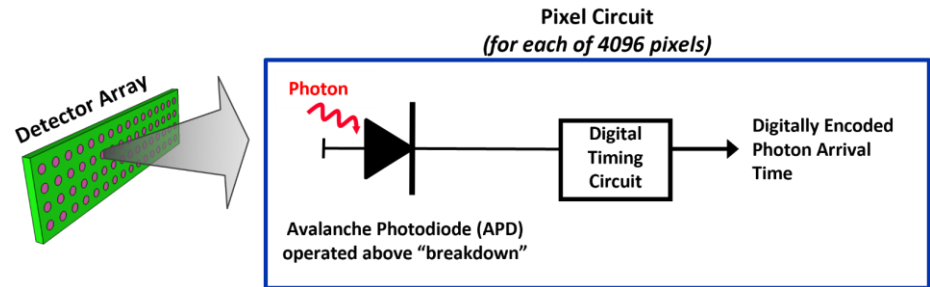
# What is Geiger-mode Lidar?

Geiger-mode lidar receivers utilize an array of pixels to digitize the time-of-arrival of individual photons reflected from a target scene.

## Flood illumination, array receiver



The laser flood illuminates the scene. The returned light is imaged onto an array of single-photon sensitive detectors. Each pixel has its own field of view.



When a photon is incident on a pixel, it can cause an avalanche of electrons, which triggers a digital timing circuit to record the photon time of arrival.

# What is Compelling About Geiger-mode?

With any lidar system, you need enough signal (SNR) to overcome the noise sources in order to have high confidence that the resulting 3D point represents a real surface.

**Linear-mode lidar** collects enough photons in each pulse to exceed the noise threshold and detect peaks in the signal.

**Geiger-mode lidar** has noiseless readout, signal photons can be distributed over many pulses, then aggregated.

*Geiger-mode has other noise sources, such as dark count rate (DCR), ambient light, and crosstalk.  
But the pixel readout process is noiseless.*

With Geiger-mode lidar, we need an average of 10 detections ( $N_{det}$ ) per bin to make a confident surface estimation.

These detections can come from different laser pulses and multiple viewing geometries.

# Georeferenced Scanning

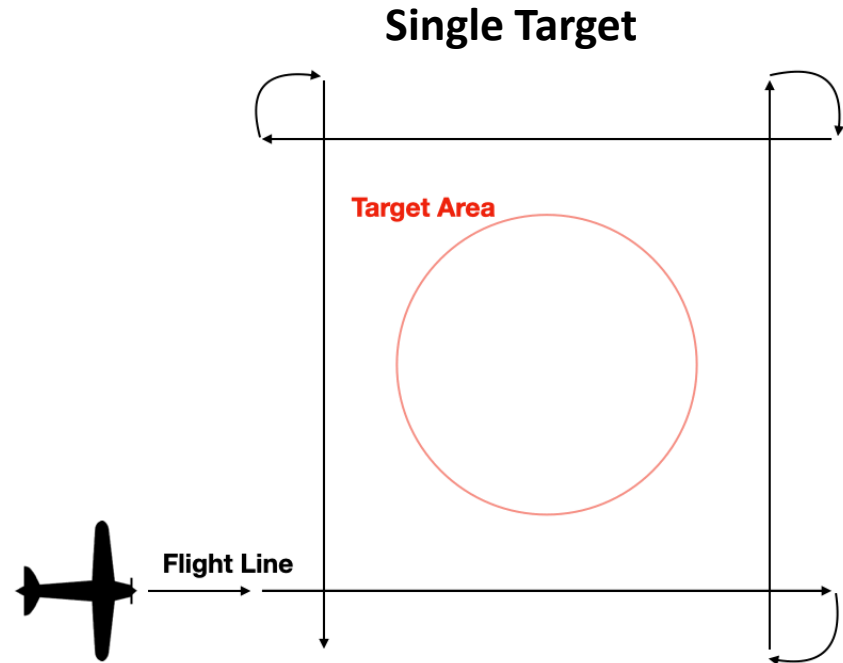
Georeferenced scanning allows us to direct the laser energy at specific areas of interest on the ground and control the viewing geometry.

