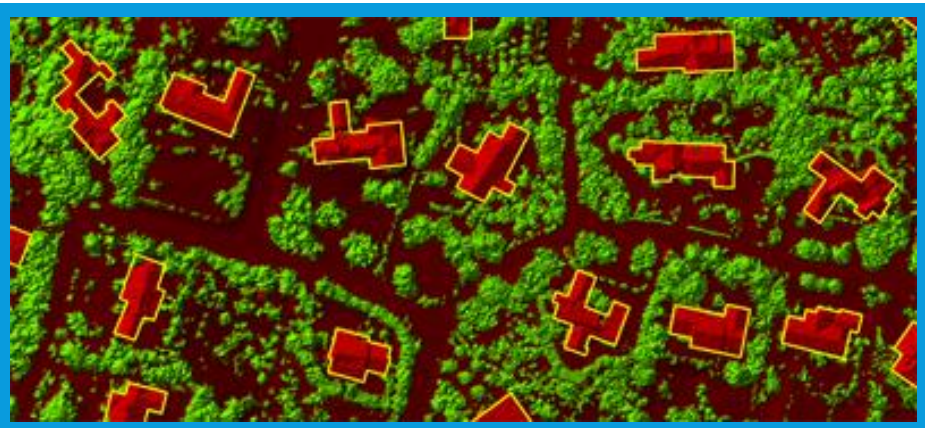
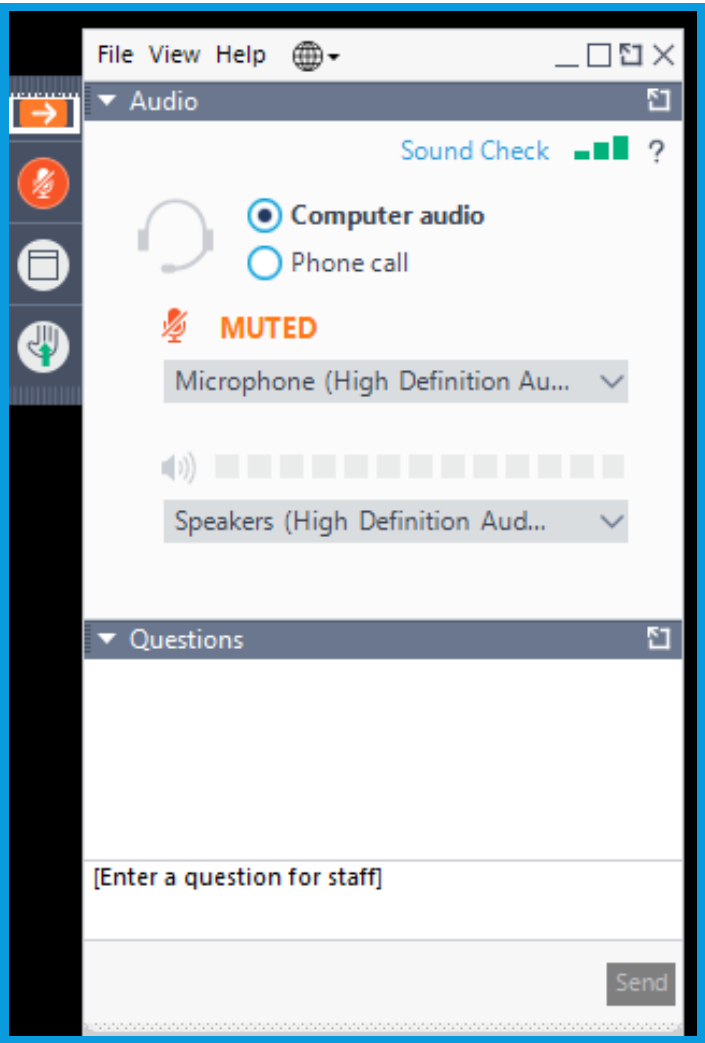
Cooperating Technical Partners Information Exchange

LIDAR QA/QC and Extracting Building Footprints



ASFPM Flood Science Center **Nov. 7, 2018**

Audio and Web Settings



Participation

Open and hide your control panel using the orange arrow button at top left corner

- Choose "Computer audio" to use computer speakers or headphones
- Choose "Phone call" to dial in using the information provided

*Submit questions & comments via the **Questions** panel*

Webinar Logistics

- All lines will be automatically be muted.
- ***Use the Question window in the control panel to submit your question or comment to the Flood Science Center Organizer.***
- Select questions will be read to the presenter and answered.
- Questions not asked during the webinar will be answered and posted to the CTP Webinar page.

Continuing Education Credits

- Certified Floodplain Managers are eligible for 1 Continuing Education Credit for participating in this webinar.
- You must have registered individually and indicated you are a CFM at time of registration.
- Eligibility for CEC is dependent on your participation in poll questions and time spent viewing the webinar, as determined by the webinar software.
- ***Attending this webinar in a group setting or only viewing the recording is NOT eligible for CEC.***

Additional Logistics

- To suggest future CTP webinar topics, please contact Alan Lulloff at *alan@floods.org* or type a suggested topic into the Questions panel today.
- **ASFPM CFM CECs will be automatically applied.**
- **Certificates of Attendance will be emailed**, please contact *cfm@floods.org* with any certificate issues.
- Follow-up email with link to slides and recording will be sent next week

Thank You for Joining Us!

NGS Webinar: Vertical Datum Changes for Floodplain Mapping

National Geodetic Survey

Positioning America for the Future

Upcoming Webinars

NOVEMBER
15
2018

2 pm eastern time

Vertical Datum Changes for Floodplain Mapping

Nicole Kinsman, NGS Regional Geodetic Advisor for Alaska and the U.S. Arctic

This webinar provides an introduction to geodetic control in the context of flood mapping, presents case studies that highlight the importance of well-defined heights, and outlines the expected impacts of a modernized vertical datum on flood maps and related products.

Intermediate Technical Content Rating: Some prior knowledge is helpful.

REGISTER

https://www.ngs.noaa.gov/web/science_edu/webinar_series/flood-datums.shtml

Coastal GeoTools 2019: Registration now open!



http://coastalgeotools.org

- *Early-bird registration ends December 14th*

ASFPM Mapping and Engineering Standards Committee
Cooperating Technical Partners Sub-committee

Co-chairs:

- Thuy Patton, CFM
  Colorado Water Conservation Board
- Carey Johnson
  Kentucky Department for Environmental Protection

Goals:

- ***Identify common concerns***
- ***Provide opportunities for information exchange***
- ***Identify training needs***
- ***Promote and document the value of CTPs***

Agenda

Introduction - *Alan Lulloff*

LIDAR QA/QC - *Lewis Graham*

Building Footprint Feature Extraction - *Lewis Graham*

Questions/Discussion

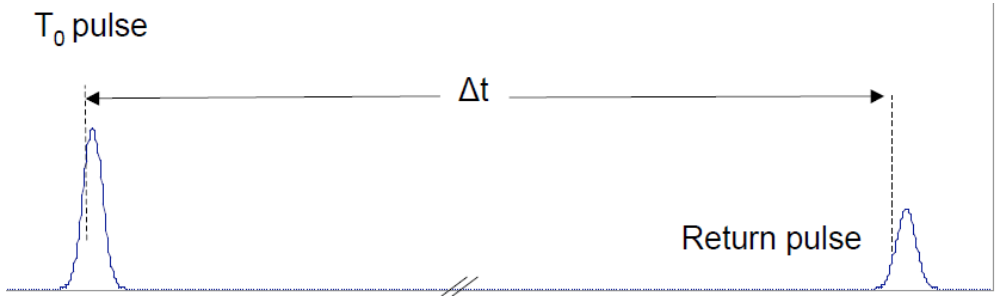
LIDAR QA/QC
Building Footprints

Lewis Graham
GeoCue Group Inc.
9668 Madison Blvd., Suite 202
Madison, AL 35758
256-461-8289
www.geocue.com

WHAT IS LIDAR?

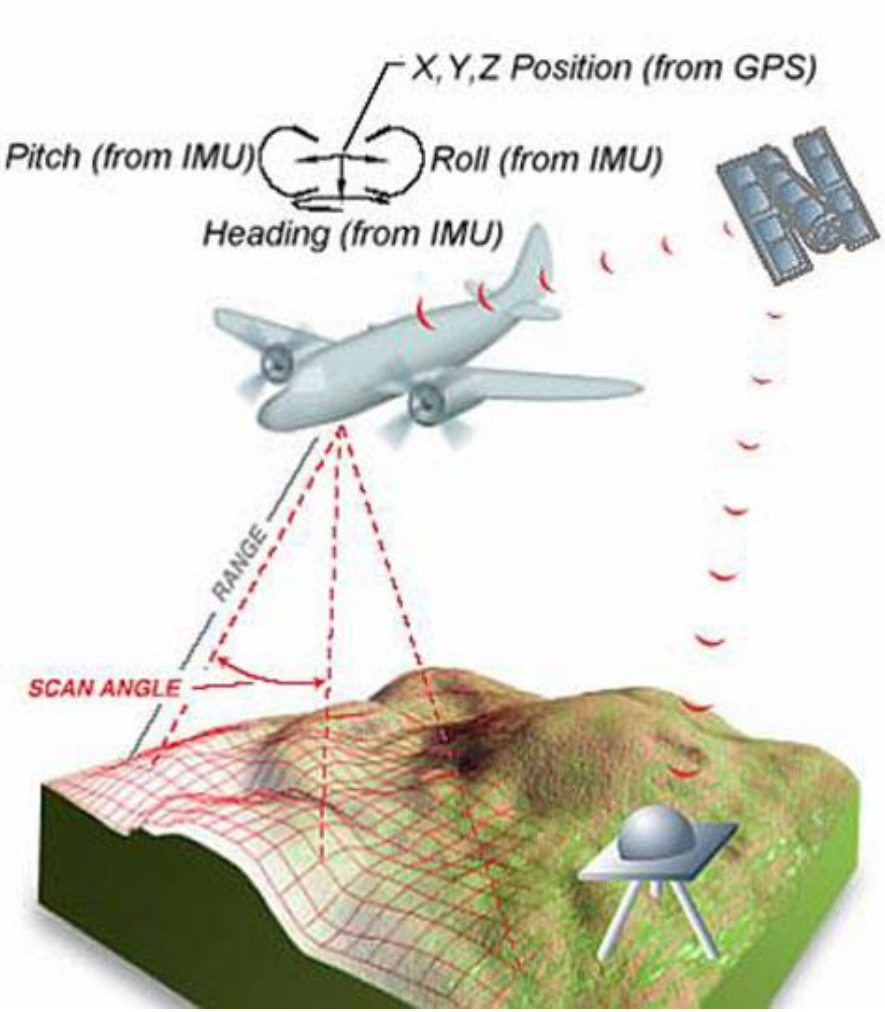
What Is LIDAR?

- Laser Imaging, Detection and Ranging (LIDAR) is the optical equivalent of radar or sonar but using an optical source – a laser - instead of microwaves or sound waves
- An optical pulse is emitted from a laser at a precisely known time, the pulse reflects from something in the 'object' space and the instrument measures the precise time a return pulse ("echo") is detected
- The time of flight is converted to a distance to the target using the constant speed of light
- The laser's precise position and orientation is known via a "Positioning and Orientation System" (POS). These supplemental data are used to derive the object space position

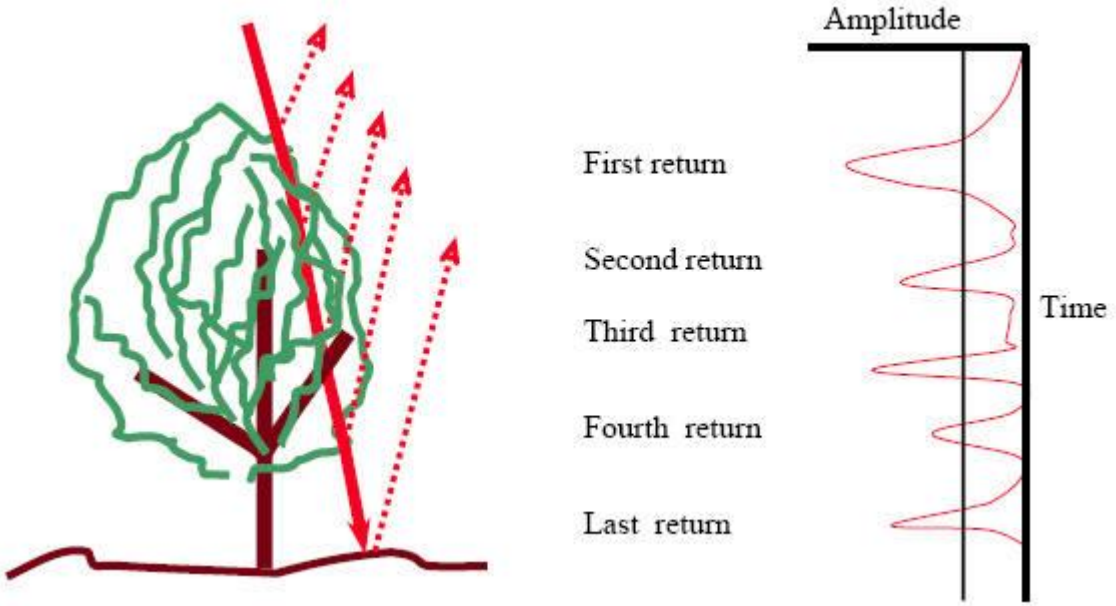


How Does It Work?

