Landscape Scale Aerial Photography and Photogrammetric Processing using Structure From Motion

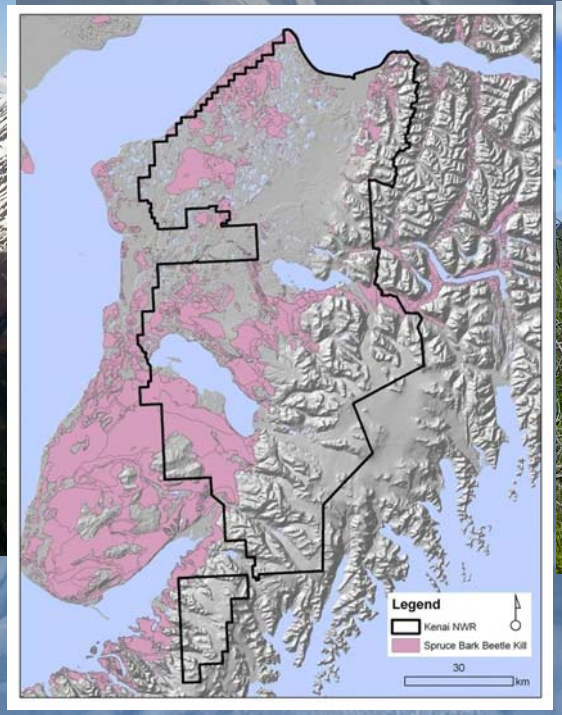
Mark Laker: Kenai National Wildlife Refuge
mark_laker@fws.gov

Overview

- Remote Sensing Needs of Kenai NWR
- Structure from Motion for Landscape Monitoring
- Components of System
- General Workflows
- Project Examples
- Results – The Good and the Bad
- Cost comparisons

Landscape Level Changes on Kenai NWR

- Increased fire activity and intensity
- Shrinking glaciers and ice fields
- Drying wetlands and lakes
- Diminishing alpine
- Expanding grasslands
- Forest Disease outbreaks

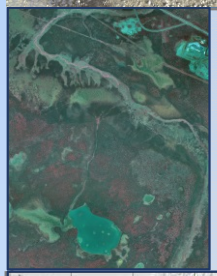


Remote Sensing Needs on Kenai NWR

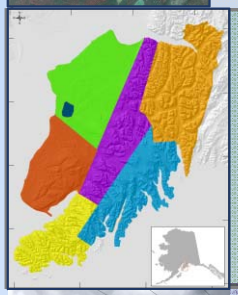
Goal: Repeat Imaging of Large Landscapes

System Criteria:

- **Fast and cheap enough to be repeatable**
- **Flexibility in collection timing**



