Aerial and Mobile Point Cloud Integration – An Industrial Perspective

Lewis Graham

GeoCue Group

9668 Madison Blvd., Suite 202

Madison, AL 35758

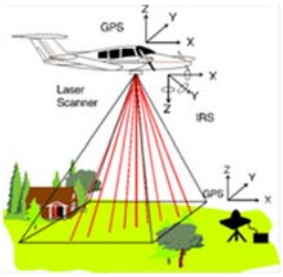
01-256-461-8289

lgraham@geocue.com

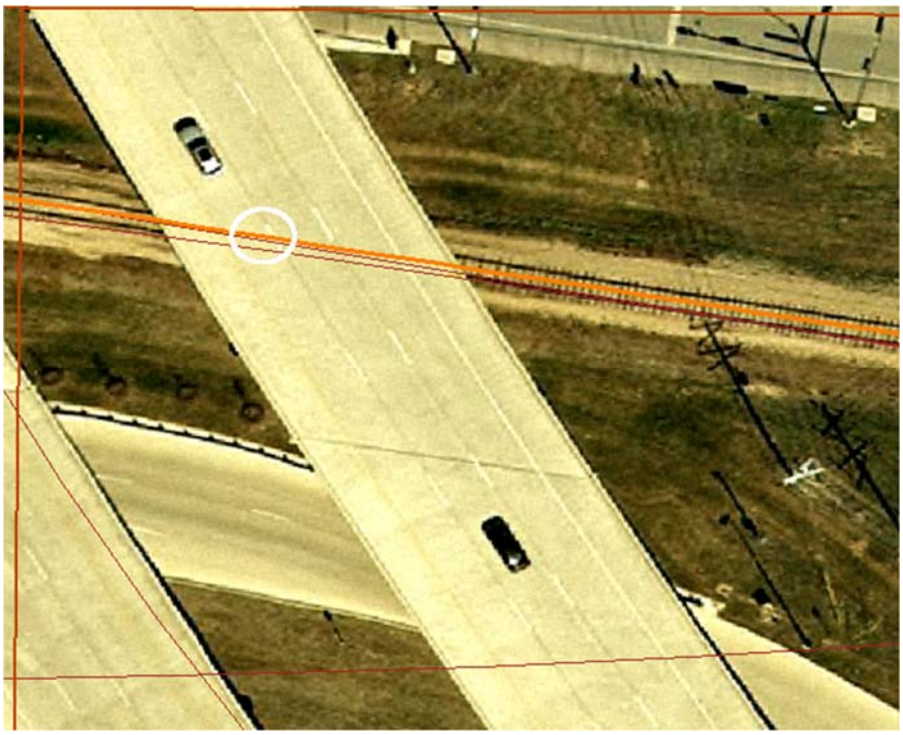
www.geocue.com

Integrating the Geospatial Workplace

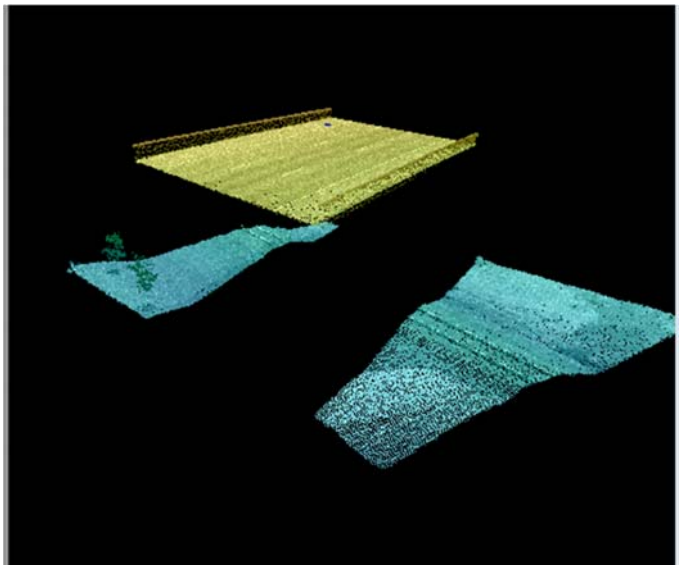
How doe we merge?



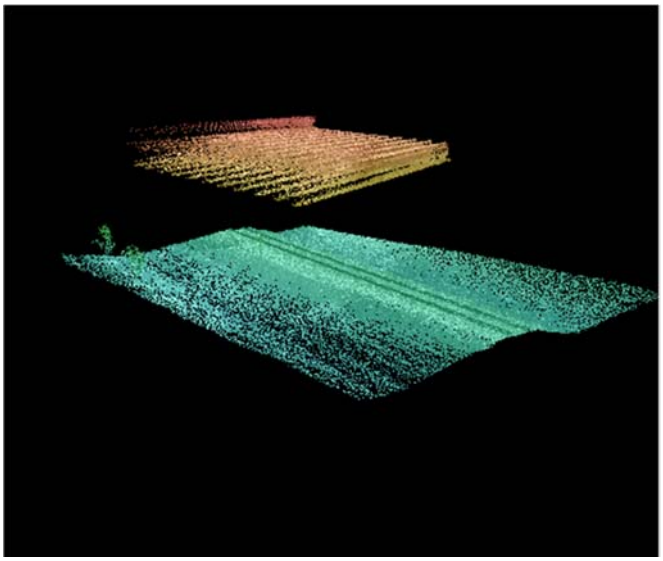
Why Merge?



