NCALM

National Center for Airborne Laser Mapping

Collecting and delivering research grade airborne remote sensing data for the geoscience community

Airborne mapping LIDAR data collection and processing for archaeological research

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SYMPOSIUM [337]

THE USE OF LIDAR IN MESOAMERICAN ARCHAEOLOGY: NEW APPROACHES TO SETTLEMENT AND RESEARCH

Behind the scenes on going…

from an
impervious
canopy

Behind the scenes on going…

from an
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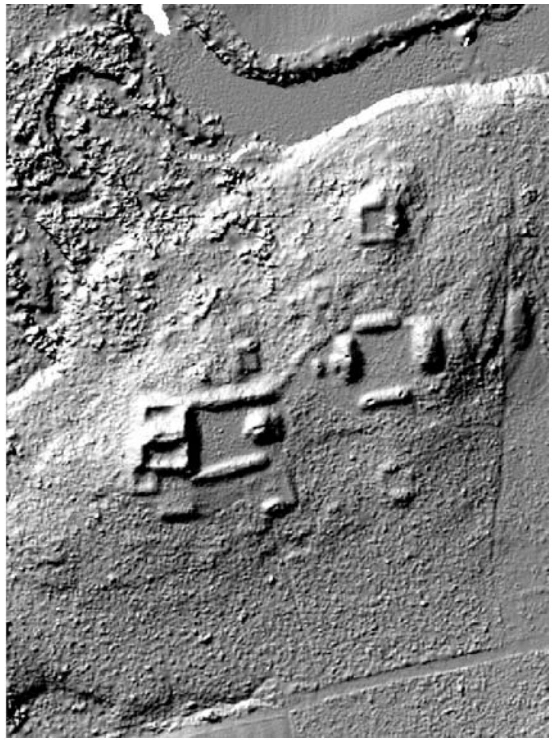
canopy

to measuring
the canopy
and ground in
3D

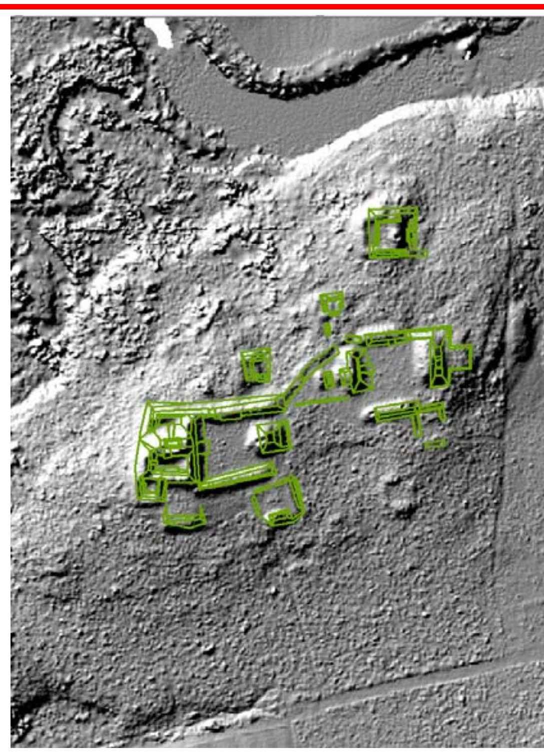
Behind the scenes on going…

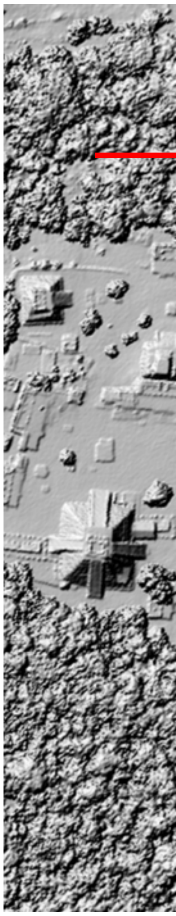
- from an impervious canopy
- to measuring the canopy and ground in 3D
- to developing the DEM



Behind the scenes on going…

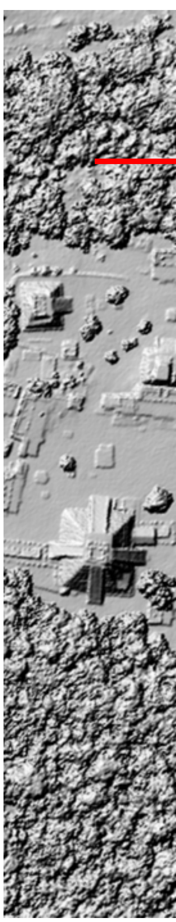
- from an impervious canopy
- to measuring the canopy and ground in 3D
- to developing the DEM
- or whatever product that enables your research





Points to take home

- Not all LiDAR products are created equal
  - 10 shots/m^2 ≠ 10 shots/m^2 (under canopy)
  - No one-size-fits-all
- LiDAR processing is both an art and a science
  - Not necessarily a linear process
  - Many more options than “standard processing”…and no “**ONE BEST WAY**”
  - If not happy go back and talk to provider
- Have to go further from DEMs/DSMs
- Not a magic bullet, it has its limitations!

