

HPA Tech Retreat 2019

UAV (Drone) Photogrammetry Techniques to Create Point Cloud Scenes



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Creating point cloud scenes

- Photogrammetry Introduction
- Point cloud creation algorithms
- UAV / UAS Image Capture
- Operational considerations
- Examples



Photogrammetry

- Introduction

- Science of making measurements from photographs
- Creating maps from aerial photography
- Satellite, flights and now drones
- “Orthophotograph”
 - Geometrically corrected for lens distortion and acquisition angle
- “Orthomosaic”
 - A composite picture created from mosaic of geometrically corrected images
- “Geo-referenced”
 - Aligned with latitude and longitude values



Photogrammetry Introduction

- Rectifying Enlarger



Photo by Wayland Mayo

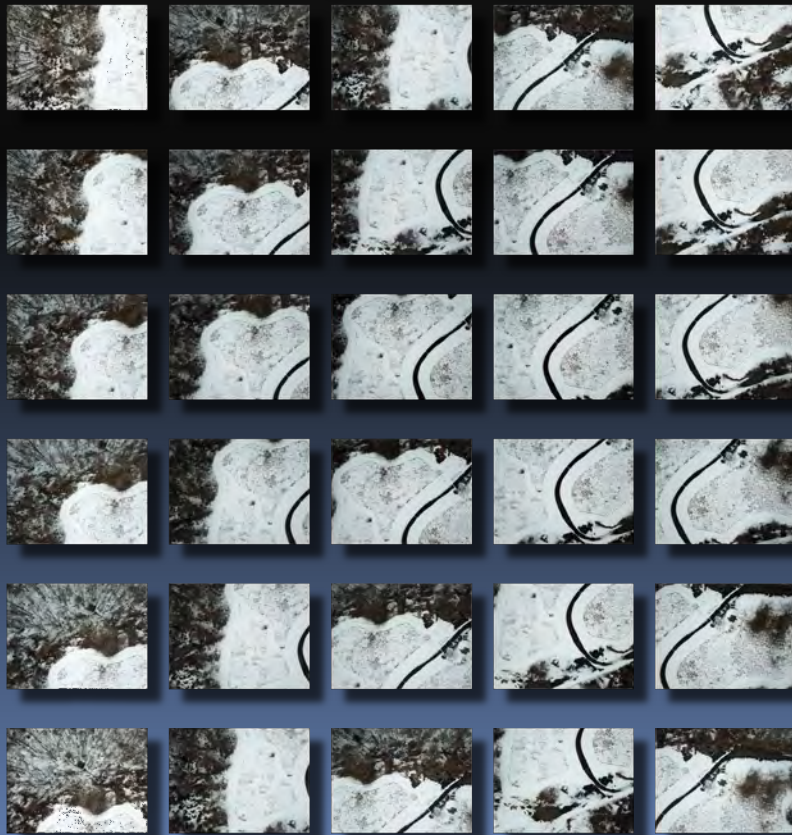


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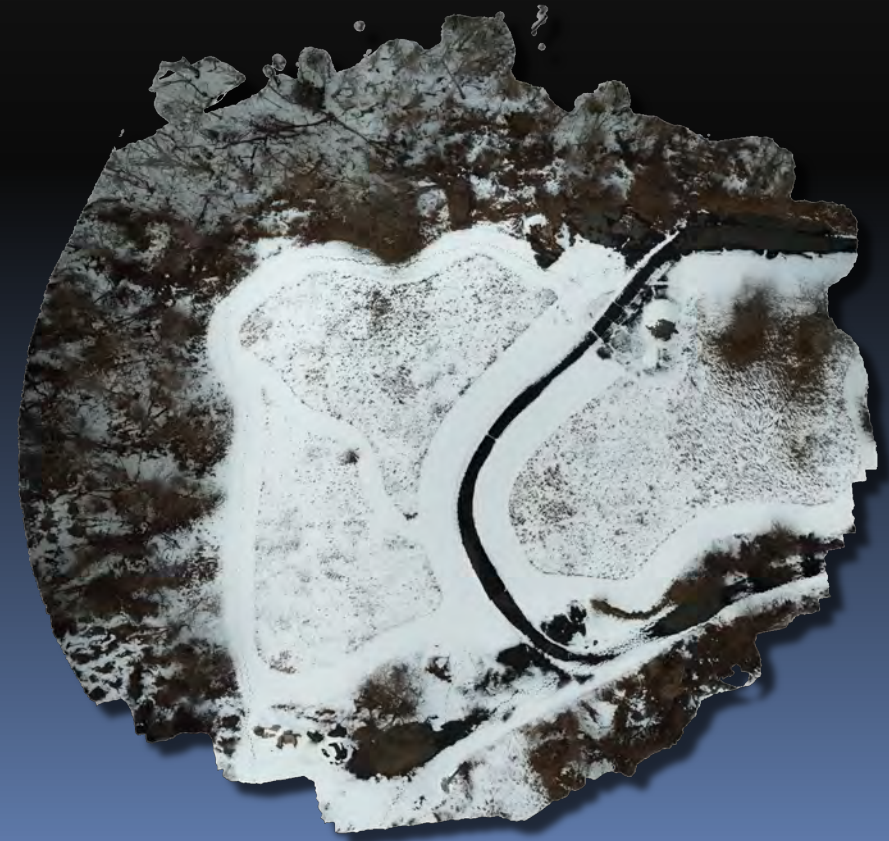
Photogrammetry Introduction