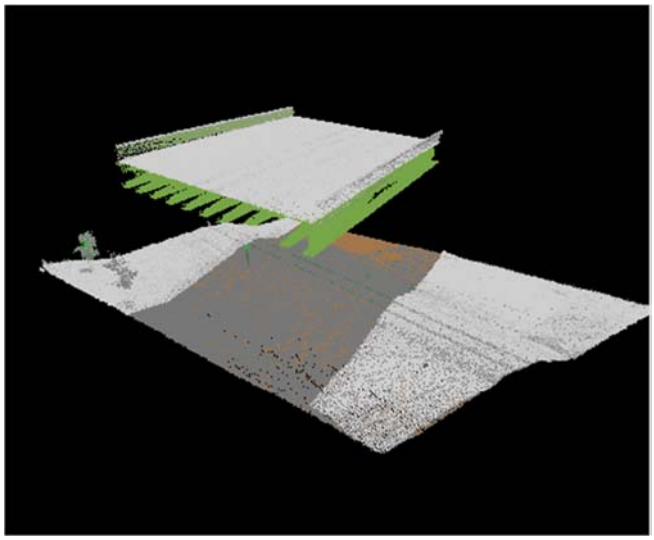
Rotary Wing LIDAR



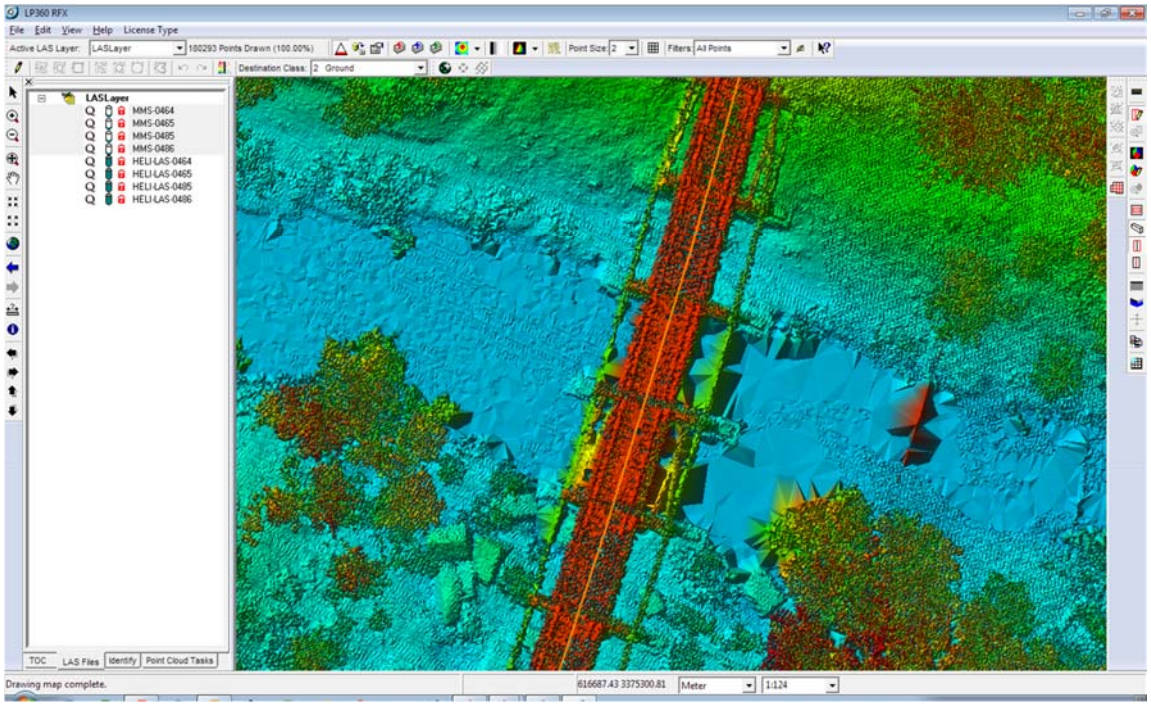
Mobile LIDAR