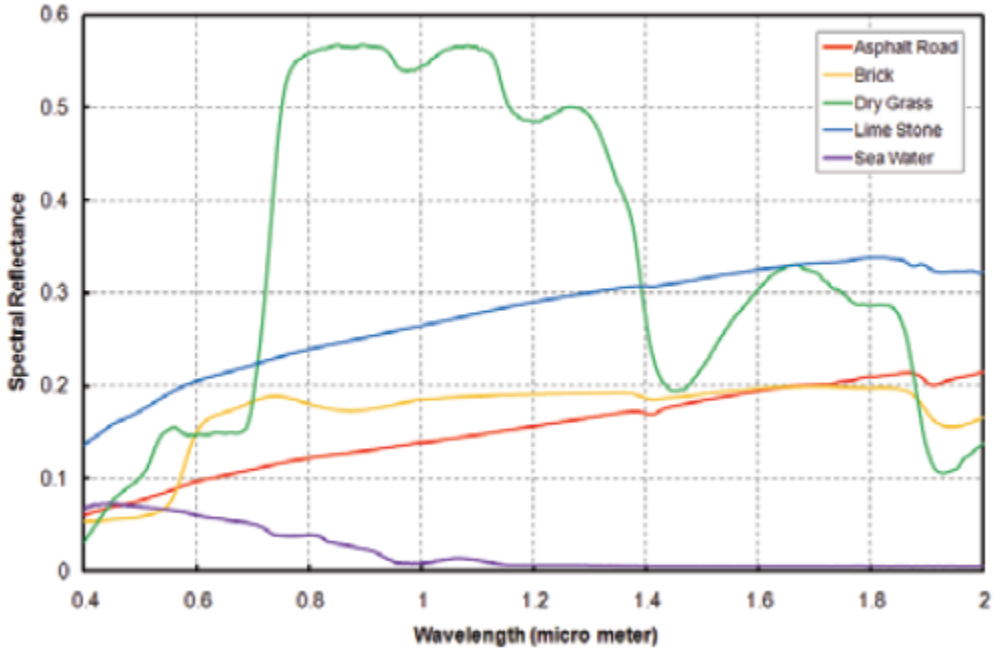
- Compact, rugged instrument installed on a small aircraft
- Laser pulses scanned across the path of the aircraft measuring range to surface
- LIDAR ranges are combined with aircraft GPS position and Inertial Measurement Unit orientation information
- Post-processing software calculates X,Y,Z position of each spot on the surface



Modern LIDARs can detect Multi-Returns ("echoes")



Laser Return Intensity



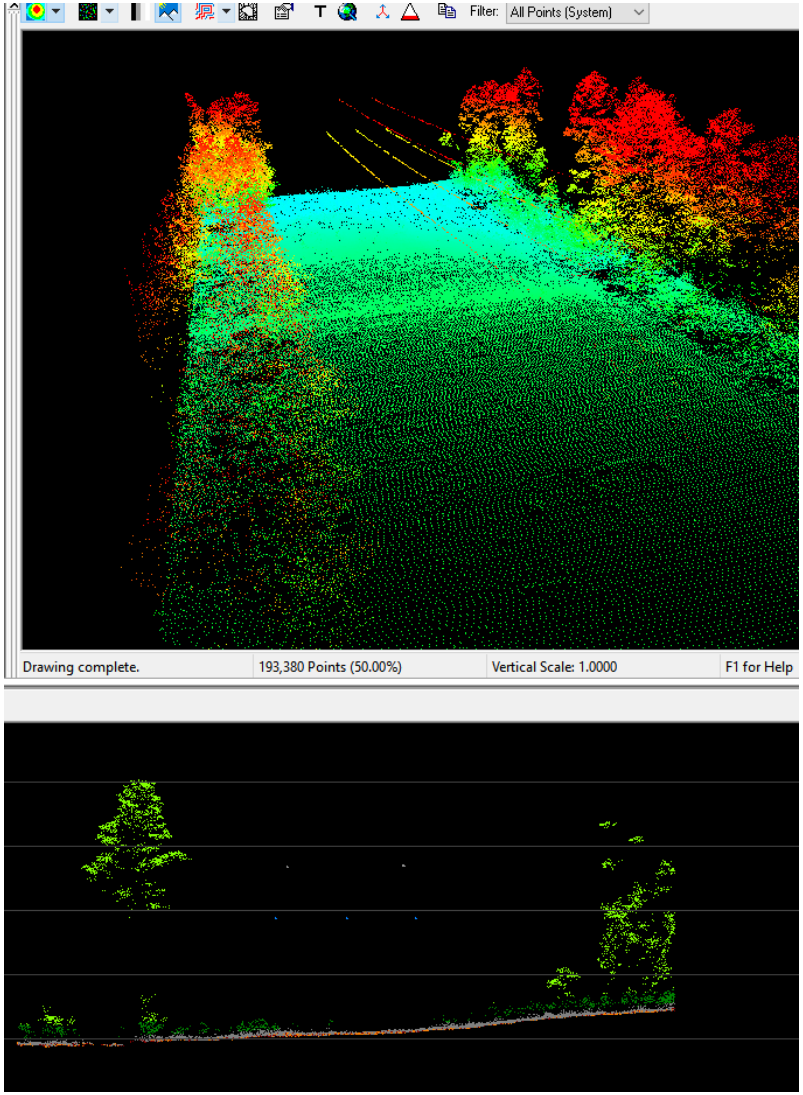
Typical Wavelengths:

Wide area mapper → 1.064 microns

Corridor mapper → 1.541 microns

Point Cloud

Because of sensor mechanics and ground undulation, the points are not uniform



Because the points are true 3D, they cannot be represented by a raster such as a DEM

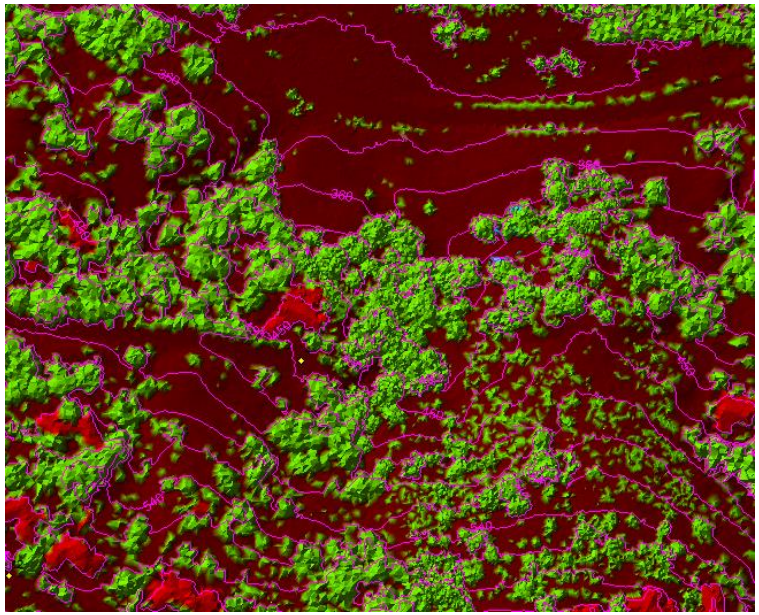
Important Point Attributes

- Attributes produced by the laser scanner:
  - Absolute time of pulse
  - Position (X, Y, Z)
  - Intensity (echo energy)
  - Return number (e.g. return “n of m”)
  - Edge of flight line
  - Scan angle
- All of the above are very important to advanced processing algorithms

Typical Point Cloud Products

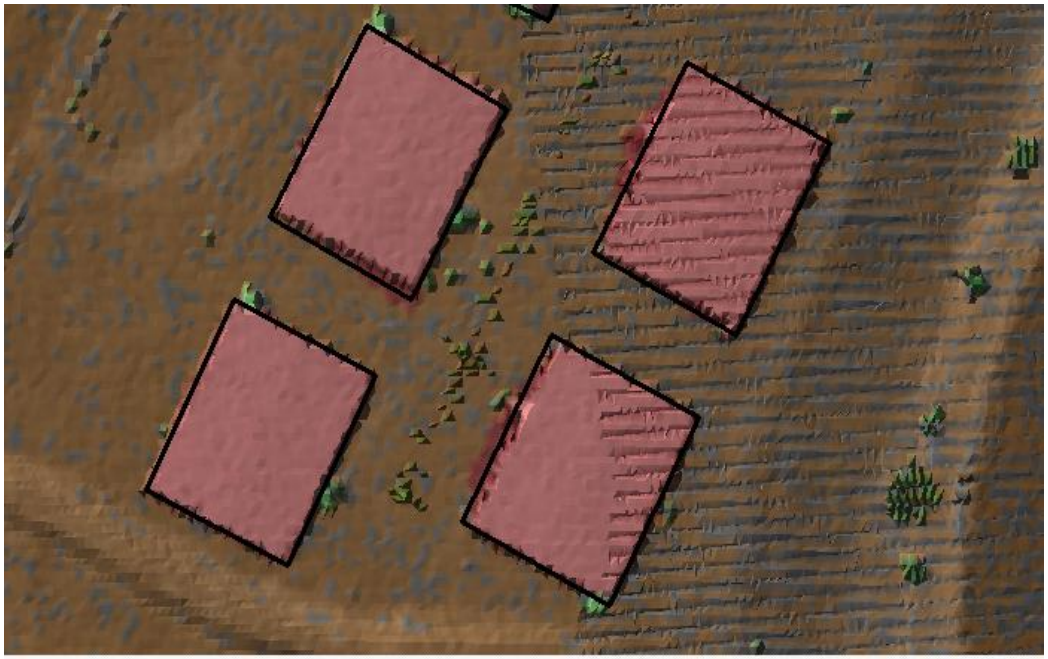
(In *all* cases, we assume geometrically corrected clouds)

- "Unclassified" - All returns, unclassified point cloud
- "Surface" cloud - This is a first return, unclassified cloud. No need for this if you specify the "all returns" data
- "Bare Earth" classified cloud - Classified ground, Classified Noise, tagged "overlap" points - should include all other points (unclassified)
- Supplemental classes – Classified ground + Vegetation, Buildings, etc.



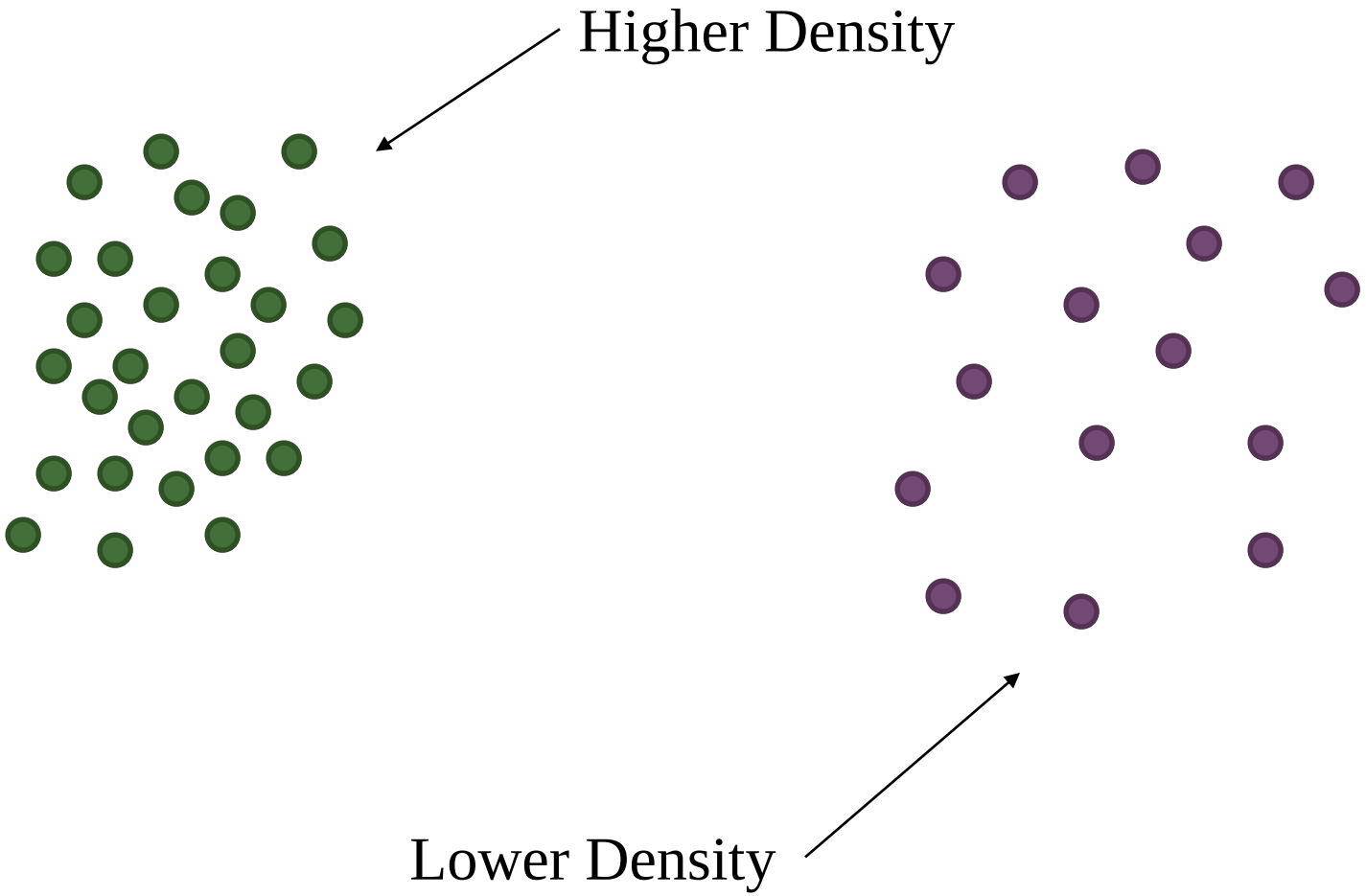
Feature Extraction

- Water bodies
- Shoreline
- Planar surfaces
  - Roof footprints, etc.
- Tree envelopes
- Specialty assets– roads, bridges, rails, etc.