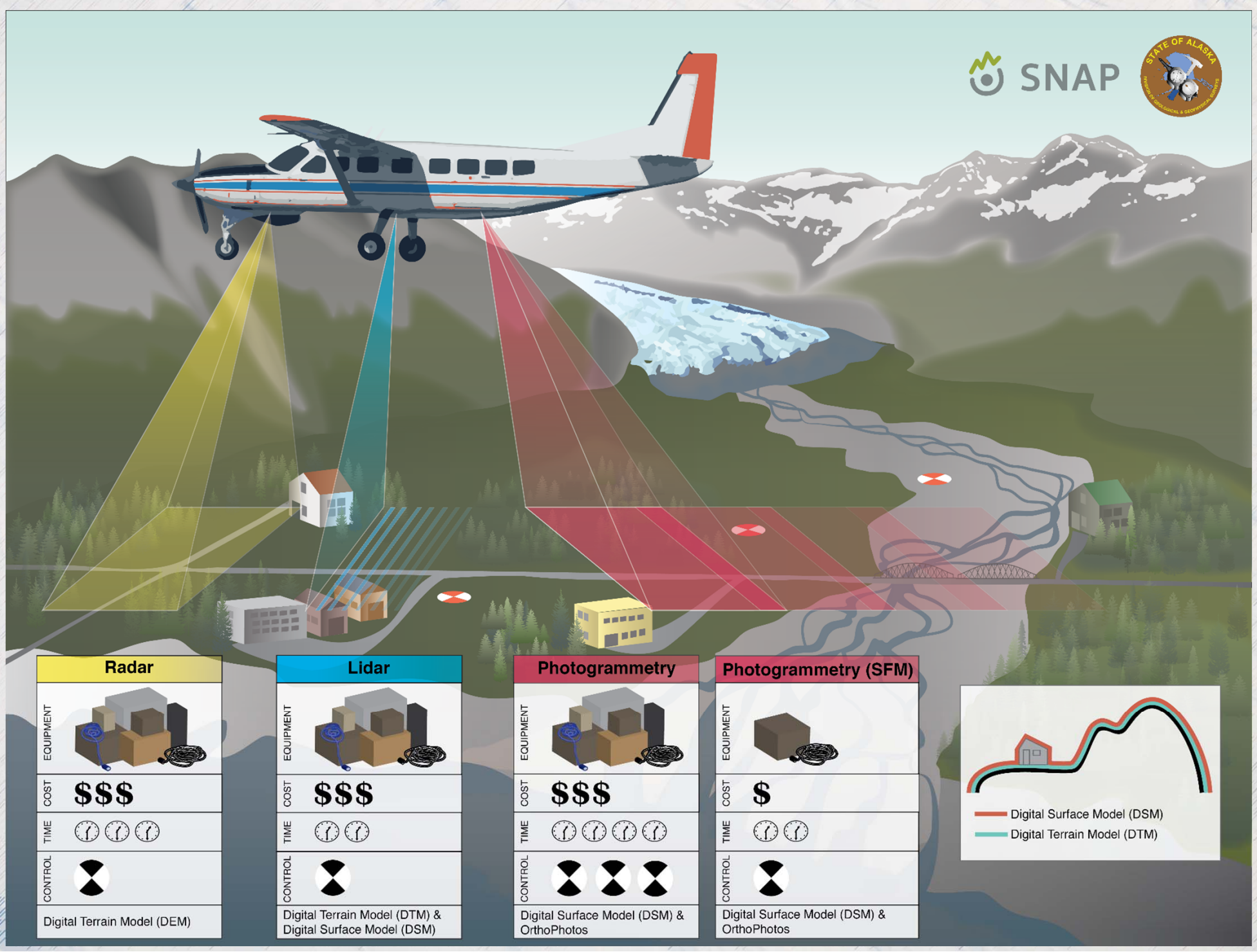
- **Create orthomosaic**
- **Create digital surface model (DSM)**
- **Record visible and near infrared**



- **Acquire data covering 100 to 5,000 square kilometers in days**

- **High to medium resolution (5 cm to 1m)**
- **High spatial accuracy with little reliance on ground control**

