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Geospatial Solutions

Terrestrial GPS setup Fundamentals of Airborne LiDAR Systems, Collection and Calibration

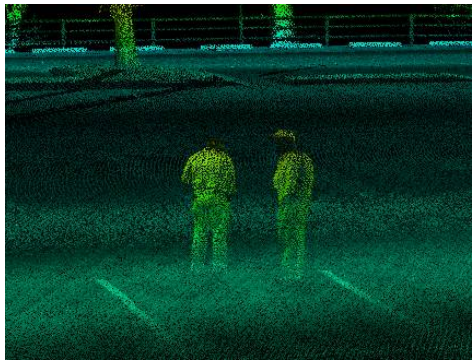
JAMIE YOUNG
Senior Manager – LiDAR Solutions

Topics

- Terrestrial GPS reference
- Planning and Collection Considerations
- Calibration
- Helicopter LiDAR
- Processing
- Survey and Accuracy

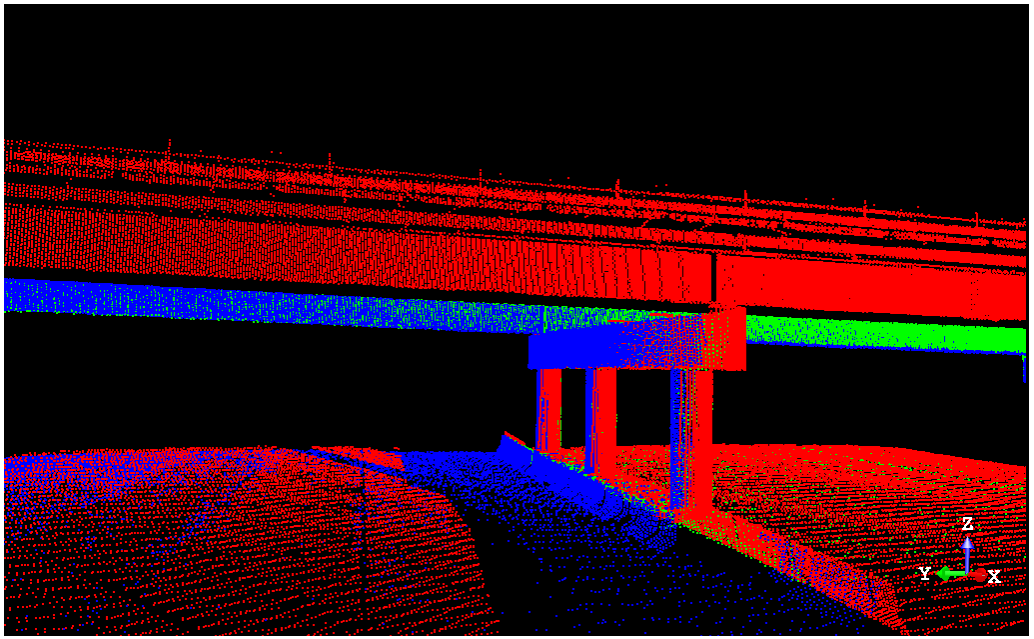
Terrestrial Setup

- Review Site location to determine Target locations
- Determine type of setup based on requirements
  - Geo-referencing required
  - Relative to itself
- Need to see everything from Scanner locations
- Similar to Survey Process
- Want to get good solution

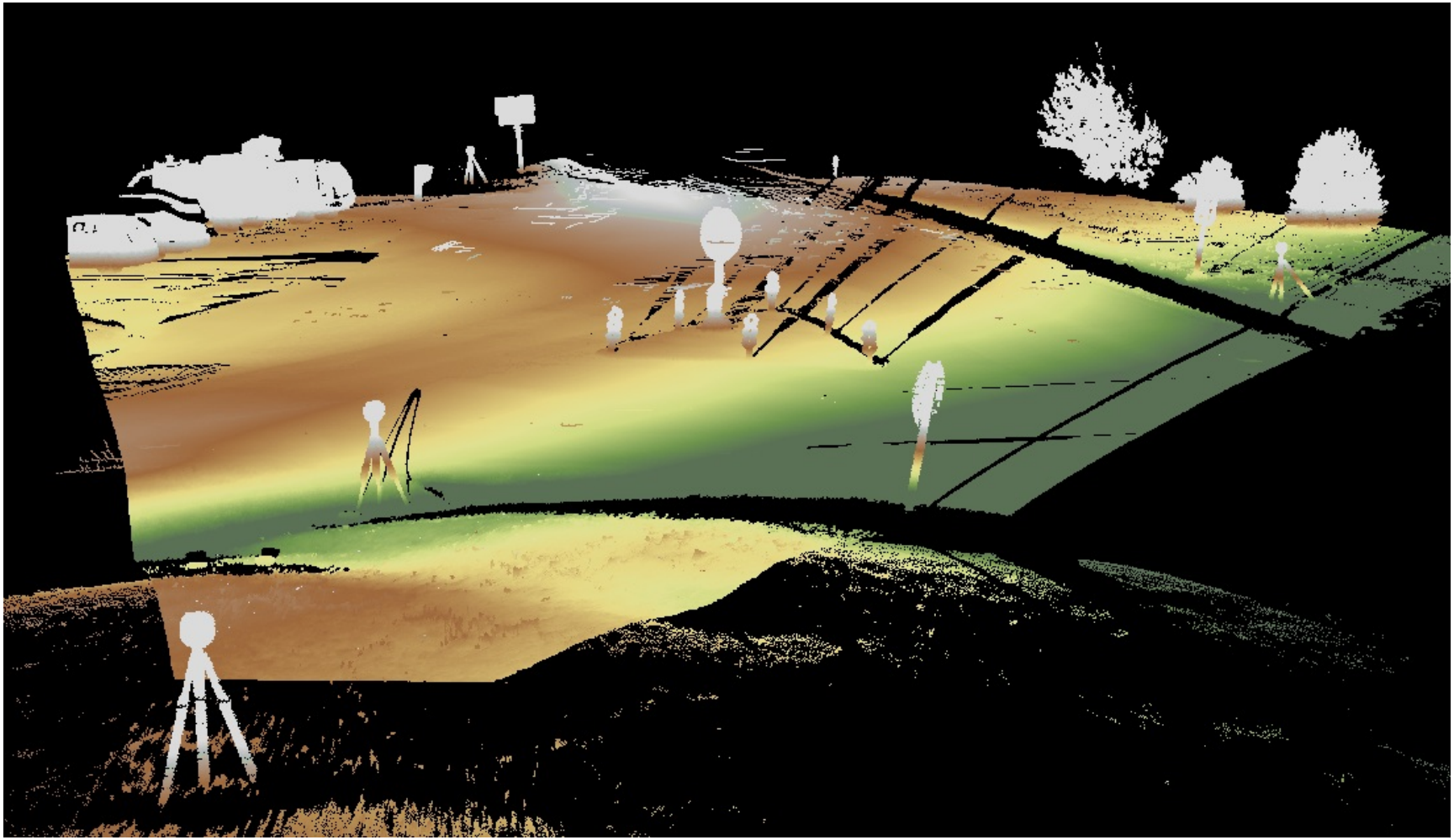


Terrestrial

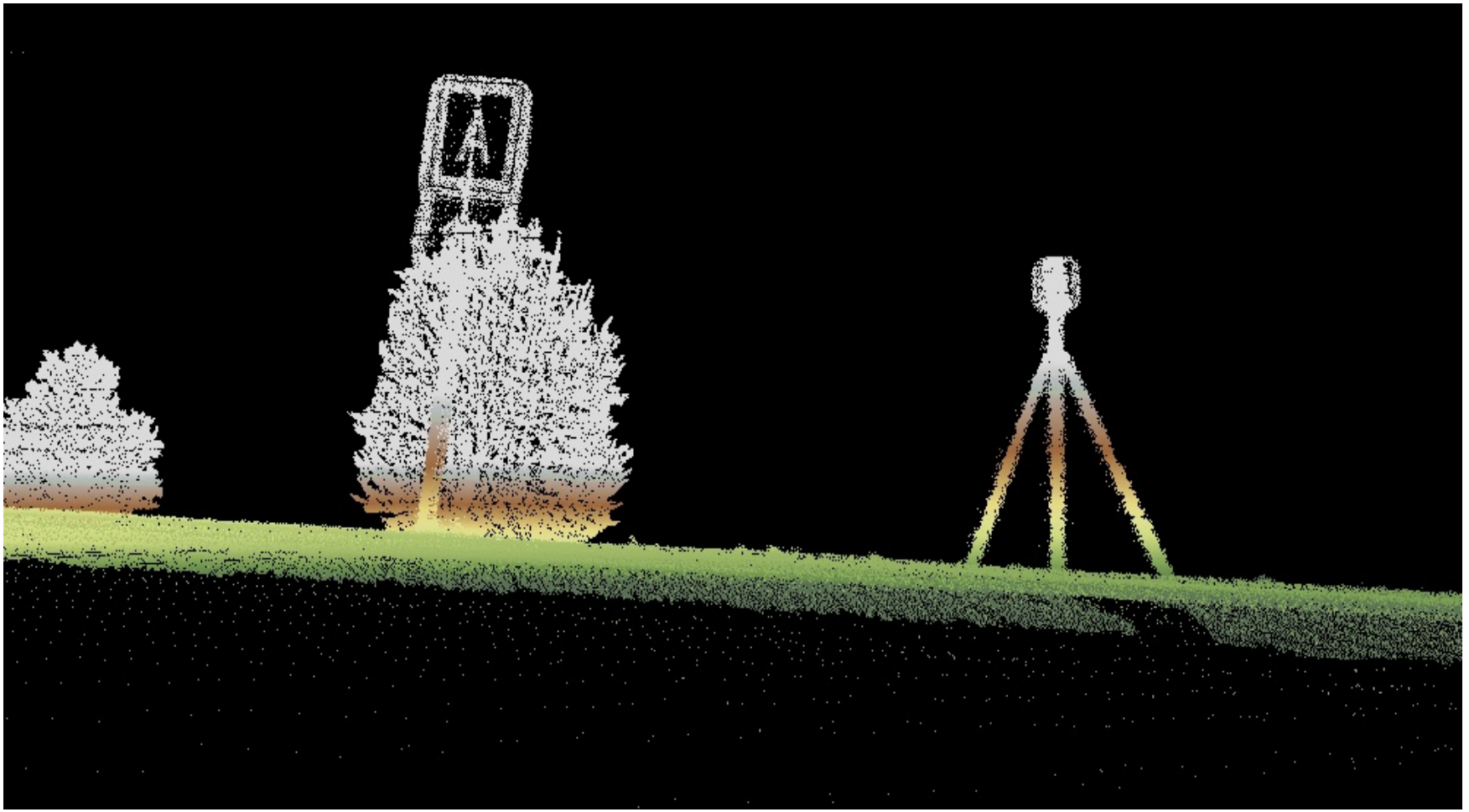
- Vertical accuracy of 3mm
- Please note that accuracy is related to Project Process
- Develop process to get better accuracy