LIDAR PARAMETERS

Density



Point Spacing/Density Measurement

- Measured as:
  - Density - Points per unit area (e.g. points per square meter, ppm)
  - Nominal Point Spacing (NPS) – average distance between points
  - Ground Sample Distance (GSD) – same as NPS

$$NPS = \frac{1}{\sqrt{Density}}$$

(e.g. A 40 ppm helicopter scan has an NPS of ~16 cm)

USGS Quality Levels

Quality level	Aggregate nominal pulse spacing (m)	Aggregate nominal pulse density (pls/m²)
QL0	≤0.35	≥8.0
QL1	≤0.35	≥8.0
QL2	≤0.71	≥2.0
QL3	≤1.41	≥0.5

Quality level	$RMSE_z$ (nonvegetated) (m)	NVA at the 95-percent confidence level (m)	VVA at the 95th percentile (m)
QL0	≤0.050	≤0.098	≤0.15
QL1	≤0.100	≤0.196	≤0.30
QL2	≤0.100	≤0.196	≤0.30
QL3	≤0.200	≤0.392	≤0.60

NOTE: USGS is still not specifying horizontal accuracy

DEMO – LIDAR VIEWING SAMPLES

DATA APPLICATIONS

What Is LIDAR Mapping?

- It is a tool used in the airborne survey field that employs LIDAR to rapidly generate elevation data that are:
  - high-density
  - accurate
  - digital
  - geo-referenced
- Can be both a complementary or competitive technology to photogrammetry
- Complete data sets should include imagery

Typical Point Cloud Products

(In *all* cases, we assume geometrically corrected clouds)

- All returns, unclassified point cloud
- "Surface" cloud
  - This is a first return, unclassified cloud. No need for this if you specify the all returns data
- "Bare Earth" classified cloud (typical 3DEP delivery)
  - Should include all other points but unclassified
- Supplemental classes;
  - Vegetation
  - Buildings
  - etc.

Supplemental LIDAR Derived Data

- Breaklines - Hydro
  - Water bodies (“flattening”)
  - Downstream constraints
  - Double line drains
- Breaklines – Other
  - Edge of pavement
  - Retaining walls
  - (Geo)Morphological interest

Feature Extraction

- Water bodies
- Shoreline
- Planar surfaces (e.g. building roofs)
- Building “roof prints”
- Tree envelopes
- Specialty assets– roads, bridges, rails, wires, etc.

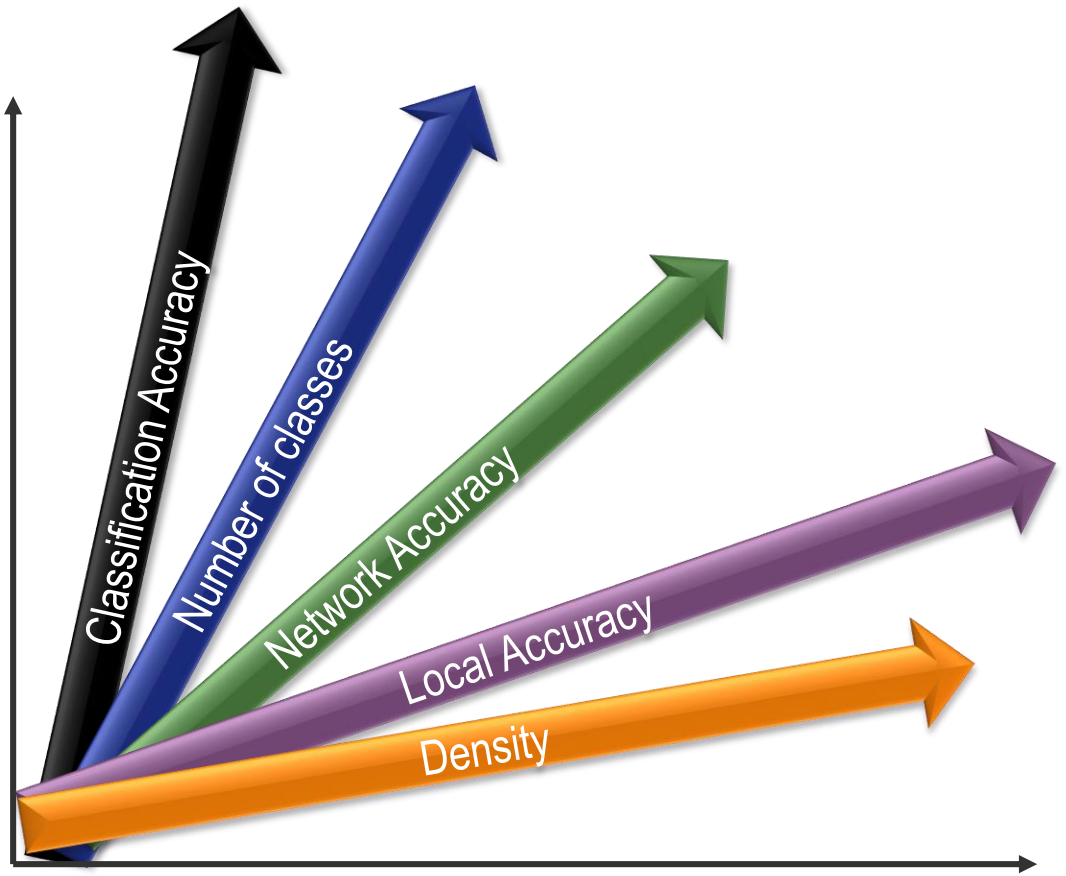
Visualization

- LIDAR “Orthos”
- 3D visualization
- Profiles

Output products

- Gridded elevation models
  - Canopy
  - Surface
  - Breakline enforced surface
- Topographic Contours
- Raster visualization products
- Features
- Derived analytics such as volumetrics

Cost Factors



Cost

increasing
quality of factor

QA, QC

Quality Assurance (QA) – Preventing Defects

Quality Control/Check (QC) – Identifying Defects

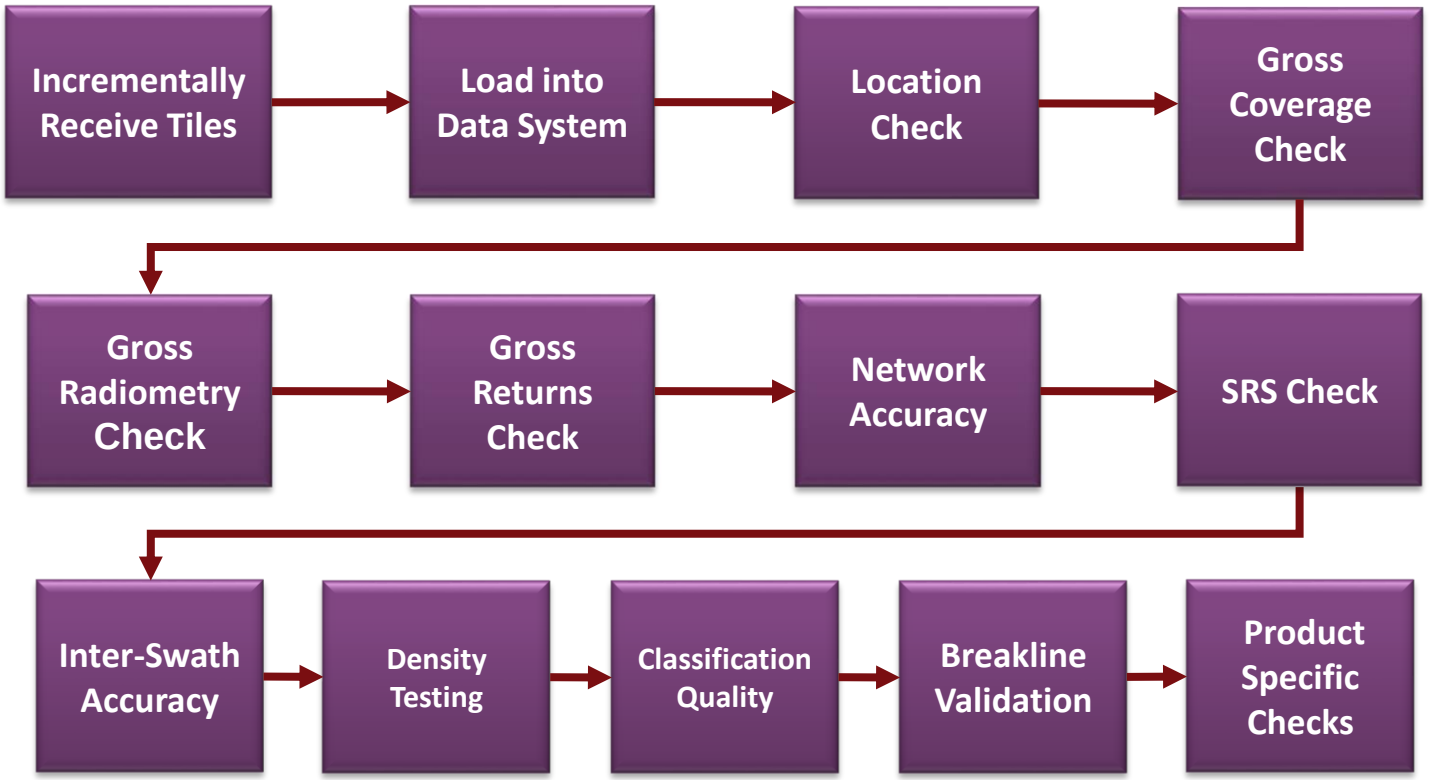
Independent Validation and Verification (IV&V) – An independent (from the contractor) QC function

Sometimes small repairs are considered part of a QC task but I would recommend these be kept separate

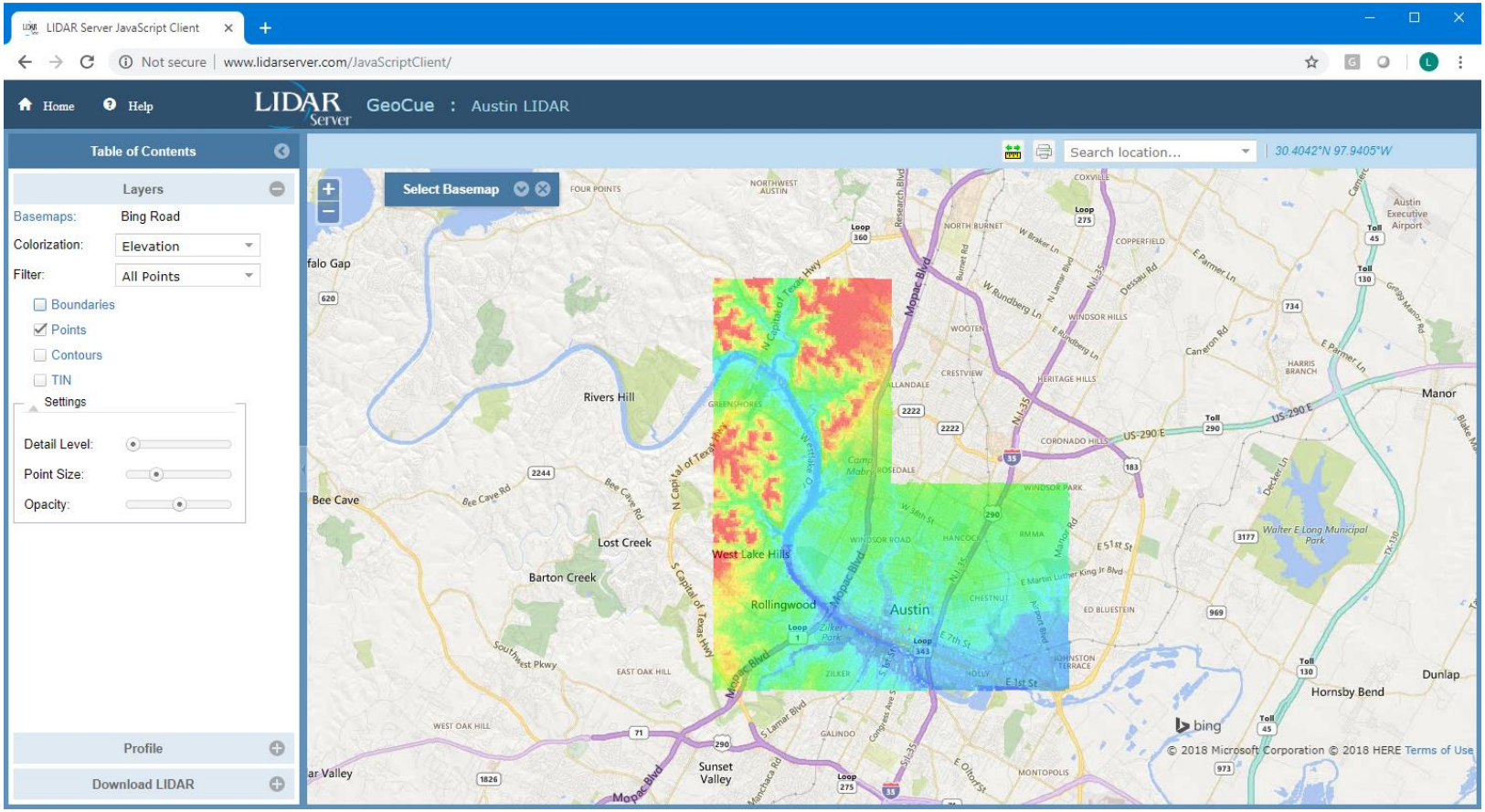
Ignoring QC

- With LIDAR, you typically find the issues months or years after the fact
- Secondary product derivation may be impossible
- Stakeholders lose some percentage of their investment
- Persons involved in the procurement lose credibility
- Often the technology (LIDAR), rather than the process, is blamed.