Photogrammetry using Structure from Motion



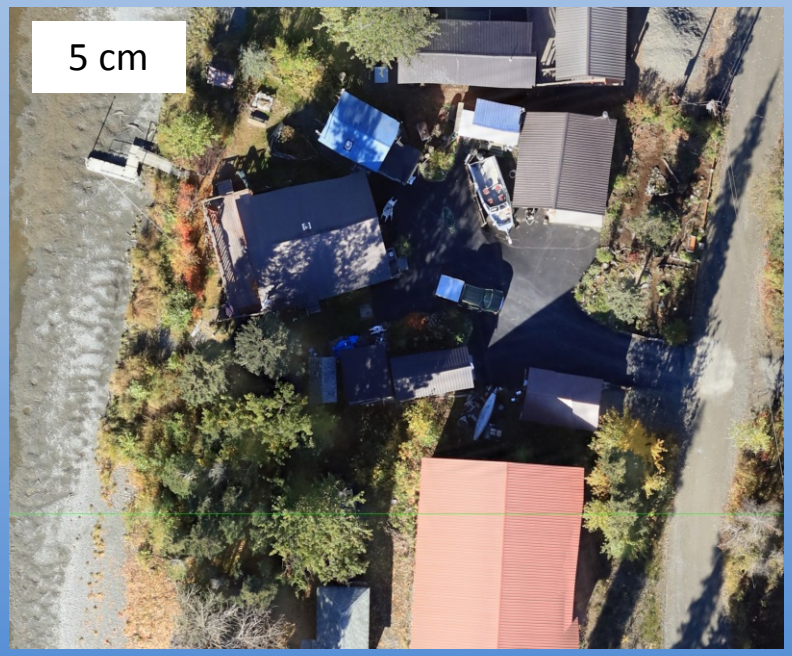
System Components

- Aircraft (fixed wing with camera port or helicopter)
- Camera (Two Nikon D810: RGB and IR, 24mm lens)
- Camera Control
  - Aviatrix software: controls camera shutter and GPS event
  - CamRanger: monitor camera and control settings with iPad
- Dual Frequency GNSS Receiver
  - Trimble R7 receiver: Aerial Control
  - Trimble Net R9: Base Station
- Software
  - Flight planning
  - Agisoft Photoscan (SfM)
  - GrafNav (GNSS processing)
  - Global Mapper (surface)

General Project Workflow

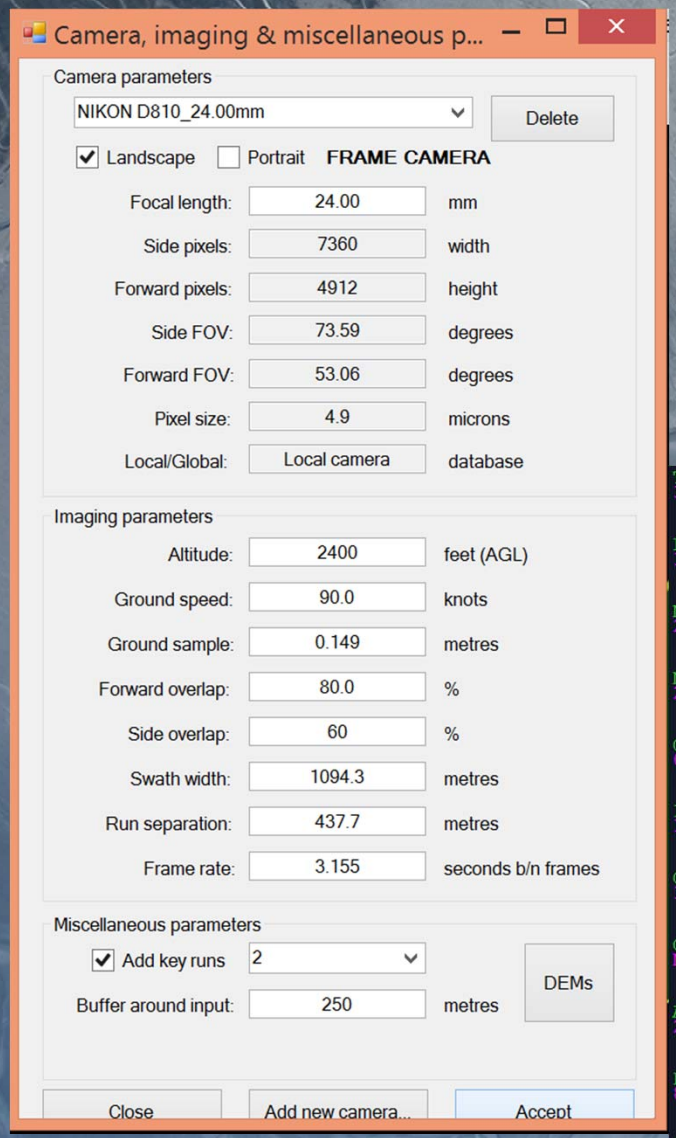
- Determine resolution and aircraft height
- Develop flight lines
- Place ground control markers
- Collect photos
- Process Aerial and Ground Control Points
- Process orthophotographs and DSM
- Archive data