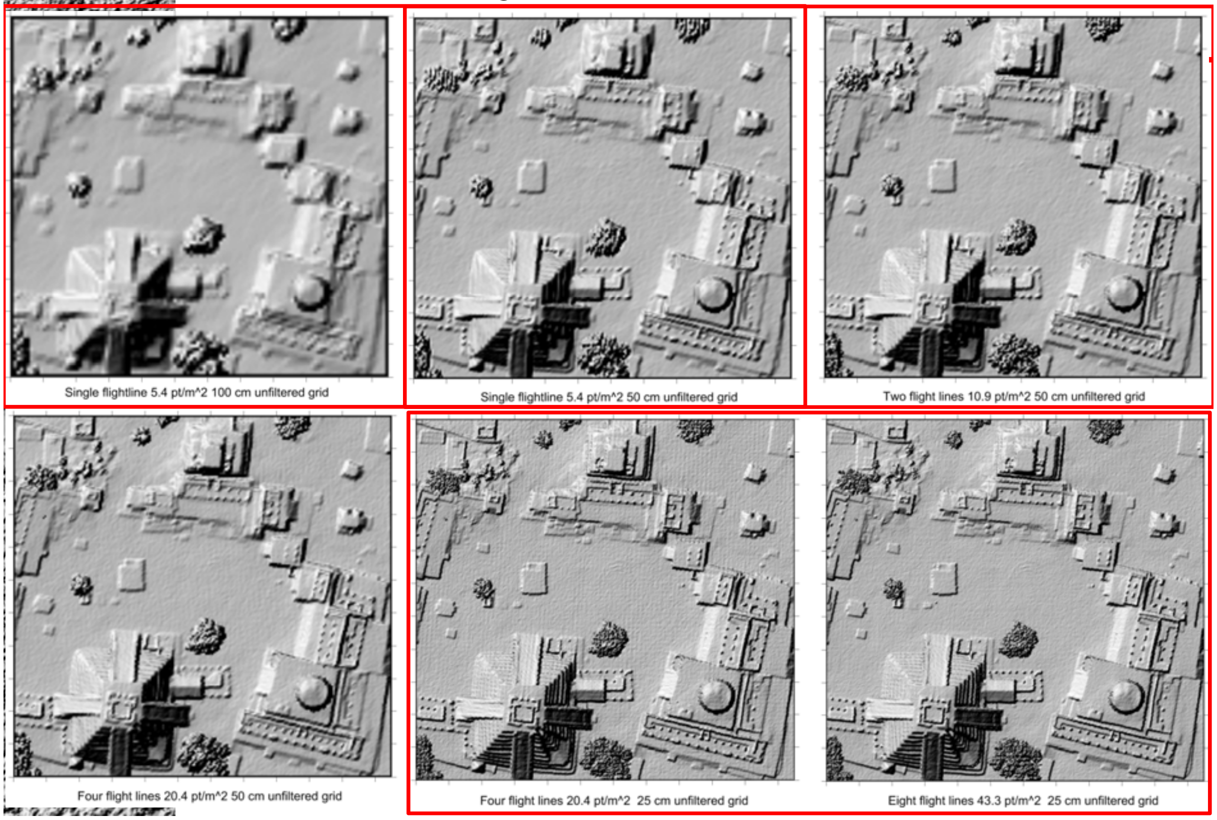


It all starts with…

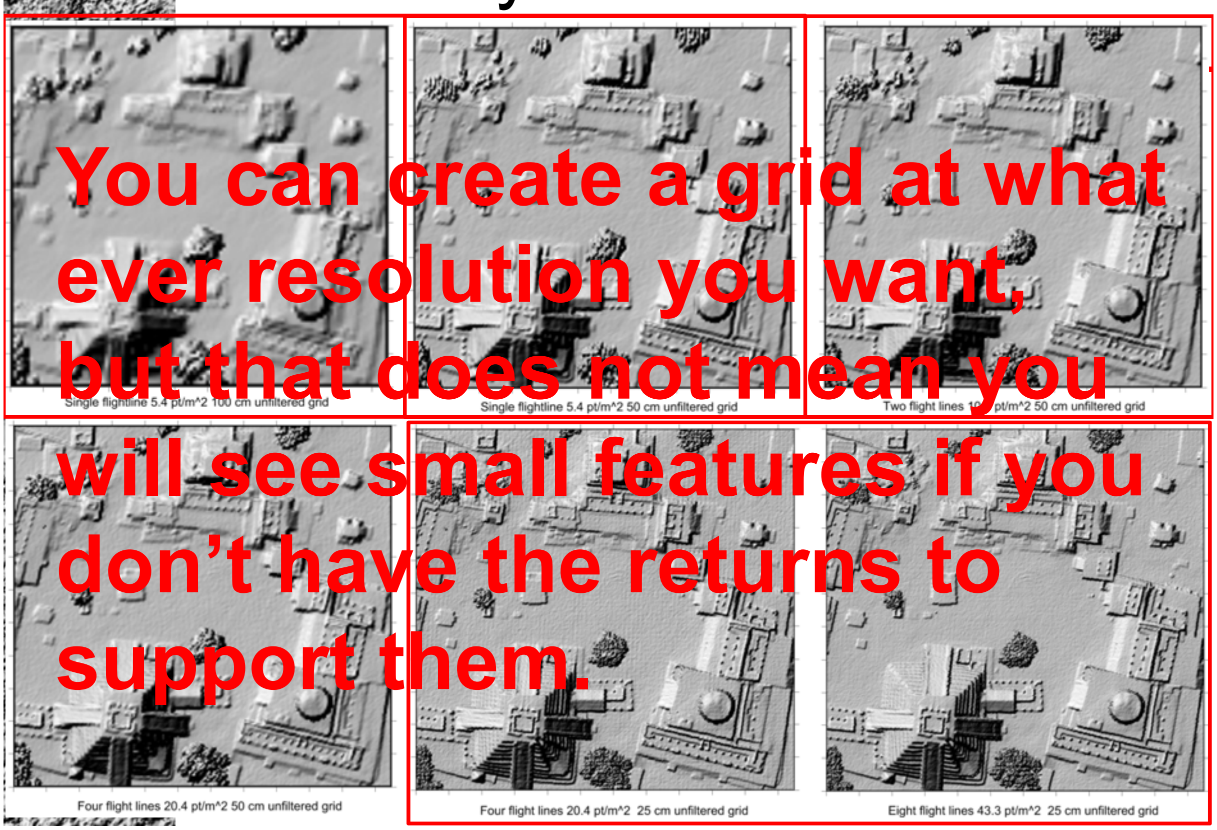
- Archaeologist: “I want LiDAR for my study area!”
- Provider: “How much money you have?”

- The PI’s requirements for the project:
  - Area to be covered
  - Desired collection window
  - Special considerations
  - Desired point density (~resolution)*
    - **Shot, Return, GROUND POINT Densities**

PC Density and DEM Resolution



PC Density and DEM Resolution

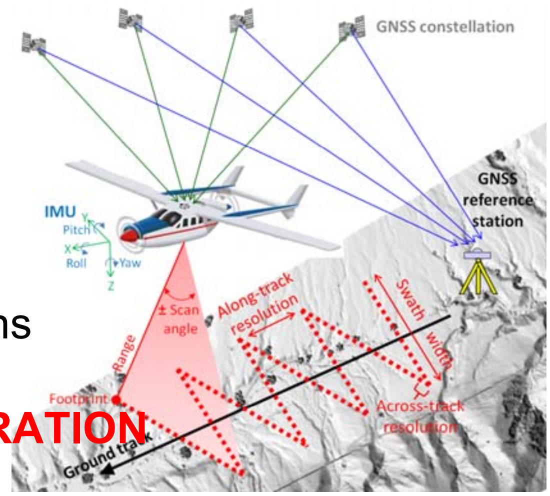


You can create a grid at what ever resolution you want, but that does not mean you will see small features if you don’t have the returns to support them.

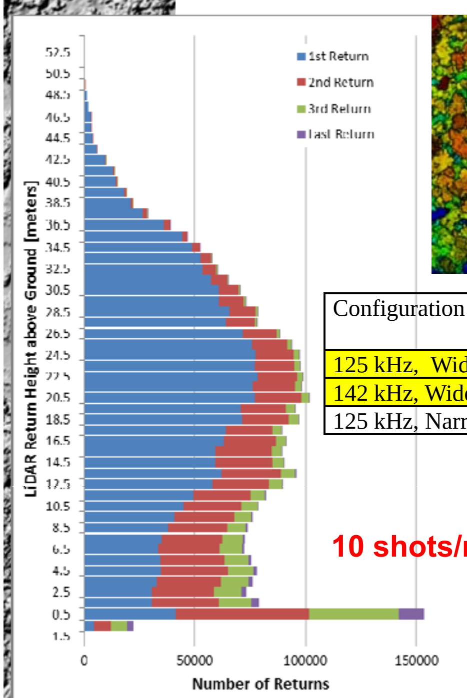
Mission Planning 1

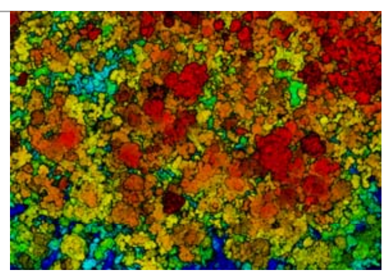
- Determining best system configuration and flying parameters to meet PI requirements:
  - Pulse Repetition Frequency (PRF)
  - Scan Angle / Frequency
  - Beam divergence
  - Flying height AGL
  - Flying speed

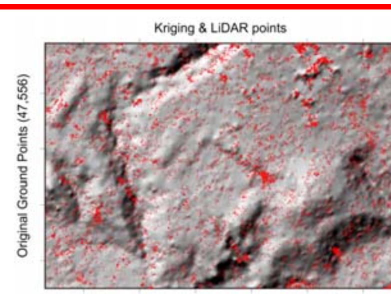
- Other considerations:
  - Safety
  - Airspace regulations
  - Efficiency
  - **CANOPY PENETRATION**



Canopy Penetration

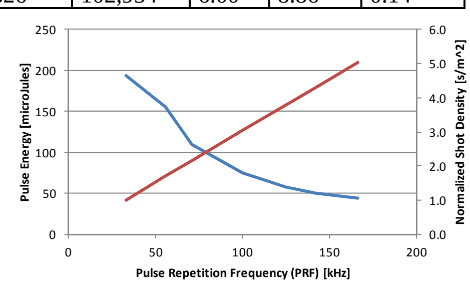






Configuration	Counts			Density [1/m²]		
	Laser Shots	Total Returns	Ground	Shots	Returns	Ground
125 kHz, Wide	4,325,637	7,179,745	118,398	5.90	9.79	0.16
142 kHz, Wide	5,106,135	7,410,600	84,627	6.96	10.10	0.12
125 kHz, Narrow	4,405,288	6,503,826	102,954	6.00	8.86	0.14