Setup

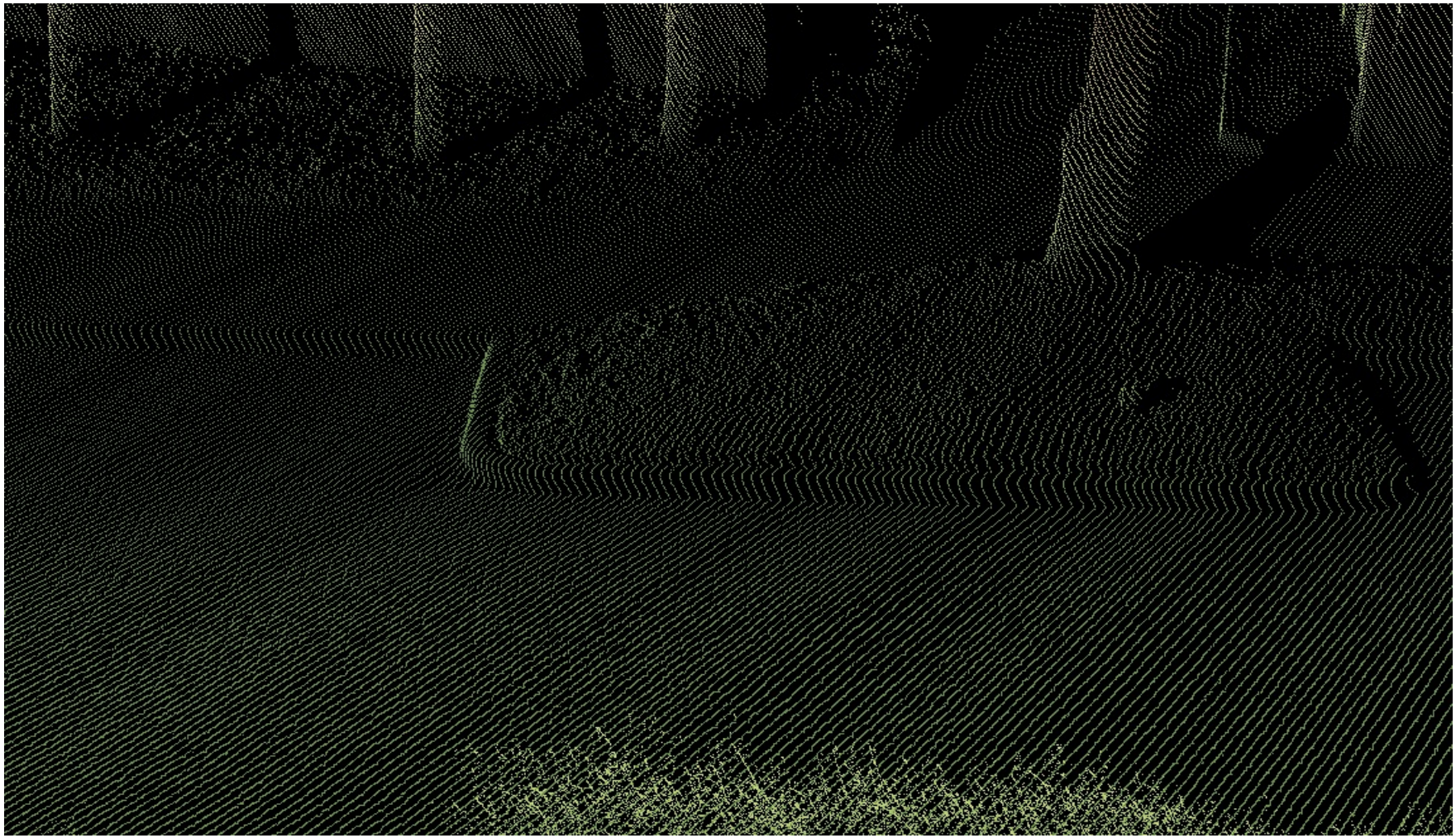


Single Set up

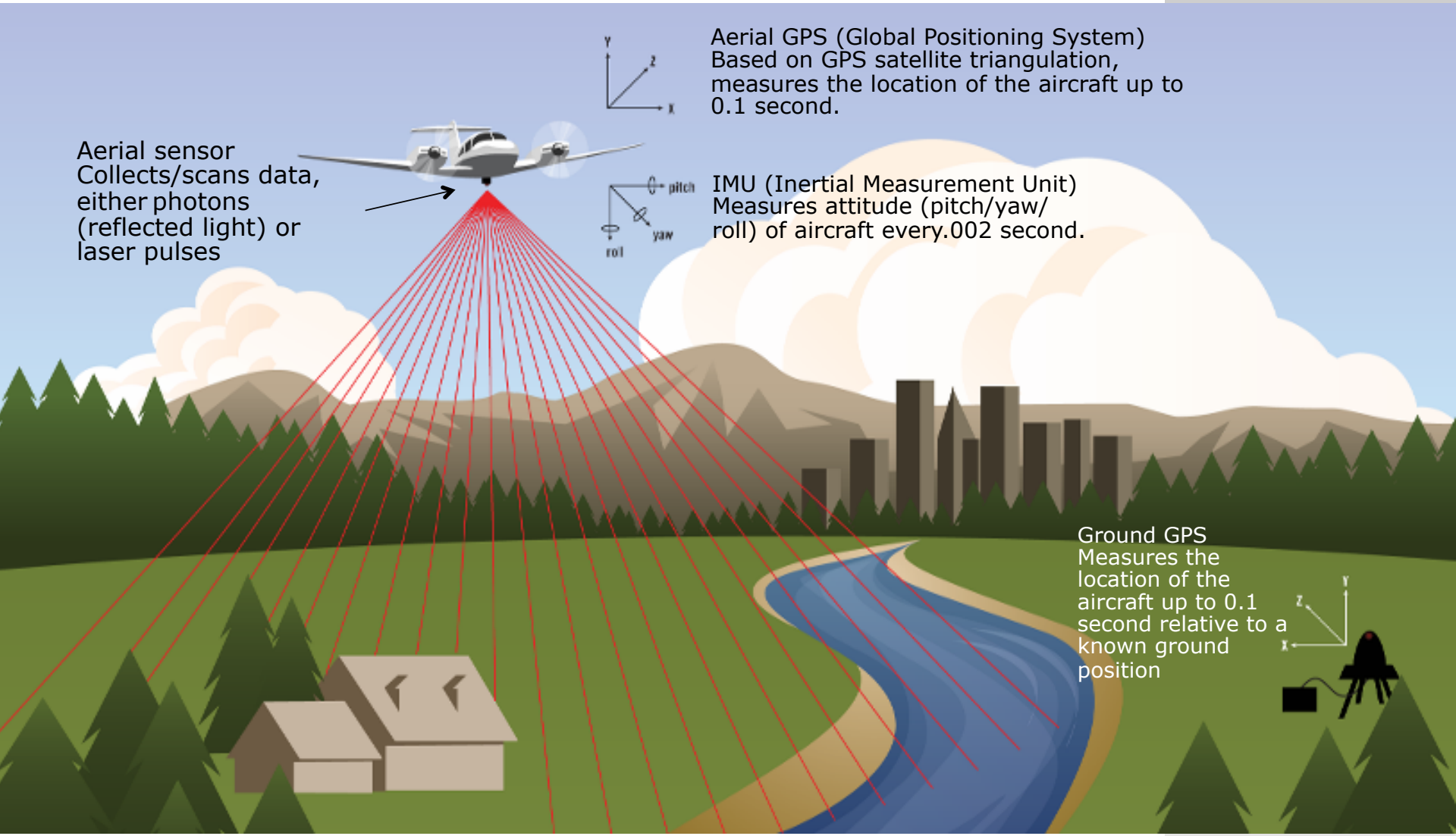


Location of Target locations in relationship to Area of interest

Detail



LiDAR: Light Detection and Ranging



LiDAR Collection Sensors

- Optech
- Leica
- Trimble
- Reigl

- 167Khz = 167,000 points per second
- Multi-pulse system = 2 pulse in air
- Scan-frequency function = 1000
- Can be full waveform

- 500Khz = 500,000 points per second
- Multi-pulse system = 2 pulses in air
- Laser beam split
- Scan angle up 75 degrees
- Full waveform on 1 channel

Please note that just because you can run at 500Khz does not mean you can collect at all elevations at 500khz

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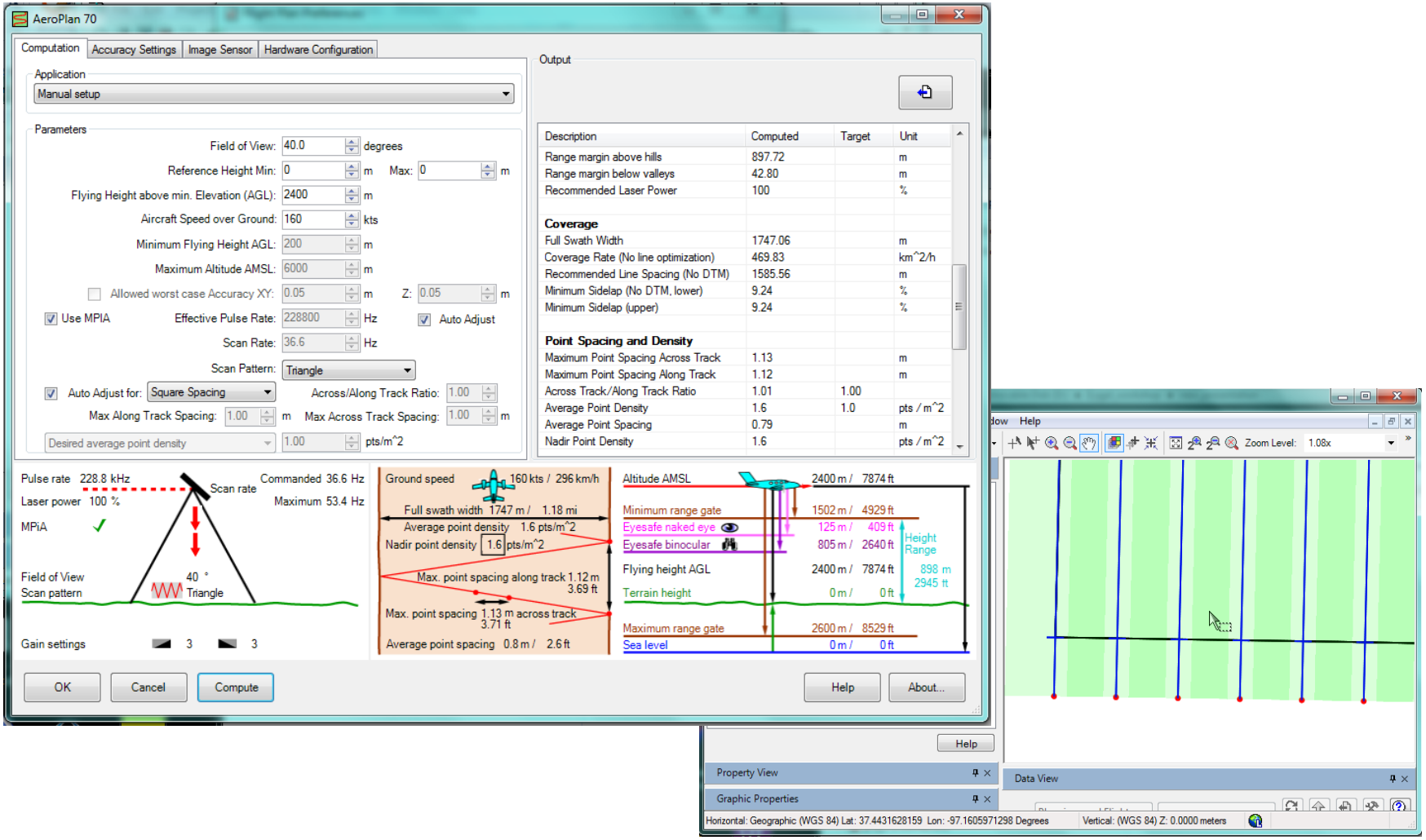
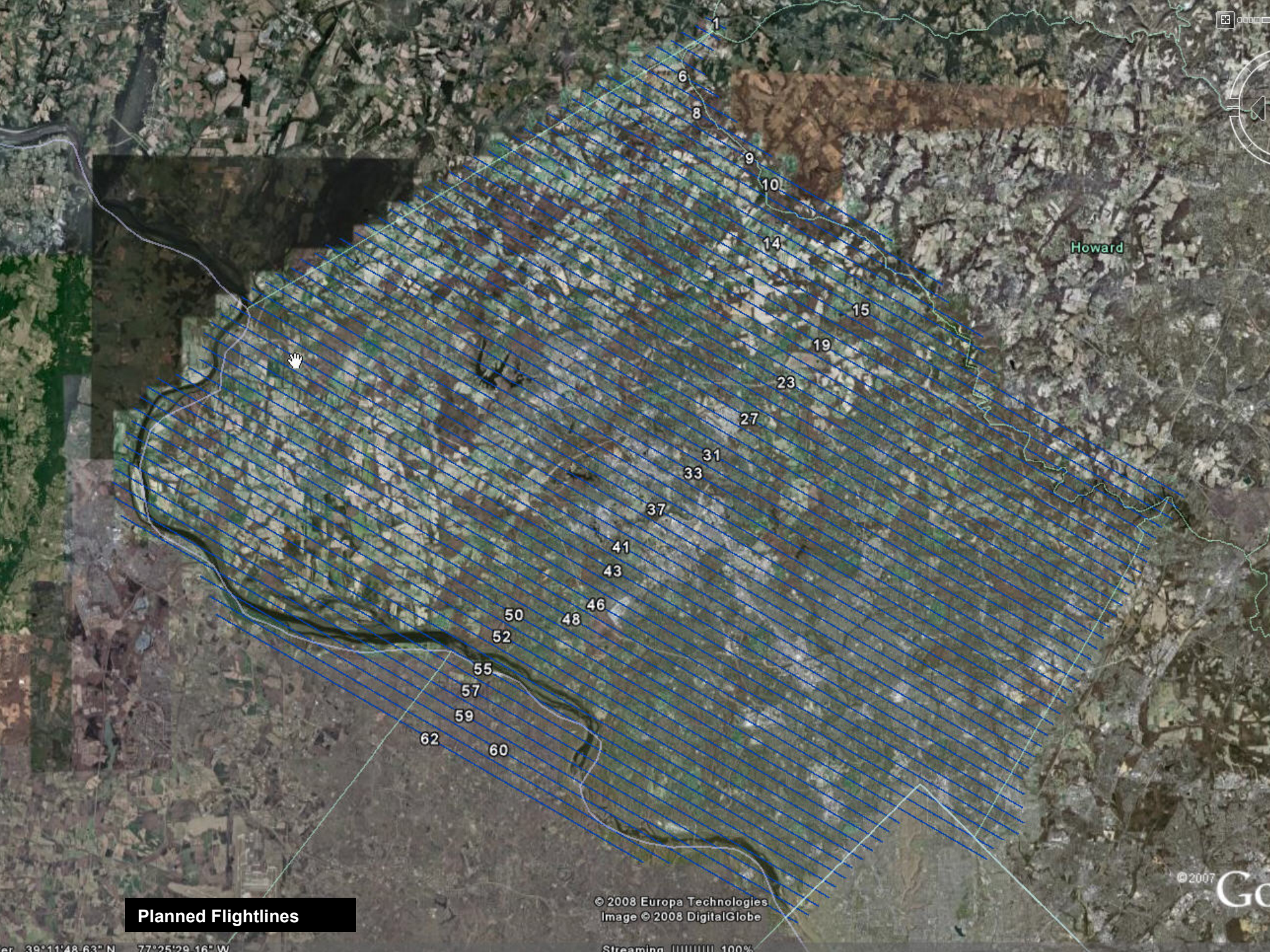
Flight planning

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Howard
Planned Flightlines
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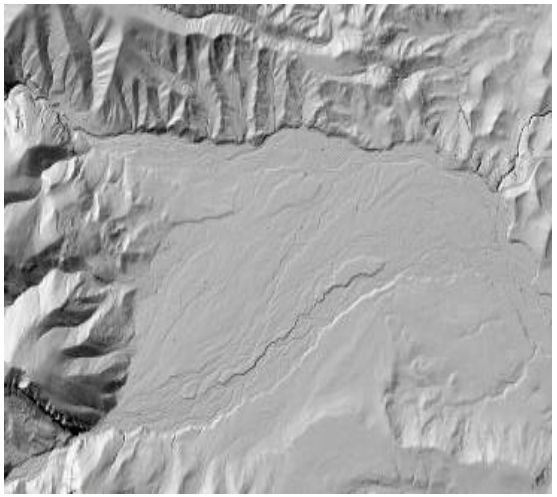
LiDAR Accuracy

Things to Consider

Accuracy is dependent on:

- Flying height
- Sensor parameters
  - Rep Rate
  - **Scan Angle – 40 degree of scan angle?**
  - Scan frequency
- System accuracy
- Terrain
- Vegetation
- Baseline distance
  - Location of base station to Aircraft



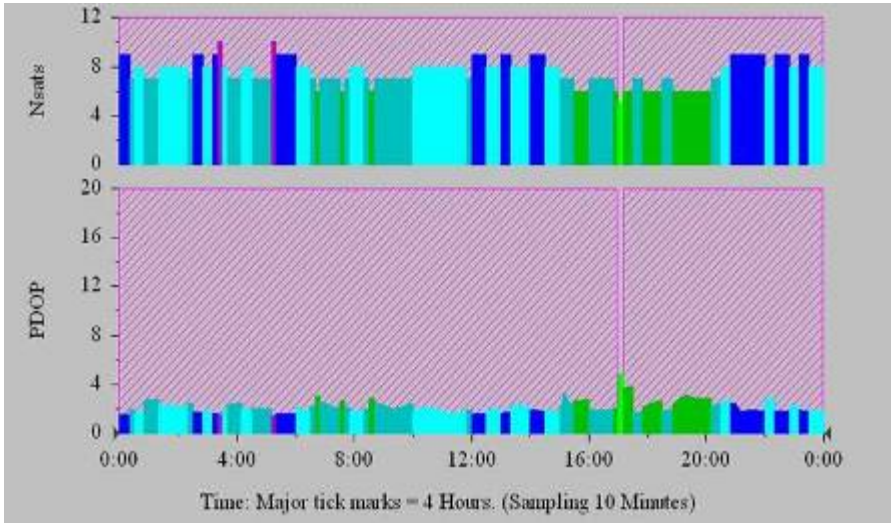
LiDAR Project Planning

- Day or Night
  - Safety considerations
- Leaf on or Leaf off
  - Application dependent
- Summer, Spring, Fall, or Winter
  - Most collects done in the spring and fall
  - Summer collects take place for special applications such as forestry
  - Winter collects based on geographic location
- Weather
- Smoke

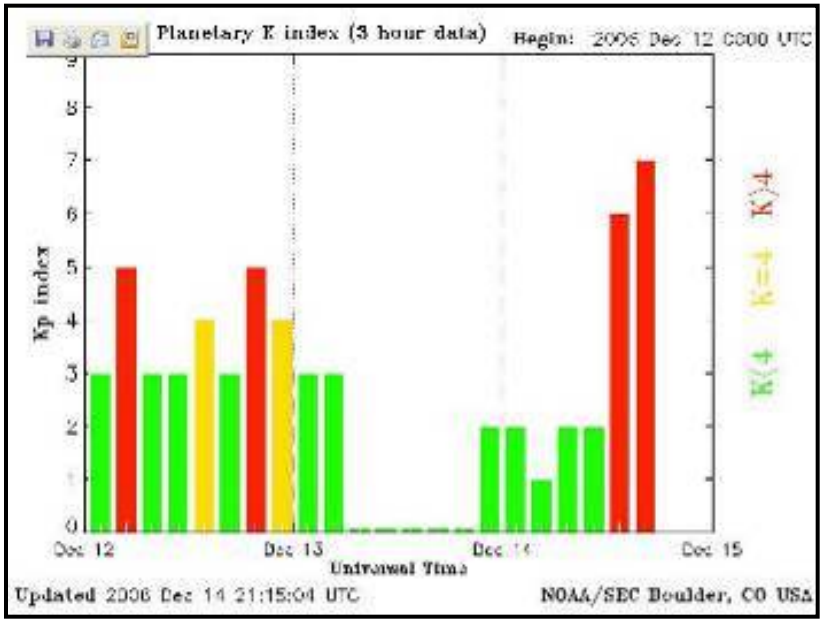
Establishing Control

- Establish control for entire mapping program prior to collection using a minimum of two Horizontal and/or CORS stations and a minimum of three Vertical Bench Marks
- Perform Fully Constrained Network Adjustment
- Apply ITRF corrections to published or as applicable
- Adjustment supports a mapping operation not a survey
- Provide adjustment to all LiDAR
- providers involved in the program