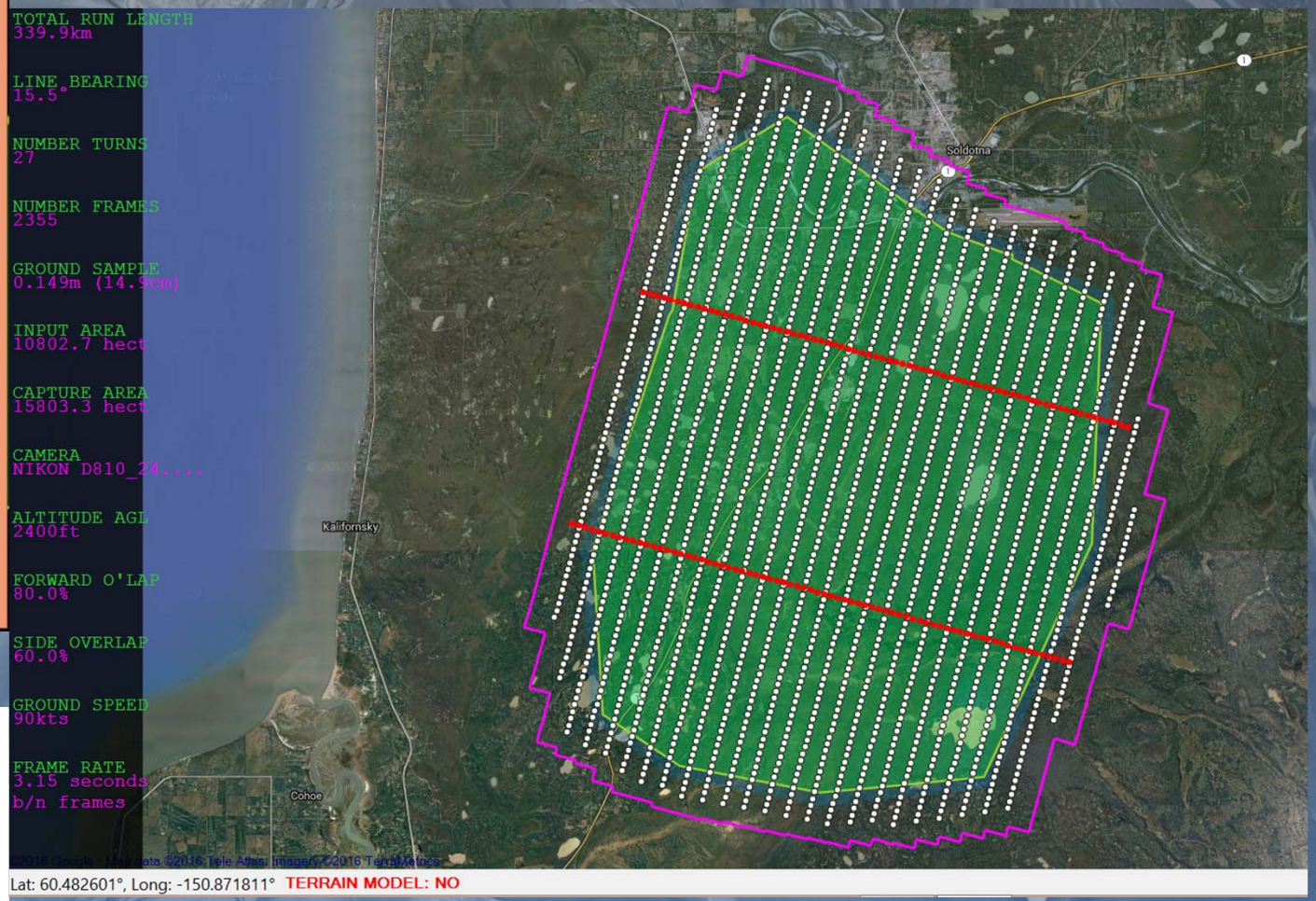
Resolution Comparison



Flight planning

Flight lines and camera positions are calculated based on camera and imaging parameters