Point and scan anywhere within a 40 x 40 deg field-of-regard

Scan polygons are defined in geographic coordinates

System automatically scans the polygons that are in view

System capability is concentrated on the region of interest



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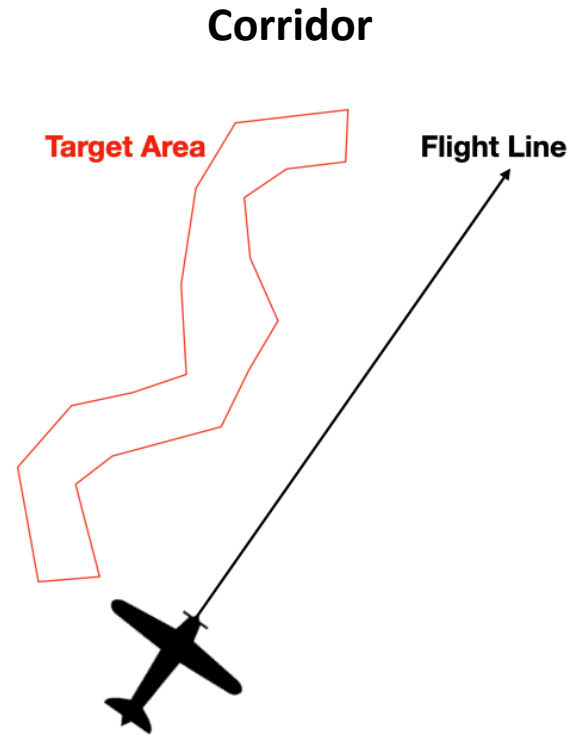
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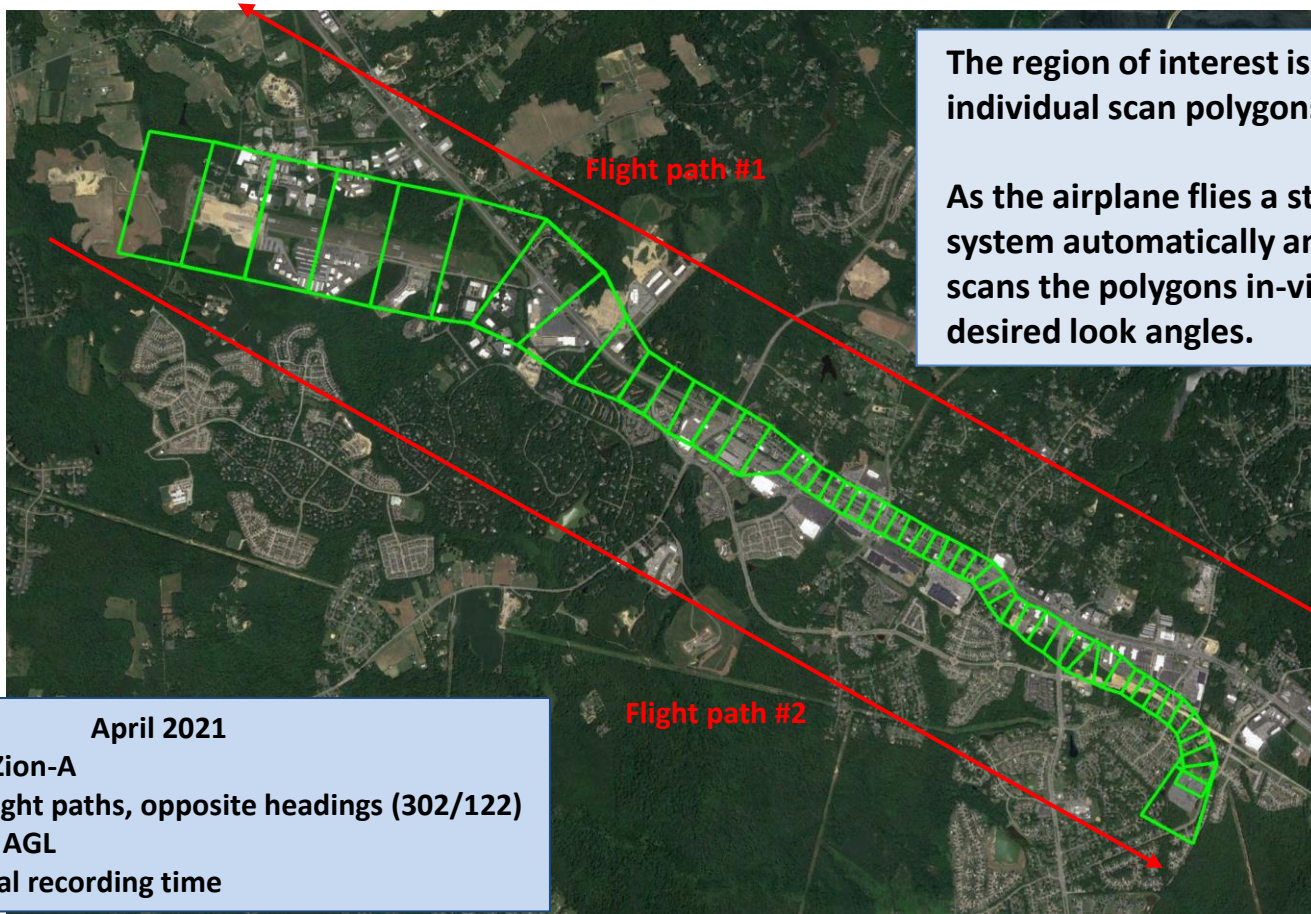
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# Corridor Mapping Example

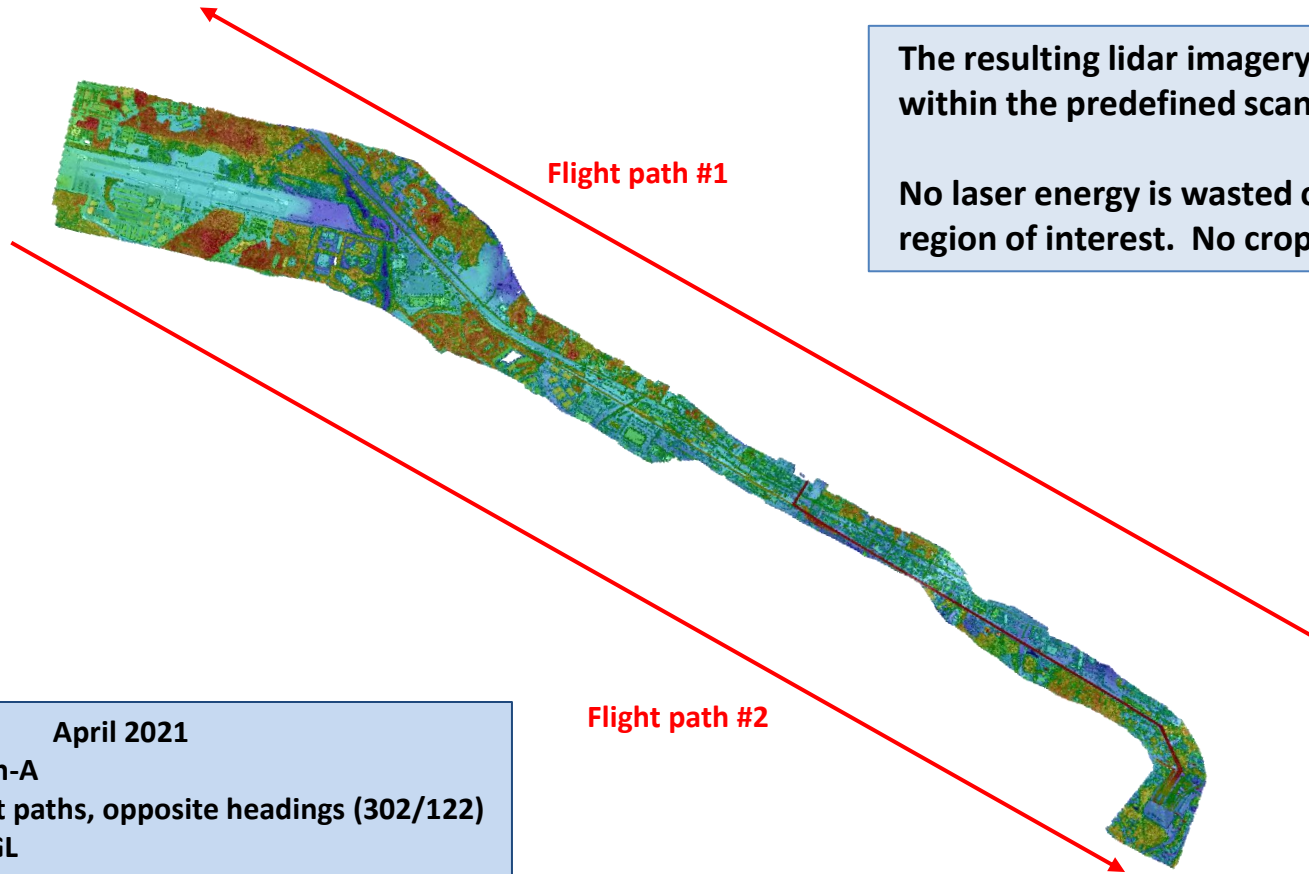


The region of interest is divided into individual scan polygons.