PDOP and KP-Index

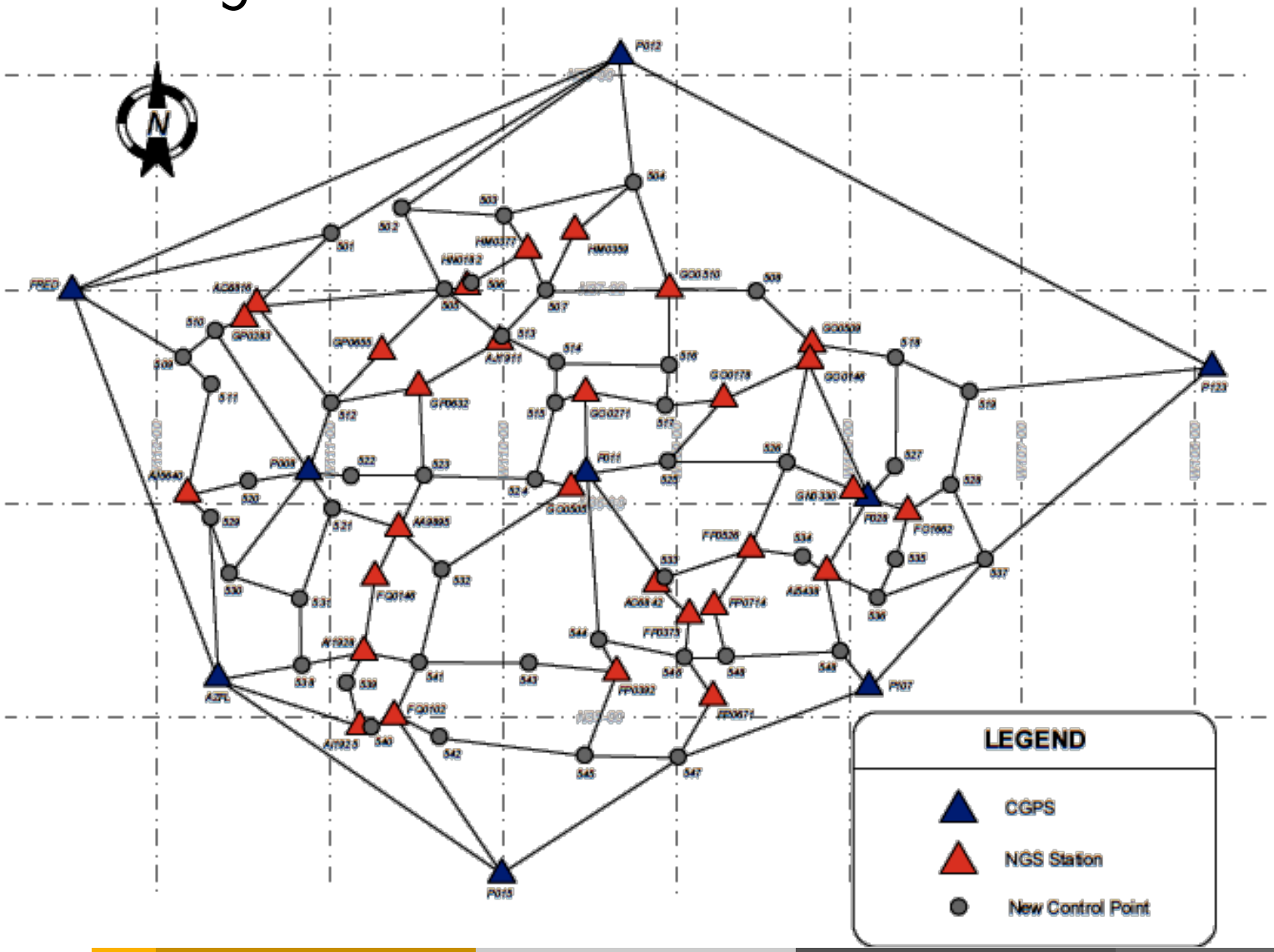


PDOP and # of Satellites

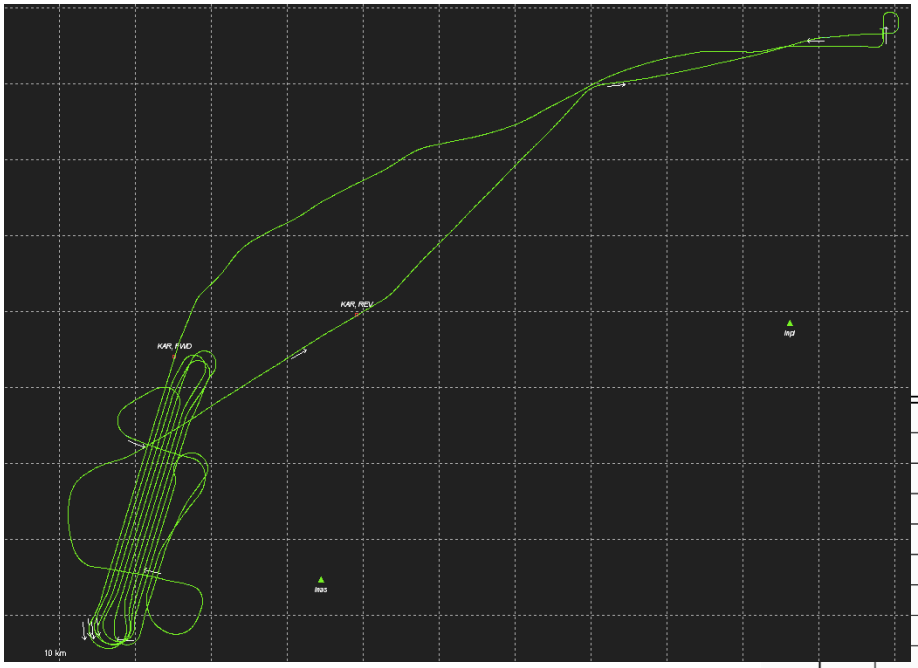


KP-index is a measure of the Geomagnetic activity from the Sun on the earth's atmosphere

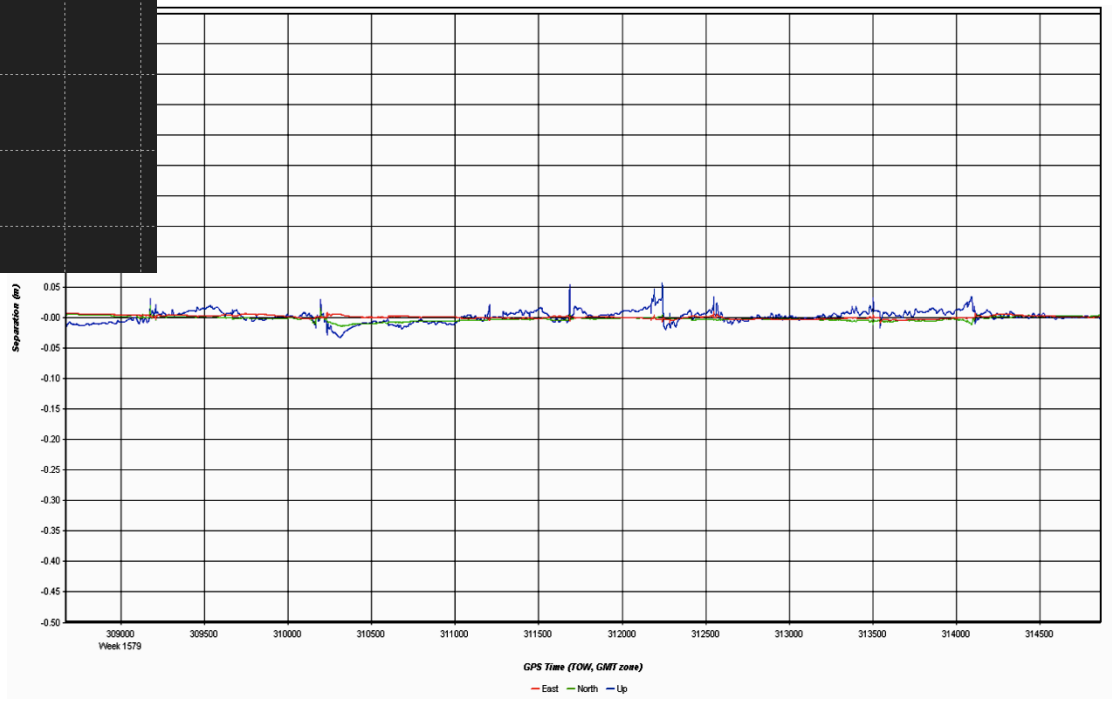
Establishing Control



GPS



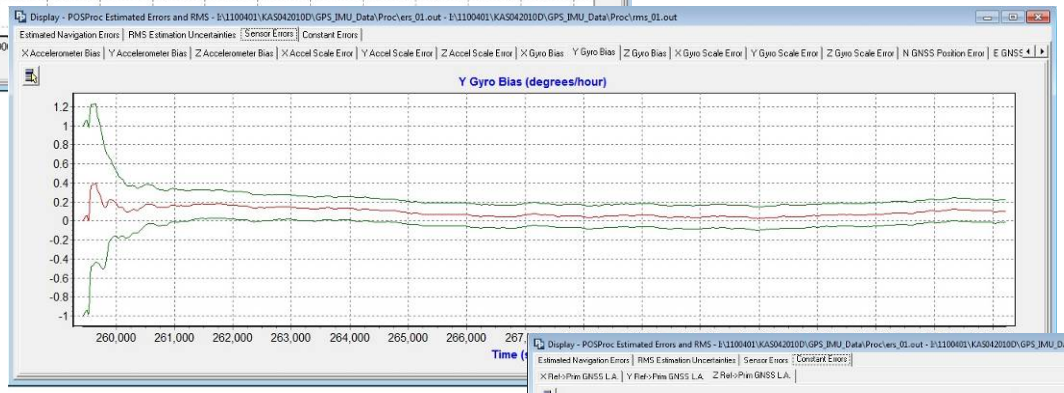
- Static initialization at start
- Static session at end
- PDOP less than 3



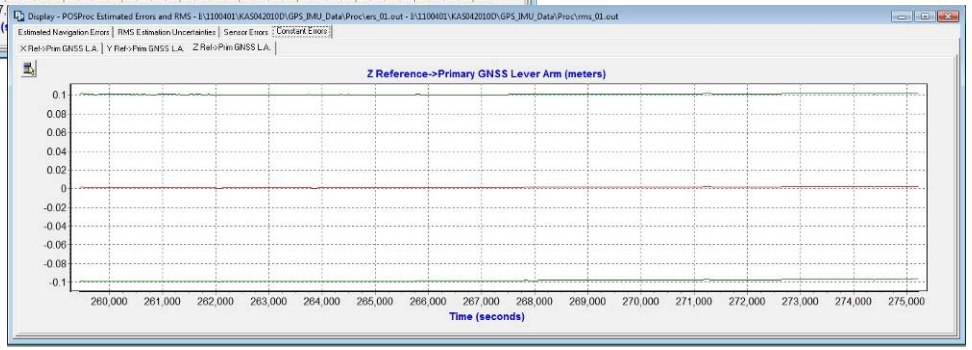
- Processing is easier
- Achieve under 5 cm combined solution

IMU data

Accelerometer

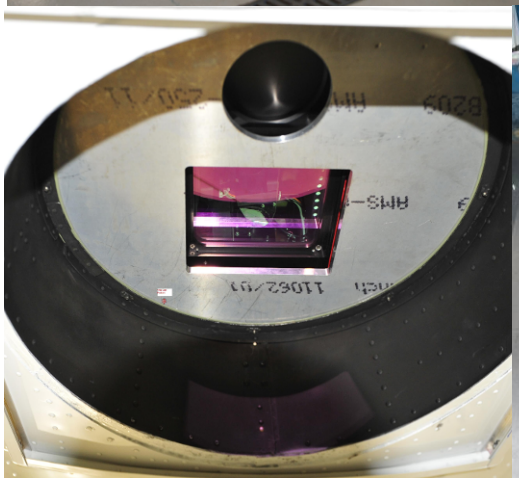


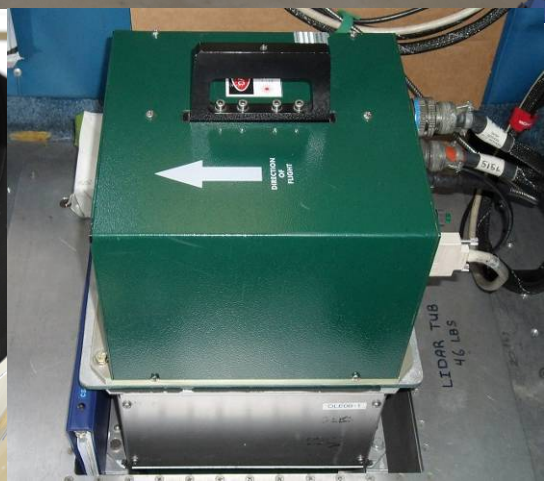
Gyro



Lever arms

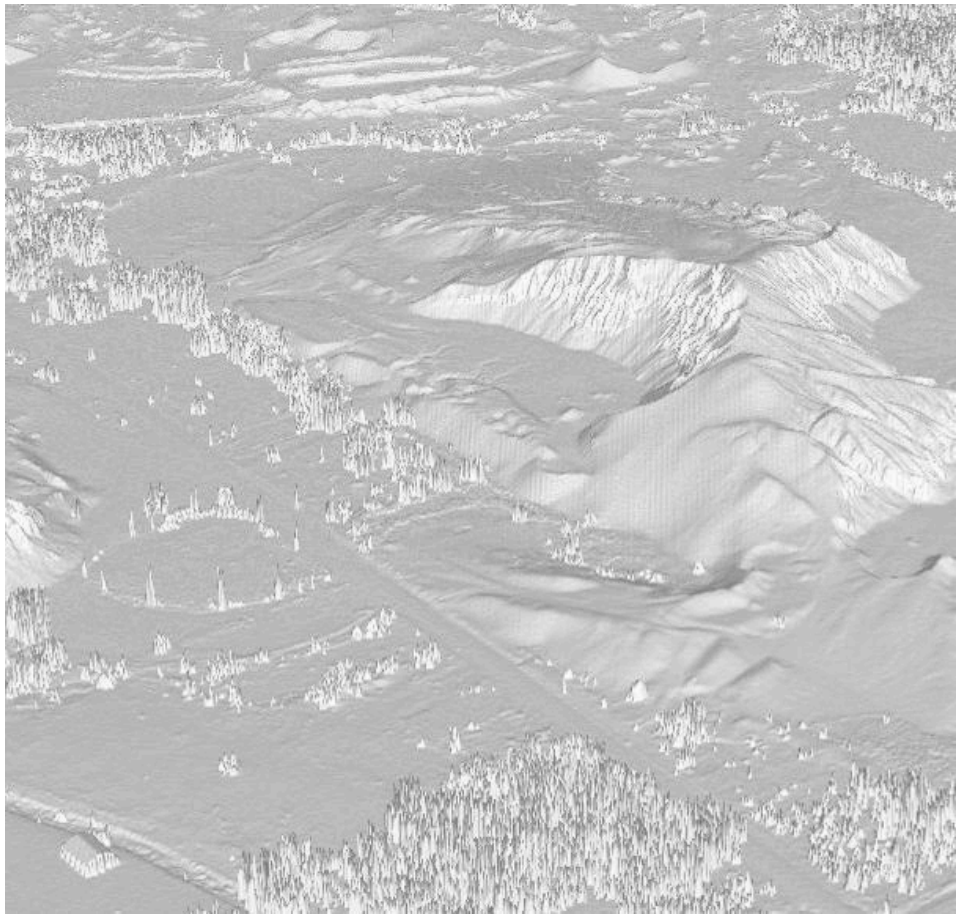
Lidar Calibration - Critically Important





- Optech, Reigl, Leica and Trimble have calibration procedures
- Proprietary sensors have custom procedures
- Proper installation and lever arm
- Survey standardization
  - GPS survey of antenna
  - Total station survey of antenna
  - PosPAC location of antenna

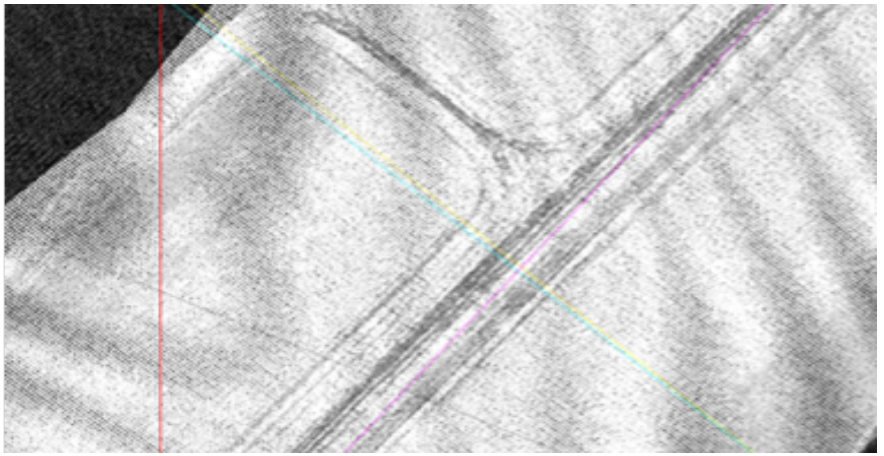
Lidar Calibration: Why Is It Important?