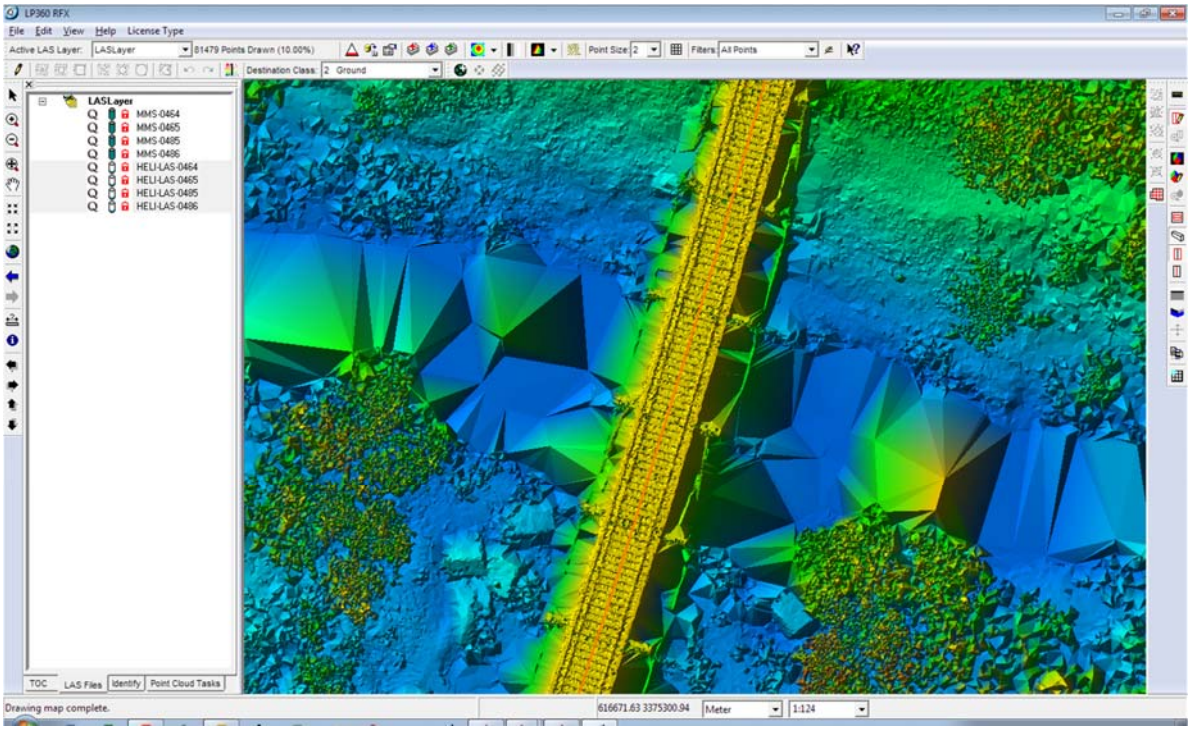
Fused



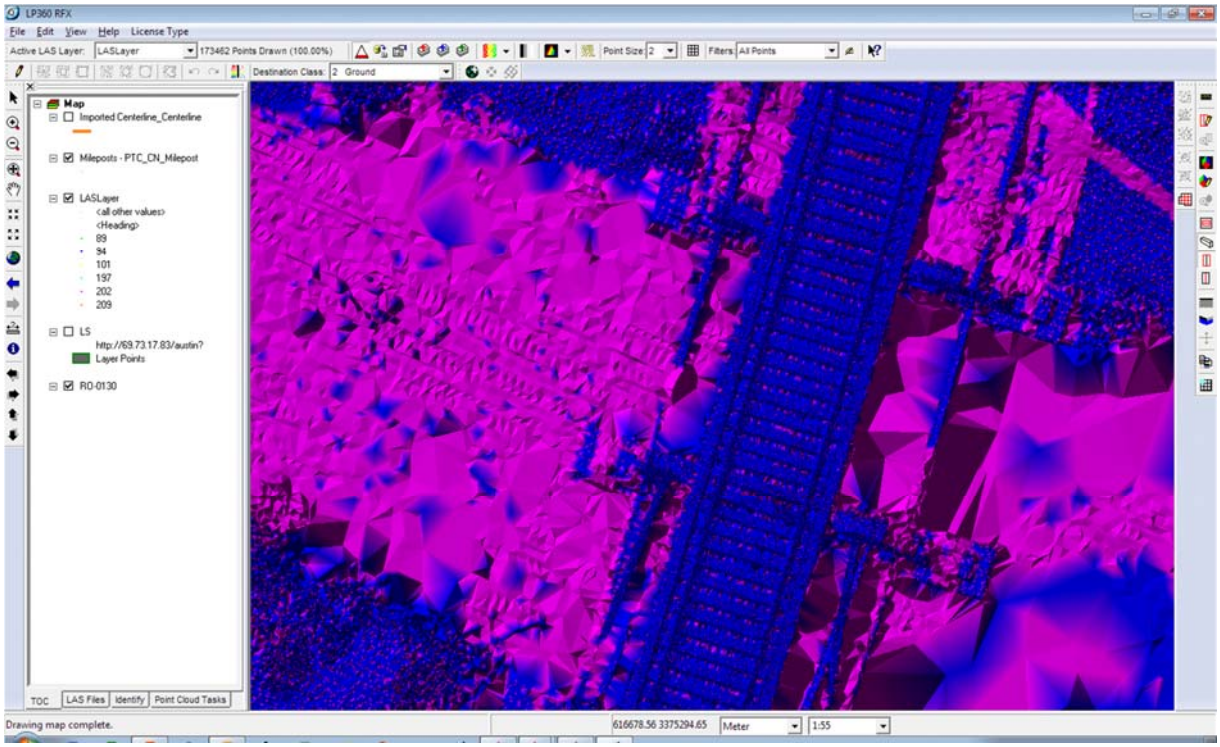
Rotary