10 shots/m² ≠ 10 shots/m²

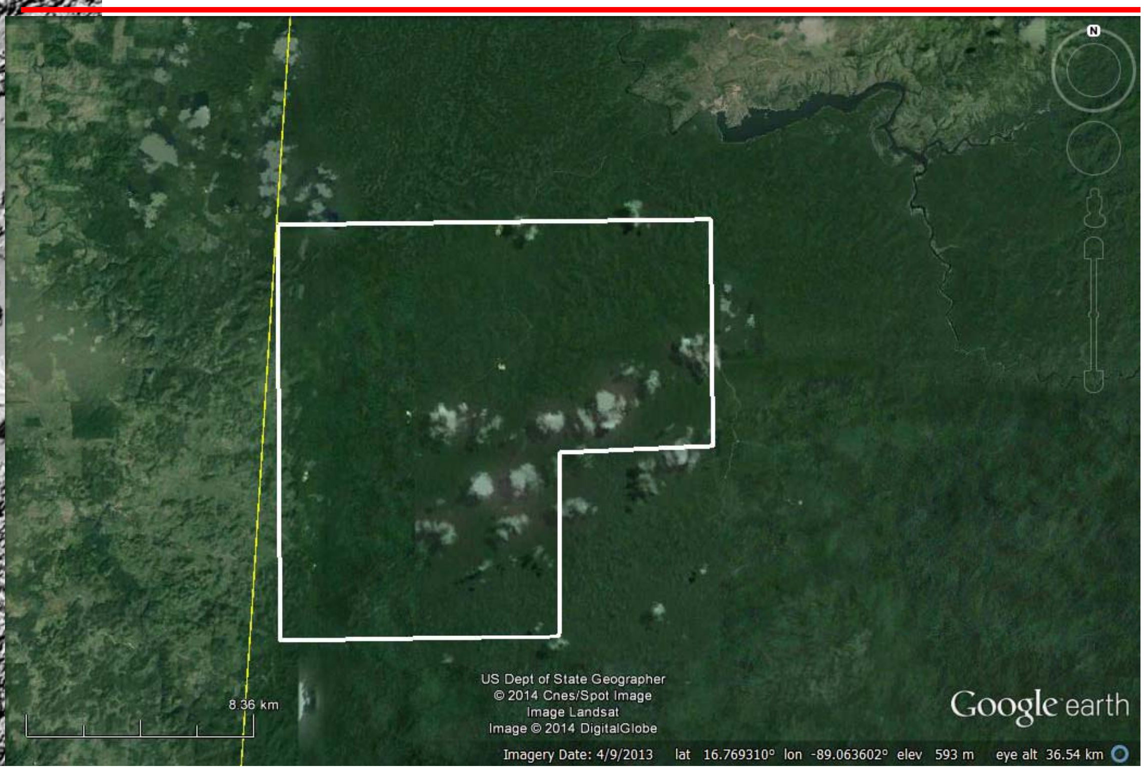


Mission Planning 2

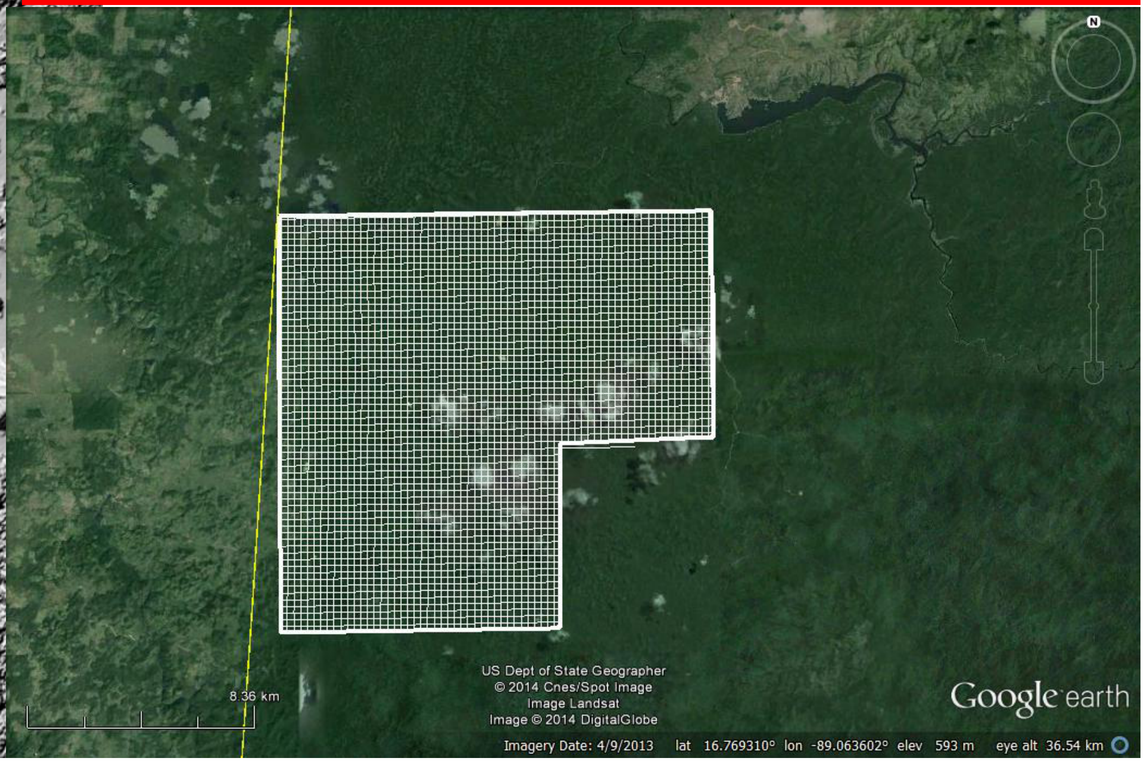
- Logistics:
  - Suitable, secure airport & support facilities
  - Locating GPS base stations
    - 100 km max baselines
  - Hotels, roads, phone, internet

- Permits:
  - US DOS – Export License for IMU
  - Foreign government permits (equivalent to the US FAA – Department of Interior)
  - Temporary import of equipment into country