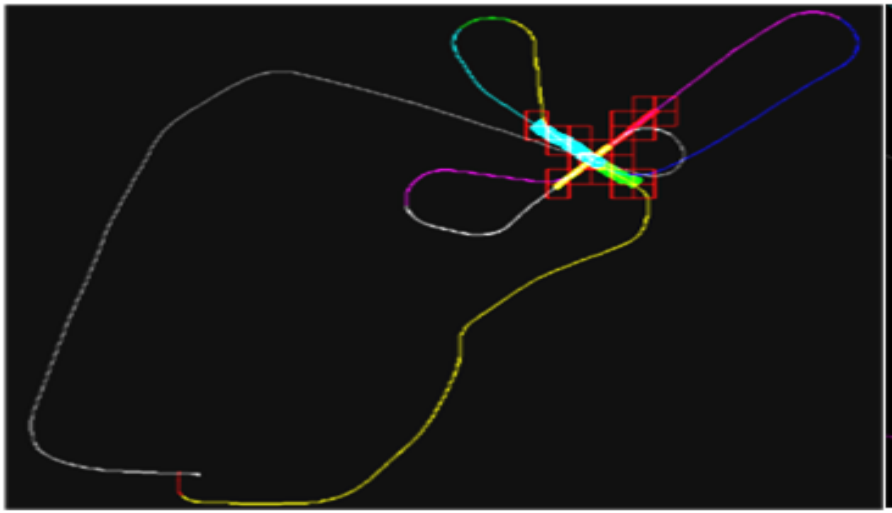


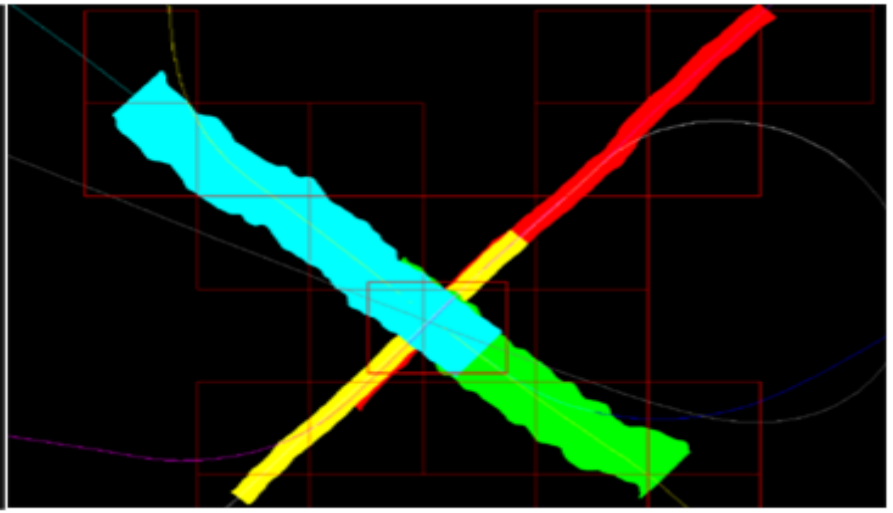
- Calibration after every installation
  - Required to make sure the system is operating correctly
- Calibration every mission
  - Provides necessary information in case of unforeseen occurrences
  - Fly a minimum of 1 perpendicular line to flight lines collected for that mission
  - Ensure ability to correct for roll, pitch, heading, scan scale and other potential biases
- 90% of problems are a result of improper installation