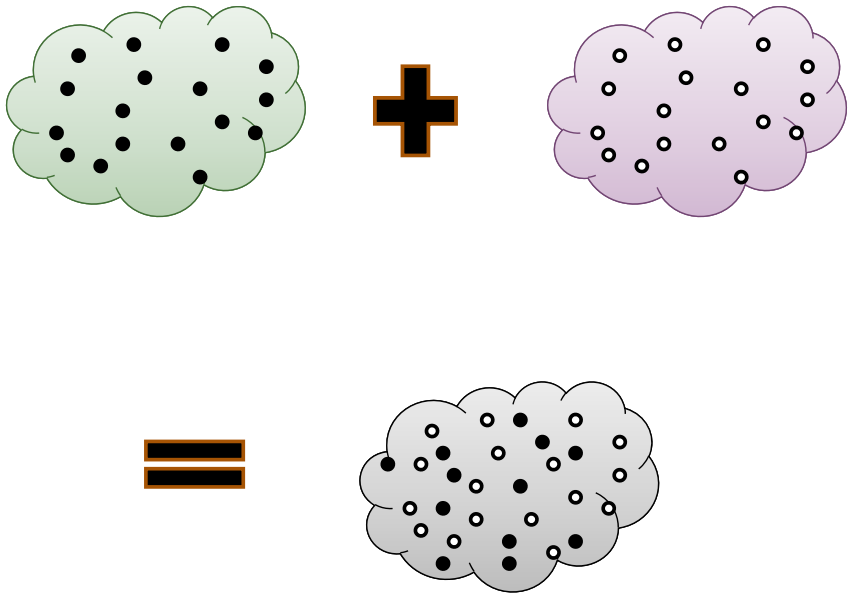
Track-based mobile



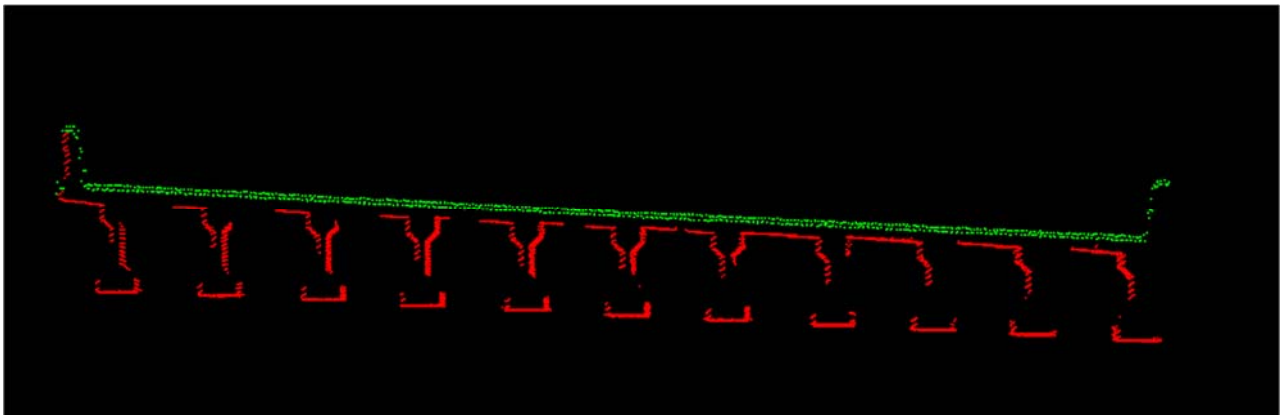
Merged



Just Merge?