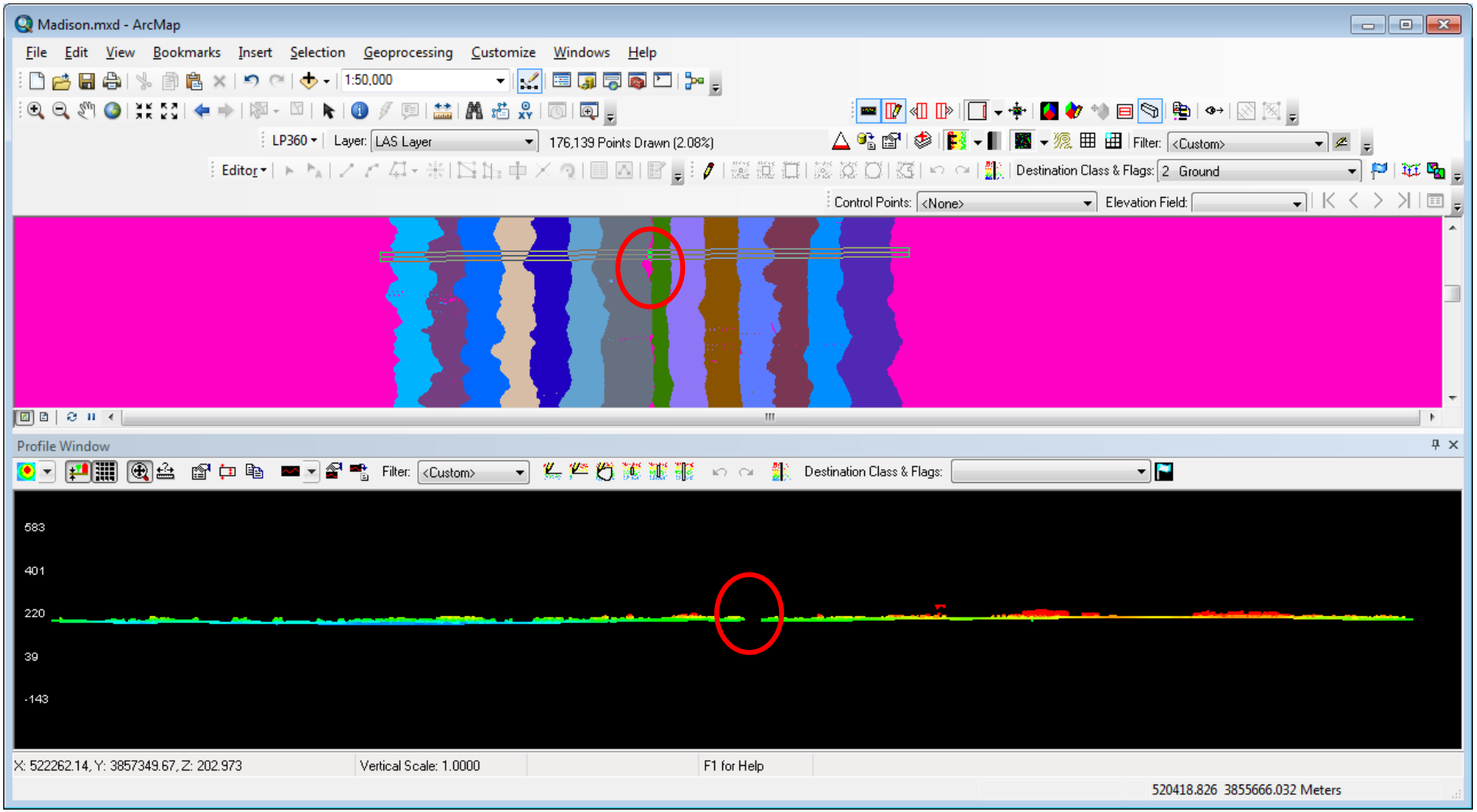
Typical QC flow



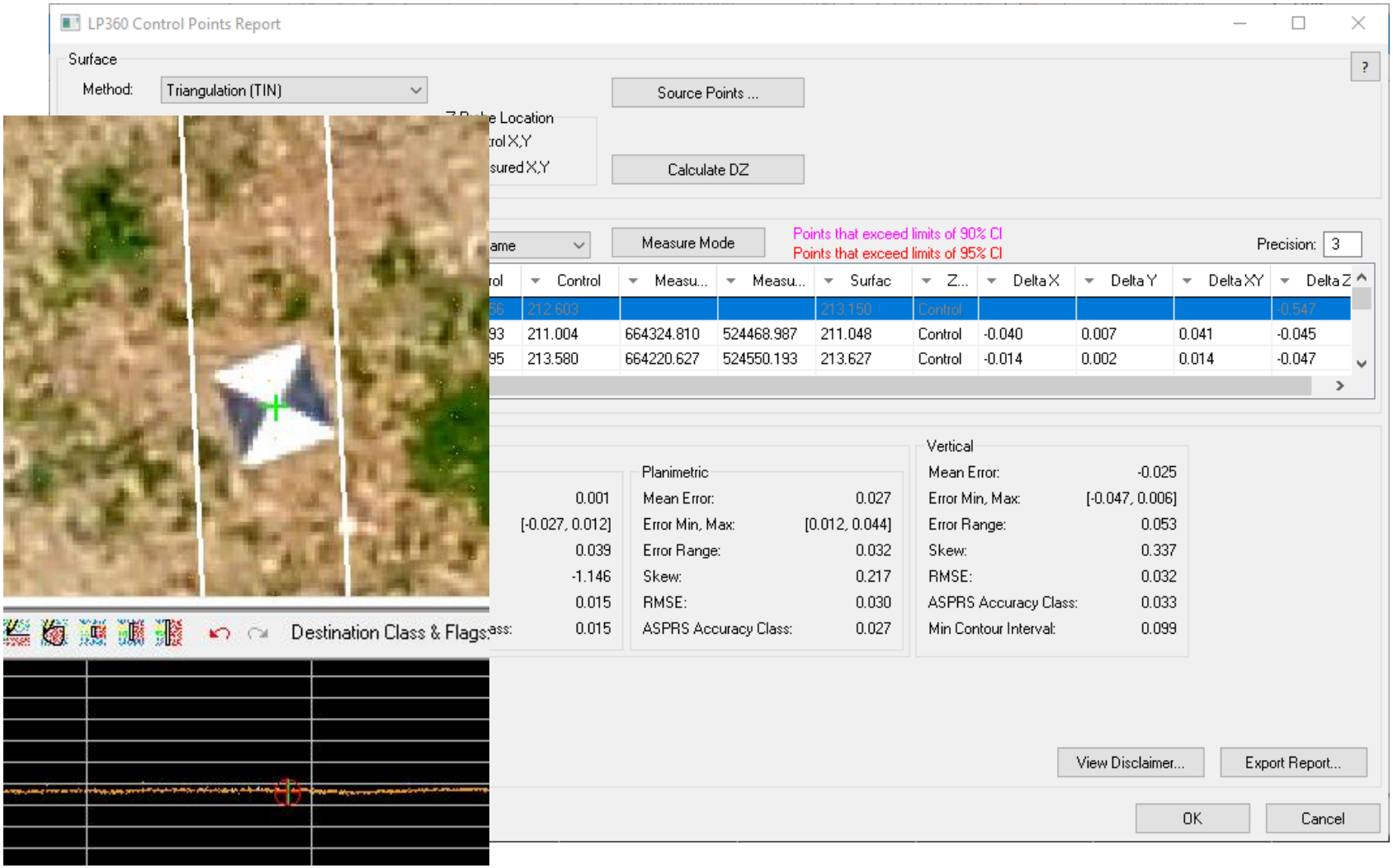
Coverage


LIDAR Server JavaScript Client
Not secure | www.lidarserver.com/JavaScriptClient/
Home
Help
LIDAR Server
GeoCue : Austin LIDAR
Table of Contents
Layers
Basemaps: Bing Road
Colorization: Elevation
Filter: All Points
Boundaries
Points
Contours
TIN
Settings
Detail Level:
Point Size:
Opacity:
Profile
Download LIDAR
Search location...
30.4042°N 97.9405°W
Select Basemap
Rivers Hill
Bee Cave
Lost Creek
Barton Creek
West Lake Hills
Rollingwood
Austin
Sunset Valley
Manor
Dunlap
Hornsby Bend
bing
© 2018 Microsoft Corporation © 2018 HERE Terms of Use

Gross Void Checks

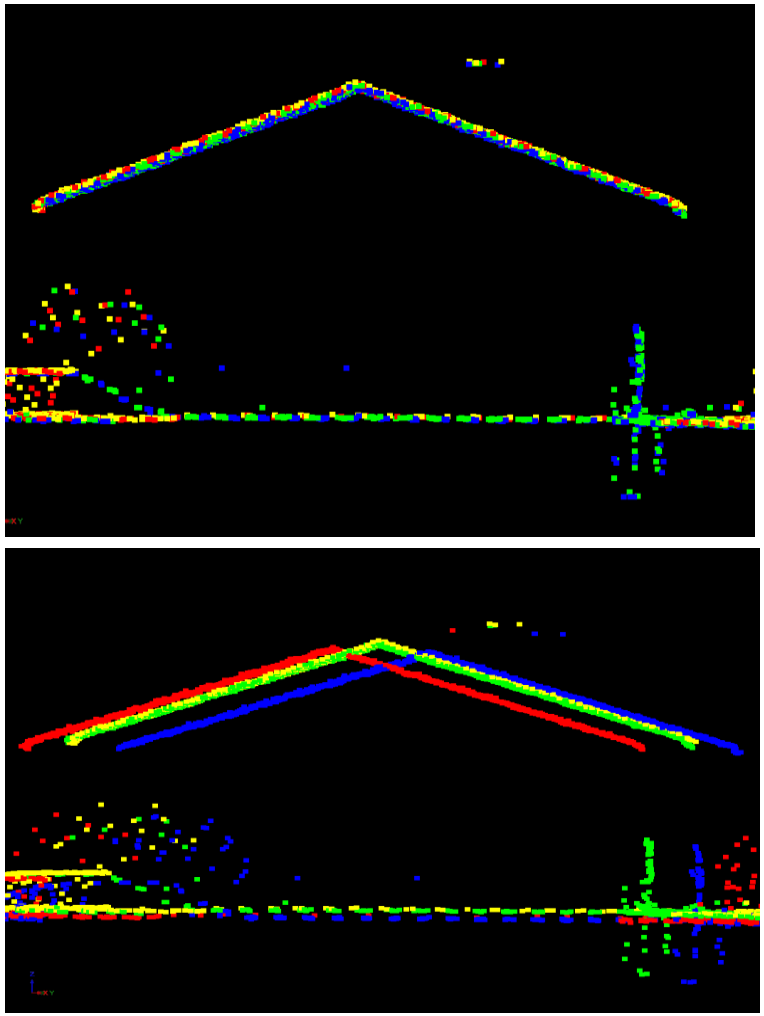


Network Accuracy



Local Accuracy

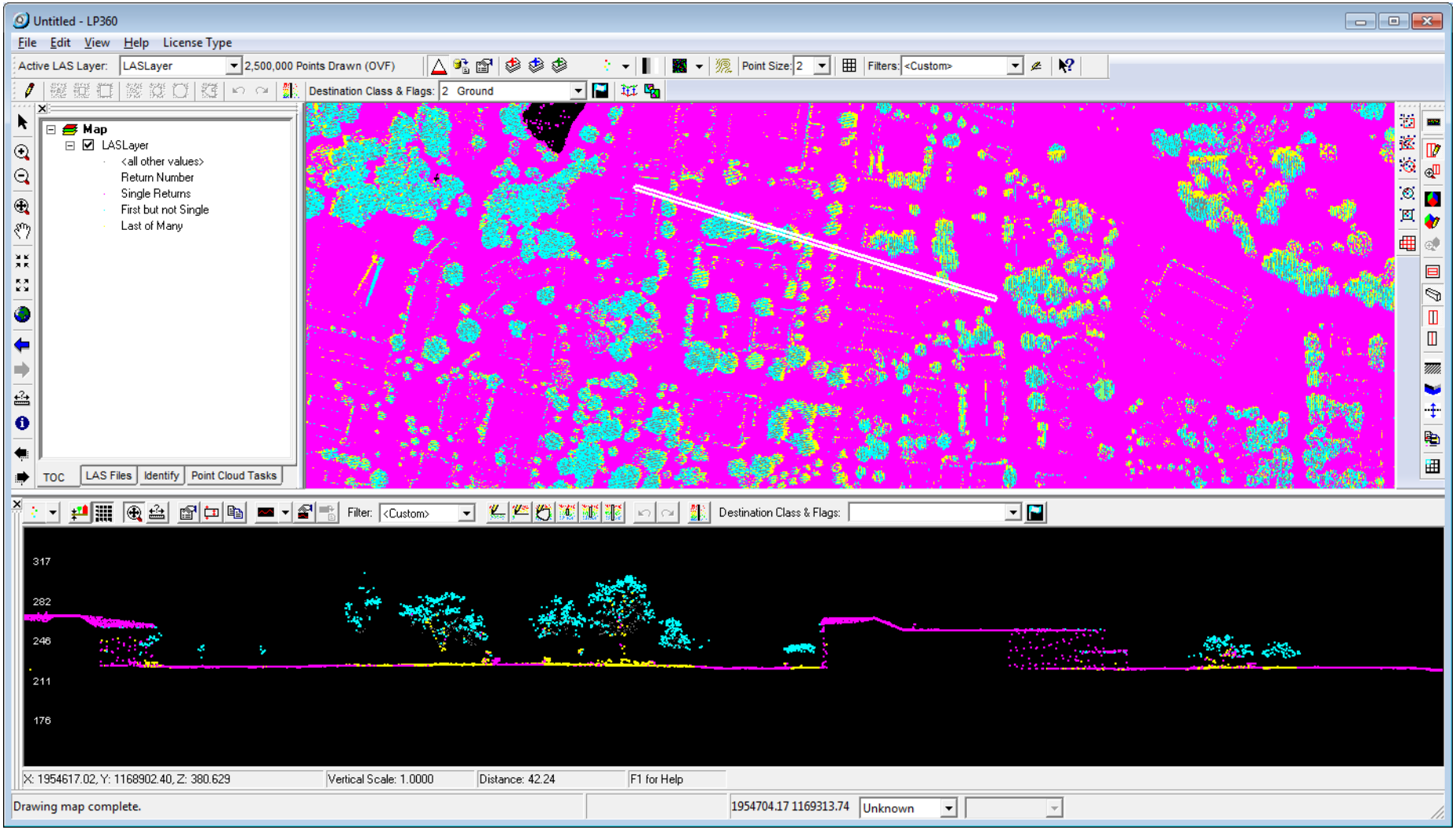
- Poor Alignment
  - Image Swaths
- Look at Flight Overlap
- Examine Surface
- Examine Cross-Sections
  - Buildings in Overlap
  - Roads
  - Parking Lots