Lidar Calibration

- Flying lines perpendicular
- Flying lines parallel
- Calibration every mission

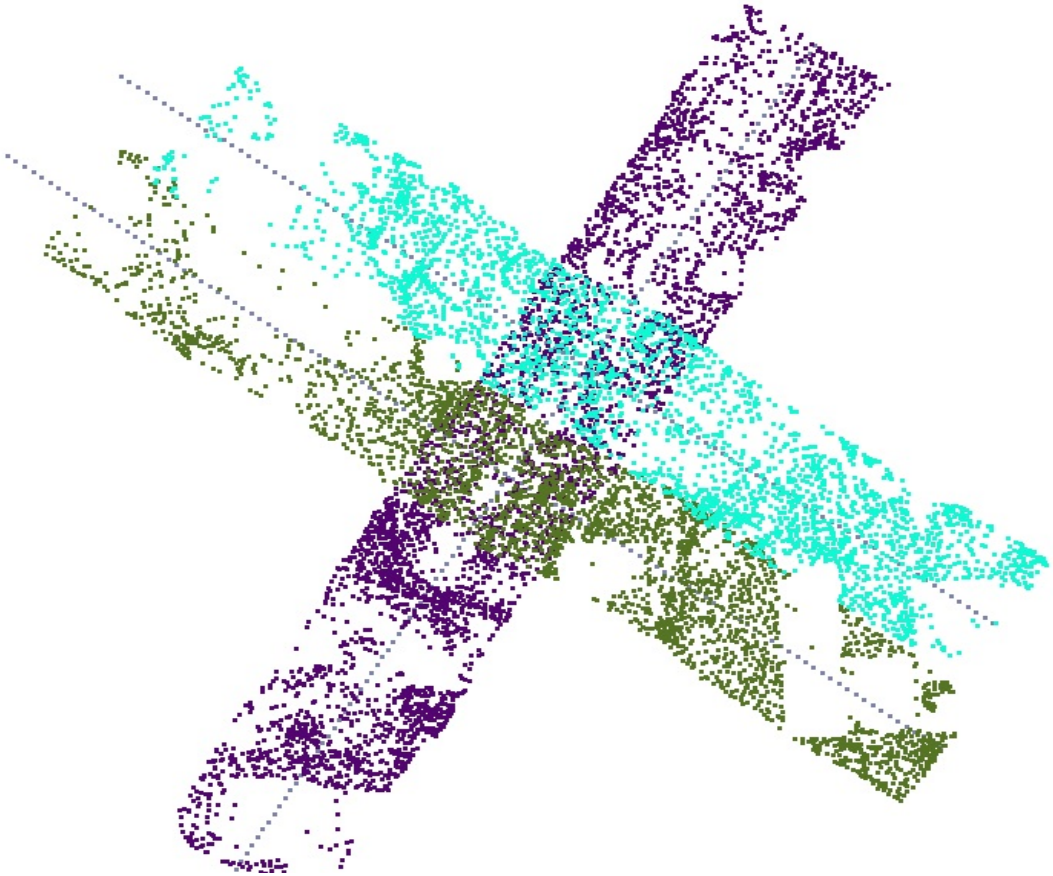






Planar Surface

Calibration process finds planar surfaces

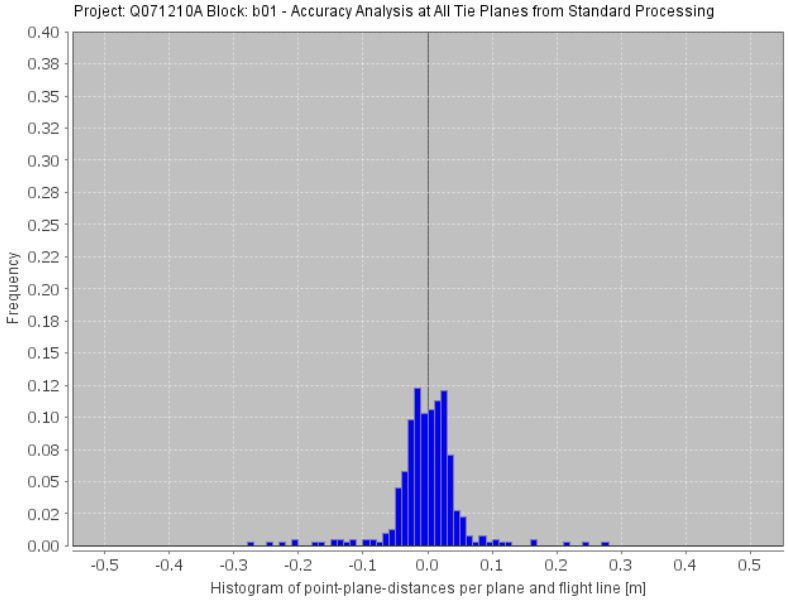


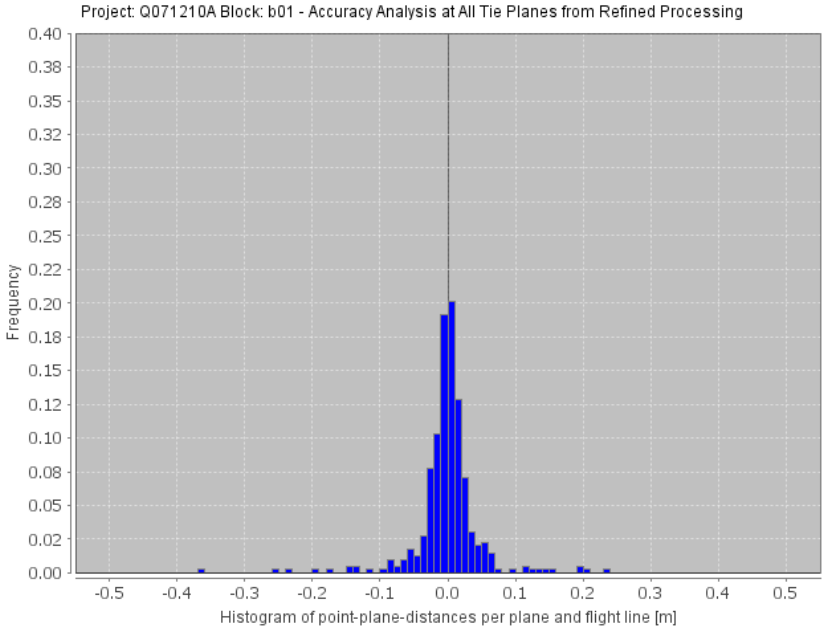
Lidar Calibration

- Flying a cross flight during collection

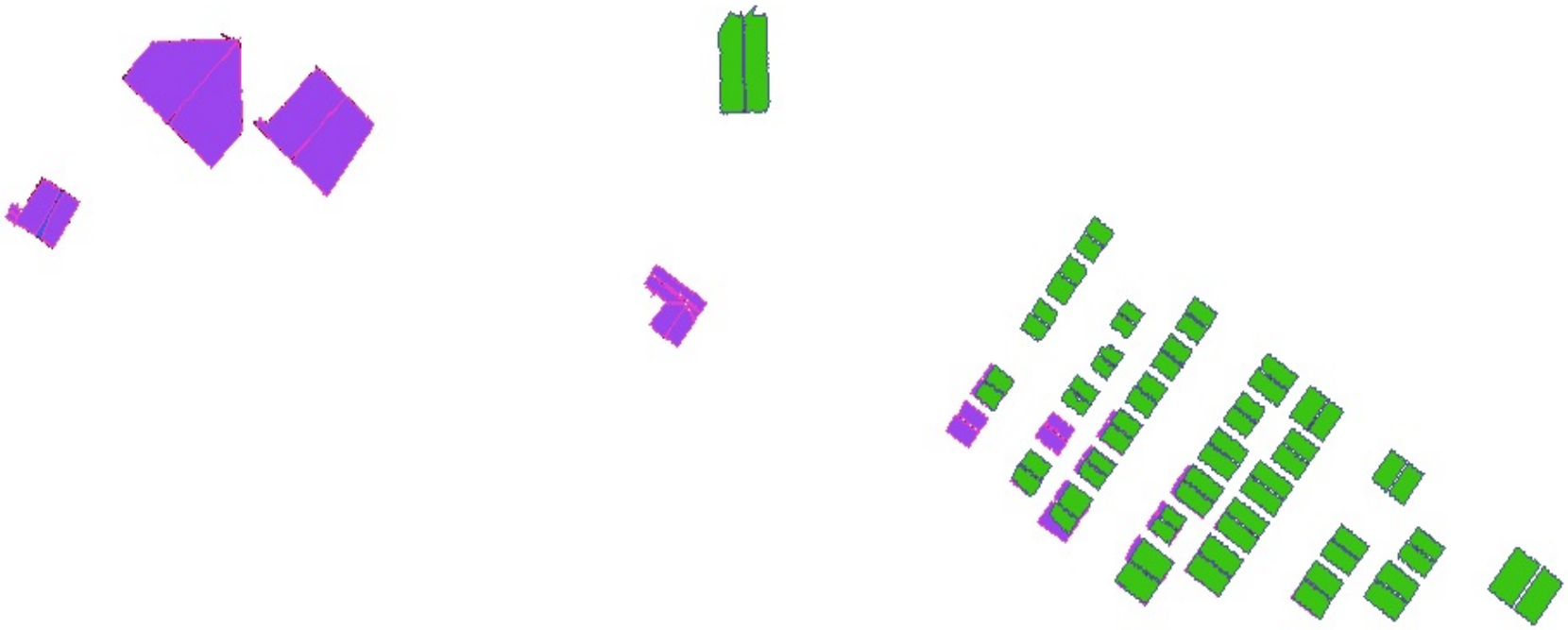
The Plane Results

Graphically speaking

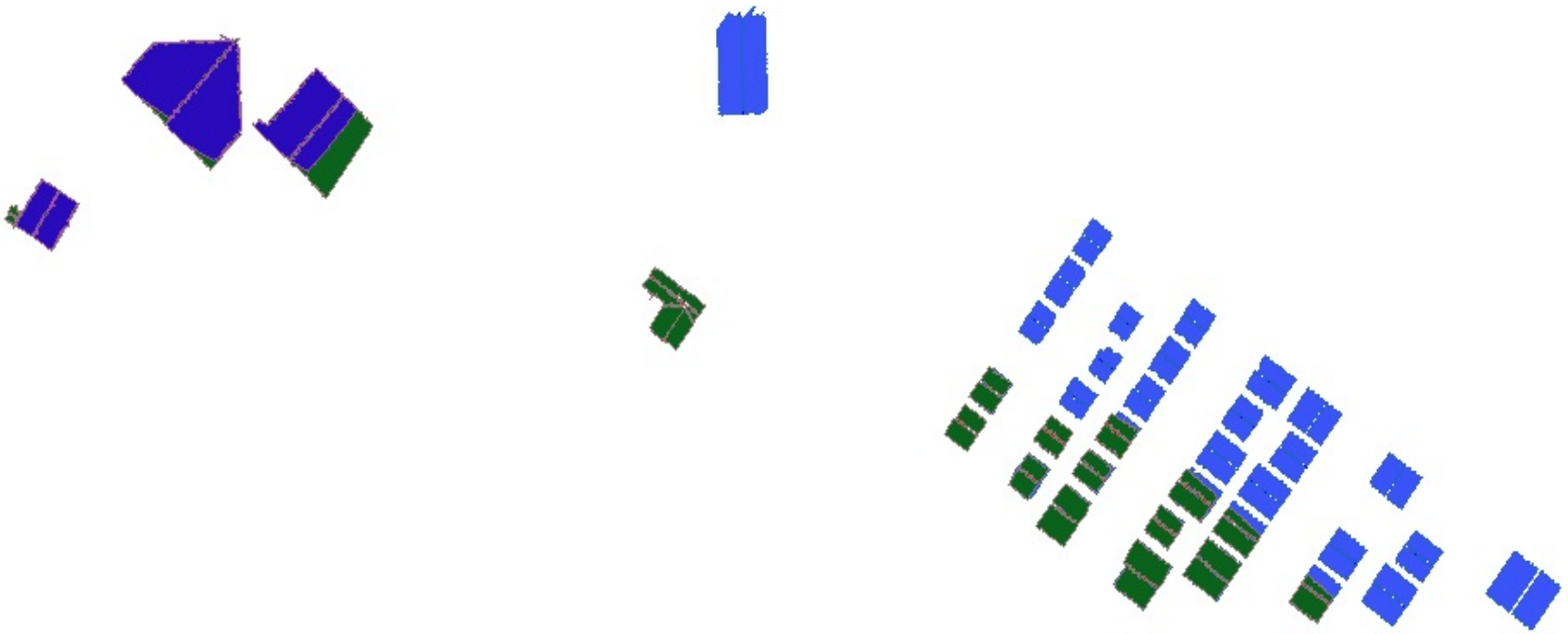




Roof Line Correction

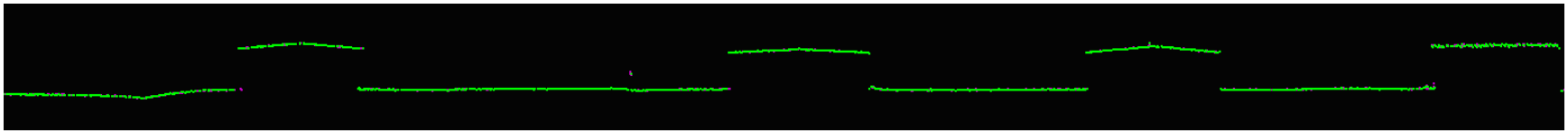


Roof Line Correction

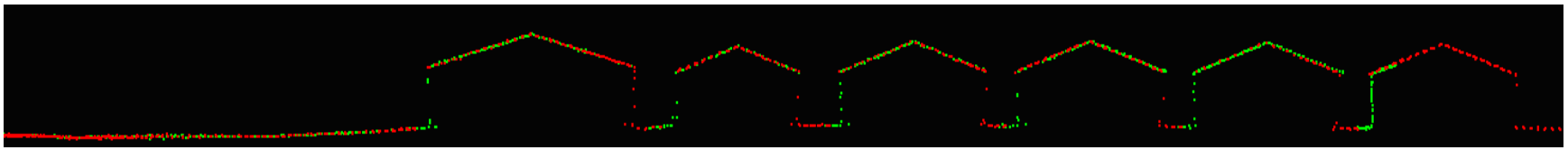


Roof Line Correction

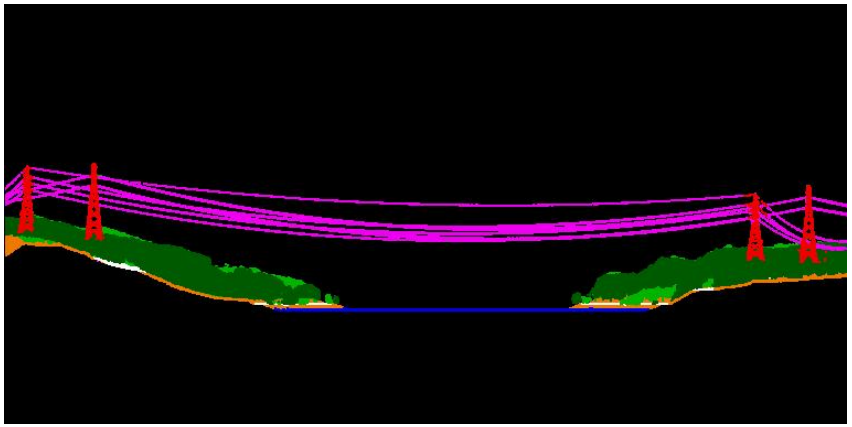
Profile of perpendicular lines at edge of scan on E-W line

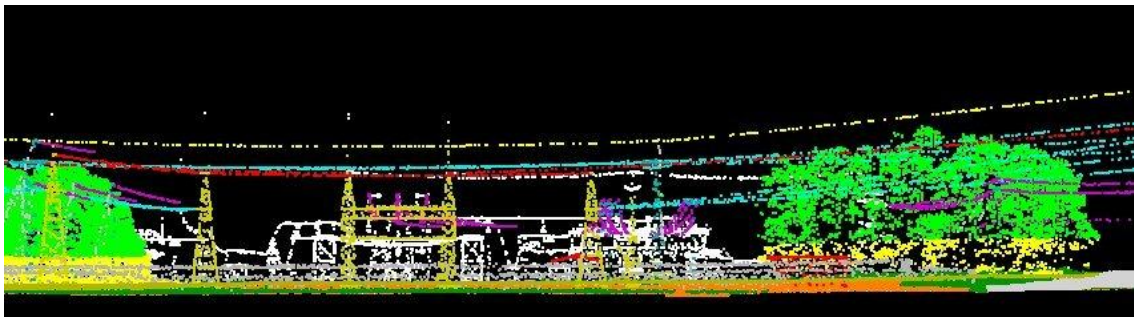


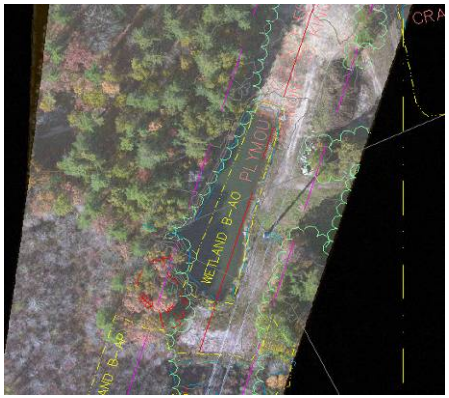
Profile of parallel lines at edge of scan

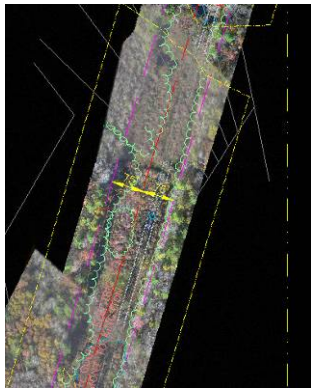


Helicopter LiDAR









Collection rates (Helicopter)

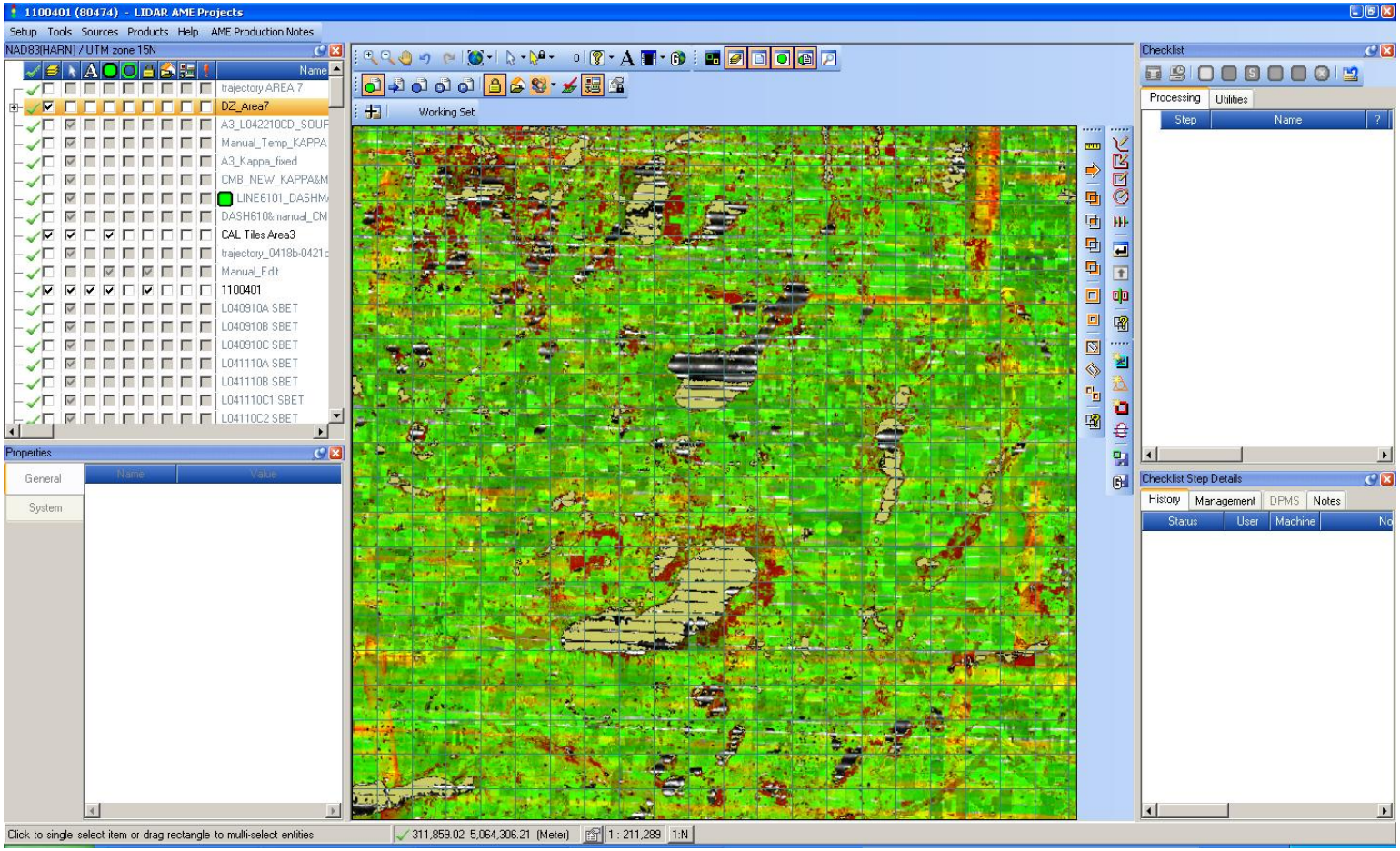
- Collect 80-160 linear kilometers a day
- Flying Height is 120 to 230 meters
- Used mostly for corridor mapping
  - Transmission mapping
  - Roadway mapping
  - Pipeline mapping
- 20 – 40 PPM

Multi-Sensor configurations

- Ortho- Applanix DSS or Leica RCD30 Digital Camera
- Multi-Spectral and Hyper-Spectral
- Video -FLIR ULTRA MEDIA II 36X RGB
- Nikon D-200 (10.3 megapixel) digital camera
  - GPS referencing
- LiDAR Sensors
    - Low Altitude
    - High Altitude
    - Both?