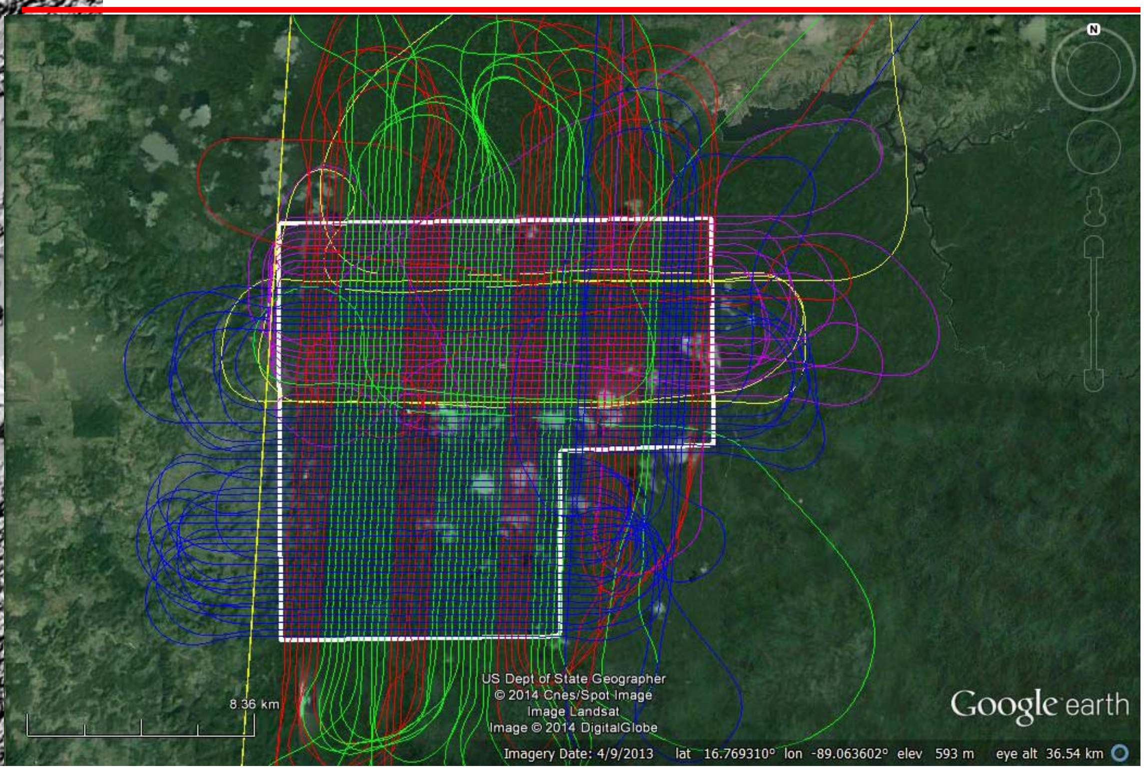
PI Requirements - Caracol



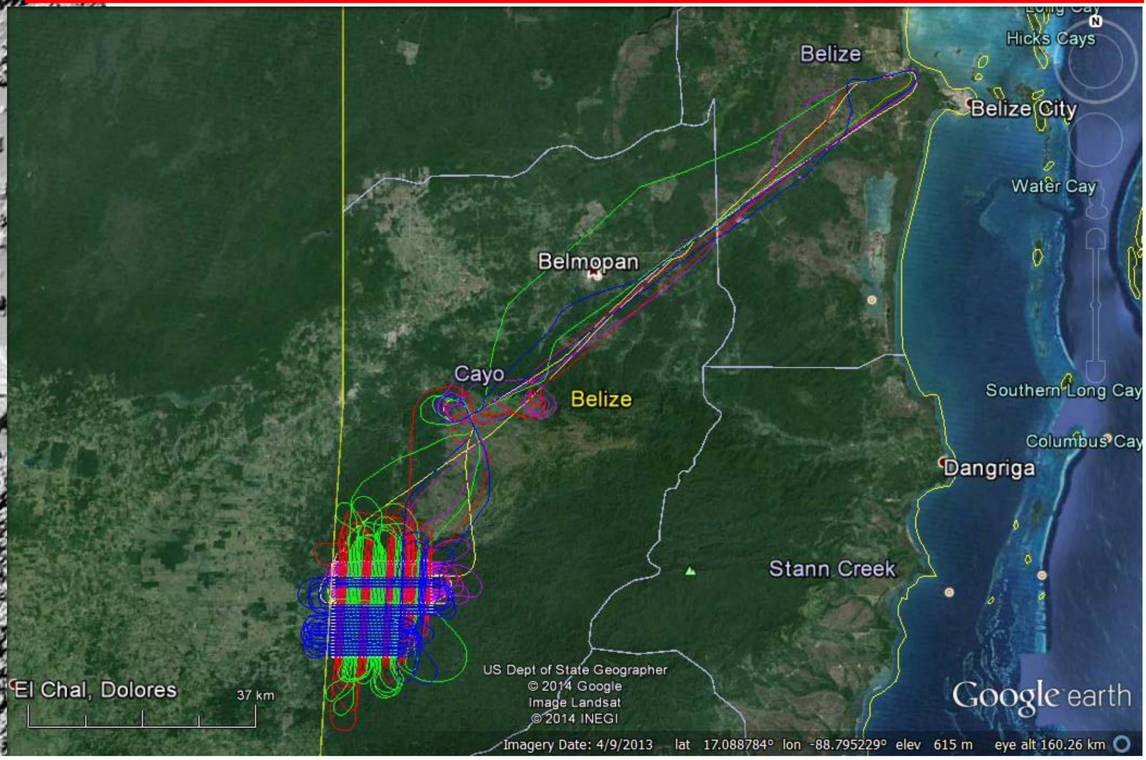
Mission Planning – Caracol



Data Collection



Data Collection



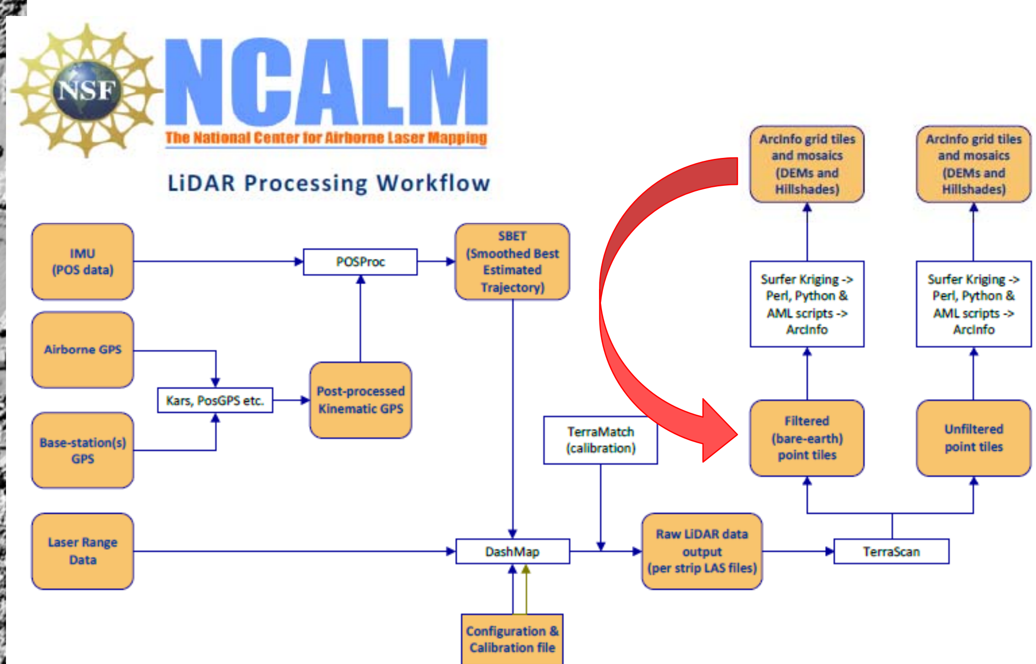
What is Collected

- Up in the air:
  - IMU and GPS data
  - Discrete range data
  - Waveform data
  - Weather
- On the ground:
  - Lever arms
  - GPS base station data
  - Ground truth data

The goodies to be delivered

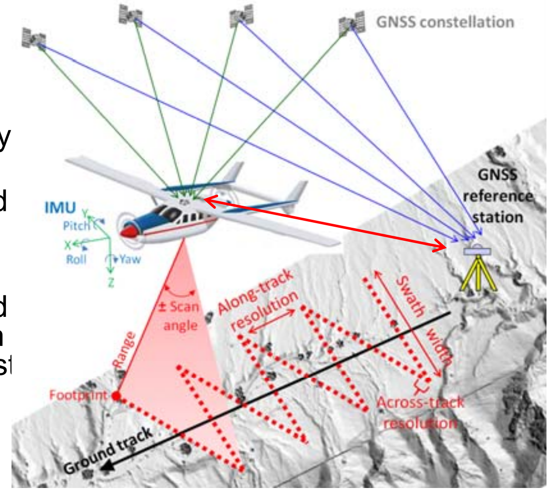
- Standard Deliverables:
  - Raw unclassified point cloud strips
  - Classified LAS tiles
  - ARCGIS 1 km x 1km tile grids
    - Bare Earth DEMs & First Surface DSMs
    - Bare Earth & First Surface Hillshades
  - Surfer Grids 1 km x 1km tile grids
    - Bare Earth & First Surface
  - ARCGIS or Surfer Mosaics
  - Project report

Processing Art/Science



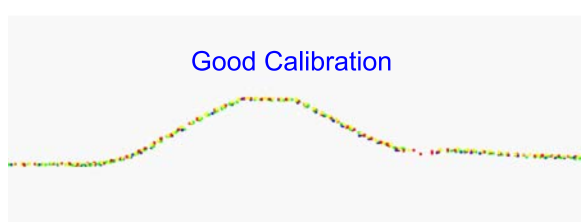
GPS Trajectory

- GPS reference stations:
  - Coordinates through NGS OPUS tied to the international CORS network.
- Airplane GPS:
  - Differential trajectories derived using KARS software (Kinematic and Rapid Static) or POS GPS to each reference station.
  - the solutions are differenced and compared for consistency
  - individual solutions are combined sing an unweighted averaging algorithm
- IMU data:
  - GPS and IMU data is blended into an INS through a Kalman filter yielding a Smoothed Best Estimate Trajectory (SBET)



Calibration

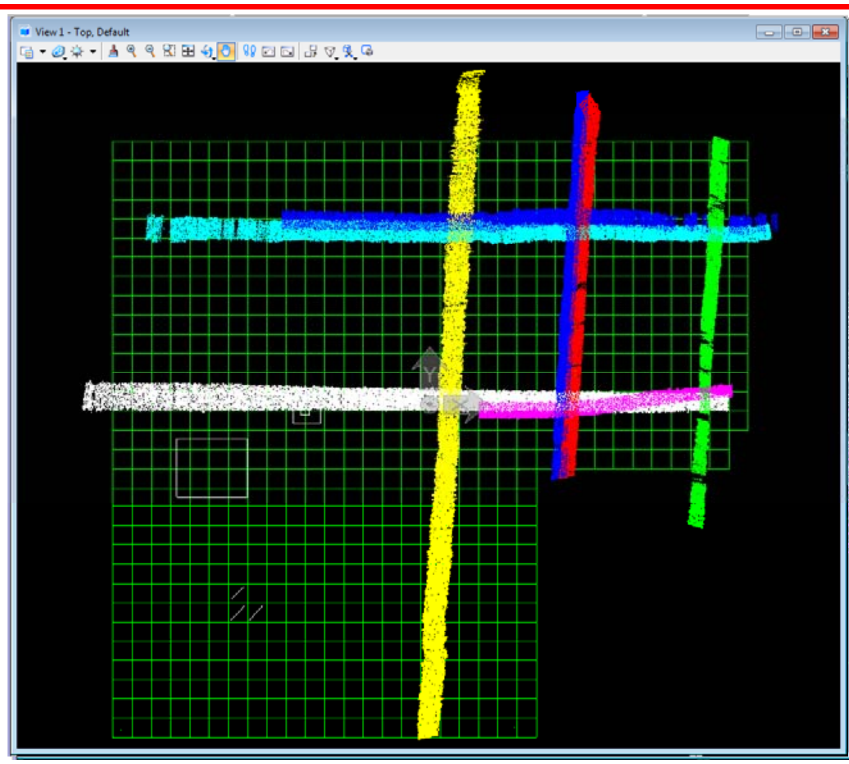
- The objective is to account for sensors systematic errors so that observations for overlapping strips match:
  - Errors in laser distance measurement
  - Scanning mirror errors
  - Errors in position (GPS)
  - Errors in orientation (INS)



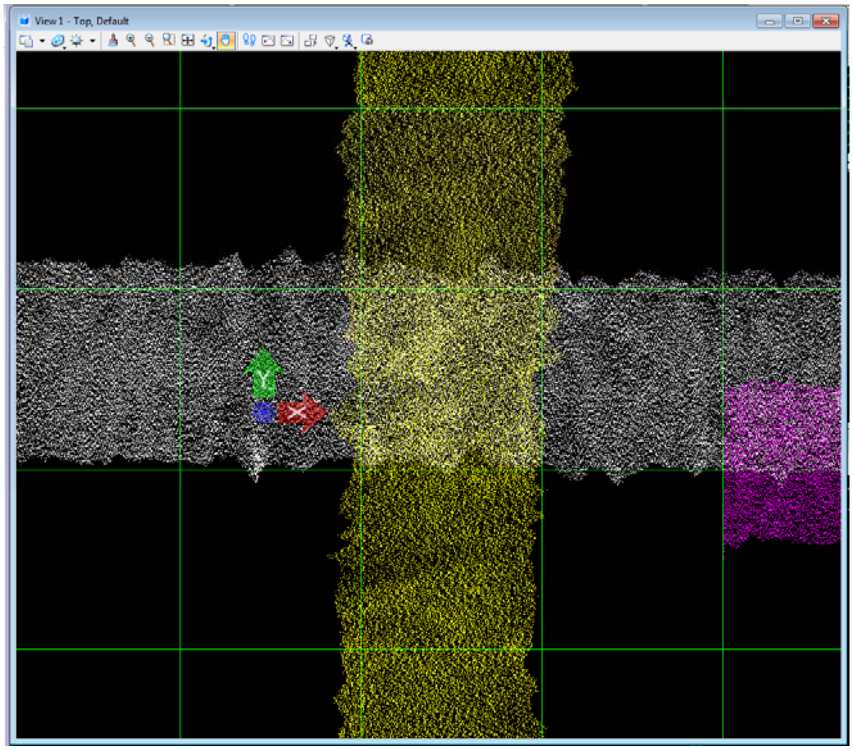
Raw point cloud generation

- The SBET, Range File (or waveform NDF) and the Calibration files are processed through DASHMAP
- The output are the raw point cloud files, usually:
  - ASPRS LAS format (Classified by Echo)
  - 1 File per strip
    - Due to planned overlap data from a given area will be contained in several strips.
    - Strips are too big for further processing