- Orthomosaic example

Original Images



Orthomosaic



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Photogrammetry Introduction

- Depth Information
 - Stereoscope

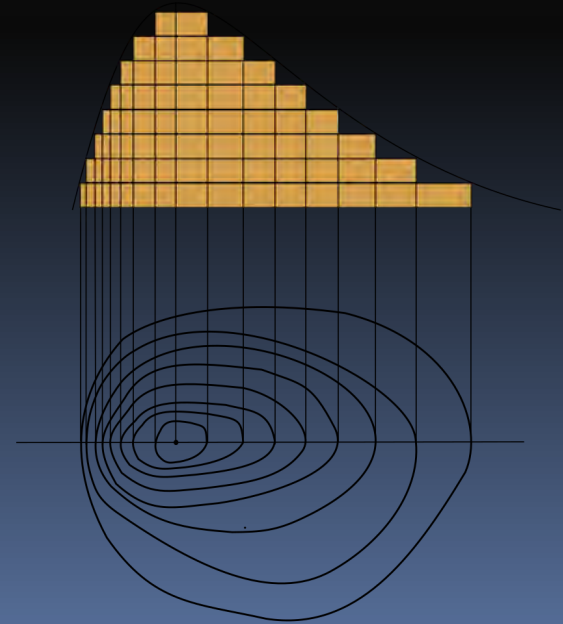


Photogrammetry Introduction

- Depth information
 - Stereo plotter



"Alpha 2000 analytical stereoplotter"
from USGS.gov by CC BY 3.0



"Elevation lines principle"
commons.wikimedia.org/wiki/File:Courbe_niveau.svg by CC BY-SA 3.0



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Photogrammetry Introduction

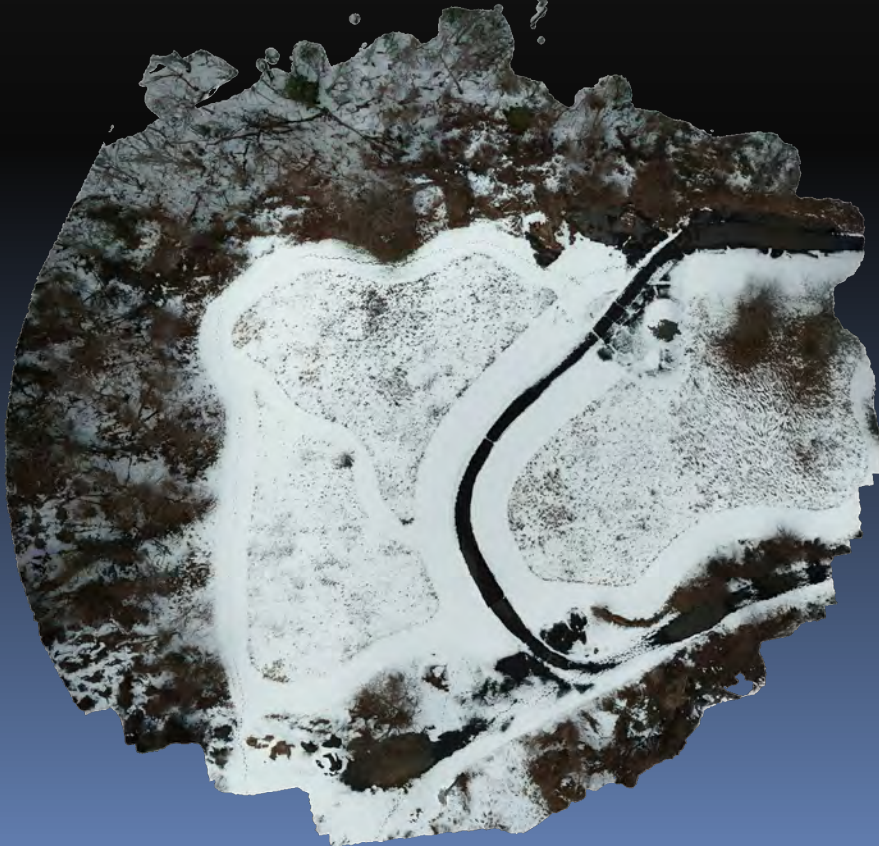
- DSM “Digital Surface Model”
 - Constructed algorithmically from a series of digital photographs
 - Another common digital mapping product
 - 3D CG representation of a terrain's surface
 - Elevation from analysis of series of aerial photographs
 - Subsets of DSM
 - Digital Terrain Model
 - Digital Elevation Model