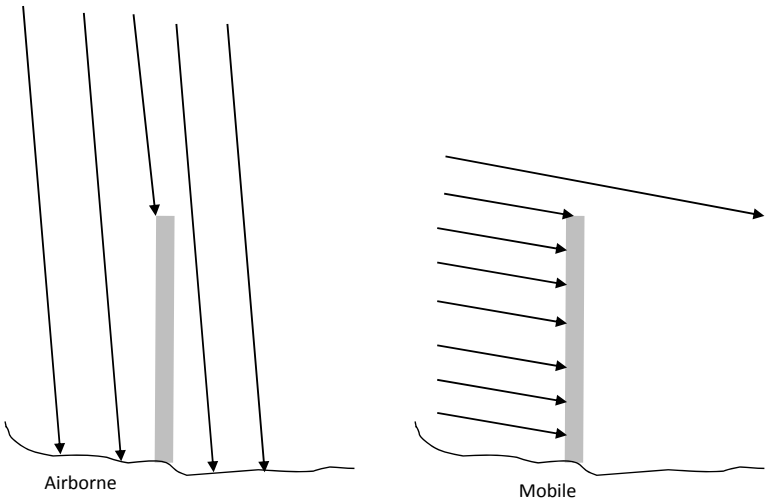


OK for Visualizing but…

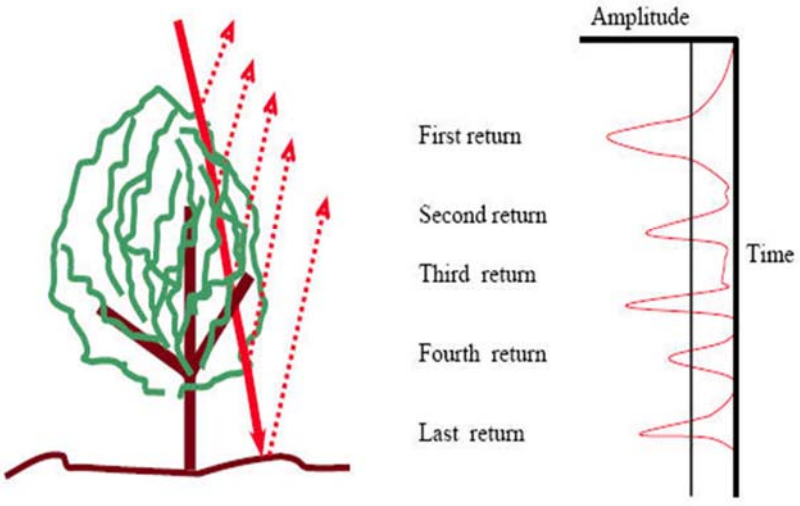


A BIT OF BACKGROUND…

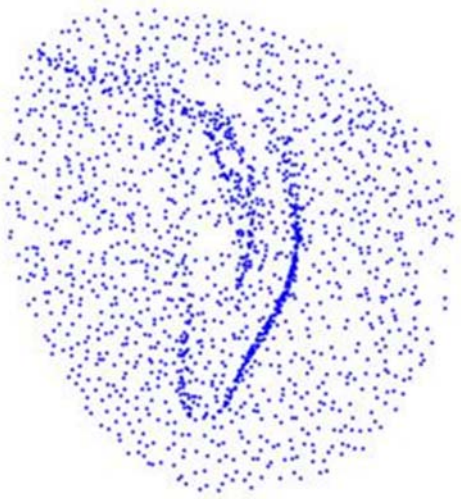
Ray perspective



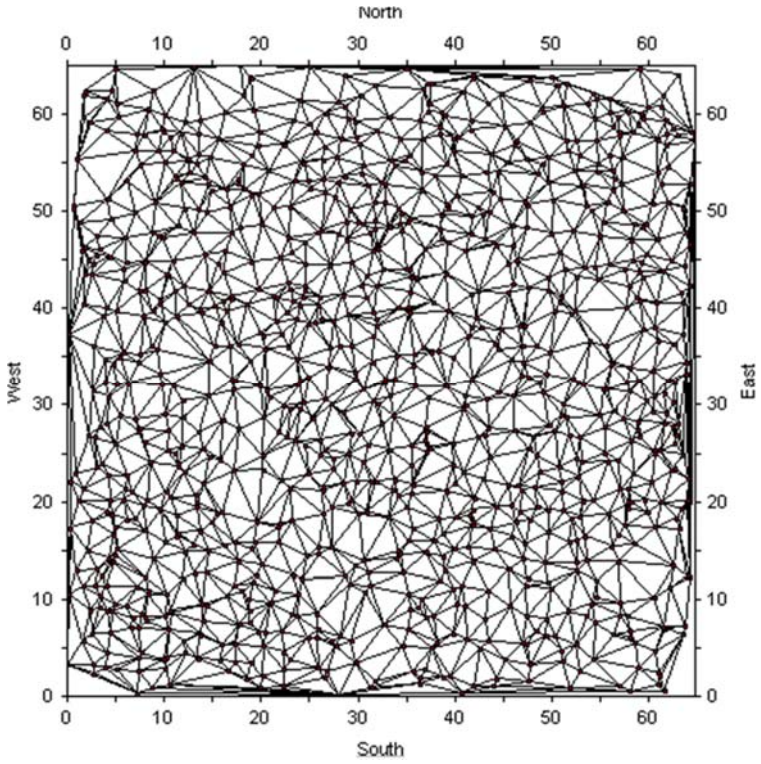
Multi-Return



Non-Uniform



2½ D TIN Limitations



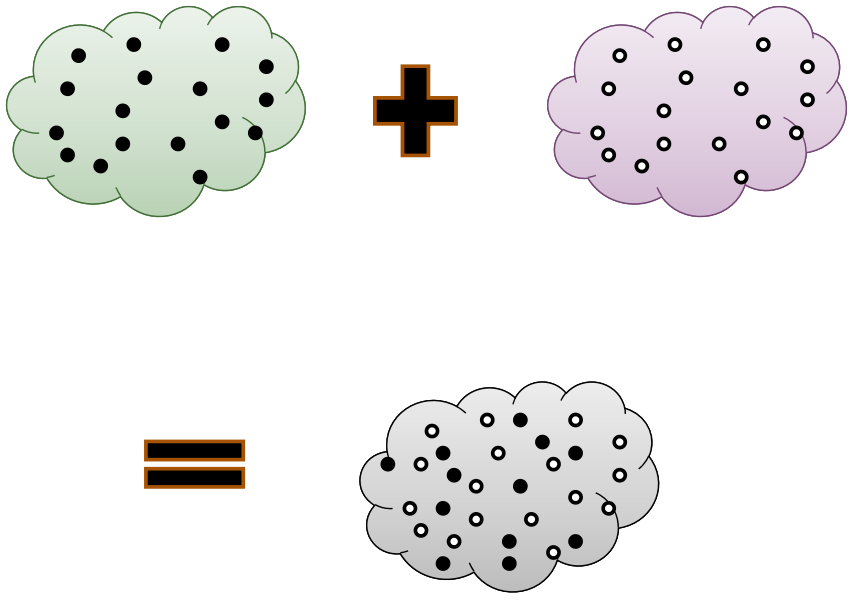
$X_i, Y_i \rightarrow Z_i$

not

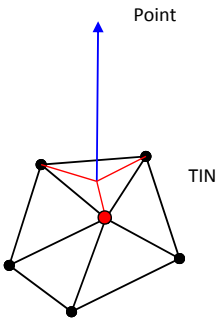
$X_i, Y_i \rightarrow Z_i, Z_j, Z_k$

SOME MERGE OPTIONS

Maintain Independent Points



Interpolate points



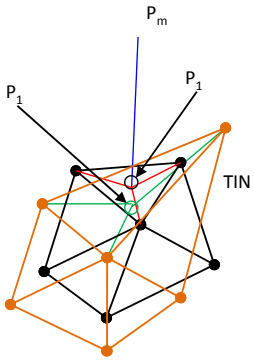