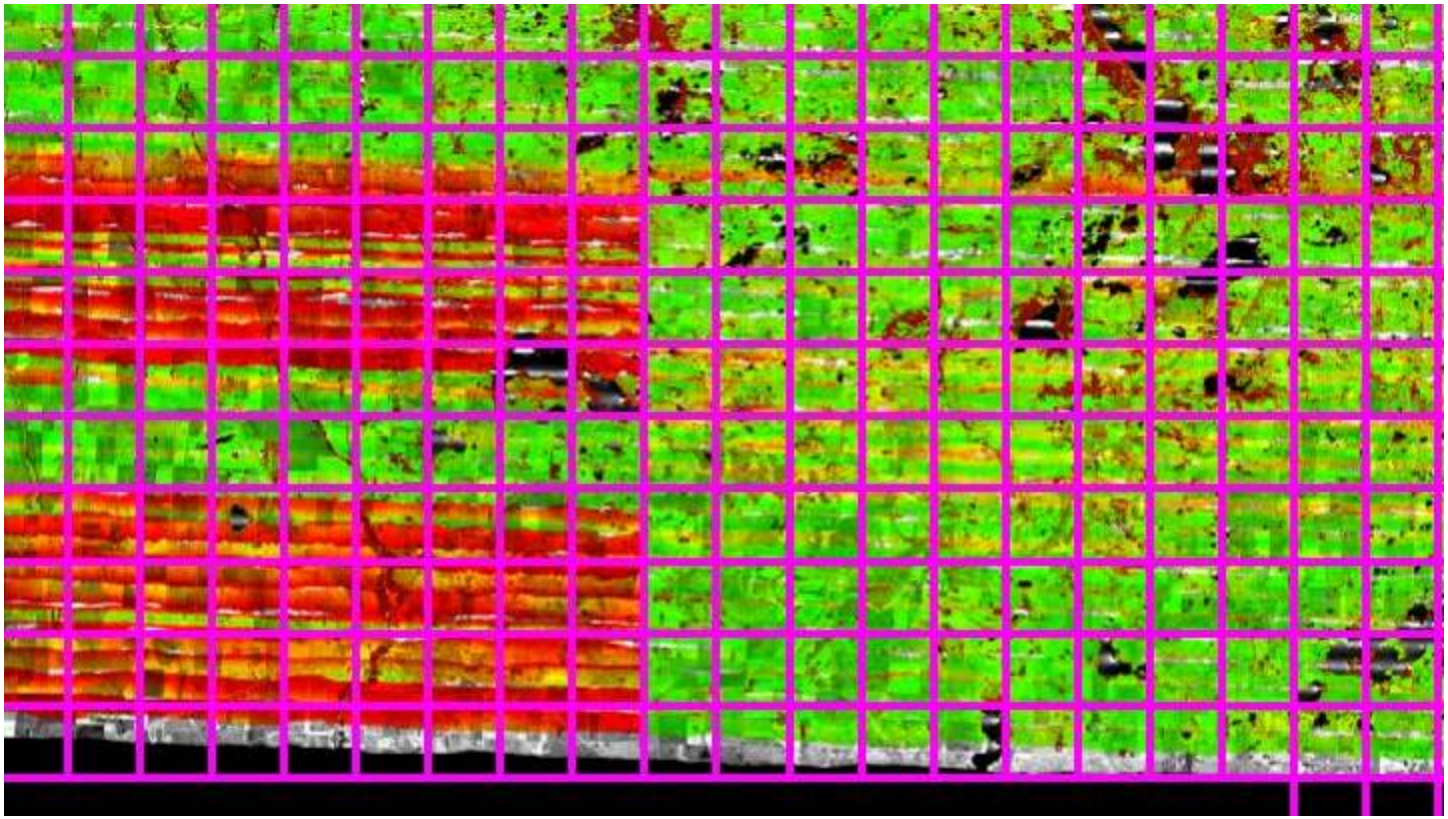
Checking Calibration

DZ ortho from several missions



Checking Calibration

Differences between bad calibration and correct calibration

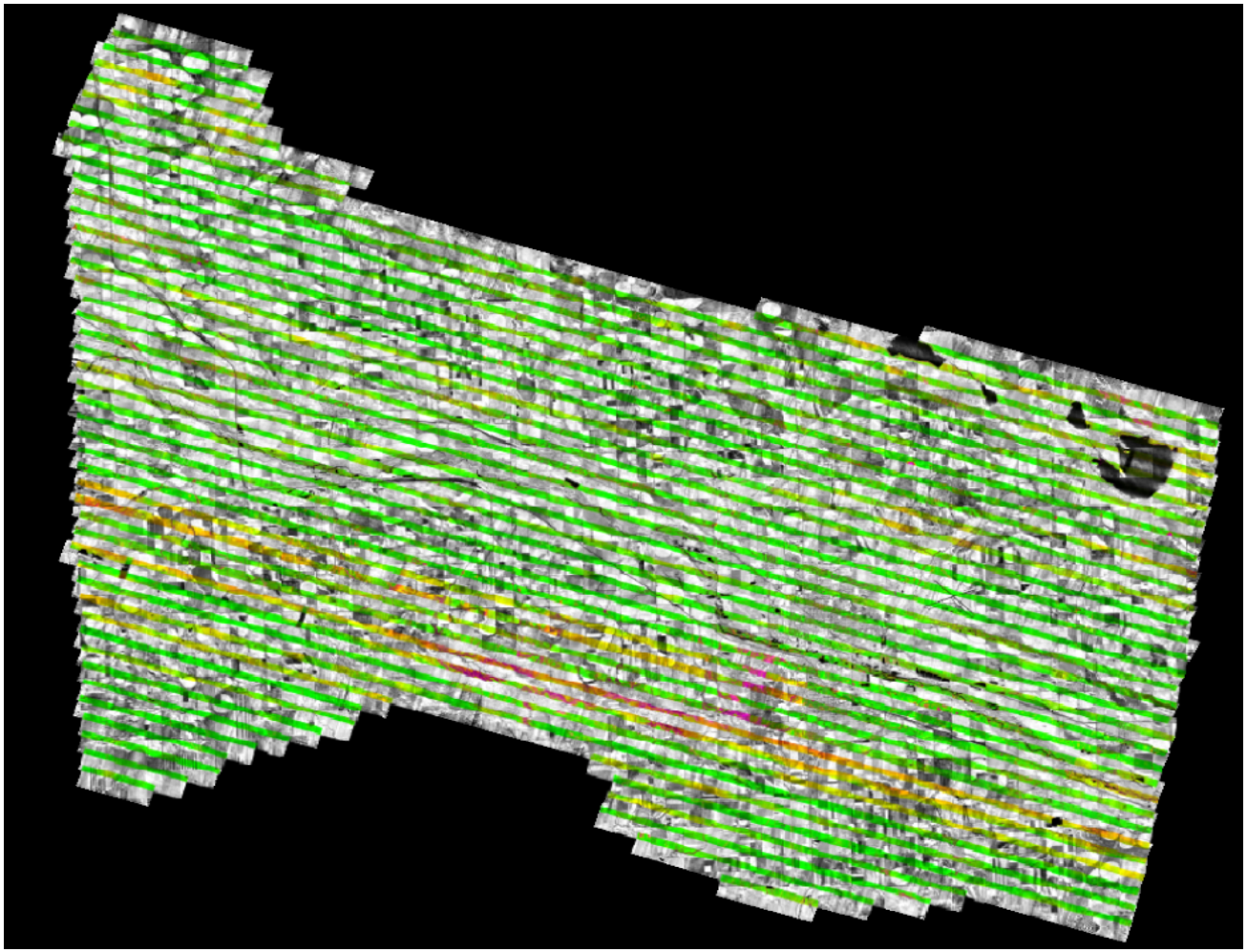


Unresolved Area

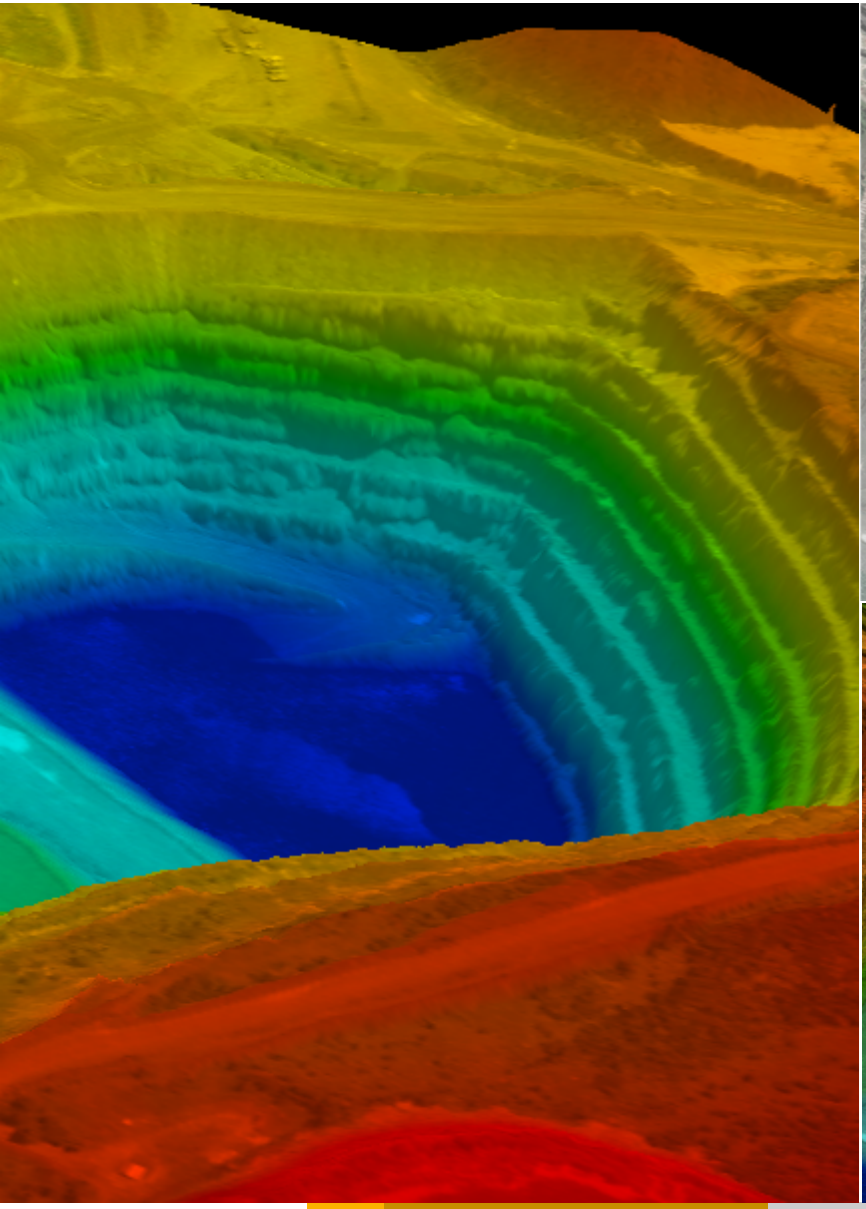
Resolved Area

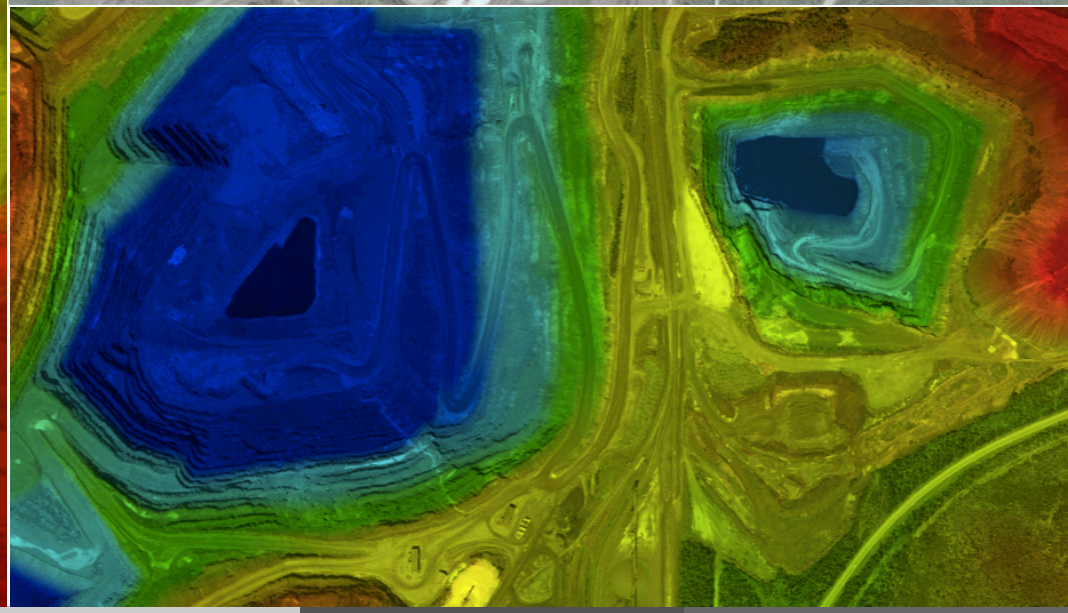
Checking Calibration

4 missions - old calibration method



Difficult Collections and Data

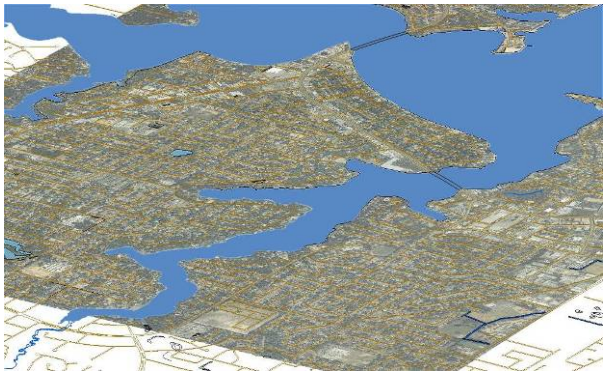


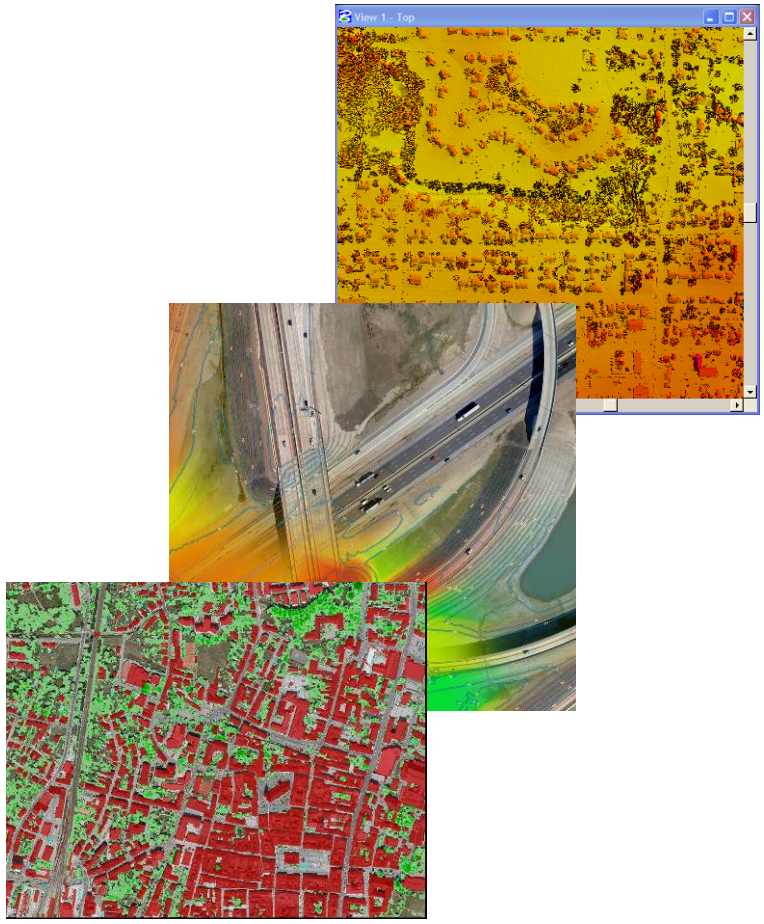


Processing Steps

1. GPS Processing
2. IMU Processing
3. Calibration
4. LAS point Cloud Output
5. Classification
6. QC Manual Editing
7. Generation products

Software Packages?

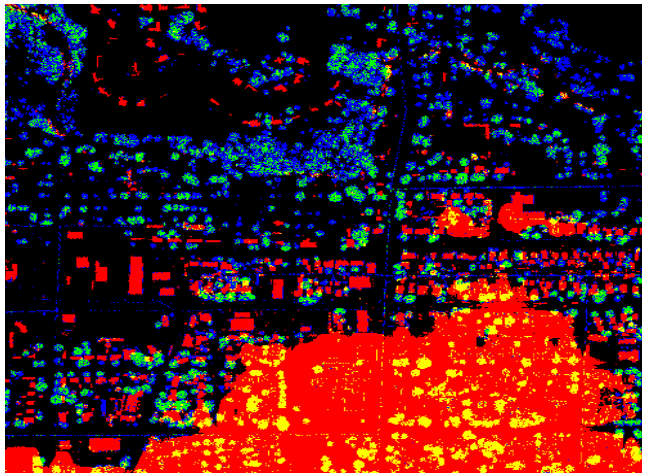


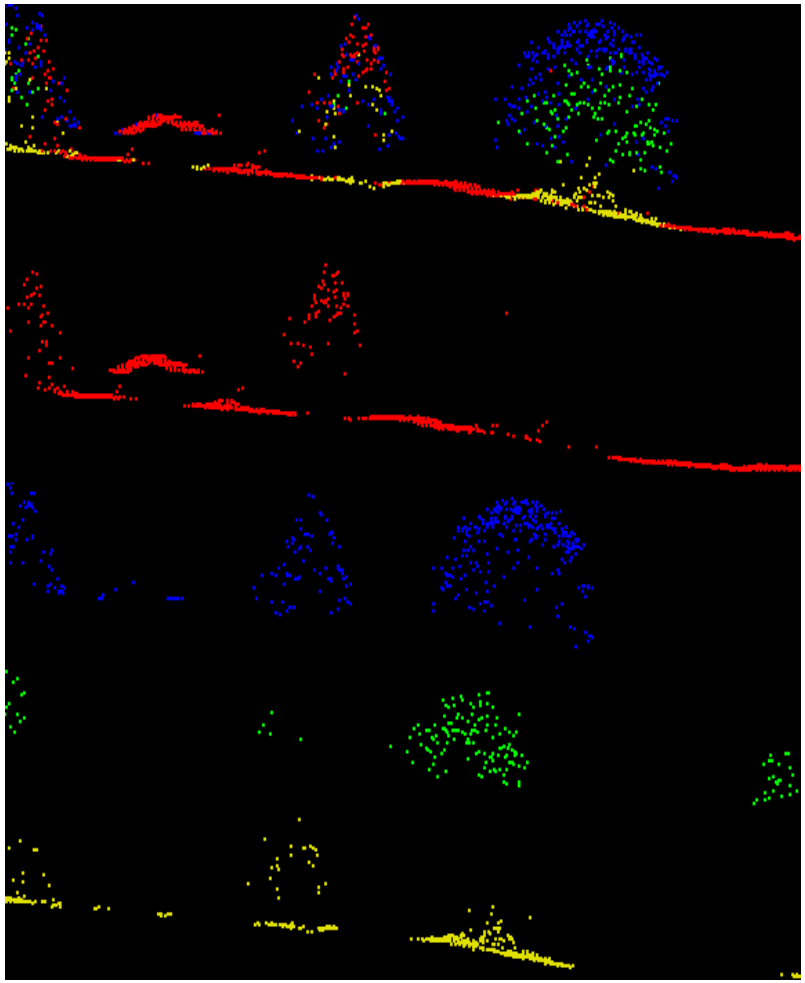


Processing - LiDAR Returns

LiDAR System Returns

- 1st Return – Red
- 2nd Return – Blue
- 3rd Return – Green
- Last Return – Yellow
- Up to Seven