As the airplane flies a straight line, the system automatically and repeatedly scans the polygons in-view, to achieve the desired look angles.

California, MD      April 2021  
Sensor: 3DEO Zion-A  
Two straight flight paths, opposite headings (302/122)  
Altitude: 10kft AGL  
<6 minutes total recording time

# Corridor Mapping Example



The resulting lidar imagery is contained within the predefined scan boundaries.

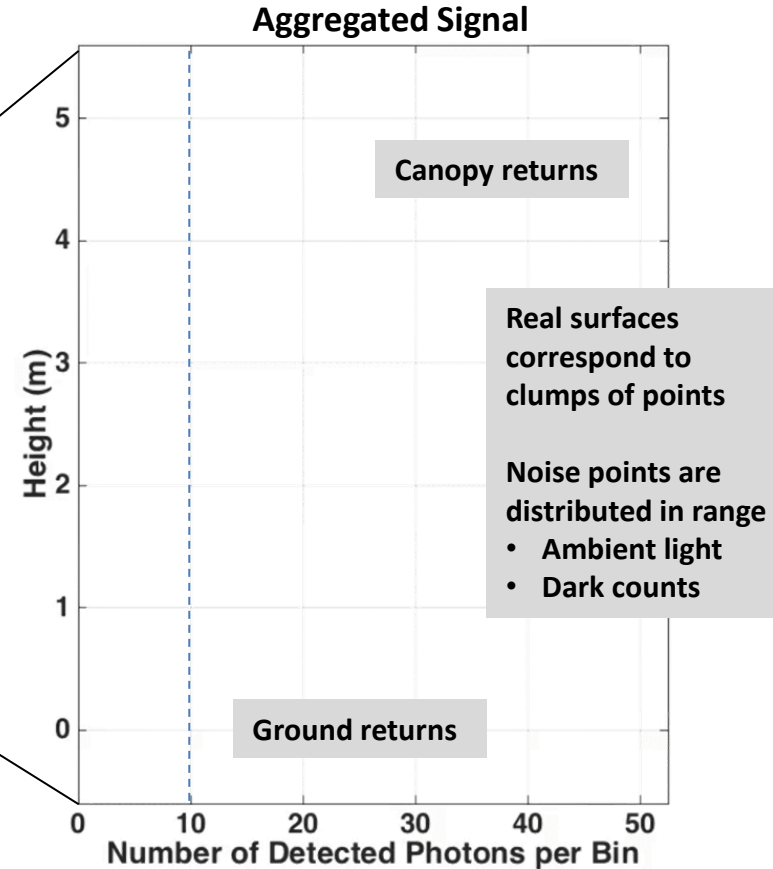
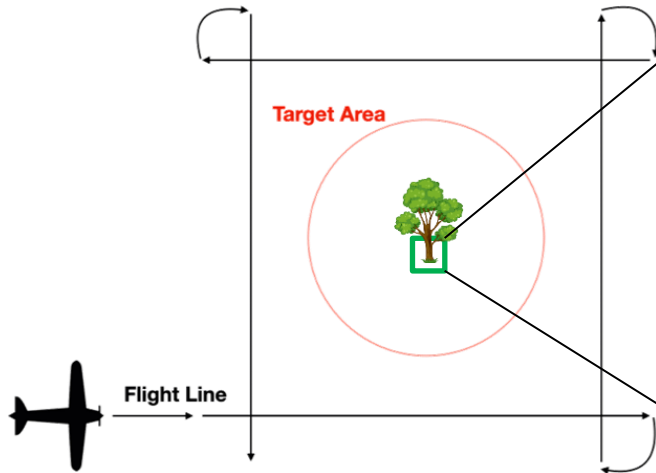
No laser energy is wasted outside the region of interest. No cropping is needed.

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# Aggregate Returns from Multiple Look Angles

The Geiger-mode receiver and georeferenced scanning system are combined to provide flexibility in sampling a collection area and how the signal is accumulated to produce the desired product.



# Forestry Example

## Scene Considerations

- High obscurations from foliage
- Need enough signal density (PPSM) on the ground for a bare earth model
- Want to image all sides of tree trunks

## Collection Planning

- Divide the scene into 150 x 400m polygons
- Aggregate weak returns from the ground over many laser pulses
- Use multiple look angles to probe gaps in canopy
  - Scan each polygon from six look angles
  - 50% swath overlap, 3 look angles per swath