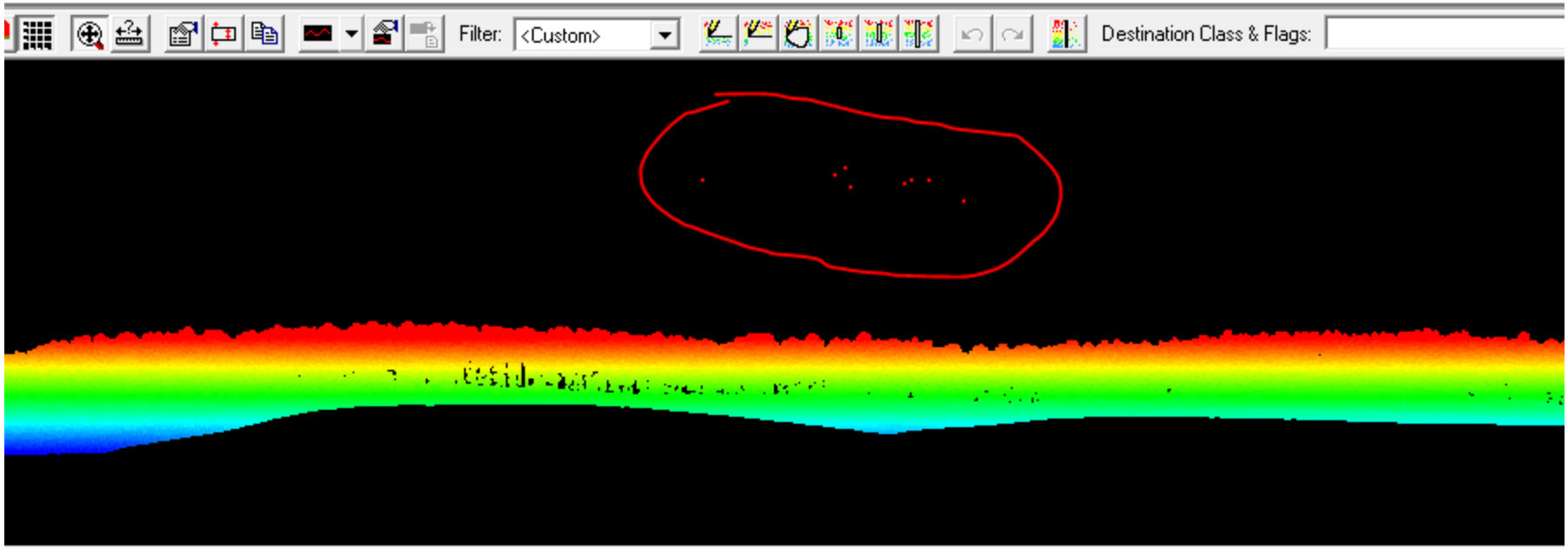
Good Radiometry



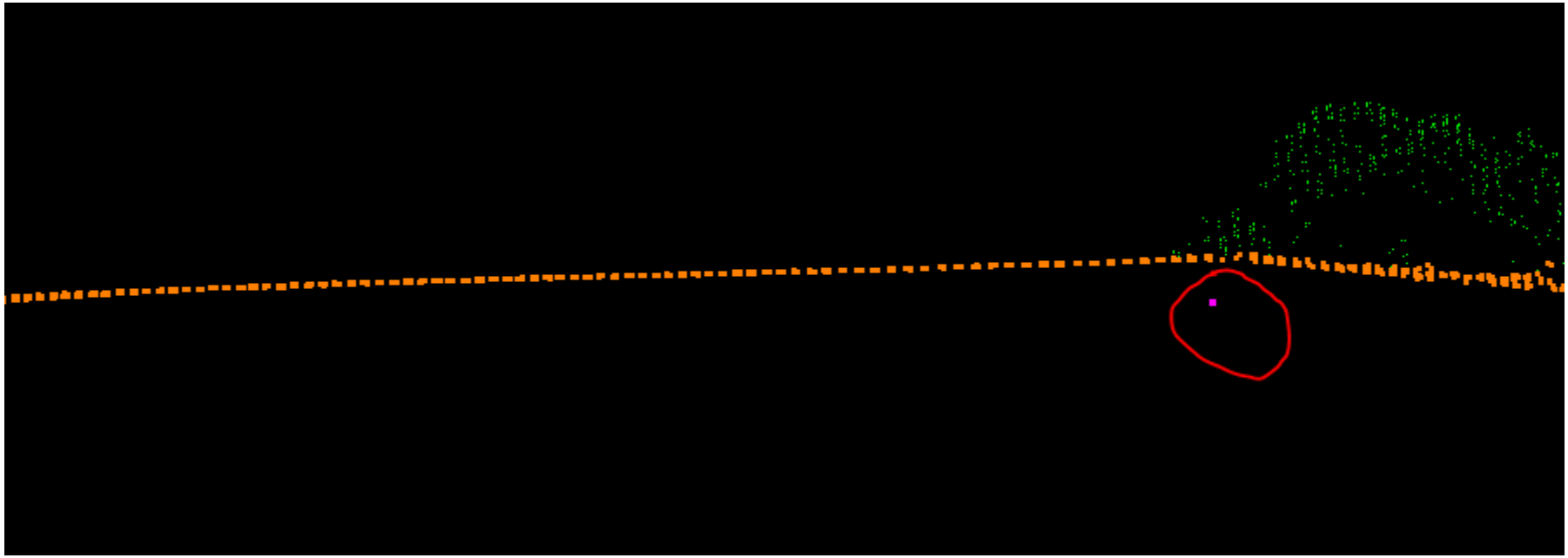
Returns


Untitled - LP360
File Edit View Help License Type
Active LAS Layer: LASLayer
2,500,000 Points Drawn (OVF)
Point Size: 2
Filters: <Custom>
Destination Class & Flags: 2 Ground
Map
LASLayer
<all other values>
Return Number
Single Returns
First but not Single
Last of Many
TOC
LAS Files
Identify
Point Cloud Tasks
Filter: <Custom>
Destination Class & Flags:
317
282
246
211
176
X: 1954617.02, Y: 1168902.40, Z: 380.629
Vertical Scale: 1.0000
Distance: 42.24
F1 for Help
Drawing map complete.
1954704.17 1169313.74
Unknown

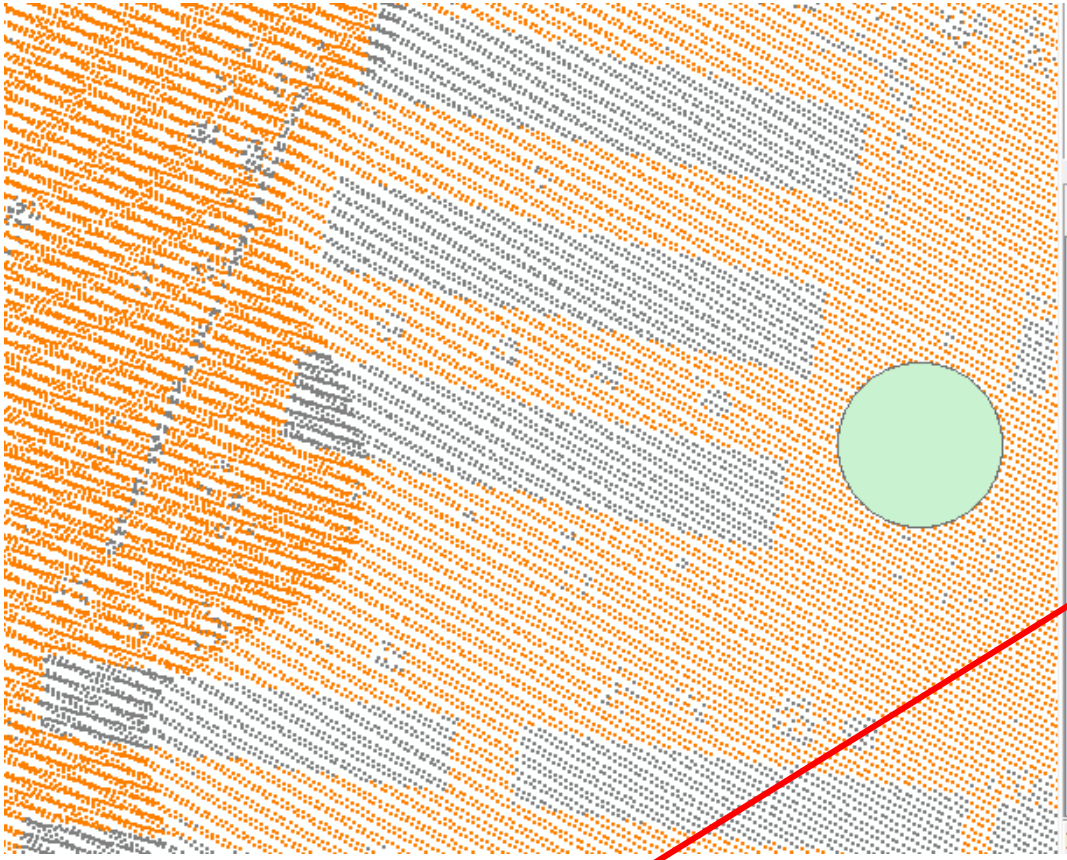
High Noise



Low Noise



Density Test



1

Location: 1,537,166.429 201,820.475 Feet

Field	Value
FID	0
Shape	Polygon
ID	1
PntCnt	461
PntCntAsDb	461
NumCLUsed	1
CLCnt_2	461
PntDen	0.0564
CLDen_2	0.0564
CL2ELAV	958.6068
CL2ELMN	955.96
CL2ELMX	961.61
CL2ELSD	1.1016

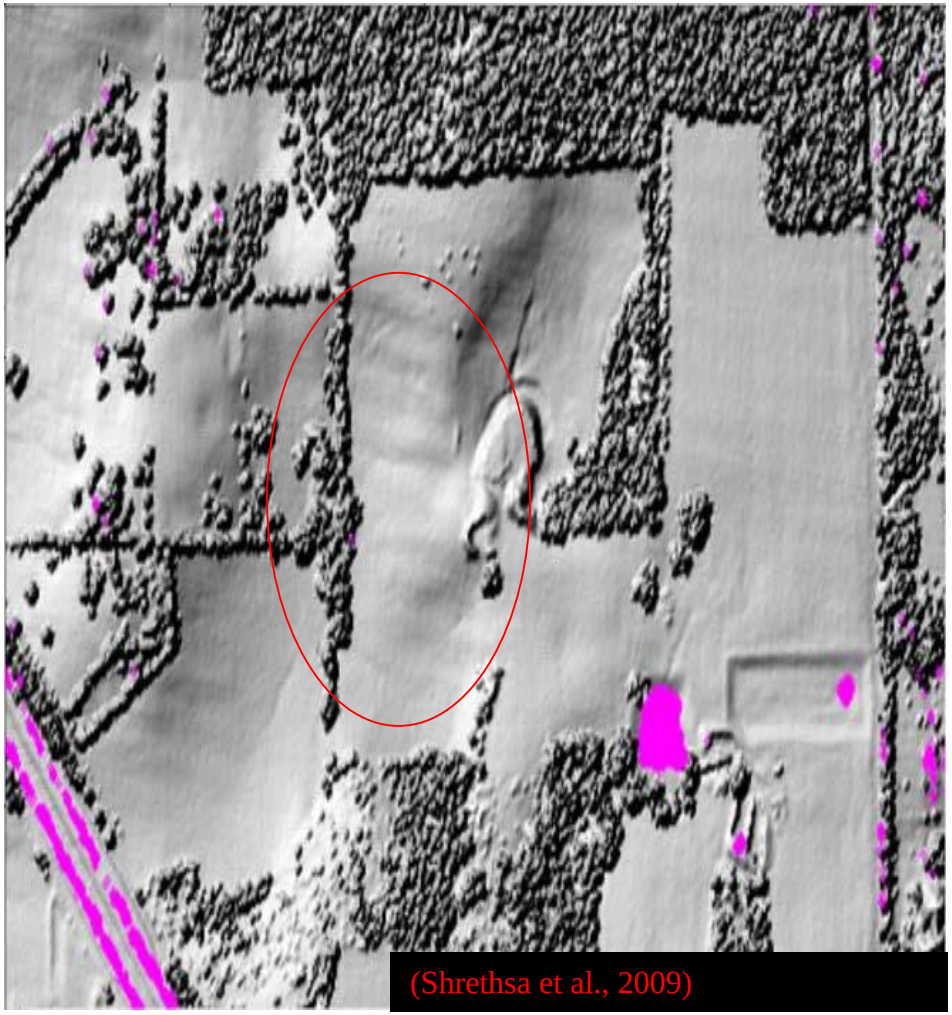
Identified 1 feature

$$NPS = \frac{1}{\sqrt{Density}}$$

4.21 ft

Error Identification: Pits, Spikes &Undulations

- Pits
  - Anomalies
- Spikes
  - Atmospheric Particles
  - Anomalies
- Undulations
  - IMU Measurement/Calibration Error