Processing – Bare Earth Model

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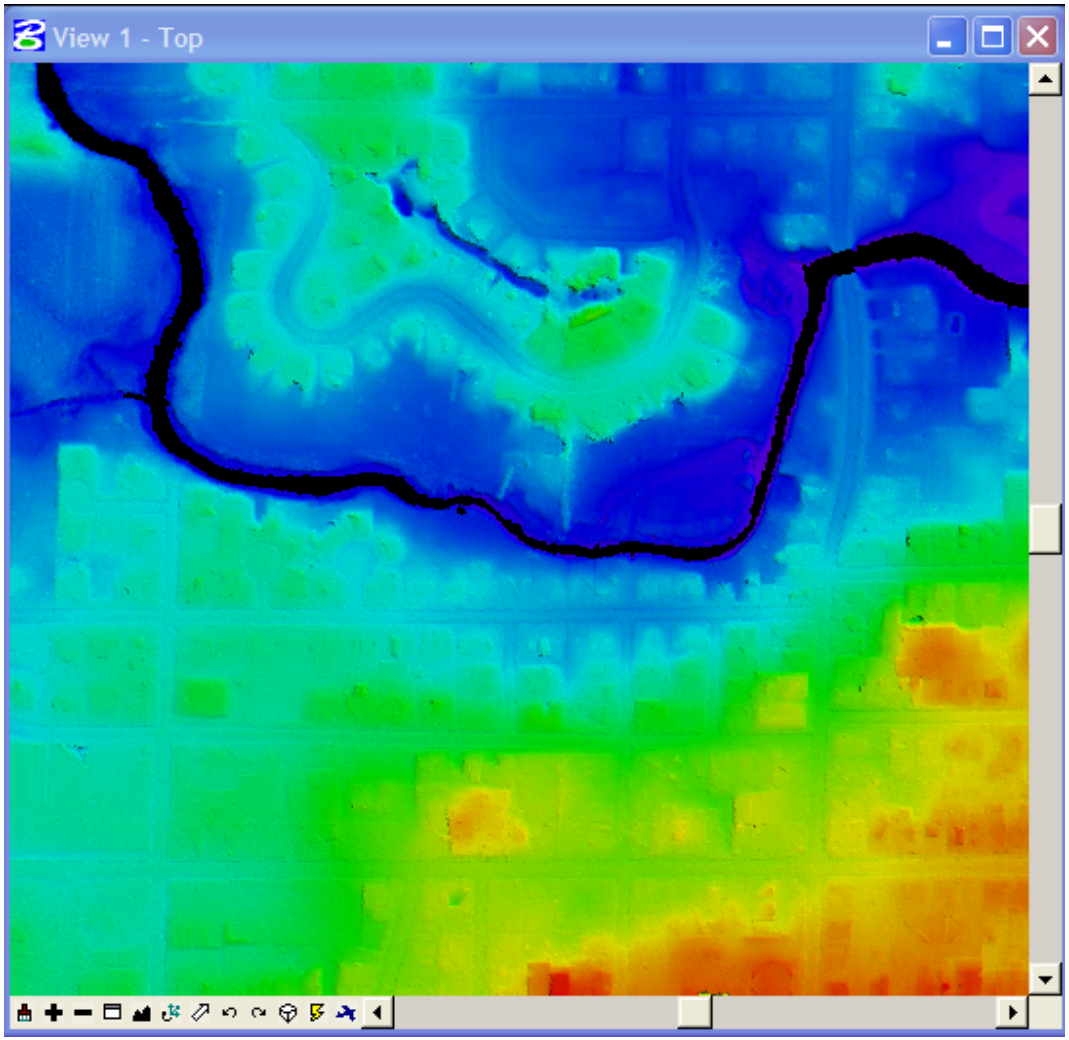
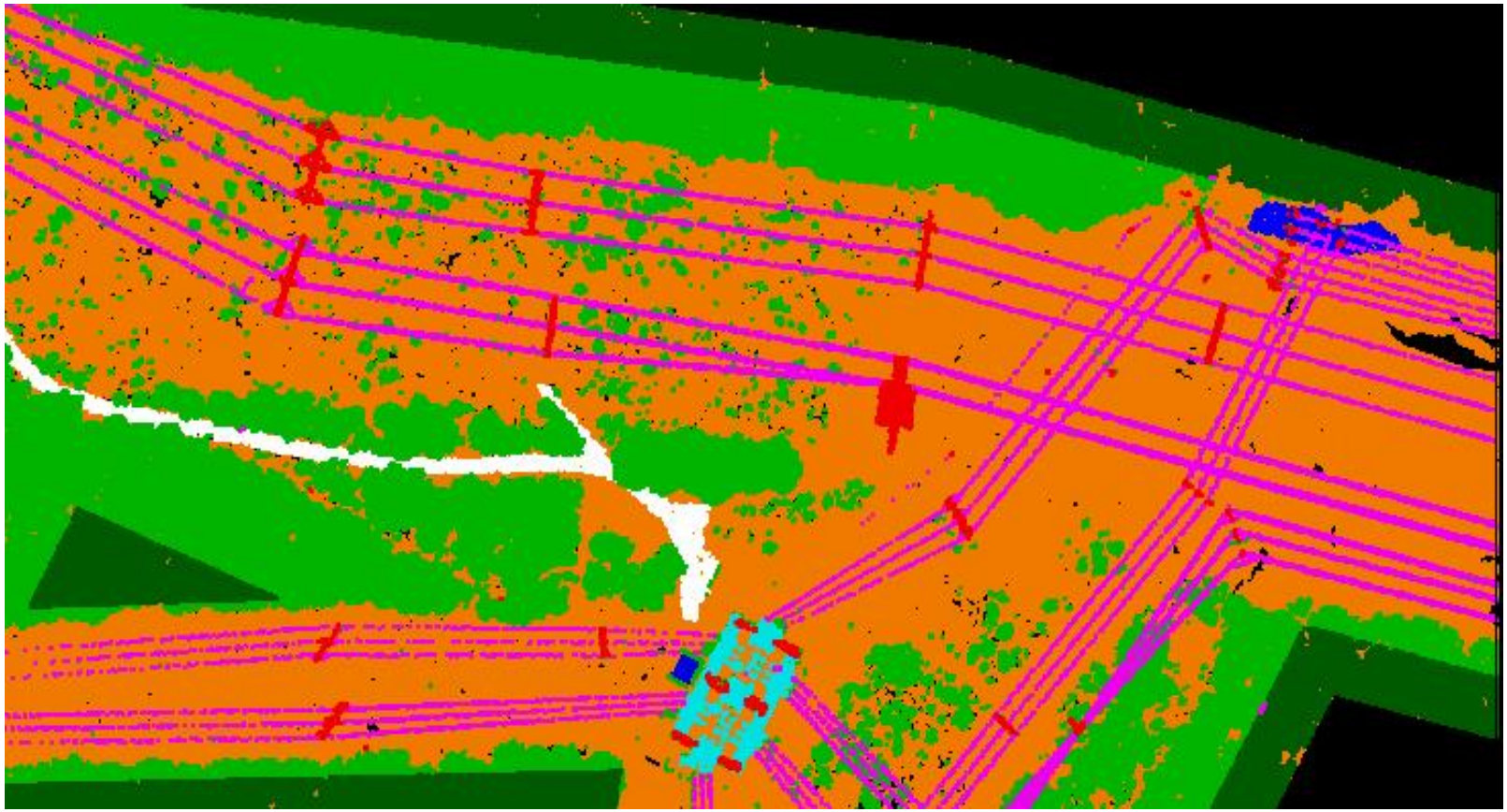
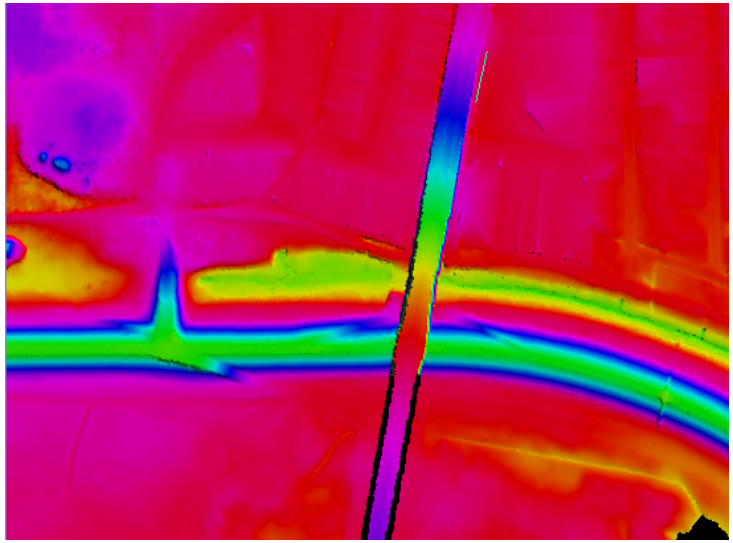
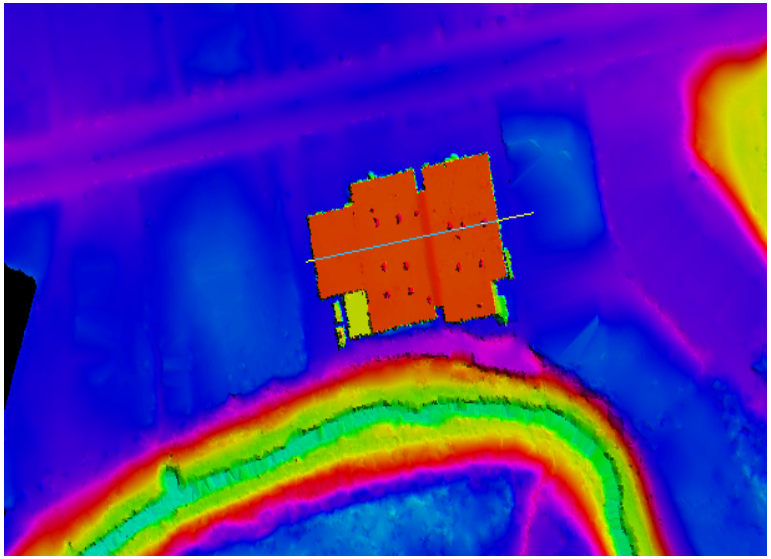


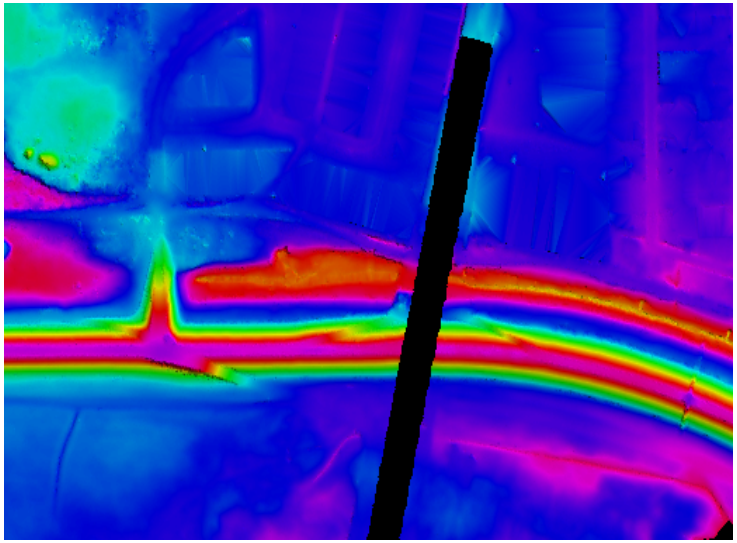
Processing -Classification

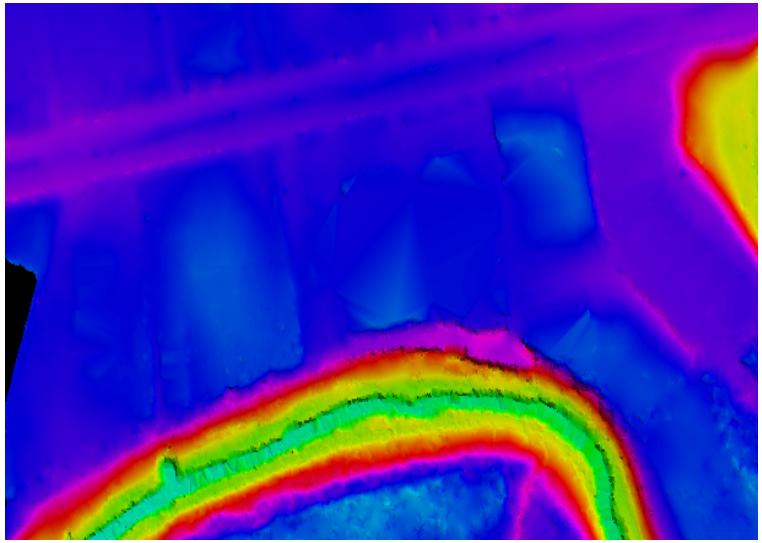


Manual Editing









LiDAR Processing

LiDARgrammetry

Point Cloud Data Classified by Intensity

What's Important?

- Relative Accuracy
- Removal of Artifacts and Outliers
  - How do you quantify this?
- Gaps
  - Unacceptable
- Vegetation Removal & Other Classifications
  - How do you quantify this?
- Check Point Verification
- Horizontal Accuracy
- Vertical Accuracy