# Forested Area With Power Lines

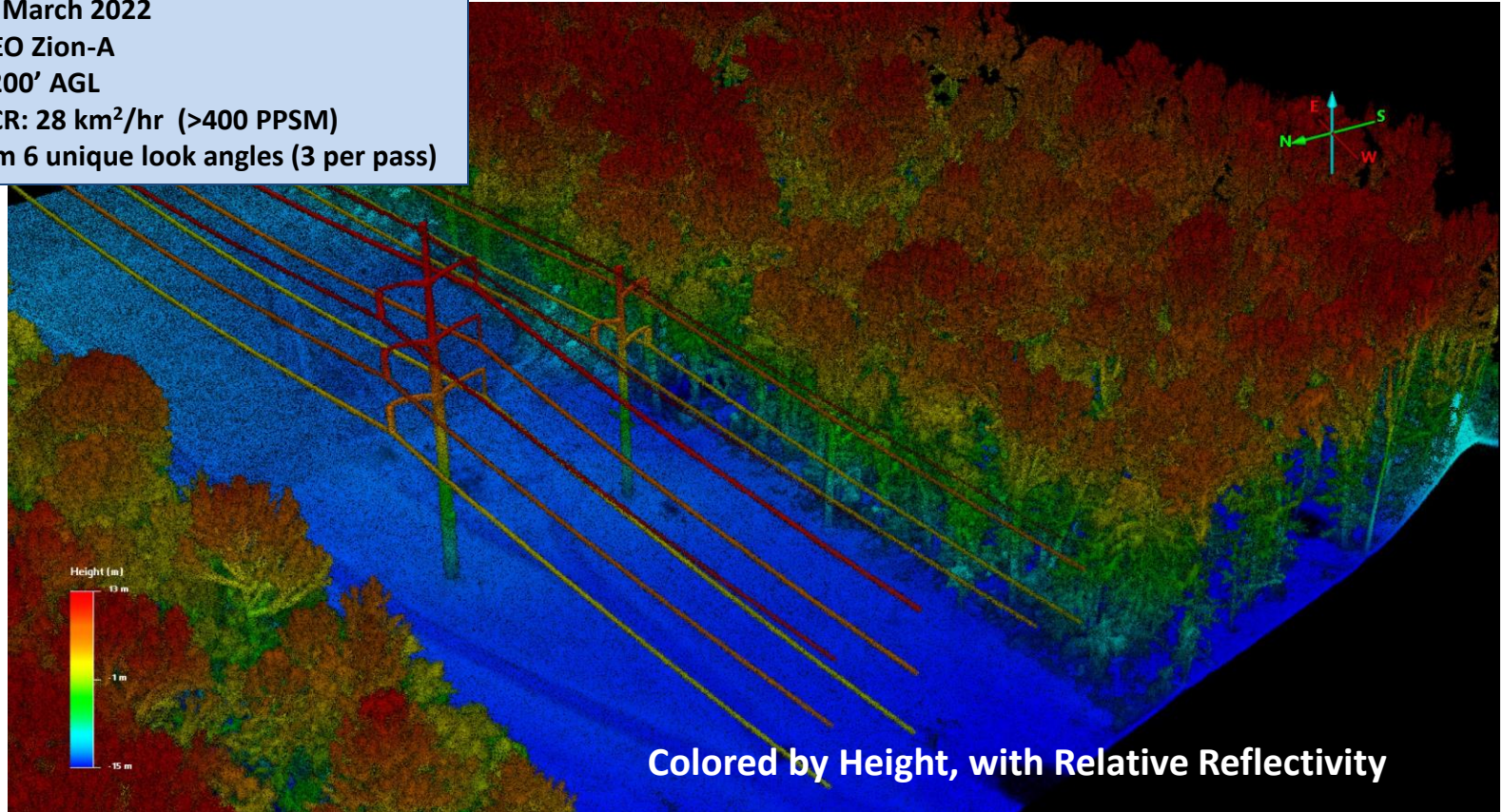
Delaware March 2022

Sensor: 3DEO Zion-A

Altitude: 3200' AGL

Effective ACR: 28 km<sup>2</sup>/hr (>400 PPSM)

Imaged from 6 unique look angles (3 per pass)





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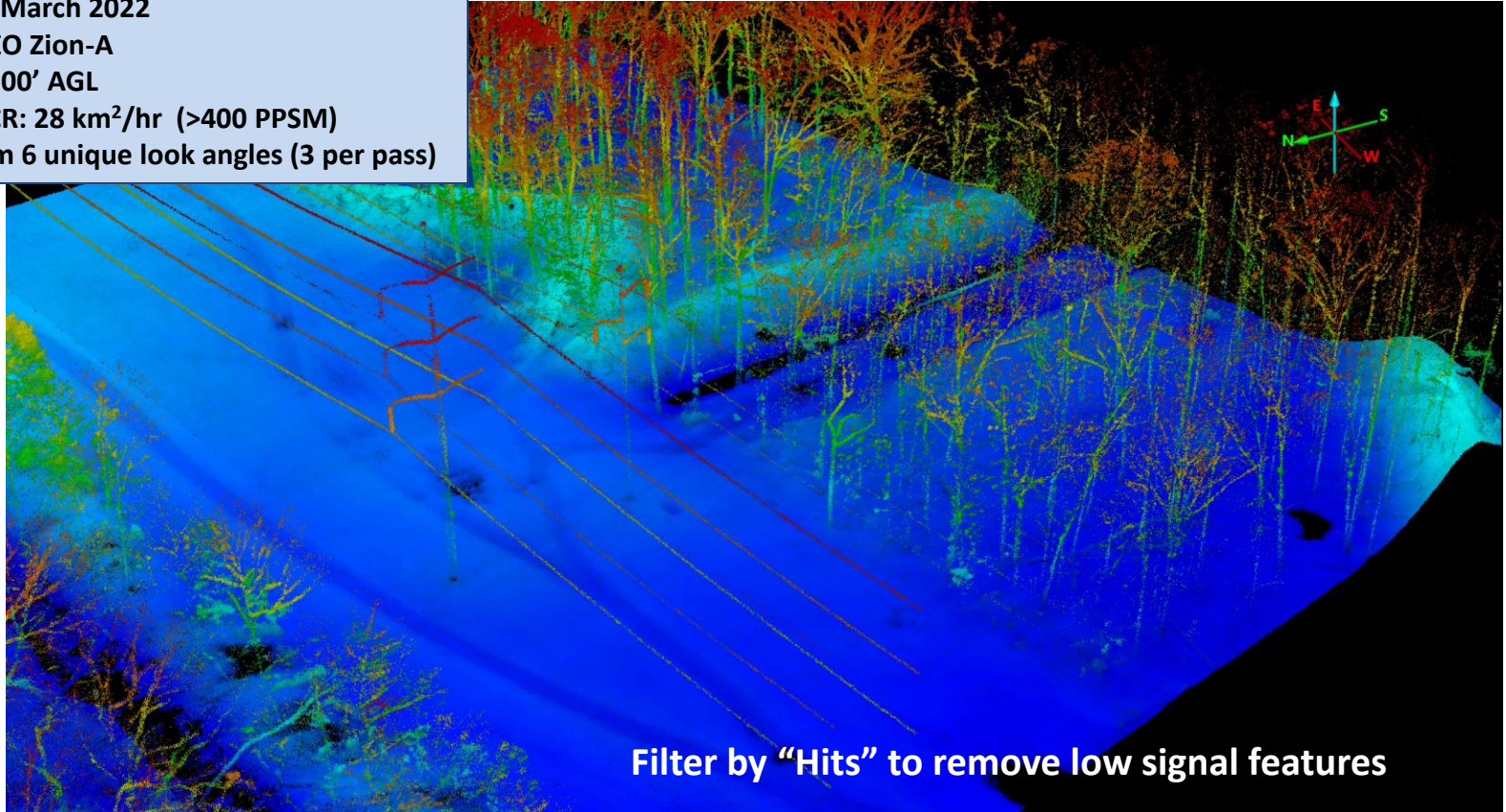
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Filter by "Hits" to remove low signal features