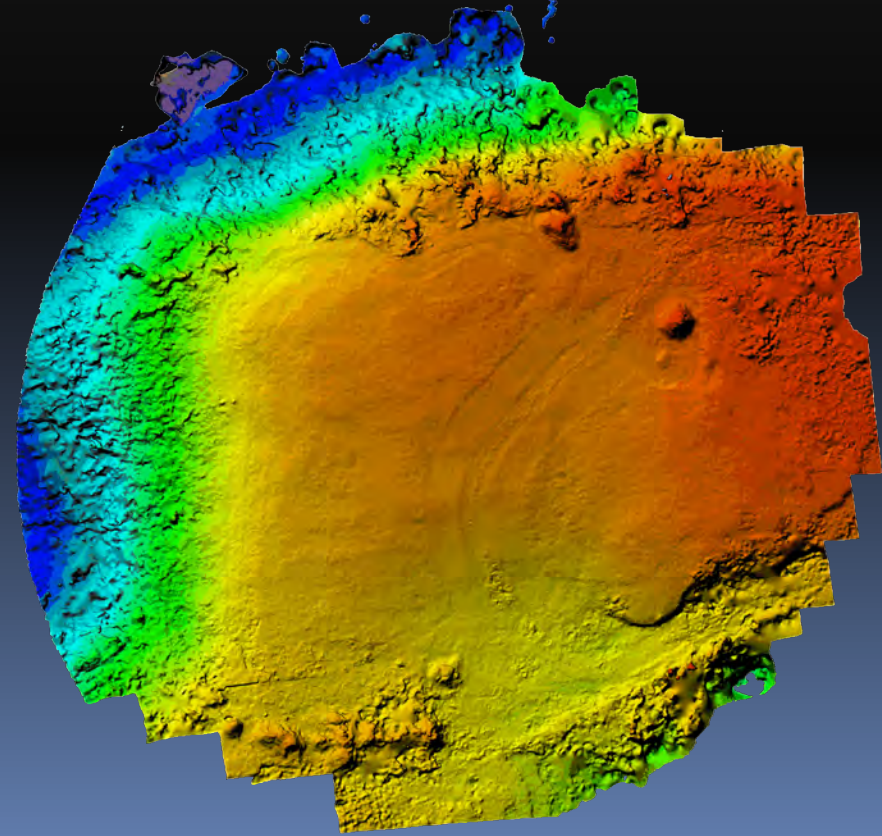
Photogrammetry Introduction

- DSM “Digital Surface Model”

Orthomosaic

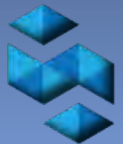
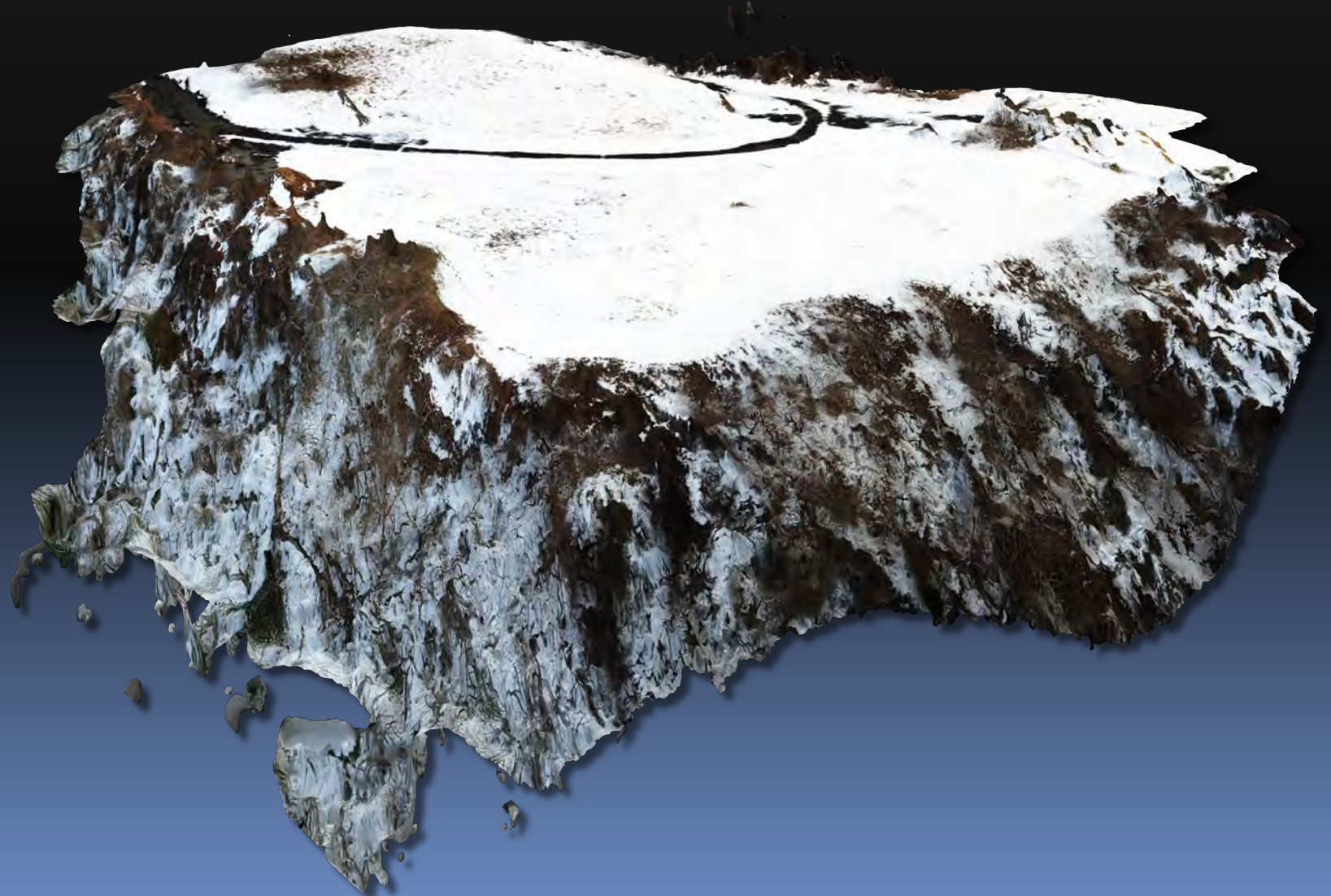