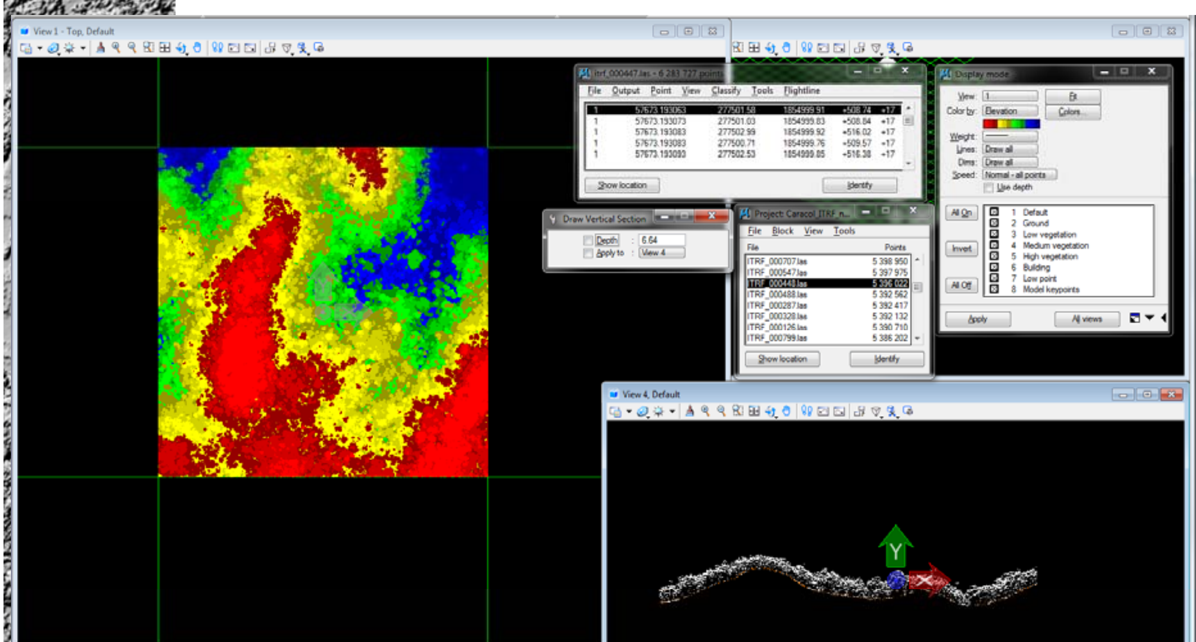
Raw LAS files per strip



Raw LAS files per strip



Breaking the project into tiles

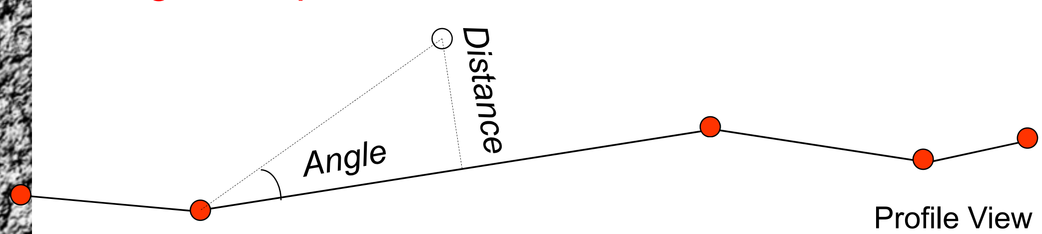


Classification (Filtering)

- AKA Filtering, but this is not correct, because is not about eliminating data
- ASPRS LAS Classes:
  - 1 Unclassified
  - 2 Ground
  - 3-5 Vegetation
  - 6 Building
  - ….
- Terrascan has several routines:
  - Low points
  - Isolated points
  - By echo, echo difference
  - By absolute elevation
  - **Ground**

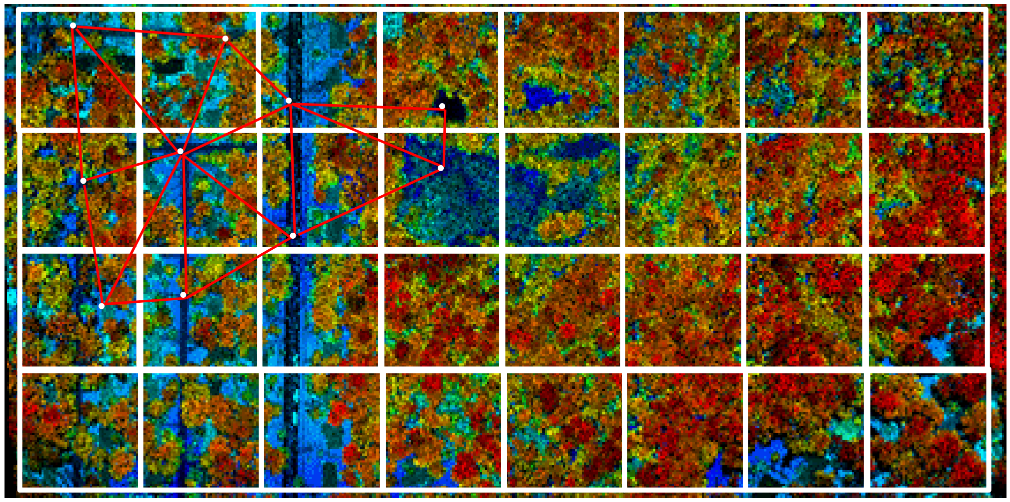
Ground Classification

- Iterative process which builds a triangulated model and molds it upwards as long as it finds new points matching iteration parameters
  - Location becomes ground if the application finds a smooth route to the top
  - Location becomes ground if you can drive a bicycle onto it from a previously established ground point