Does not account for variability of accuracy

Does not properly account for 'phase' shift

Statistical Merge

$$\sigma_m = \sqrt{\frac{\sigma_1^2\sigma_2^2}{\sigma_1^2+\sigma_2^2}}$$

$$\mu_m = \frac{\mu_1\sigma_2^2 + \mu_2\sigma_1^2}{\sigma_1^2+\sigma_2^2}$$

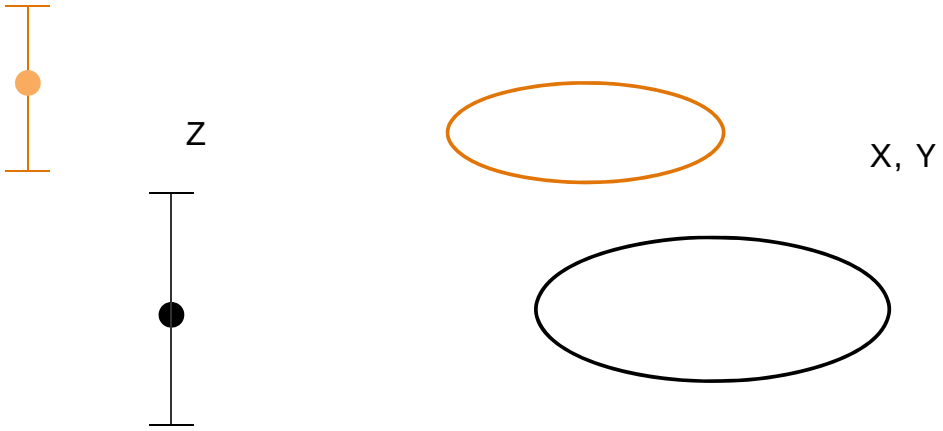


Of course, this requires:

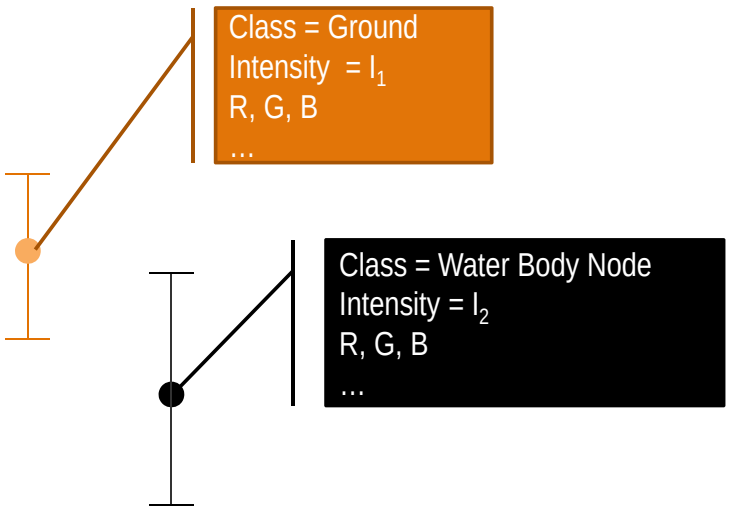
1. You know the statistics
2. *The points be coincident in x, y*

Generally, We Do Not Know Errors

ε_R	Random Error	(1)
ε_C	Platform Calibration Errors	(2)
ε_T	**Trajectory Errors**	**(3)**



And attributes?