Digital Surface Model DSM



Photogrammetry Introduction

- 3D Model



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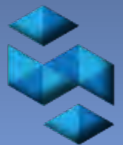
Photogrammetry Introduction

- **Photogrammetry**

- Techniques for satellite and flight photogrammetry is mature
 - Remote sensing for scientific, industrial, agriculture and military
- Many new photogrammetry applications and platforms
- Lidar and IfSAR used to provide digital terrain information
 - Providing granular depth information

- **UAVs provide lower altitude acquisition**

- UAVs provide low cost low altitude flights
 - Possibility of high ground pixel density



Point Cloud Creation Algorithms

- Process
 - Identifiable key point detection
 - Key point correlation between images
 - Depth information extraction
 - Point coloring and/or texture creation
 - From that you can derive/render other products
 - Orthomosaic
 - DSM



UAV / UAS Trends

- UAVs
 - Impact on media production
 - Created a new production aesthetic
 - Rapid growth and adoption
- UAV growth
 - Low cost GPS
 - Low cost 6DOF sensors
 - Battery technology
 - Efficient motors



UAV / UAS Trends

- Robotics software advancement
 - Feedback theory
 - Digital filtering
 - Sensor fusion
 - Real time sensor information processed to deduct position
 - GPS Altitude
 - Accelerometer
 - Barometer Relative Altitude
 - Magnetometer



UAV / UAS Scene Capture

- UAV Photogrammetry
 - Provide low altitude capture
 - 400 ft and below
 - Many choices for camera payload
 - Small integrated camera
 - Larger format camera on large gimbal
 - Capable of repeatable autonomous flight
 - Mission Planning
 - Repeatability



UAV / UAS Scene Capture

- Mission Planning
 - Application to prepare for an autonomous flight
 - Many “mission planner” with specific features
 - Can create scan patterns for structures or scenes
 - Define type of path over the structure
 - Nadir and Oblique
 - Mapping uses Nadir (orthogonal) view
 - Oblique views
 - Ground photography