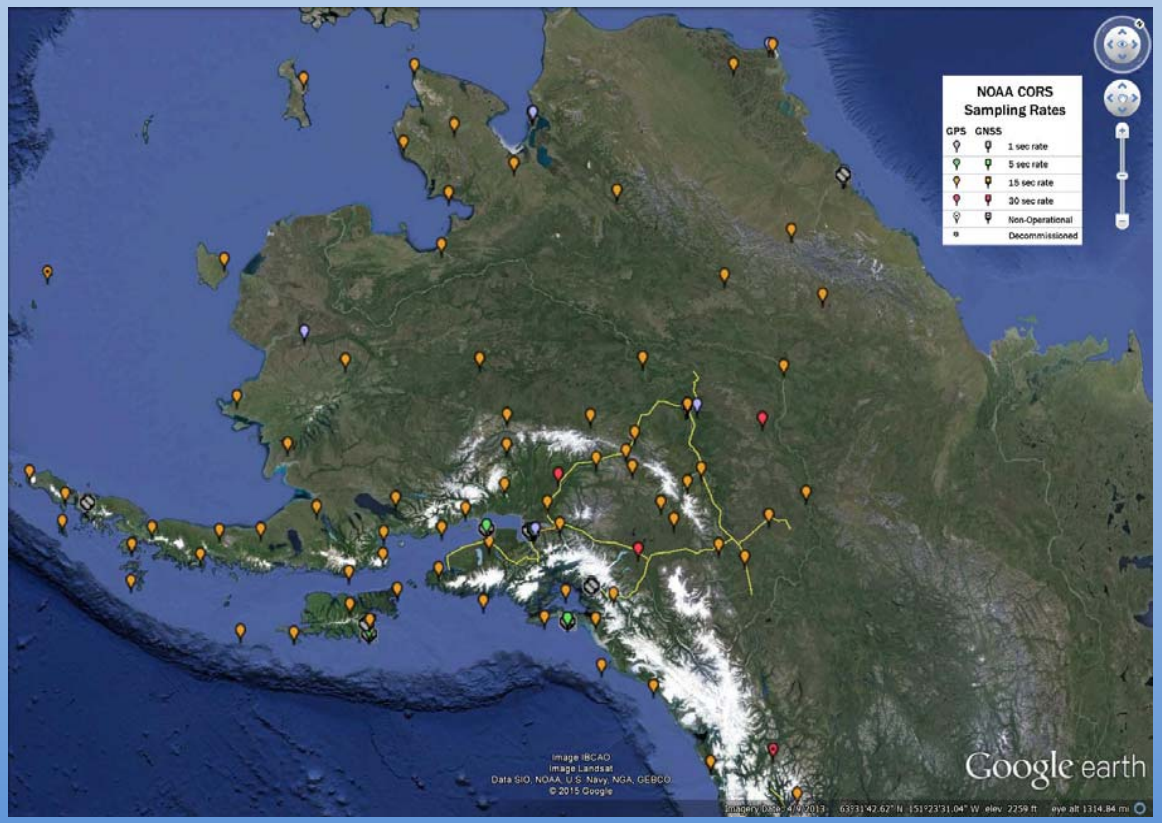


The camera sensor, focal length and flying altitude determine the ground sample size