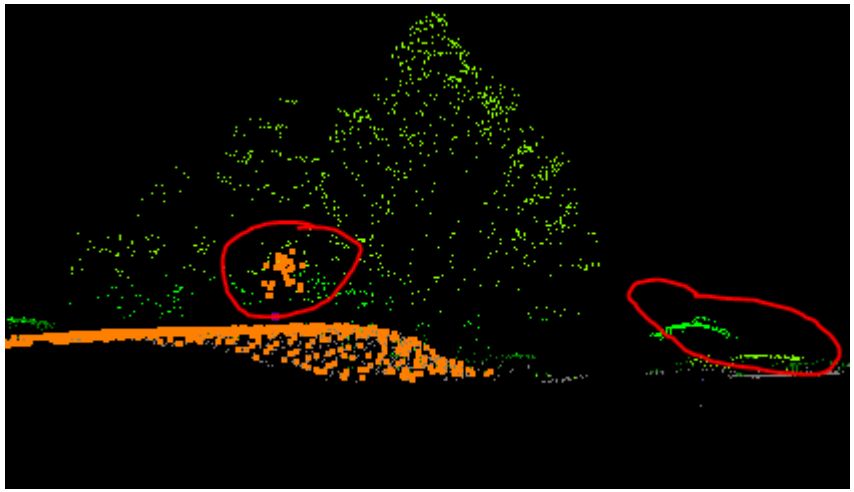
(Shrethsa et al., 2009)

Classification Accuracy

A Classification "Confusion" Matrix

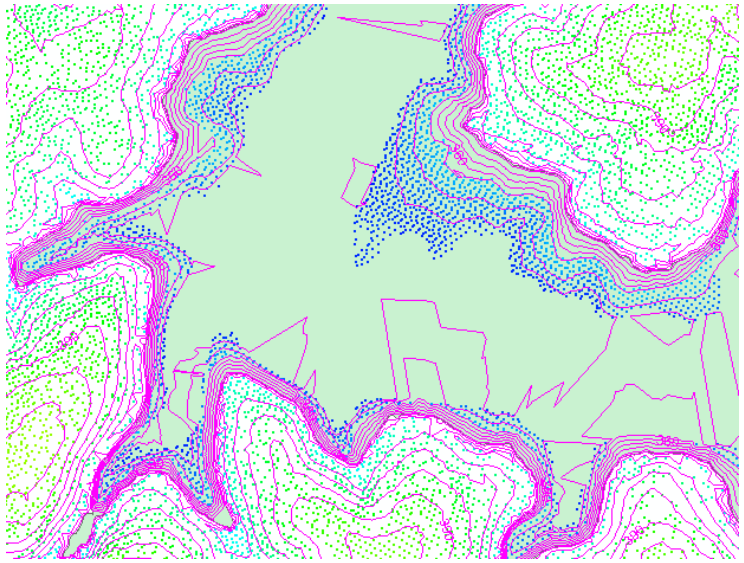
		Ground Truth				
		B	V	C	G	Total
Classified Data	B	**16326**	2178	224	1486	20214
	V	1709	**24635**	62	1535	27941
	C	111	252	**263**	327	953
	G	667	4827	257	**20257**	26008
	Total	18813	31892	806	23605	**75116**

B = Building
V = Vegetation
C = Car
G = Ground



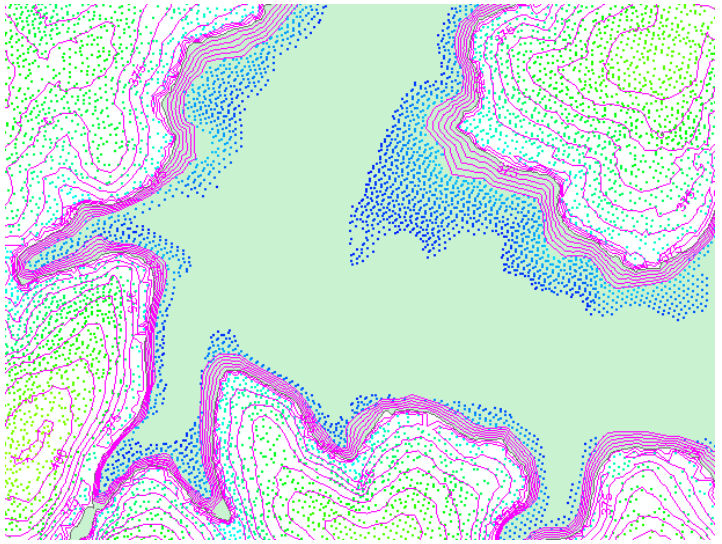
(misclassified Ground and Building

Breakline Checks

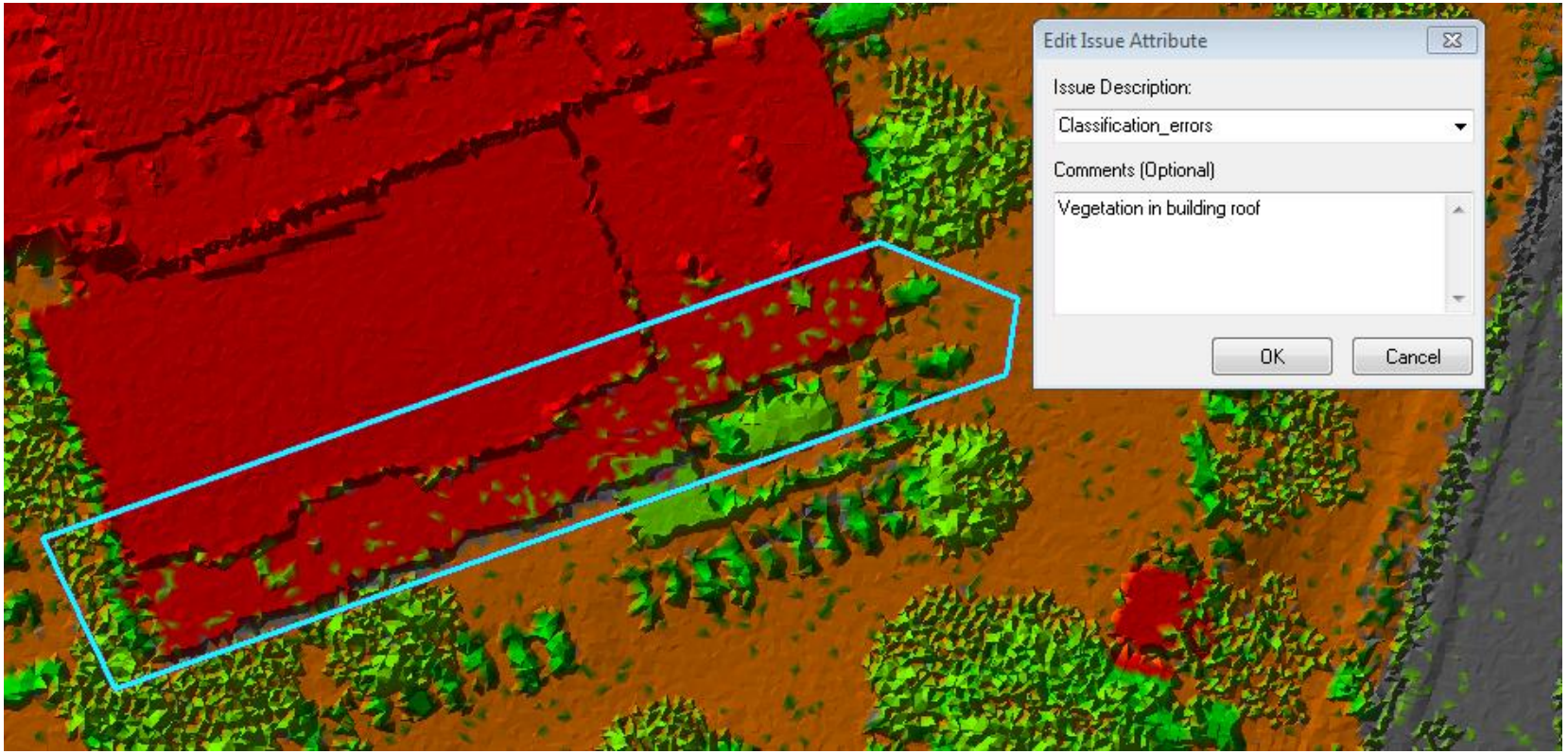


Breakline errors

Flat water body (correct)



Communicate Spatially!



QC-FOCUSED DEMOS

Poll Question

QC of LIDAR data upon receipt is very important because:

> Problems that are not detected early in the delivery cycle are difficult to refer back to the collection contractor

> Properties valuable to data extraction such as multiple returns may not have been examined in the contractor QC phase

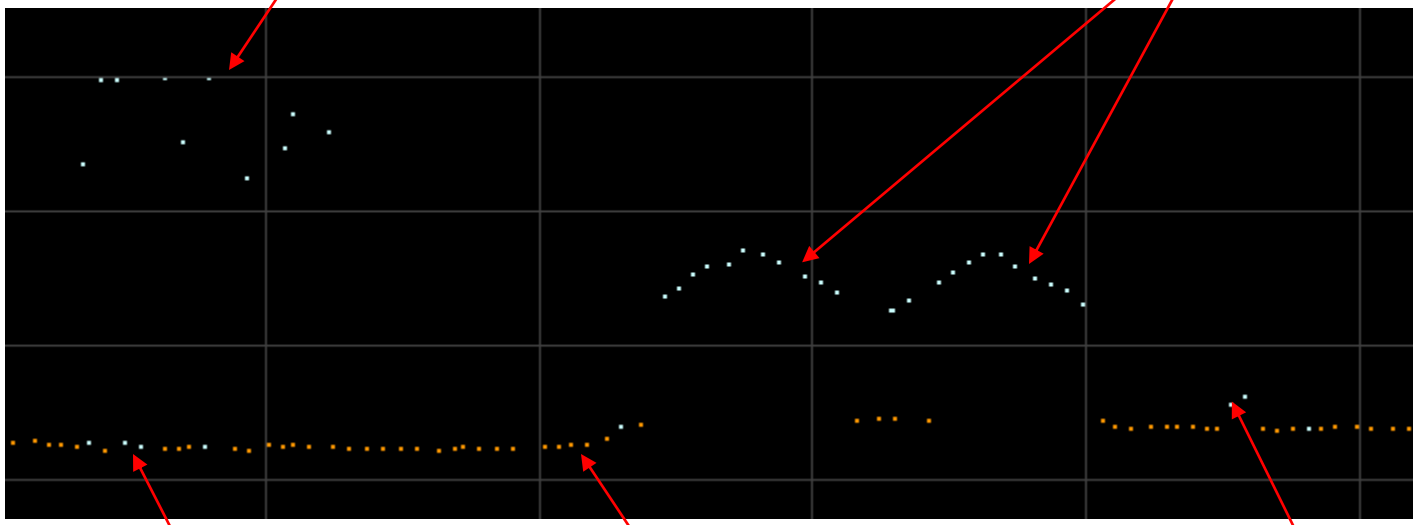
> Many LIDAR collects place the majority of the QC emphasis on the ground surface quality only