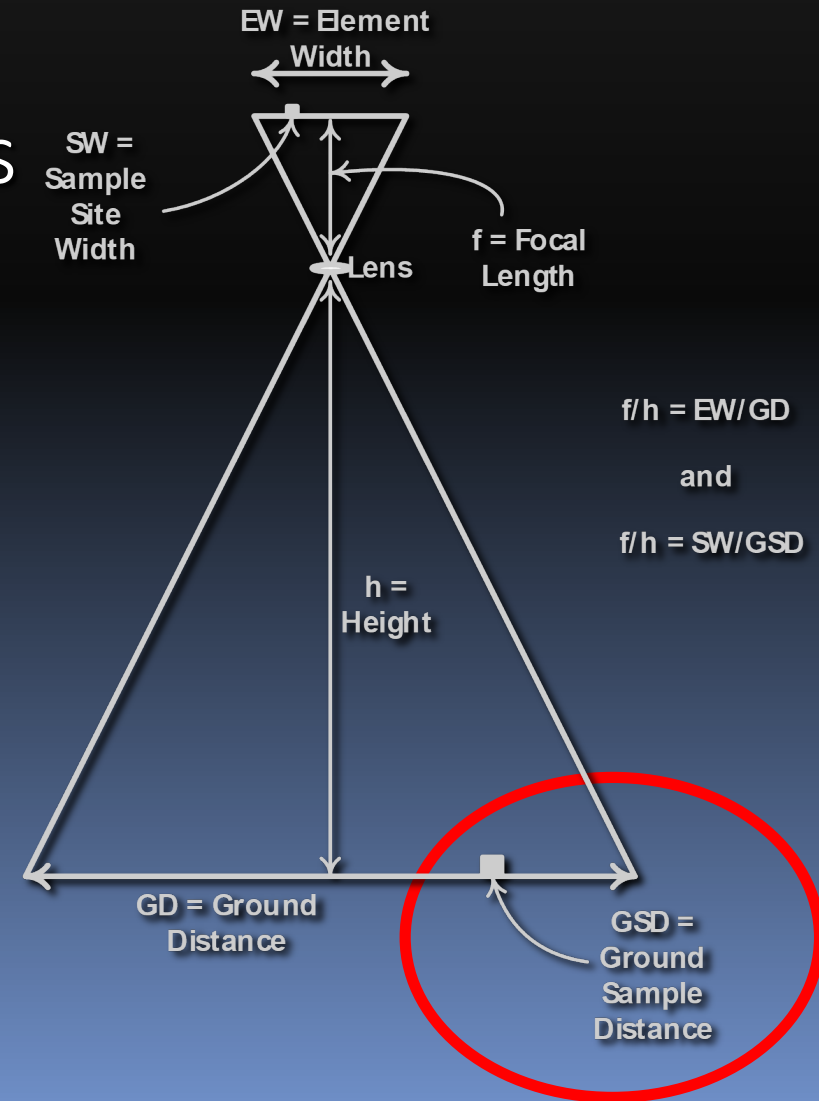
UAV / UAS Scene Capture

- Mission planning
 - Define camera control parameters
 - Exposure, focus
 - Define the appropriate amount of image overlap
 - Define gimbal and orientation control to the target
 - Allow you to plan for a targeted ground pixel density
 - Define the altitude of acquisition
 - Useful to start with DSM
 - Visualization tools



UAV / UAS Scene Capture

- Ground Sample Distance GSD
 - Drives the density of resulting products
 - Dimensions of a sample on ground



UAV / UAS Scene Capture

- Imaging considerations
 - Large depth of field
 - Top of trees/structures to the ground
 - This is needed for the feature and depth extraction
 - Fast enough shutter speed
 - Vibration
 - Motion
 - Mission can be constructed to stop for each photo
 - Overcast (diffuse light) versus sunny day (distinct shadows)



UAV / UAS Scene Capture

- GPS tagging
 - Well integrated camera
 - Has embedded GPS location image EXIF data
 - Know the source of the altitude data
 - Non-integrated camera
 - Extract shot locations from log
 - Insert into EXIF data
 - GPS correction technology
 - RTK – real time kinetics
 - PPK – Post processing kinetics
 - 1-3 mm positioning accuracy
 - Requires a second GPS as a base station