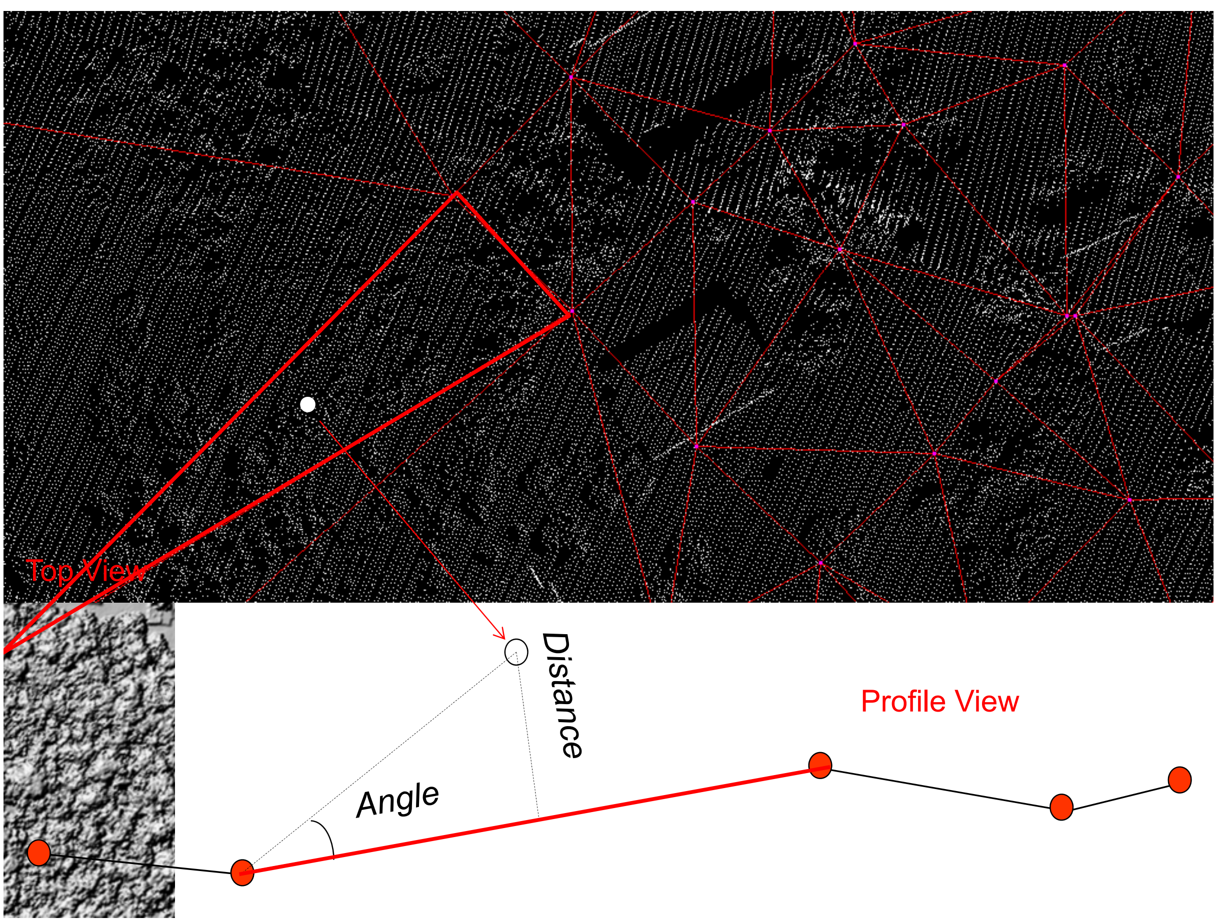


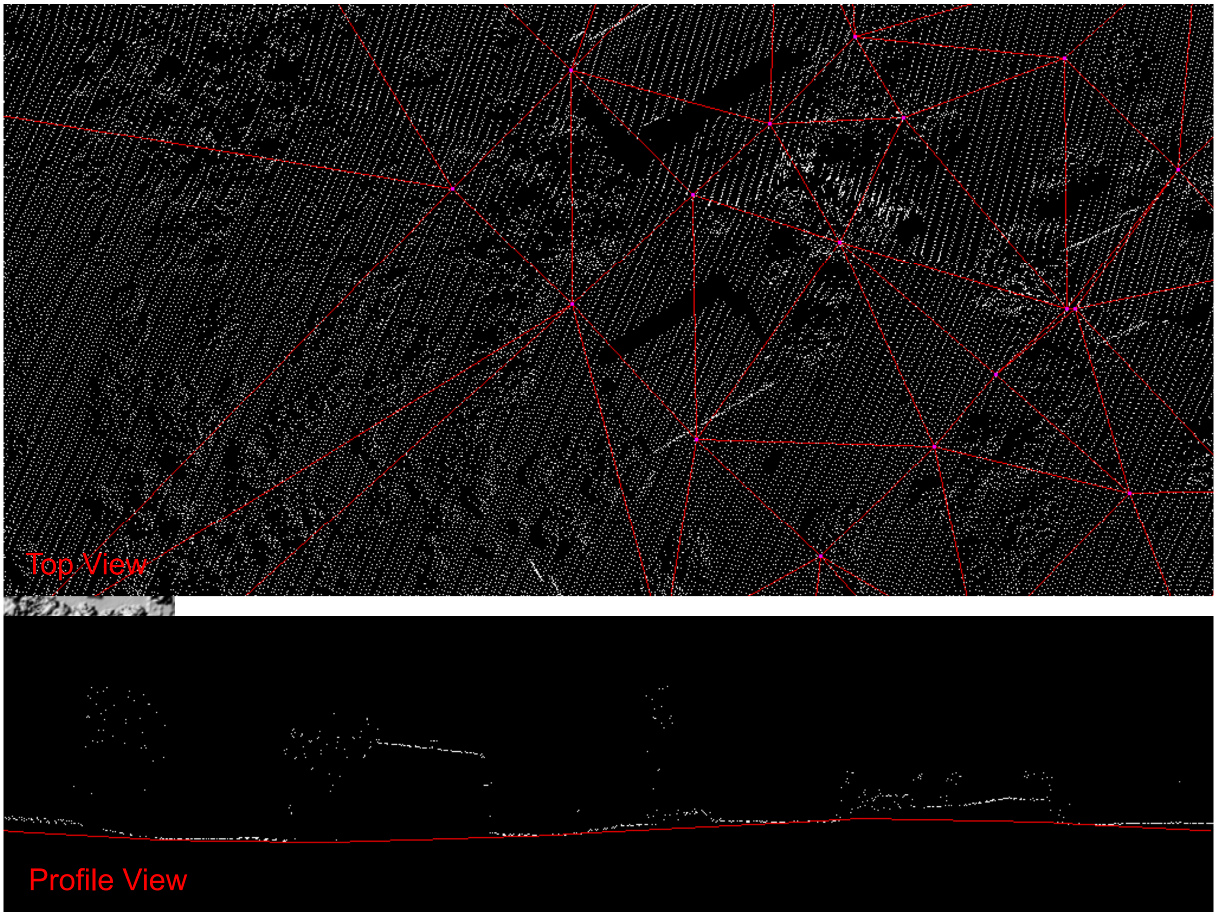
Ground Classification

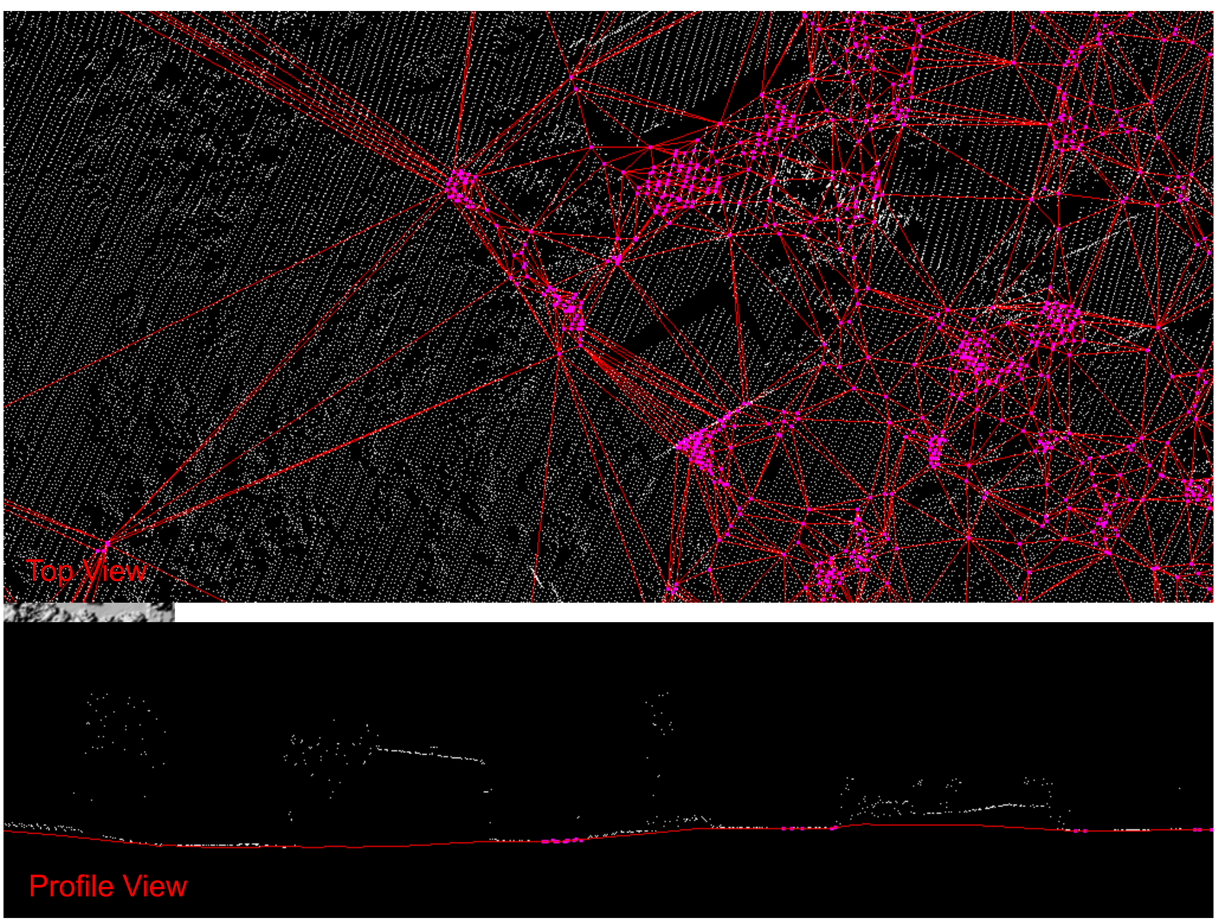
- Initial Logic: No building covers an area of given dimensions
- A grid is crated using that maximum building dimension
  - Lowest point in any such grid cell is ground