Check Point Surveys

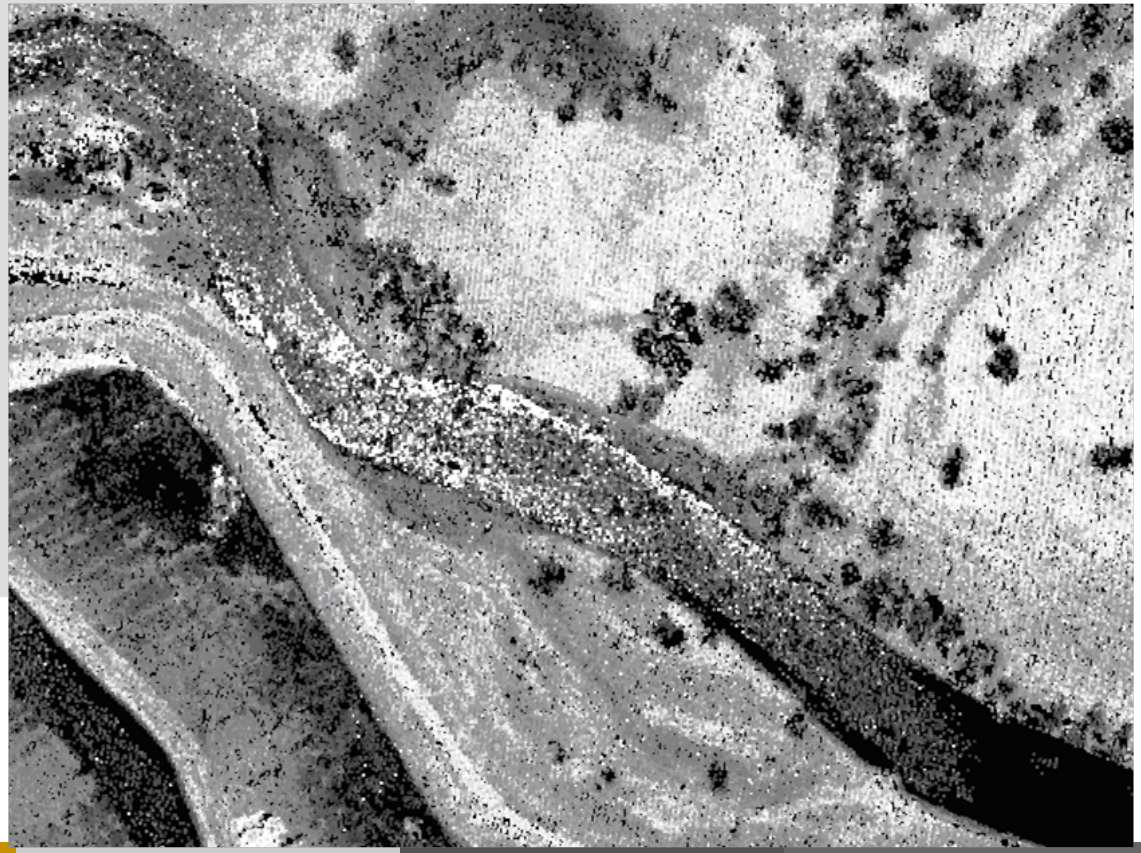
Five Main Categories

- Hard Surface
- Low Grass
- High Grass
- Brush
- Forest

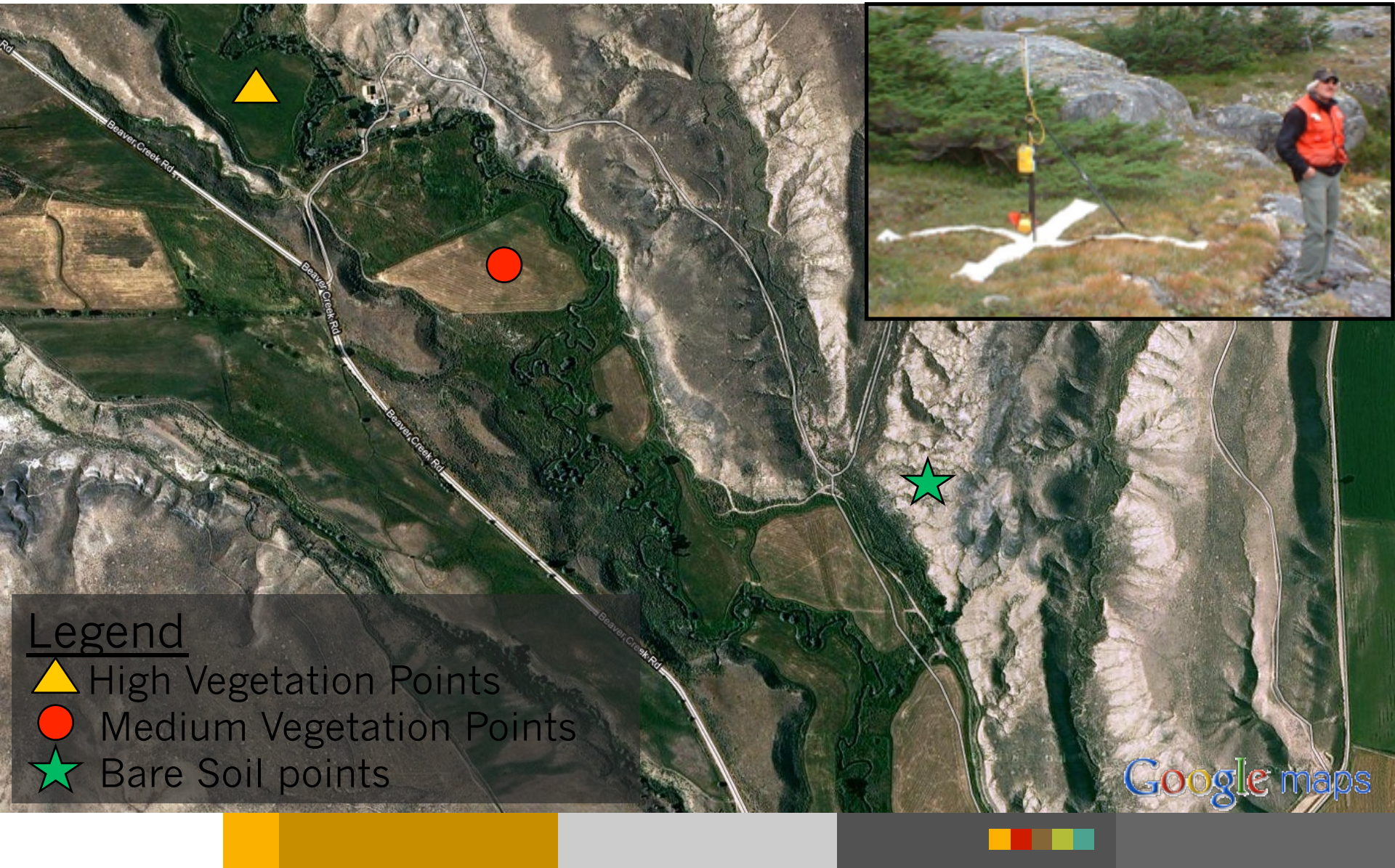
What does this mean?

By region?

Point distribution?



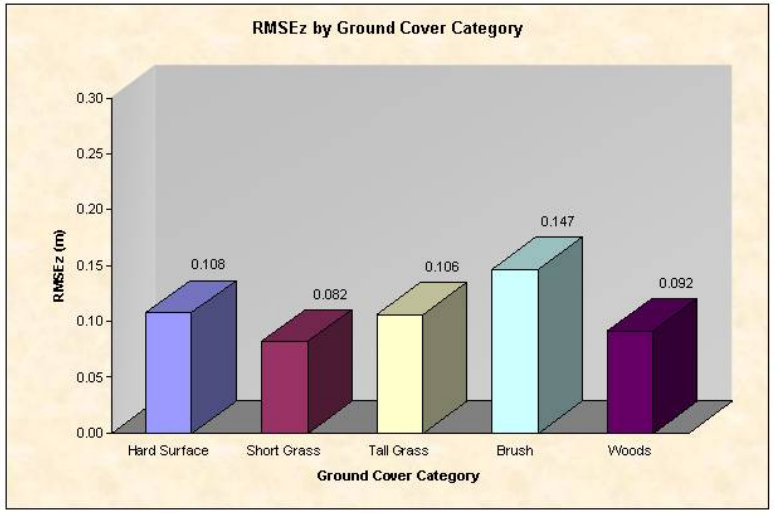
Verification of Point Class



Accuracy

What accuracy do you need?

What are you doing?



Quality Control Report (All Check Points)

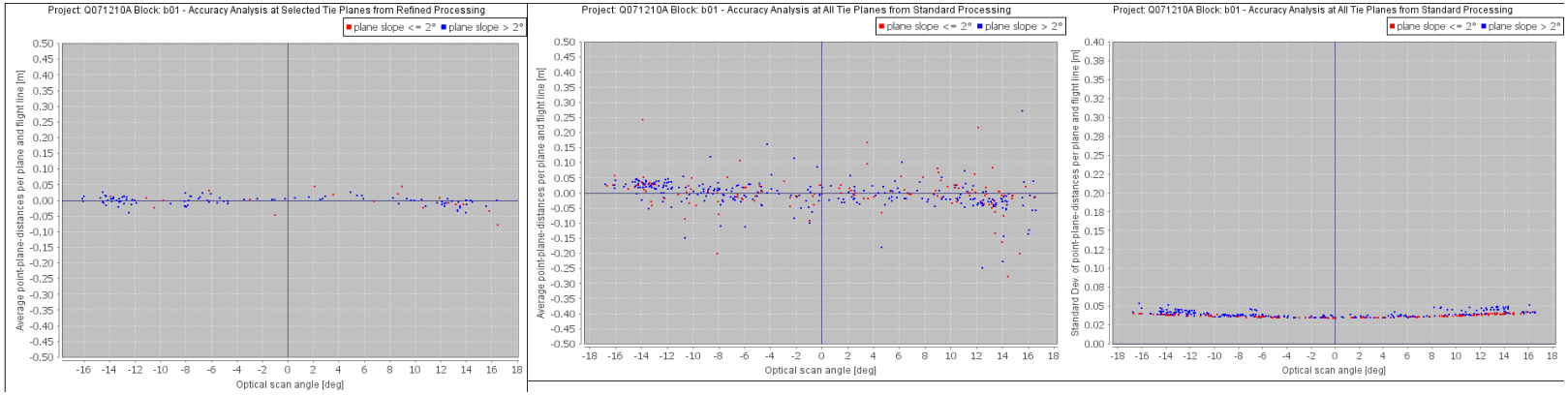
D:\1081001_MN_DNR\QAQC\Control_Points\1081001_all.txt

Number	Easting	Northing	Known Z	Laser Z	Dz
100	540834.061	4862280.474	391.901	391.960	+0.059
101	475506.406	4882502.397	339.050	339.040	-0.010
102	485582.255	4867963.234	382.263	382.280	+0.017
103	501136.859	4872590.172	387.736	387.670	-0.066
104	461403.811	4826690.475	390.018	389.940	-0.078
105	463346.842	4822470.654	386.420	386.370	-0.050
106	507098.434	4892184.660	360.016	359.960	-0.056
107	511287.264	4863176.906	409.482	409.580	+0.098
108	534746.004	4832525.284	423.079	423.110	+0.031
109	501478.759	4836597.598	371.967	371.900	-0.067
110	560234.546	4821511.856	403.804	403.800	-0.004
111	573316.951	4836514.746	300.922	300.920	-0.002
112	589012.207	4833472.032	344.679	344.660	-0.019
113	599379.146	4849657.186	223.972	224.120	+0.148
514	[illegible]	4866399.[illegible]	380.502	380.290	-0.212
515	528133.612	4877670.838	349.313	349.280	-0.033
516	545430.927	4901148.398	331.918	331.850	-0.068
517	454263.775	4829289.264	389.563	389.460	-0.103
518	470432.122	4820366.513	371.156	371.180	+0.024
519	468669.792	4853781.788	390.864	390.870	+0.006
520	484145.763	4877613.129	374.382	374.330	-0.052
521	496331.426	4855544.460	387.599	387.520	-0.079
522	500405.293	4836787.206	373.900	373.820	-0.080
523	523731.851	4840120.258	432.643	432.500	-0.143
524	534834.946	4820643.149	394.806	394.830	+0.024
525	550736.899	4847132.421	373.429	373.370	-0.059
526	557554.021	4827902.532	408.238	408.270	+0.032
527	580423.954	4833713.623	331.643	331.620	-0.023
528	615447.986	4863138.157	408.504	408.540	+0.036
529	565088.237	4855170.949	307.314	307.260	-0.054
530	481512.950	4891211.080	354.386	354.250	-0.136
531	489886.984	4858080.057	388.762	388.780	+0.018
532	493361.018	4839013.965	385.313	385.240	-0.073
533	449990.650	4816486.635	392.661	392.610	-0.051
534	495611.402	4844116.597	392.610	392.430	-0.180

Average dz	+0.001
Minimum dz	-0.222
Maximum dz	+0.526
Average magnitude	0.082
Root mean square	0.109
Std deviation	0.109

Typically Speaking?

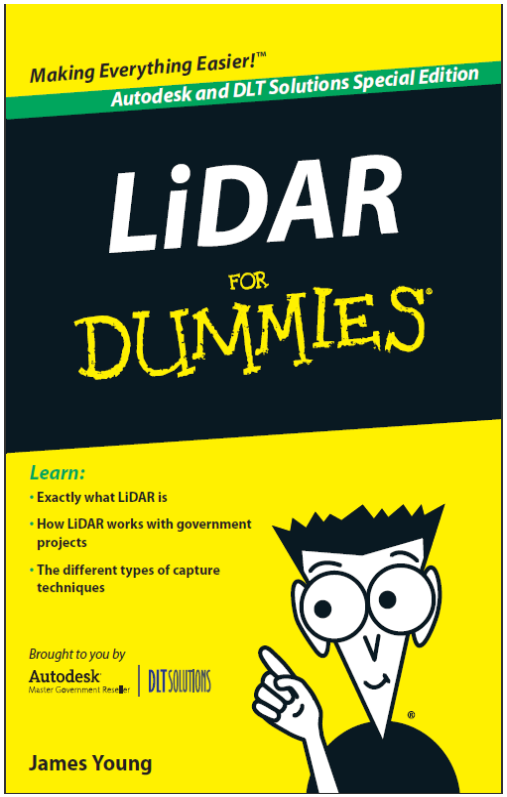
- **Fixed Wing MPia, ALS-70 and GEMINI**
  - Vertical accuracy achieved: **3 – 12 cm**
  - Horizontal accuracy achieved: **10 – 27 cm**
- **Helicopter LiDAR – Reigl 680, Optech Orion and Leica ALS70-C**
  - Vertical accuracy achieved: **1-2 cm**
  - Horizontal accuracy achieved: **5-10 cm**



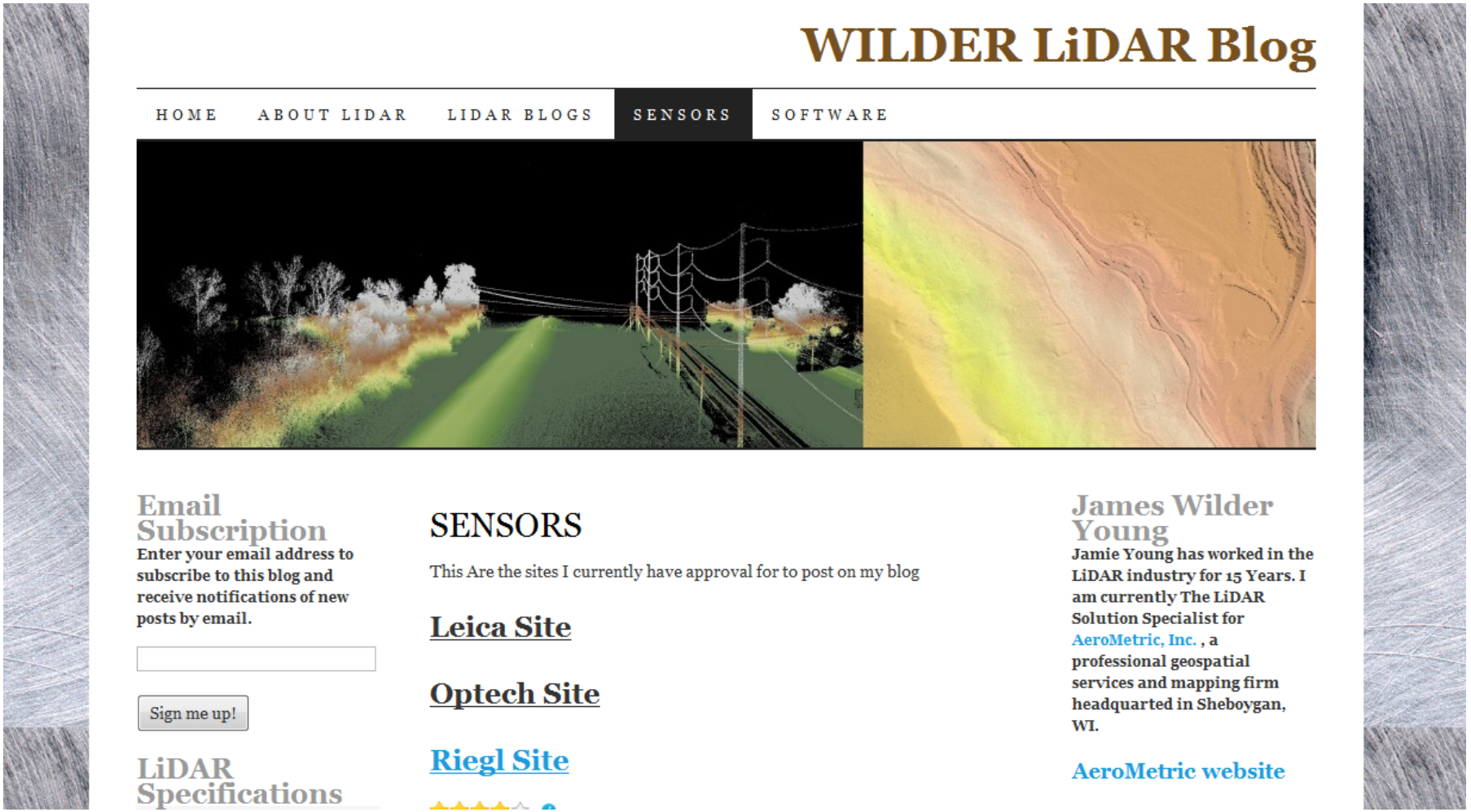
Data meets accuracy specification?

Publications

- LIDAR for Dummies
- American Surveyor – Mobile Mapping
- Professional Surveyor –Calibration Software



WILDER LiDAR Blog



http://bloglidar.com

Thank You