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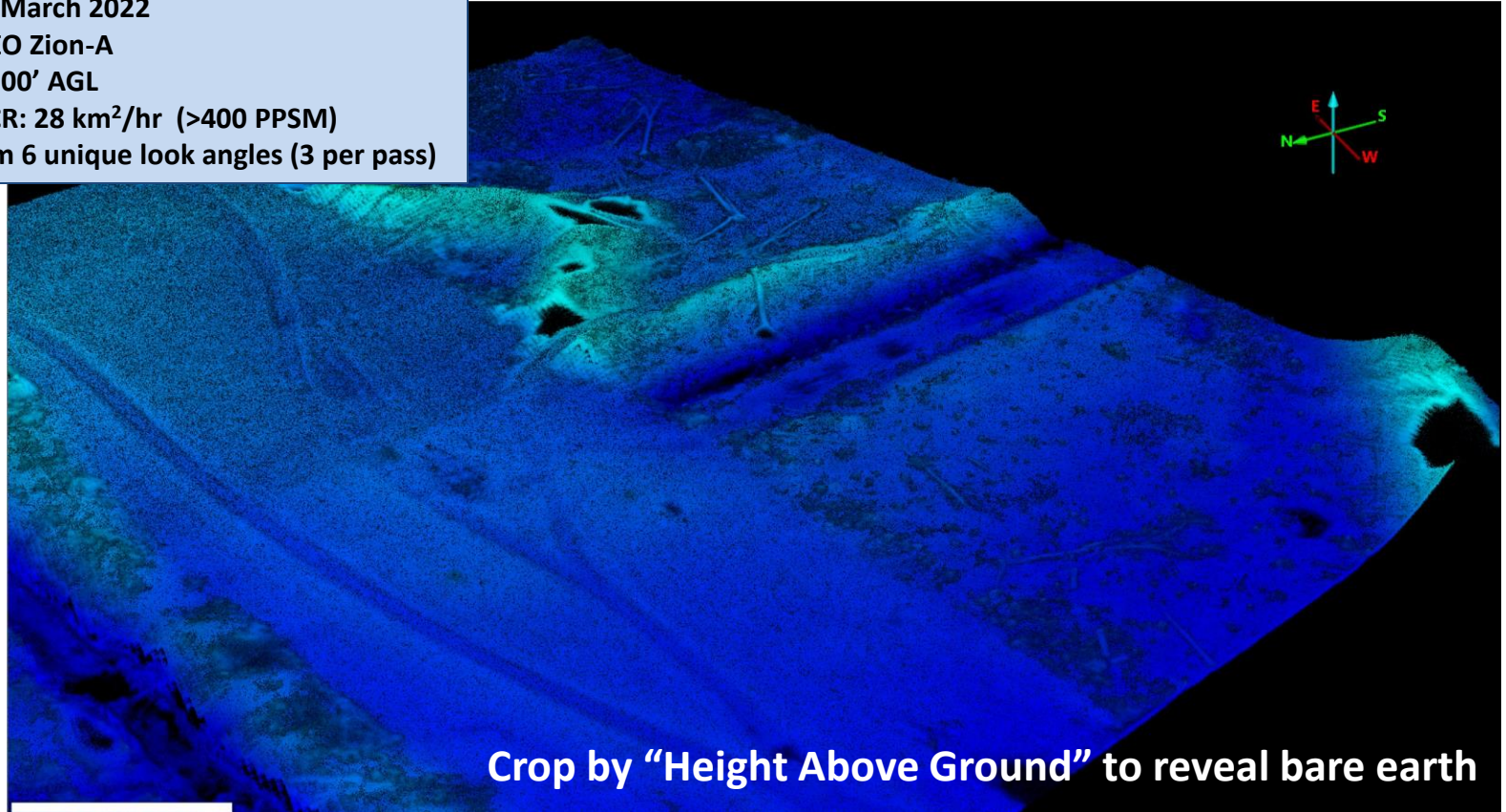
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Crop by "Height Above Ground" to reveal bare earth



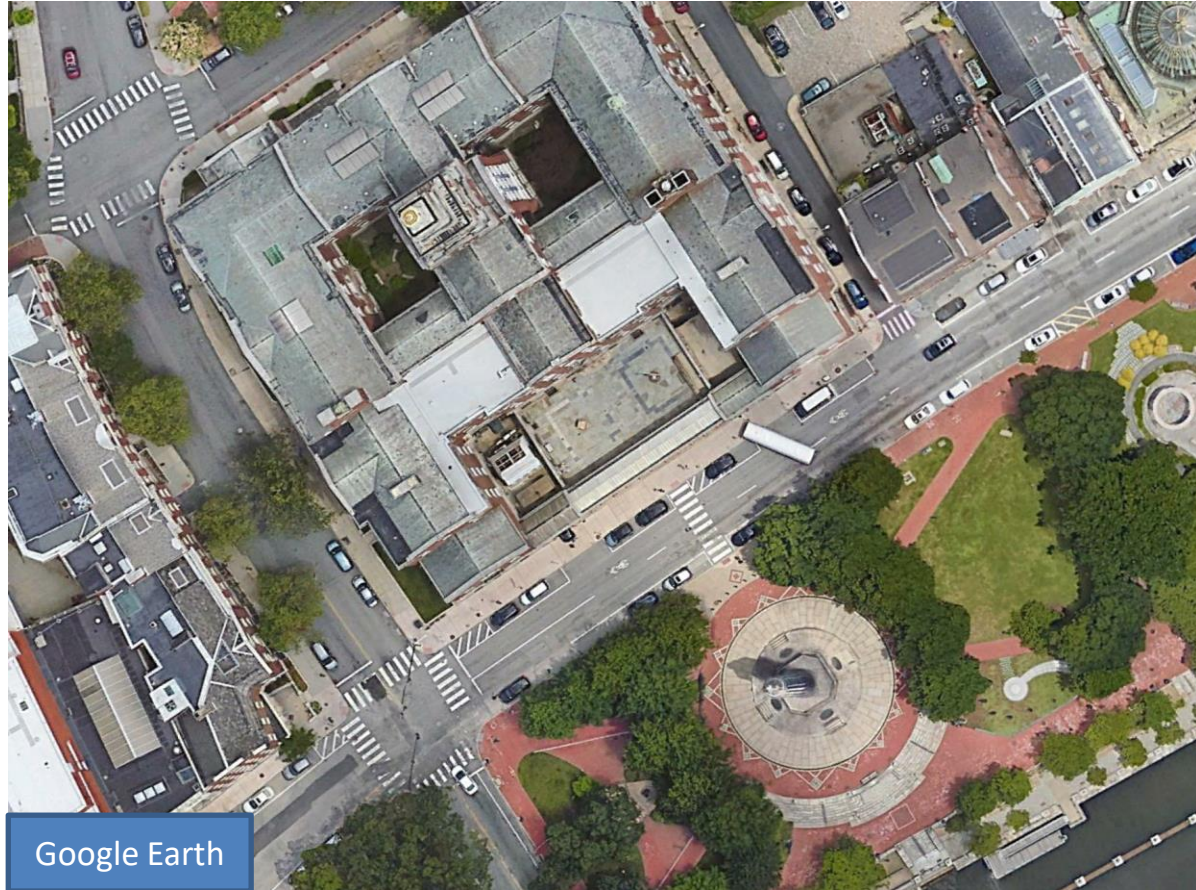
# Urban Mapping: a Matter of Perspective!