Top View




Top View
Profile View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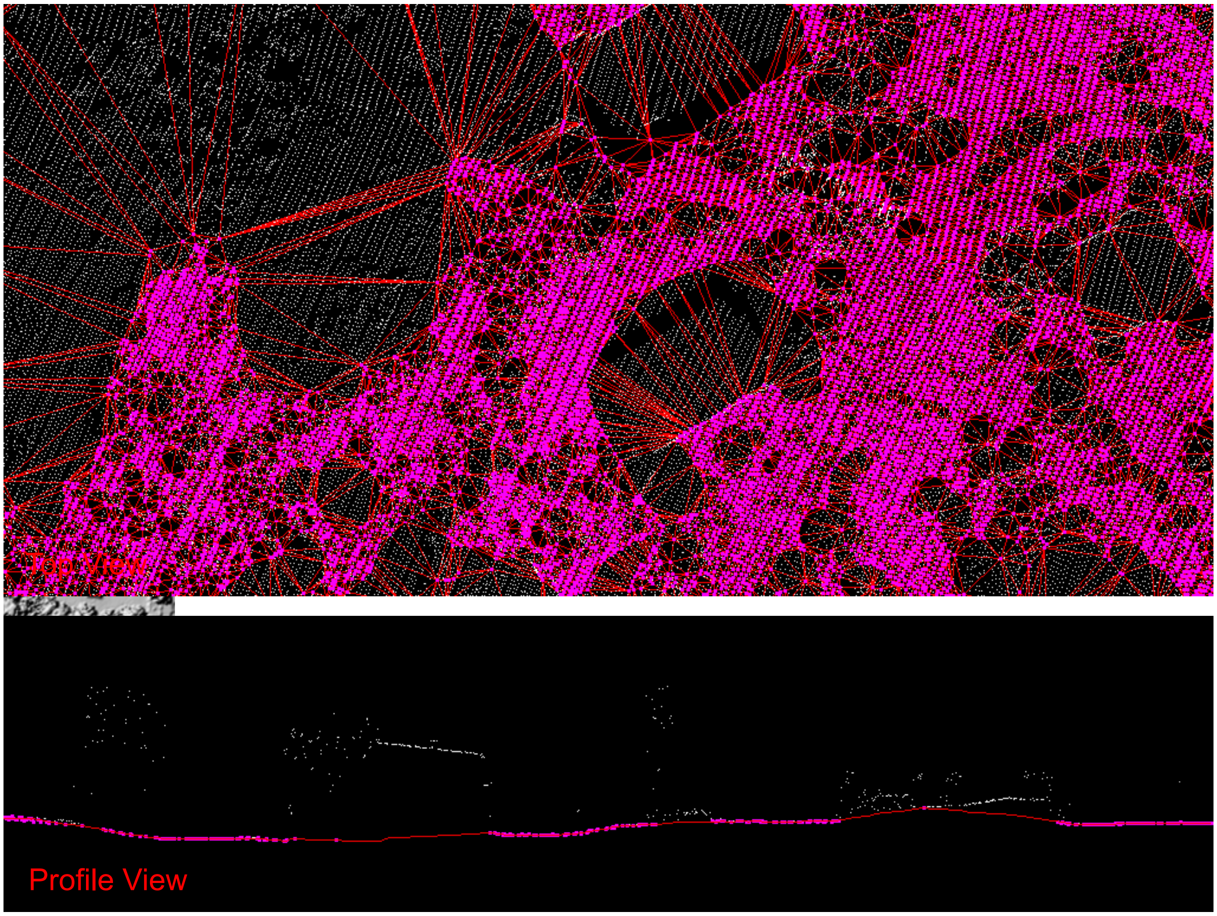
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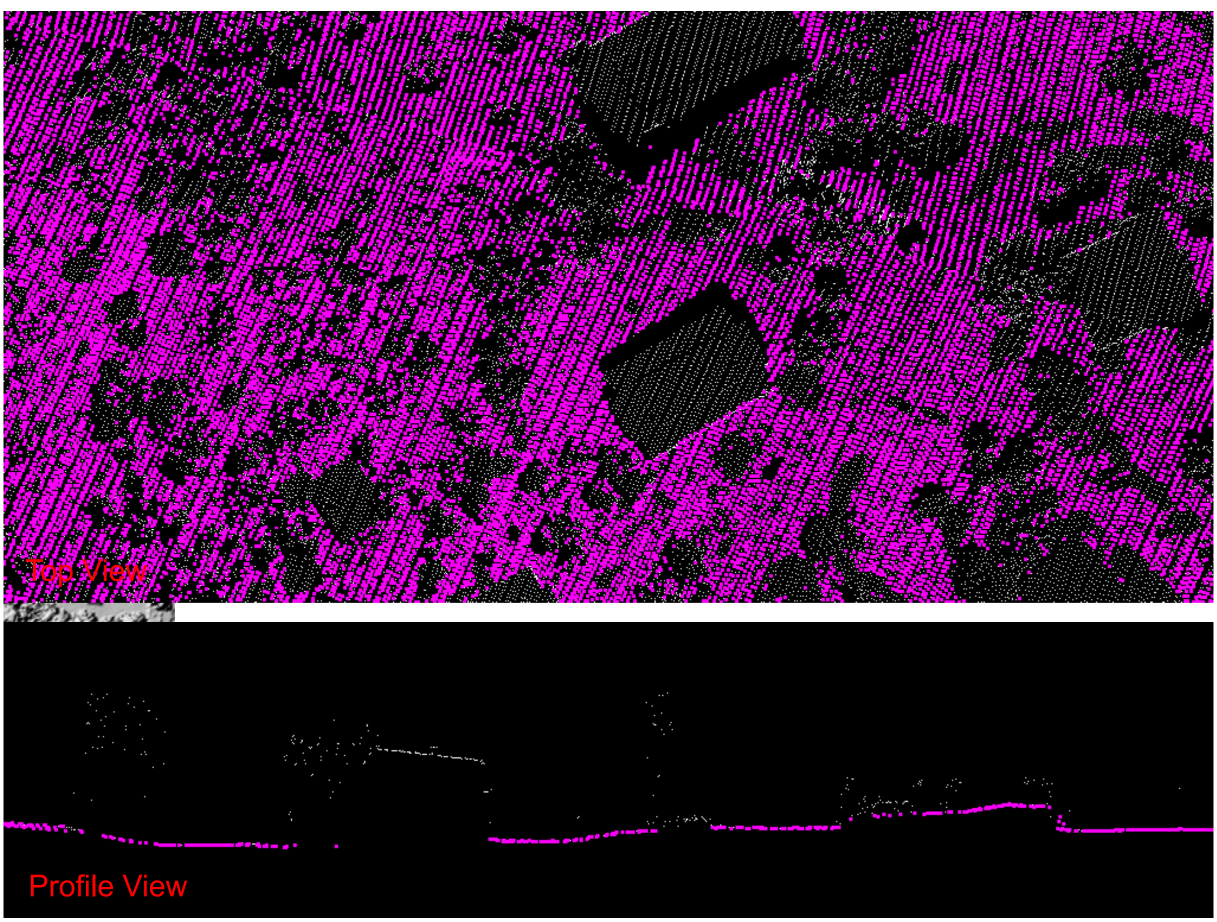
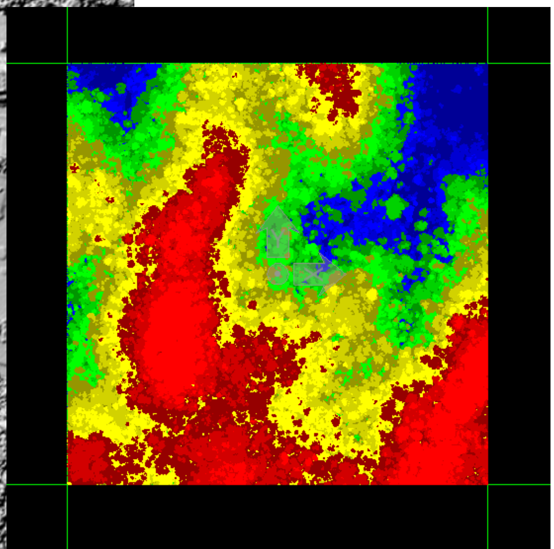

Top View
Profile View

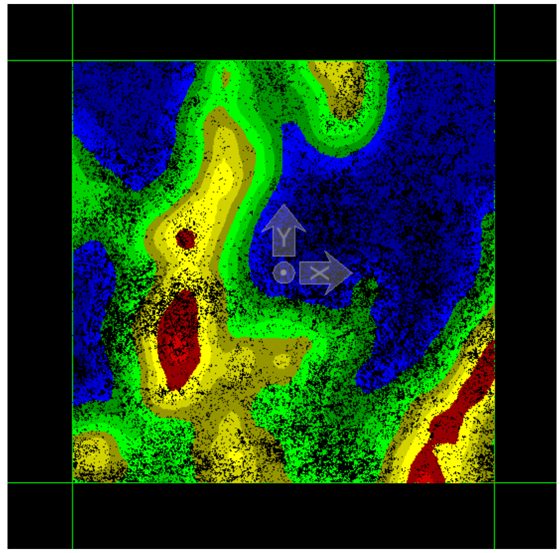
Classification (Filtering)