> You may not have received the full point cloud

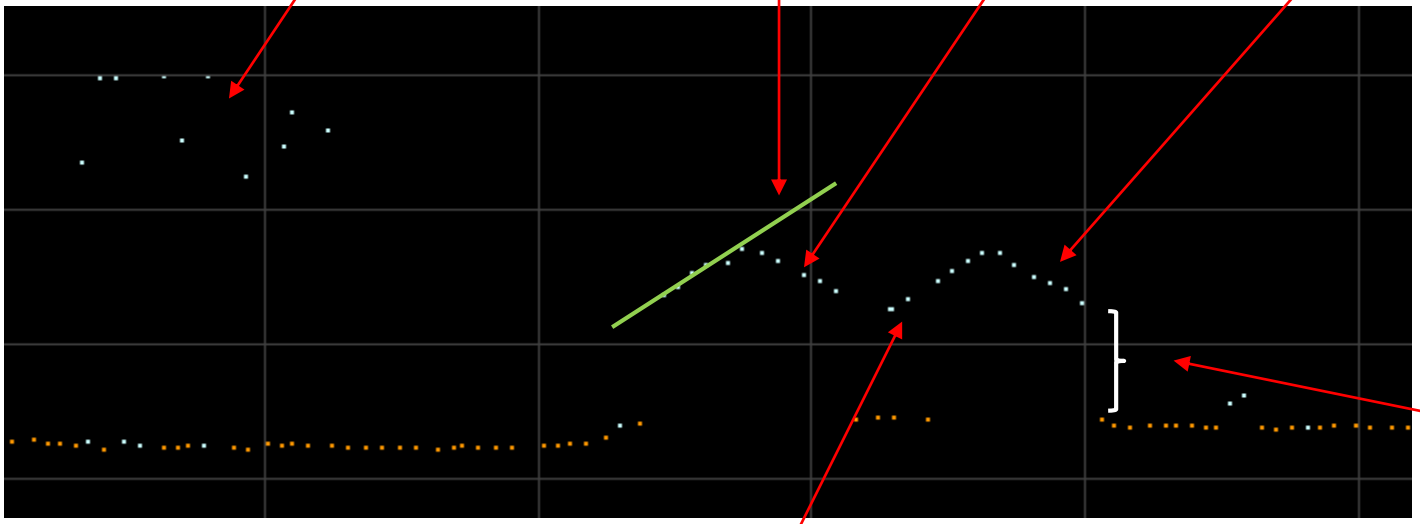
> All of the above

BUILDING EXTRACTION

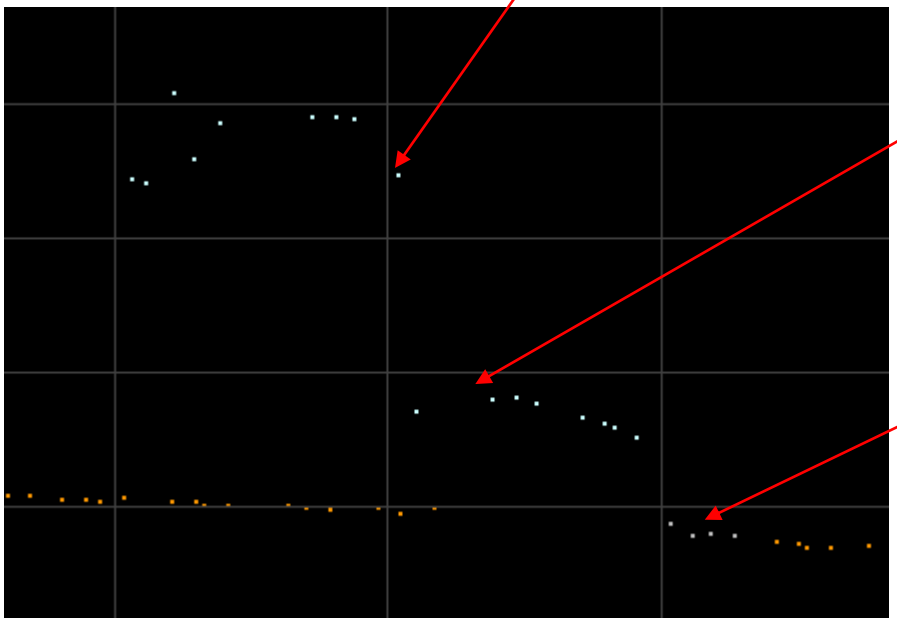
A Point's View of a Building



Useful metrics



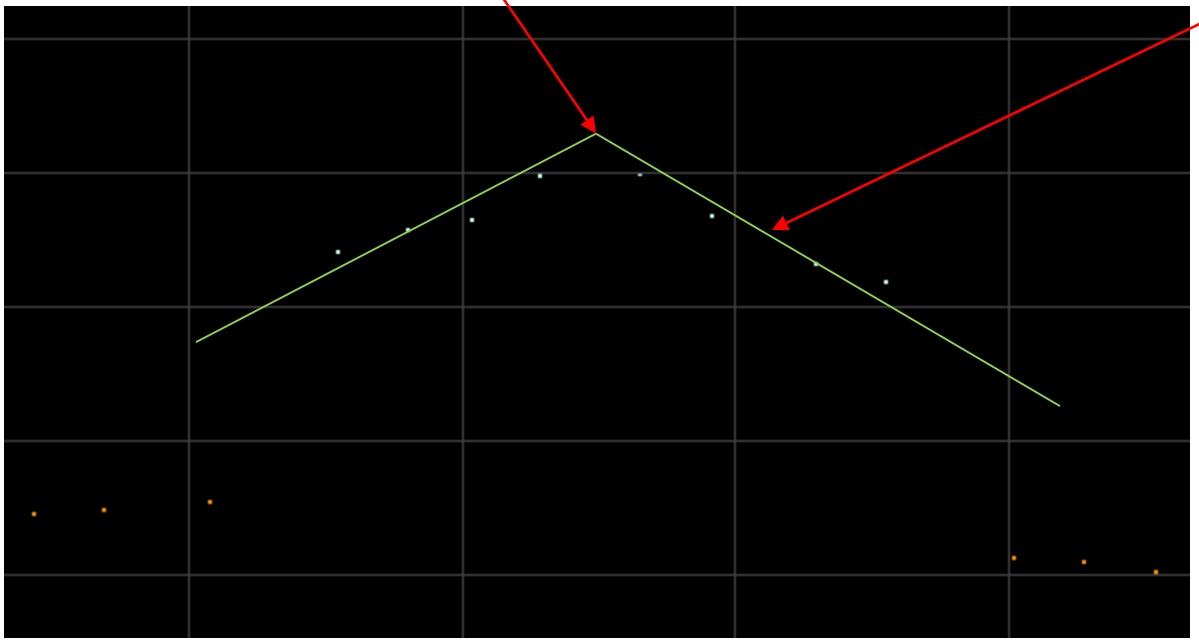
Problems


Tree (or other) points over roof
Sparse roof areas
Unclassified ground points

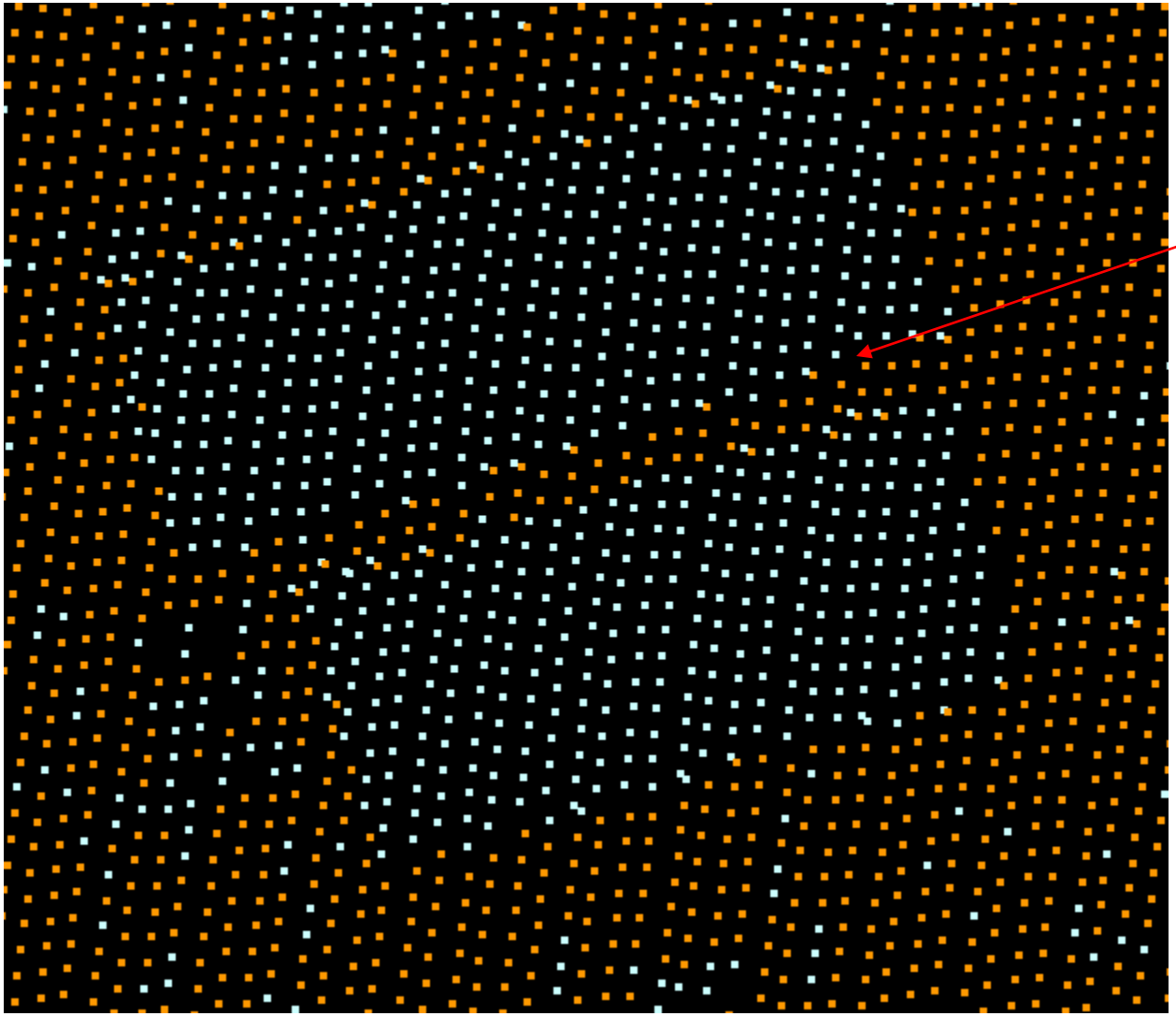
Problems (cont)

Undefined planar intersections

Noise relative to “best fit” plane

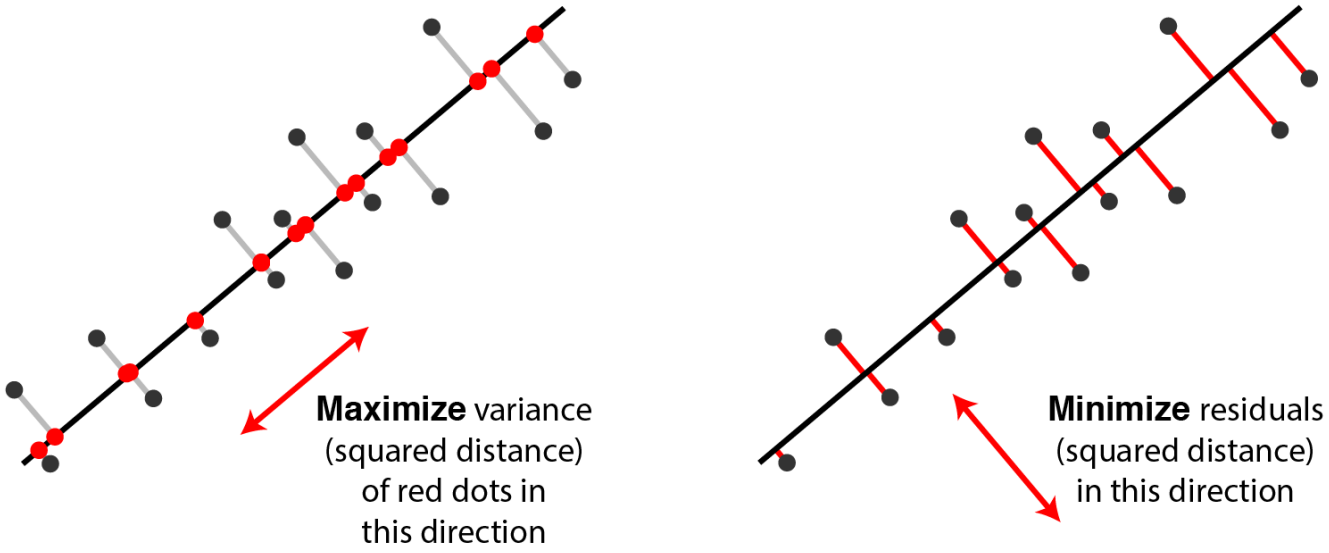


Problems (cont)



Extraction – Planes

Principal Component Analysis (PCA)



For each plane, derive Centroid (where is the center of the plane) and Normal (what is the elevation and azimuth?)

Planar Factors

How many contiguous points fit the plane (growing)?

What is the minimum required size of the plane?

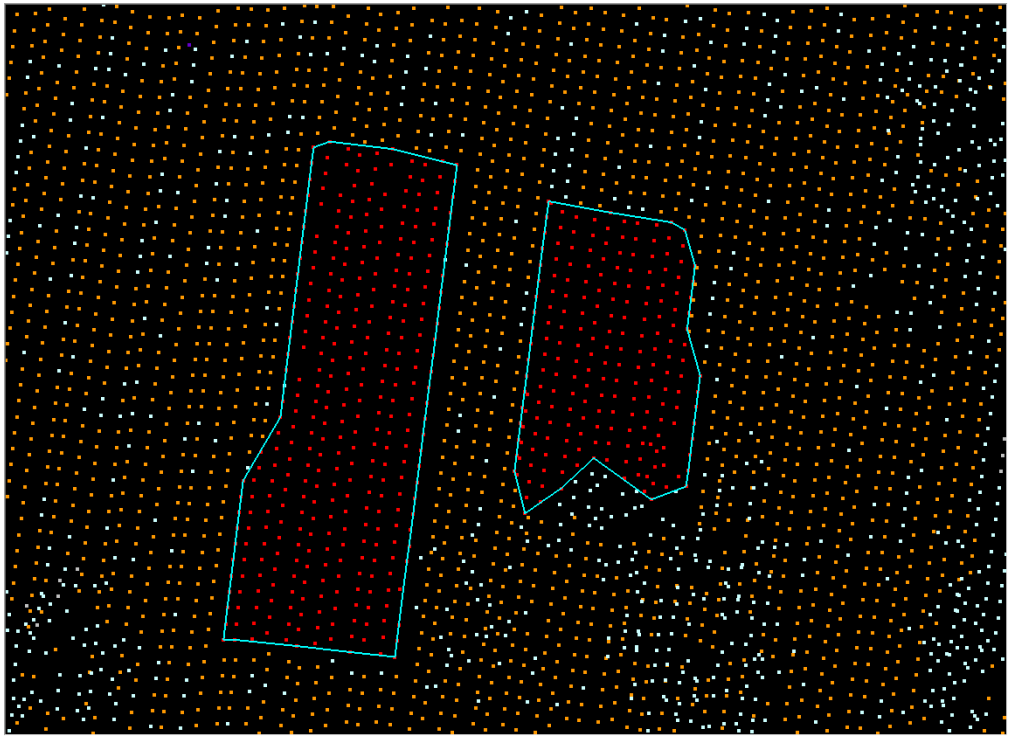
How far do we allow a point to deviate from the plane (noise)?