## Scene Considerations

- Variations in reflectivity
  - Different surface materials
- Fine details require high spatial resolution
- Obscurations from buildings
- Want to image sides of buildings and into the courtyards

## Collection Planning

- Collect at least 3 scans per pass
- Each scan images the building from a different perspective
- Aggregate all scans together to produce a complete 3D representation



Memorial Park, Providence, RI

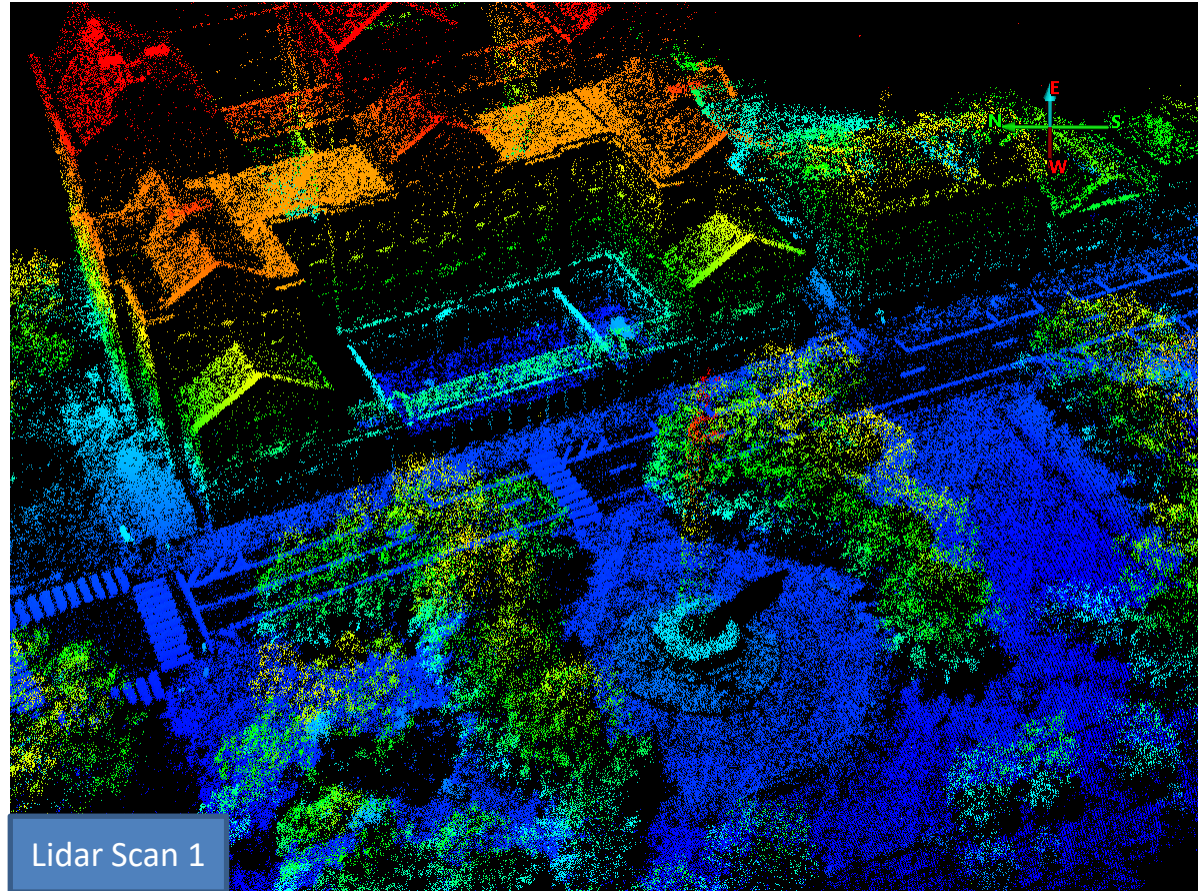
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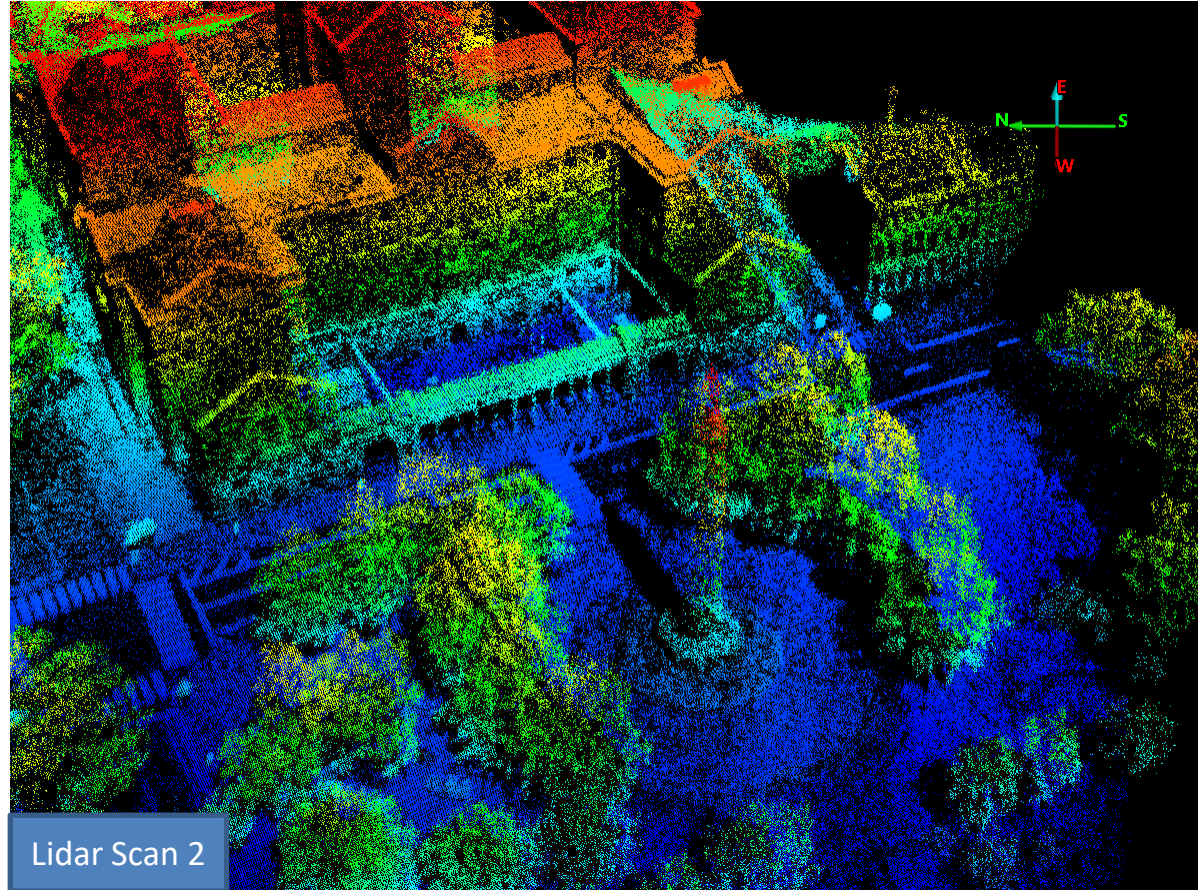
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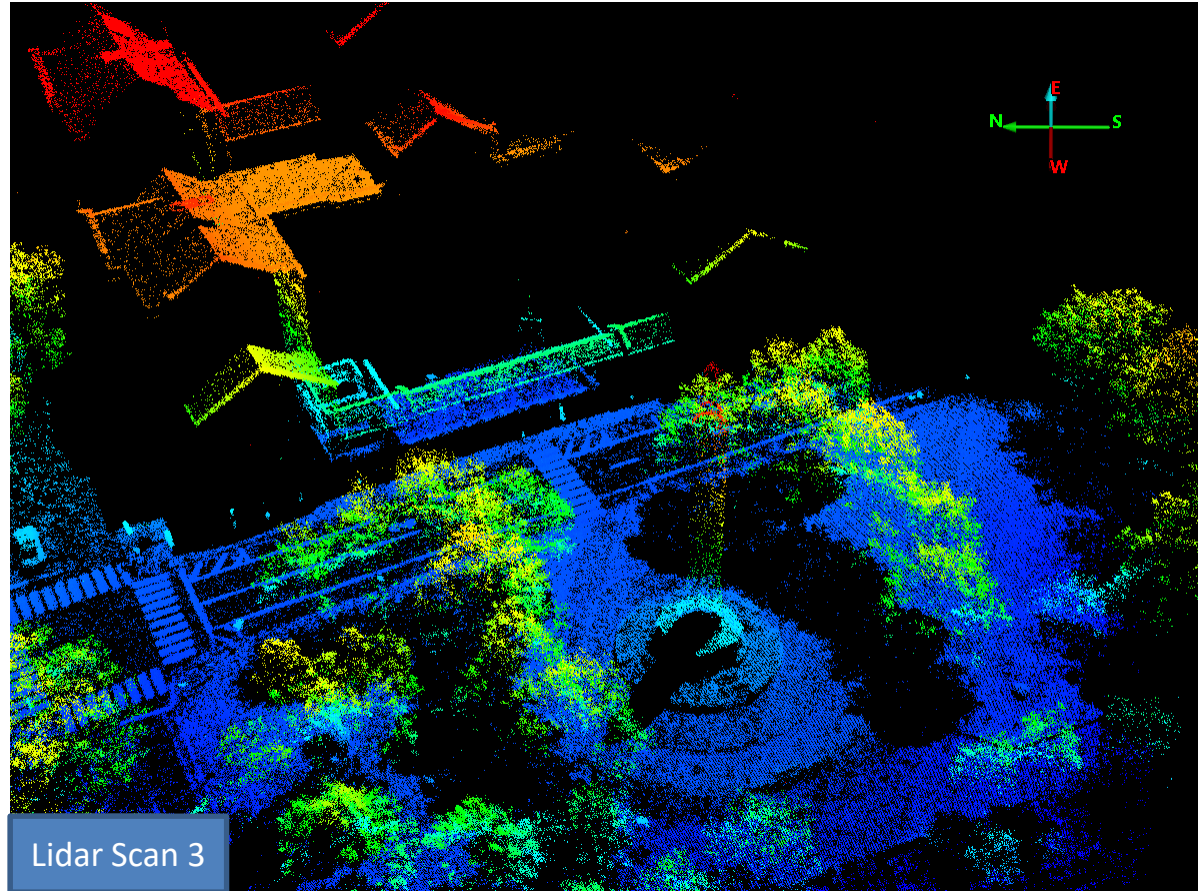
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Lidar Scan 3