All Points



Quasi Uniform Distribution

Only Ground Points

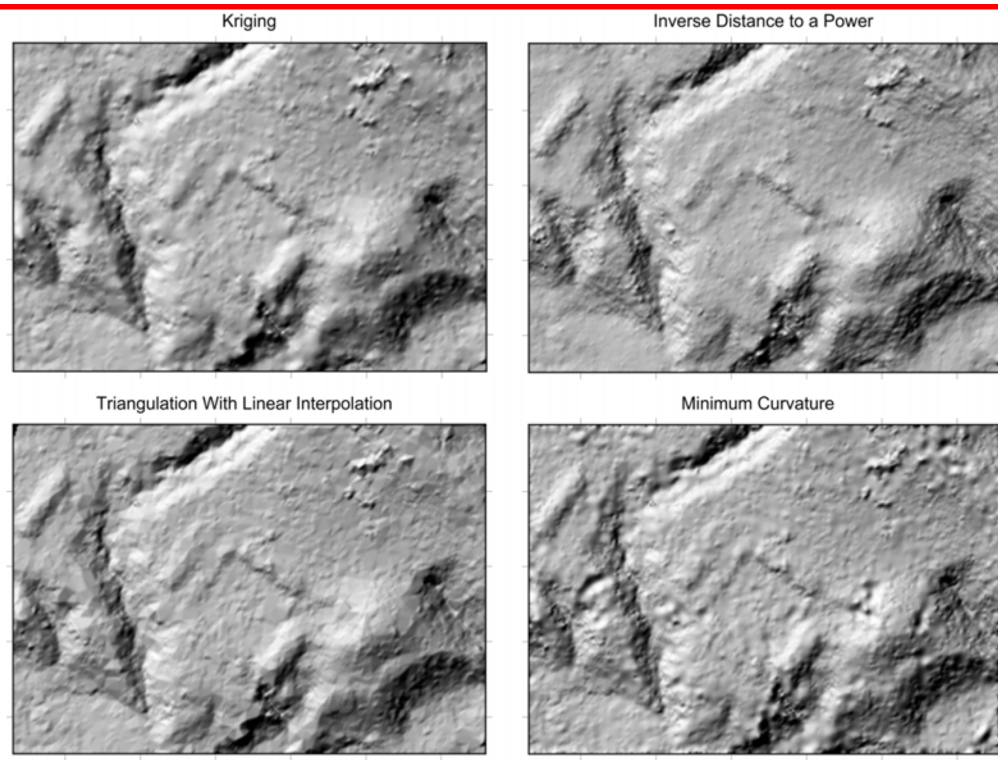


Non-uniform Distribution

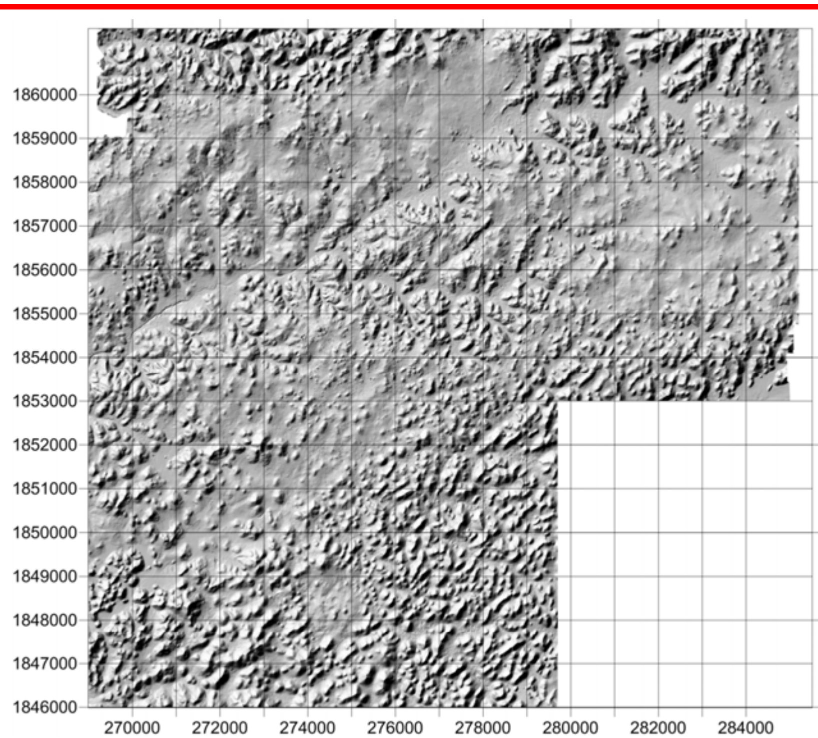
Gridding

- Point clouds are irregularly spaced 3D datasets
  - Full information (6-40 returns/m²)
  - Hard to Manipulate
- Grids are regularly spaced 2.5D datasets
  - Easier to manipulate
  - Resampled info (1 or 4 pts/m²)
- Grids are displayed in a variety of ways
  - Shaded Relief Maps, Image Maps, Contours
- Creating a grid (out of the tiles)
  - Create equally spaced horizontal mesh (nodes)
  - Interpolate elevation for each node
    - Nearest neighbor, WID, TLI, **Kriging**

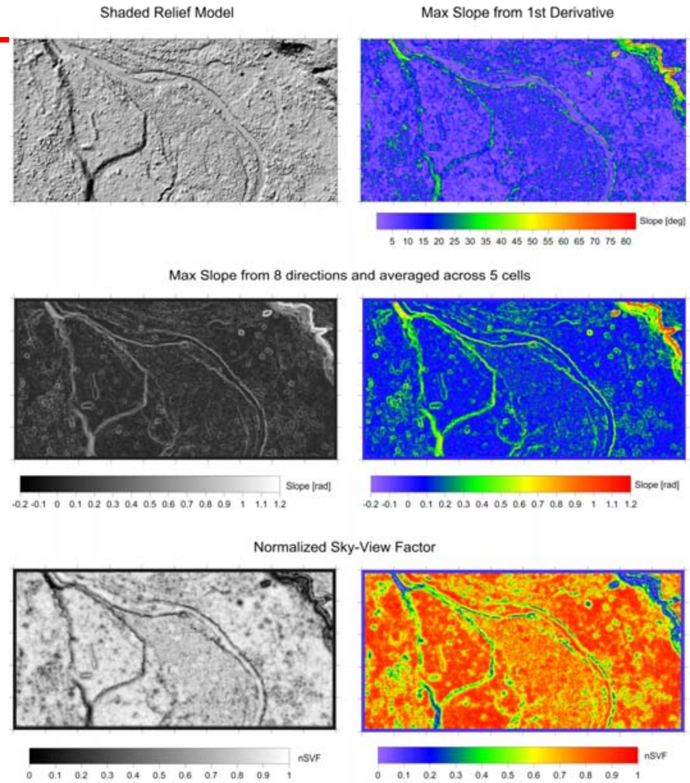
Interpolation Methods



Grid Mosaics – Hillshade



Moving Beyond the DEMs



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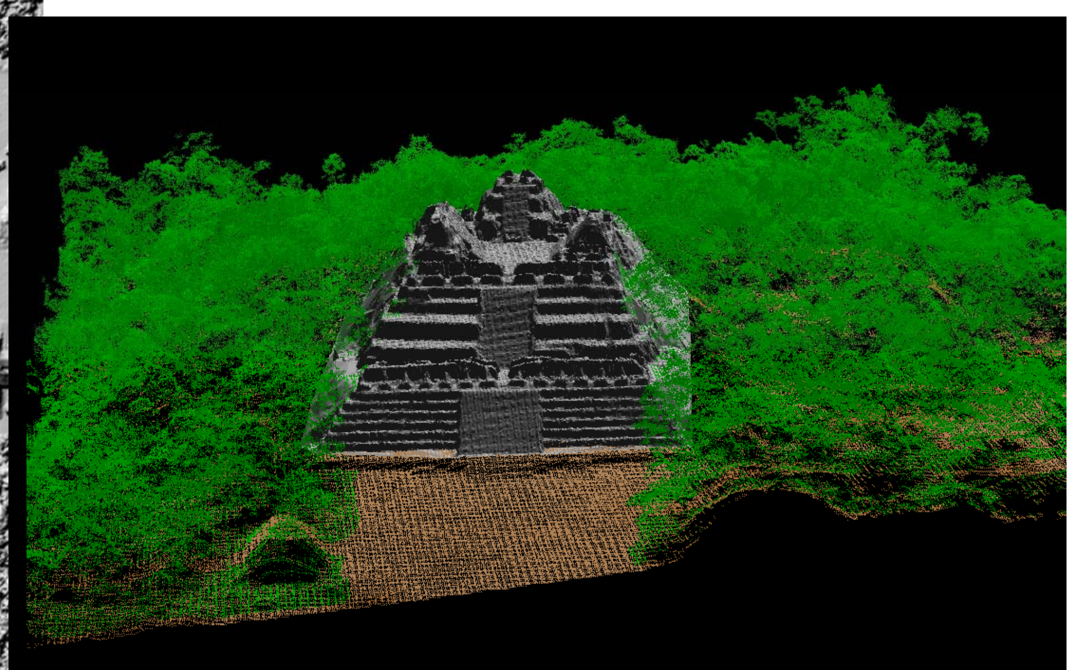
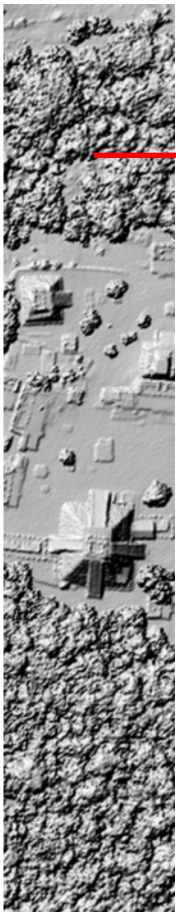
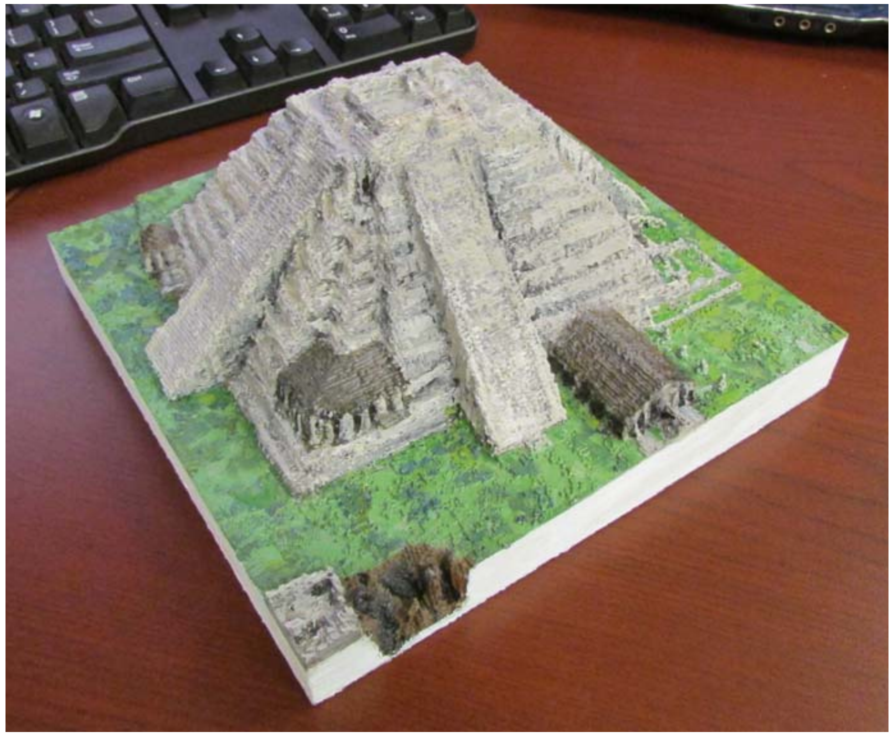
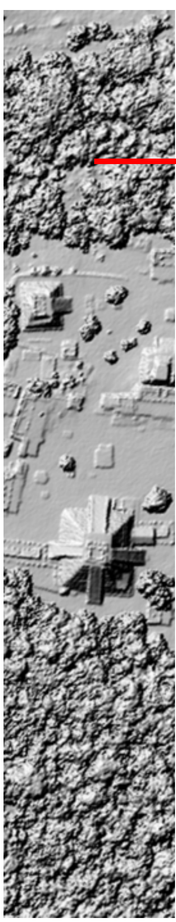




3D Printing





Limitations

- Mapping LiDAR is a spatial sampling technology – not full illumination
  - Random illumination of target
    - Resolution of an Image ≠ Resolution of DEM (Cell Size)
- There is uncertainty (accuracy/precision) in the measurements
  - GPS, attitude, ranging, footprint size
  - Mixed return signal
  - 20-50 cm horizontal, 5-15 cm vertical
- Not X-ray vision, line-of-sight, see thru gaps
- Return classification is probabilistic in nature
  - False positives, false negatives
- Hard to identify the point of diminishing returns