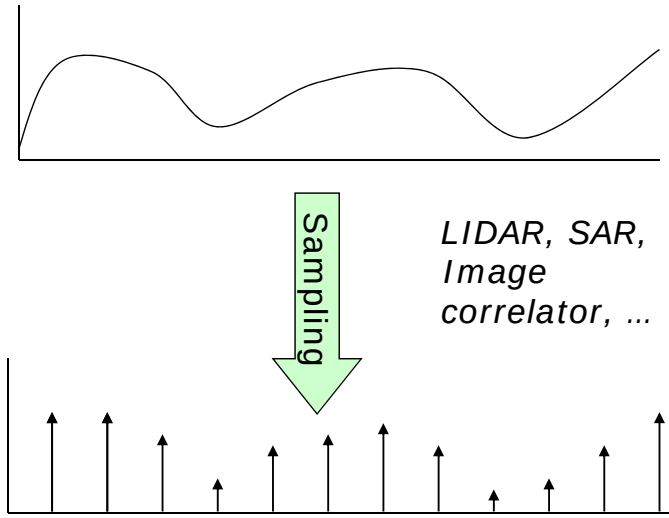


WE DIGRESS – HOW TO MAKE POINTS COINCIDENT?

Making Data Coincident

1. Sample each set to a grid (use a post spacing "tighter" that the point cloud x, y spacing)
2. Choose a destination grid spacing (how?)
3. Sample each source grid into this destination grid

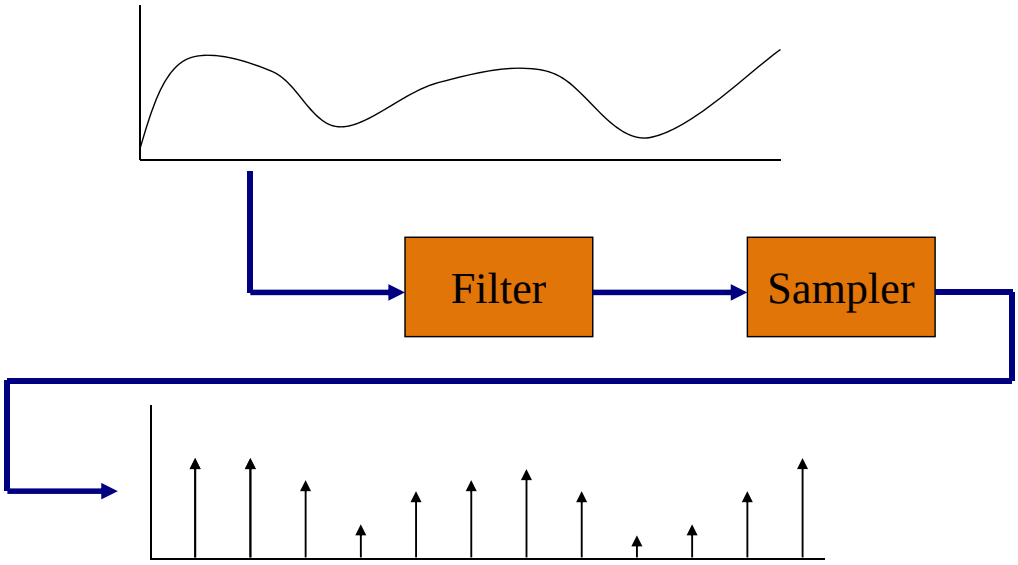
Sampling – Where all problems begin…



Digital Signal Processing

- Digital signal processing is an approximation to an analog process. Typical processing:
  - Convert from analog to digital
  - Perform processing in the digital domain
  - Convert to analog for presentation

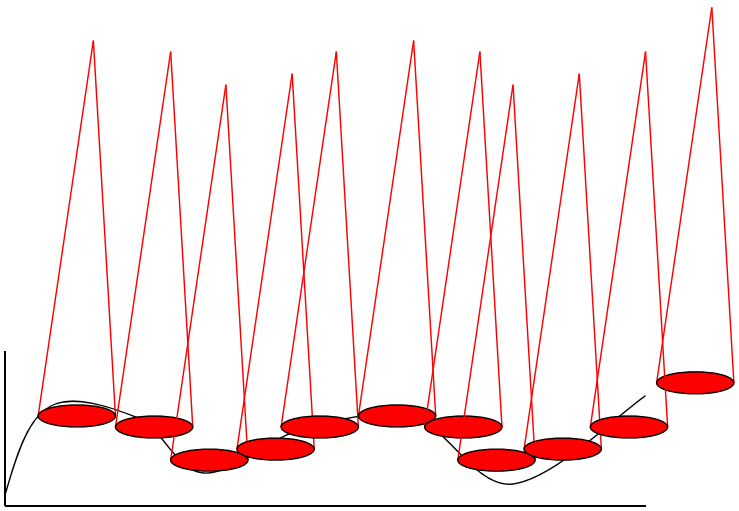
Proper Data Sampling



Nyquist Sampling Criteria

- Under rather liberal conditions (the Dirichlet conditions) a band limited signal can be perfectly reconstructed if it is sampled at a rate at least twice the band limit frequency.