Memorial Park, Providence, RI

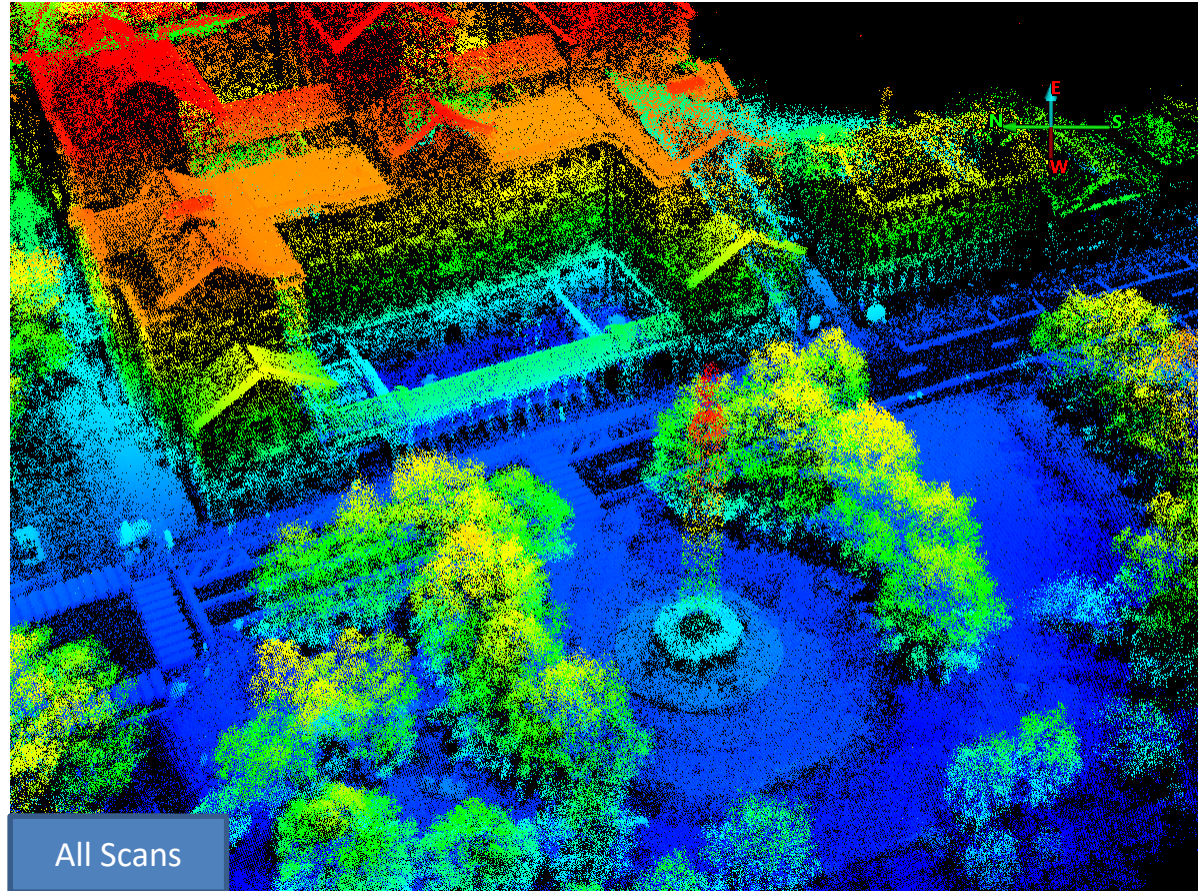
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All Scans

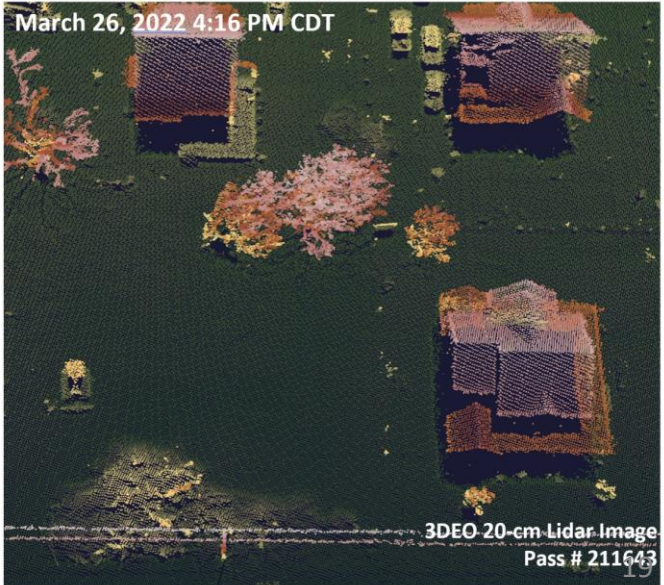
Memorial Park, Providence, RI



# Disaster Response Example

A devastating EF-3 tornado struck parts of New Orleans on the night of Tuesday, March 22, 2022.

3DEO responded by dispatching our aircraft and crew from Maryland to collect high-resolution lidar imagery of the affected areas.



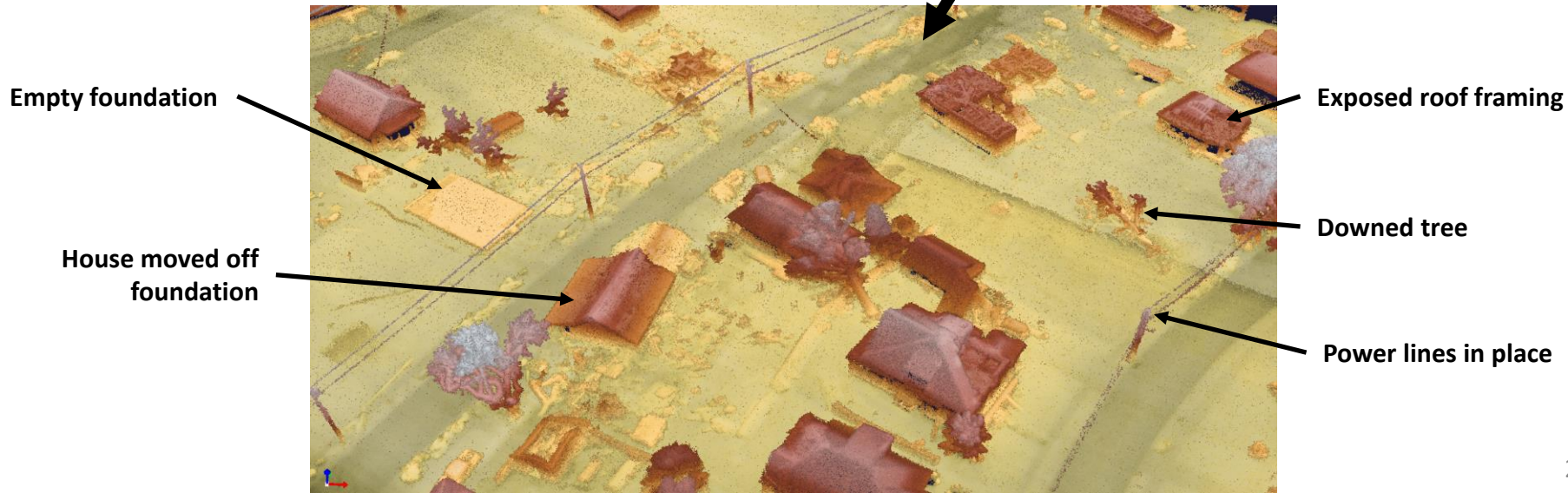


# New Orleans Mapping Example (Zion-A)

**Mission:** Map damage in tornado path through New Orleans.

**Collected area:** 40 km<sup>2</sup> at 13 cm resolution and 500 PPSM.

**Collection time:** 66 minutes on station



# Summary

**Geiger-mode lidar allows us to distribute the required signal over different laser pulses and viewing geometries.**

**Georeferenced scanning concentrates the system capability of the region of interest and allows us to control the viewing geometry.**

*Together these capabilities enable flexible, efficient lidar collections of complex scenes*