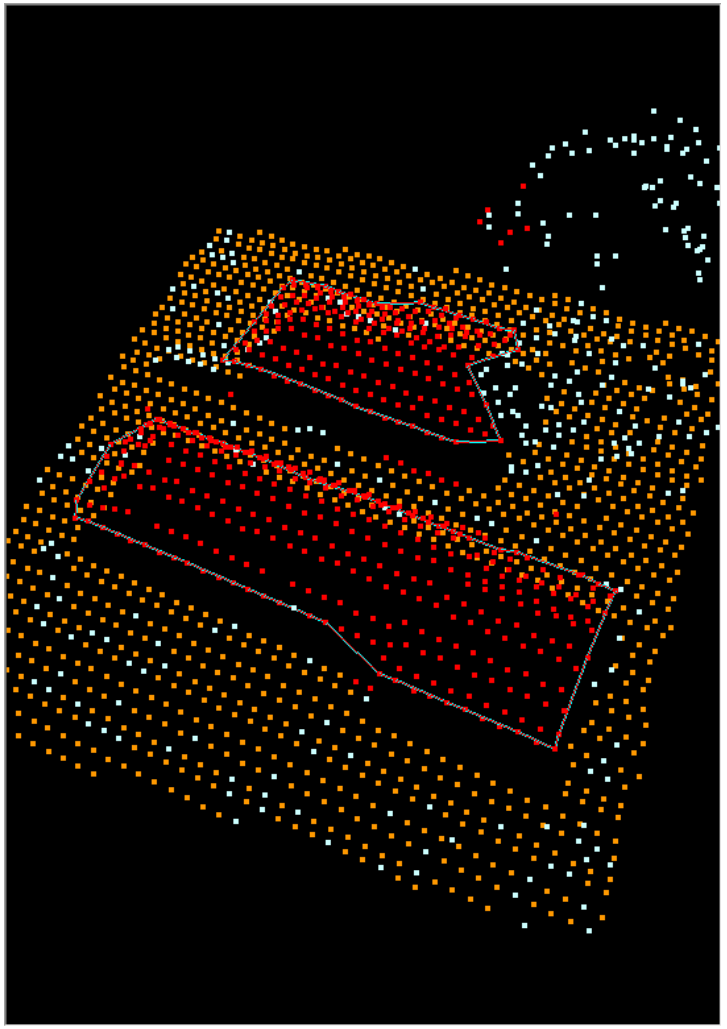
What is the minimum and maximum slope of the plane?

What is the minimum height of the plane above ground?

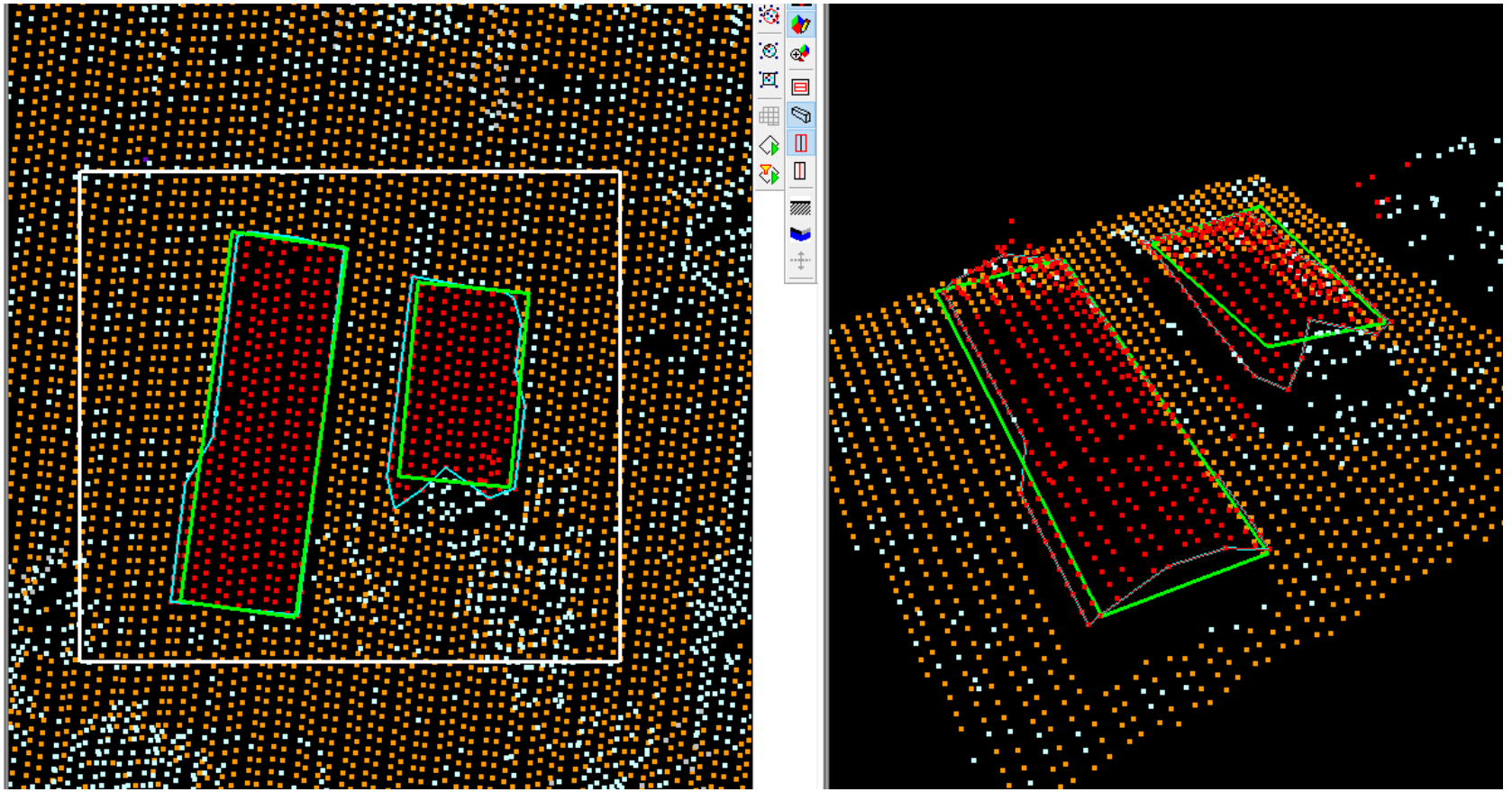
What is the maximum height of the plane above ground?

Traced Classified Planes

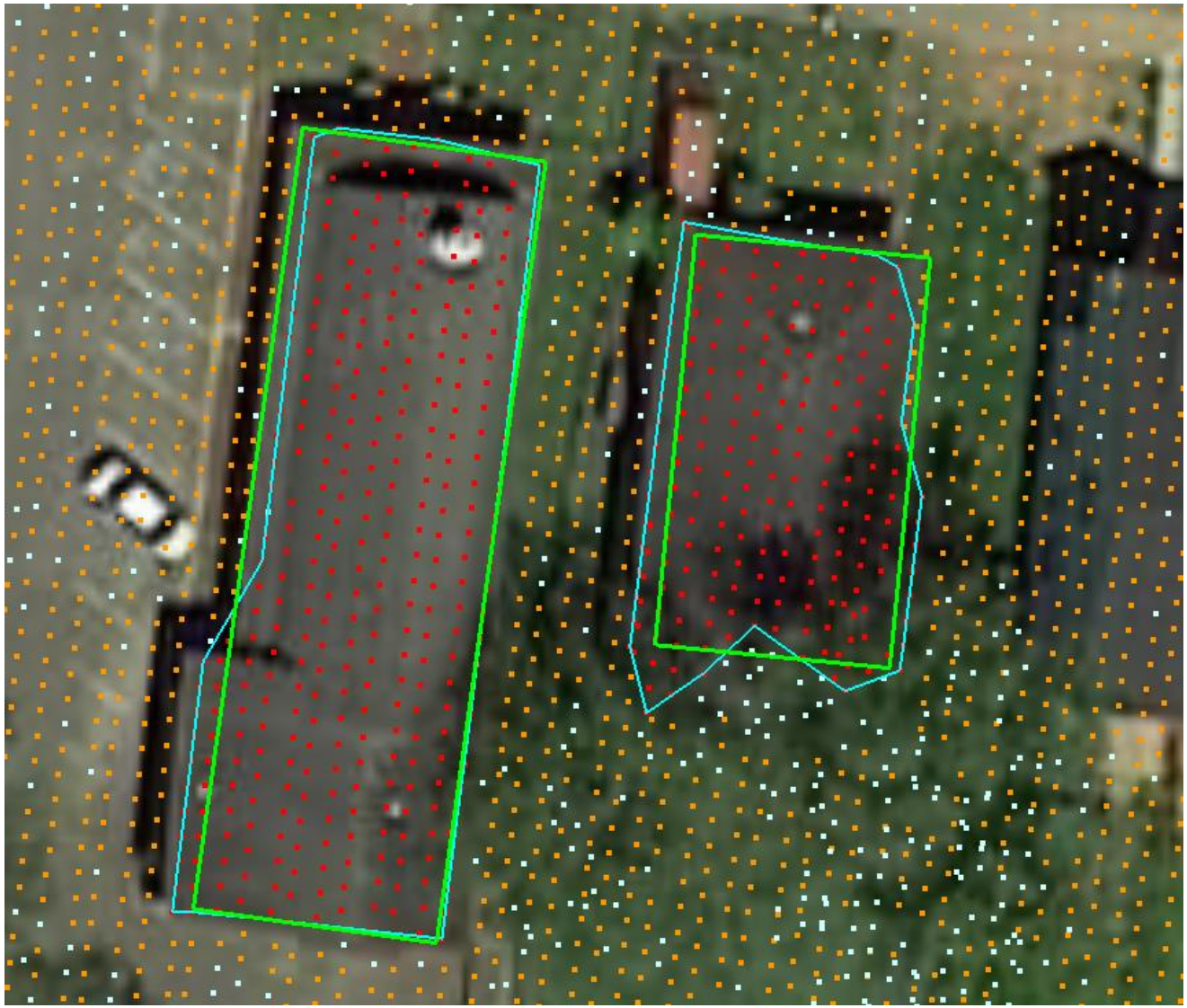




Squaring



Reality



BUILDING EXTRACTION DEMO

Poll Question

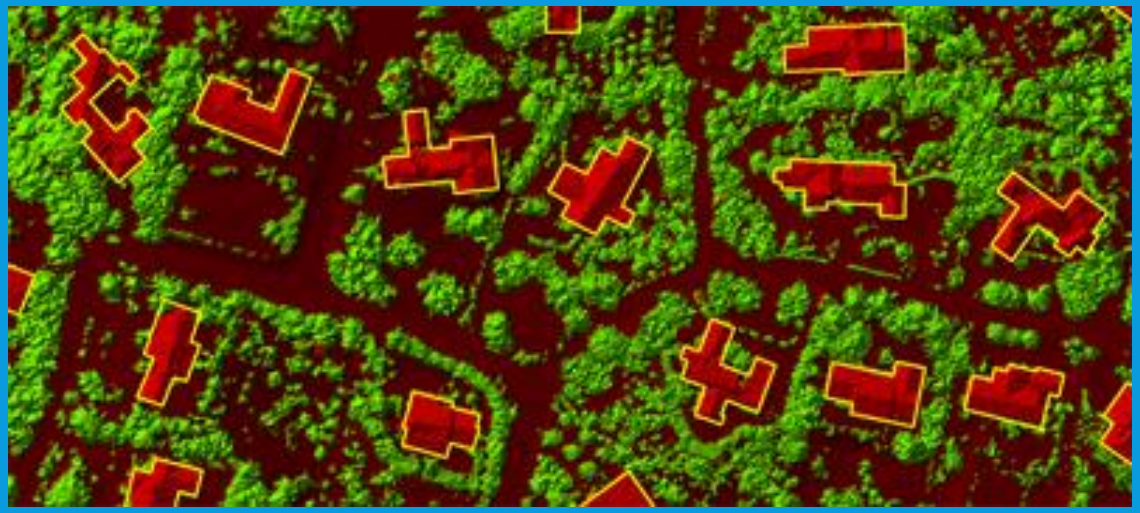
The most significant factors that can impact the ability of automated tools to extract building outlines (roof/footprint).

- RGB colors of the points
- Point noise level and point density
- The wavelength of the laser
- The altitude of the sensor
- None of the above

Summary

- “All Points” data with ground classified are invaluable for a myriad of information extraction tasks
- High noise and low density are the enemies of high-quality extraction
- Some level of QC should be implemented regardless of the flow path to you
- Low cost desktop tools can be used post-acquisition to add considerable value to data

Questions & Discussion



Alan Lulloff

alan@floods.org

Lewis Graham

lgraham@geocue.com

GeoCue Group

Cooperating Technical Partners Information Exchange

CTP COOPERATING TECHNICAL PARTNERS

Association of State Floodplain Managers

ASFPM Flood Science Center

Poll Question

Please rate this webinar.

Continuing Education Credits

- Certified Floodplain Managers are eligible for 1 Continuing Education Credit for participating in this webinar.
- You must have registered individually and indicated you are a CFM at time of registration.
- Eligibility for CEC is dependent on your participation in poll questions and time spent viewing the webinar, as determined by the webinar software.
- ***Attending this webinar in a group setting or only viewing the recording is NOT eligible for CEC.***

Closing Comments

- To suggest future CTP webinar topics, please contact Alan Lulloff at *alan@floods.org* or type a suggested topic into the Questions panel today
- **ASFPM CFM CECs will be automatically applied**
- **Certificates of Attendance will be emailed**, please contact *cfm@floods.org* with any certificate issues
- Follow-up email with link to slides and recording will be sent next week

Thank You for Joining Us!