UAV / UAS Scene Capture

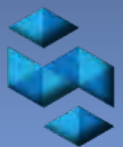
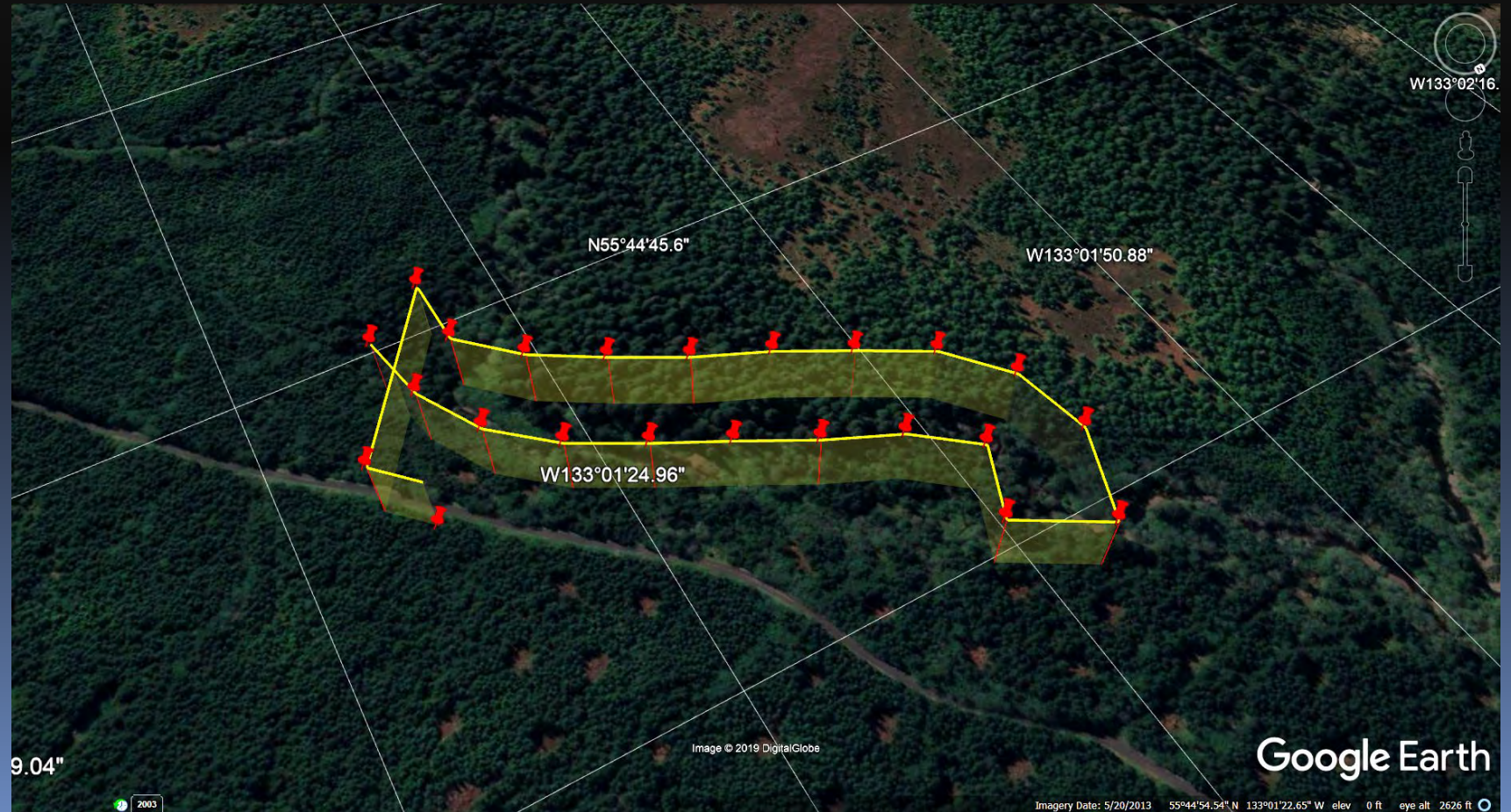
- Ground control points
 - Visual targets of known precise location
 - Very helpful
 - Correlating images
 - Target appears in multiple images
 - Correlating GPS data
 - Different days
 - Different systems
 - Reference point for geolocation



Alaska Stream

- Mission Parameters

| Parameters | |
|--------------|--------------------|
| Height | 400 ft |
| # Images | 454 |
| Imager | 1.55 μm |
| Pixels | 4000x3000 |
| Focal length | 4.7 mm |
| Overlap | Medium-Low |
| GSD | 3.94 cm/pix |



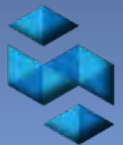
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Alaska Stream