"Natural' LIDAR Spatial Filtering



Spot size can act as a low pass sampling filter

Up-Sampling Reconstructor

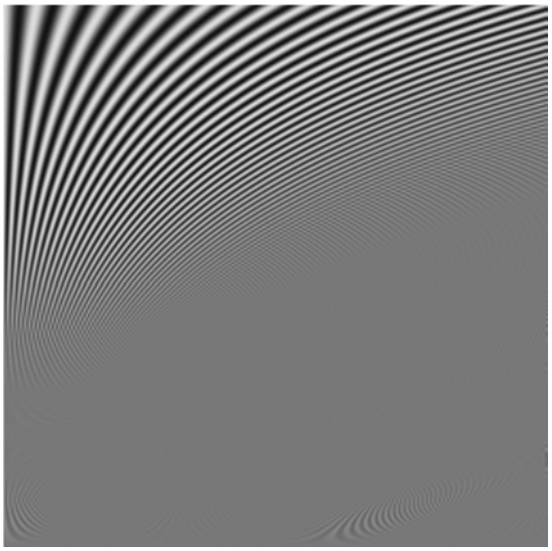
$$f(x,y) = \sum_k f(kL_x, jL_y) sinc(2\pi B_x x - k\pi) sinc(2\pi B_y y - j\pi),$$

where

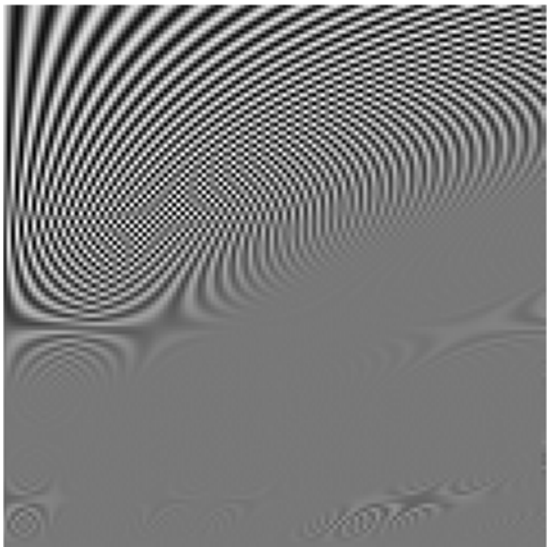
$$B_x = \frac{1}{2L_x}, B_y = \frac{1}{2L_y} \quad the\ spatial\ bandwidth$$

We must use this (or an approximation), even for a phase shift! So interpolating from a TIN is generally a very bad idea.

Downsampling without filtering

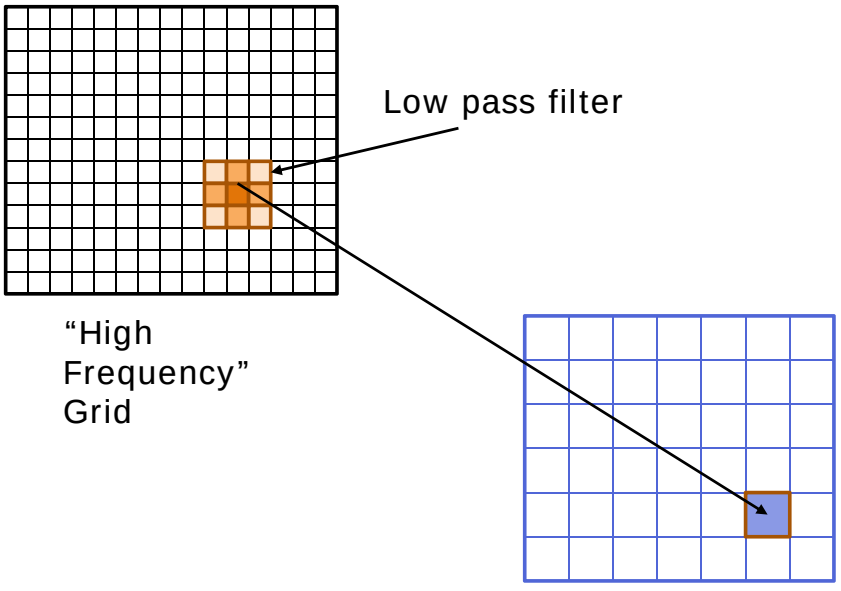


Correctly sampled



Aliasing due to under-sampling

Downsampling



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Summary

- Merging point cloud data is a necessary and highly useful operation for derivative products
- Merging data of significantly differing accuracies is only useful for visualization
- Merging for analysis must be done in accordance with strict precepts of Digital Signal Processing
- Research into non-uniform sampling is needed
- Software applications are needed!