Screen capture video of the point cloud rotating and zooming

- Point Cloud

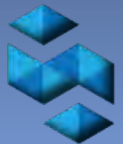
- 240 mil vertices



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Alaska Stream

- Orthomosaic
 - 32K x 29K



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Alaska Stream

- Frame Render



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Alaska Stream

- Frame Render



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Alaska Stream

- Frame Render

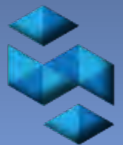
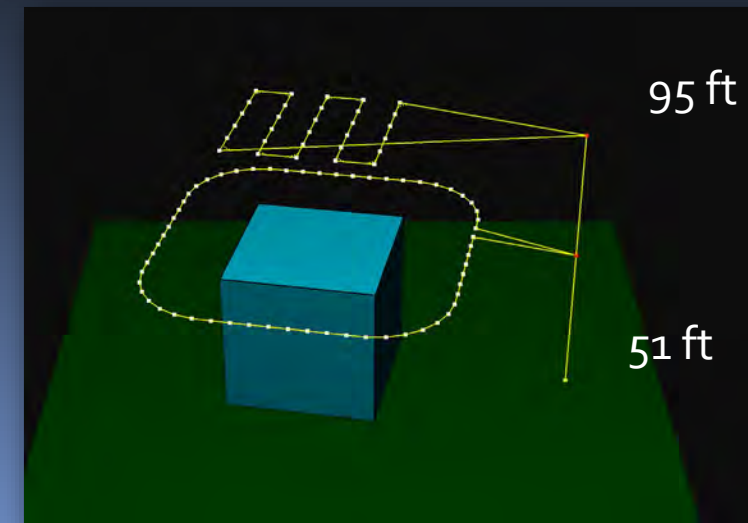
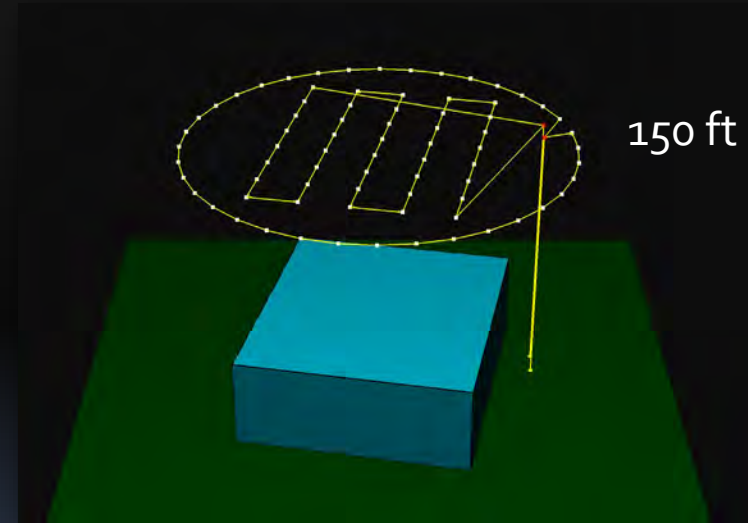


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Lighthouse

- Mission Parameters

- Multiple patterns
 - GSD range
 - 0.5 – 1.5 cm/pixel
- 319 Images
- High Overlap
- Challenges
 - Multiple days
 - Shadows
 - Railings
 - Windows

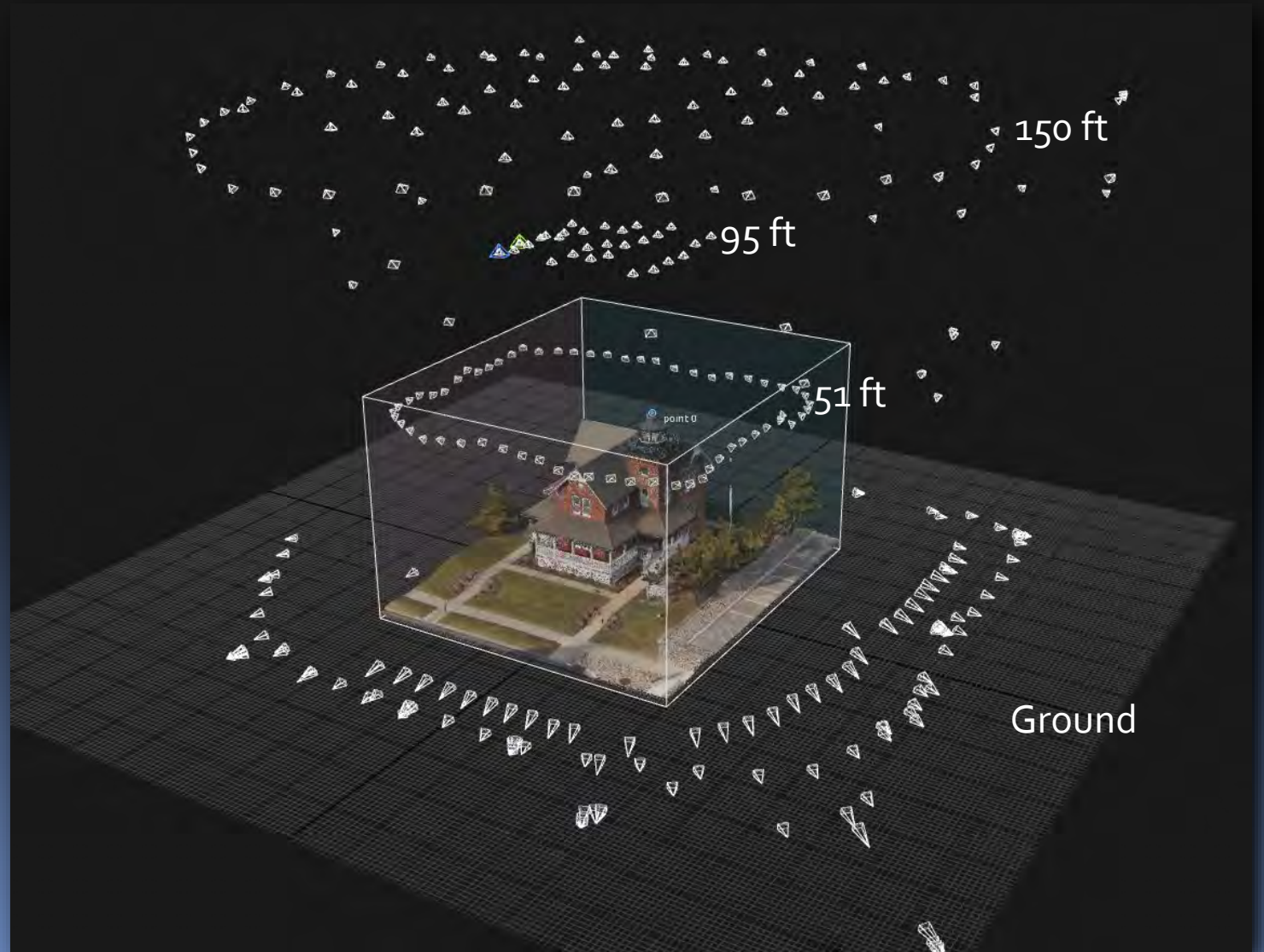


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Lighthouse

- Mission Parameters

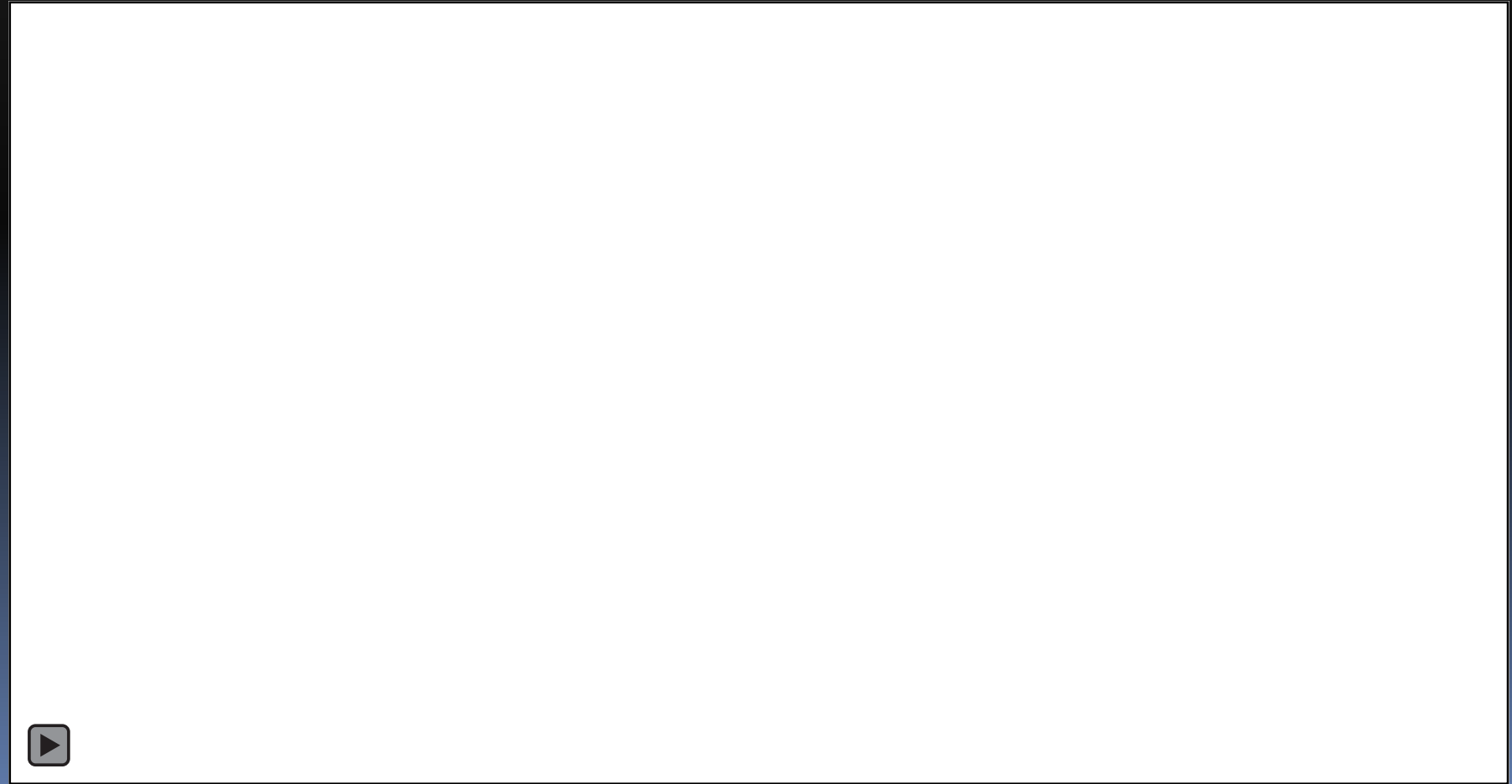
- Multiple patterns
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Lighthouse

- X vertices



Lighthouse

- Render and photo



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Lighthouse

- Render and photo



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