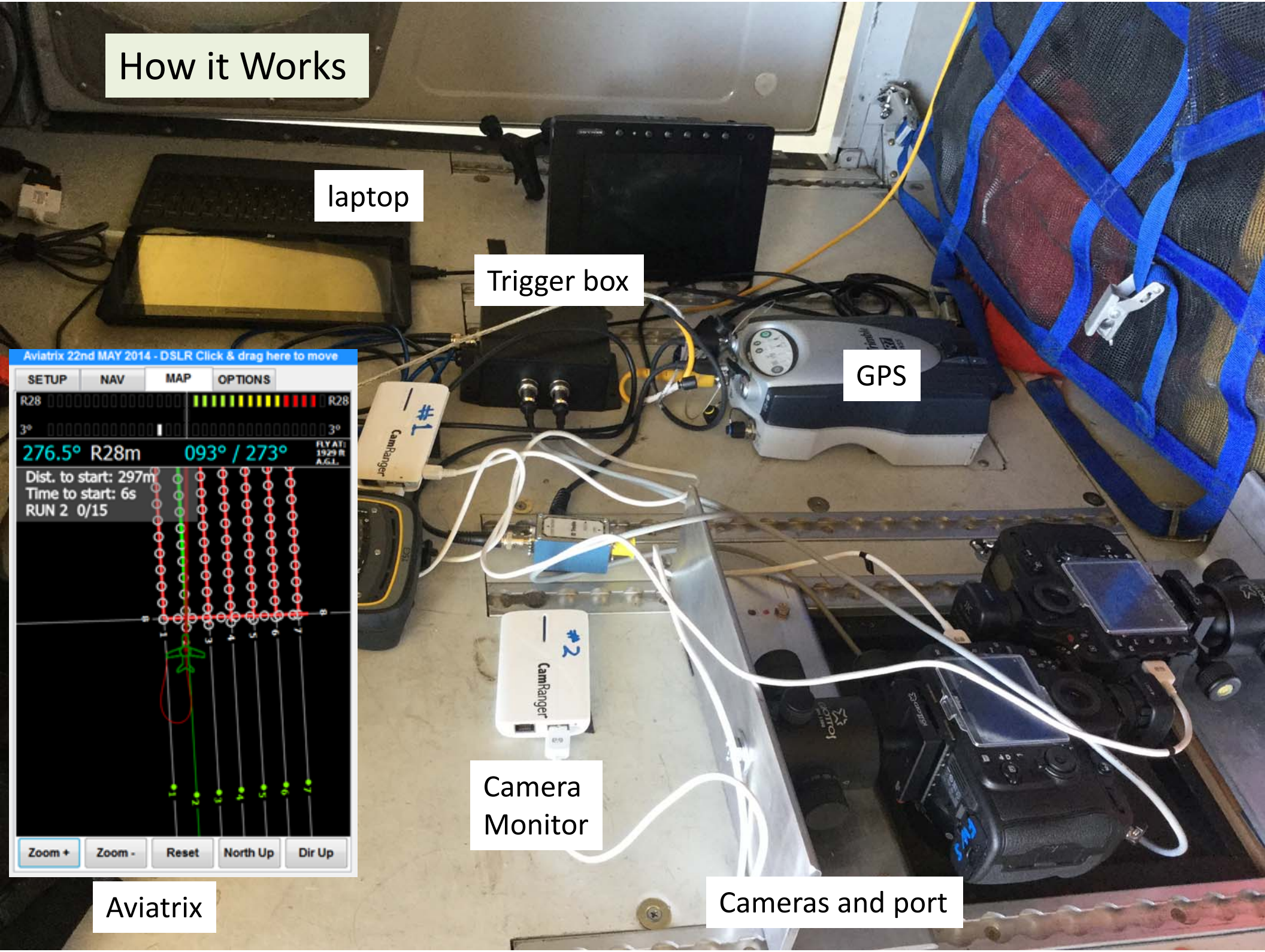
*Created using FlightPlanner Pro. by Aeroscientific.

Ground Control and Base Stations

- Need one ground control point (GCP) for accuracy check
- GCP's are not required for georeferencing if precise camera position is known
- If area is > 100 miles from CORS a mobile base station for differential correction is recommended

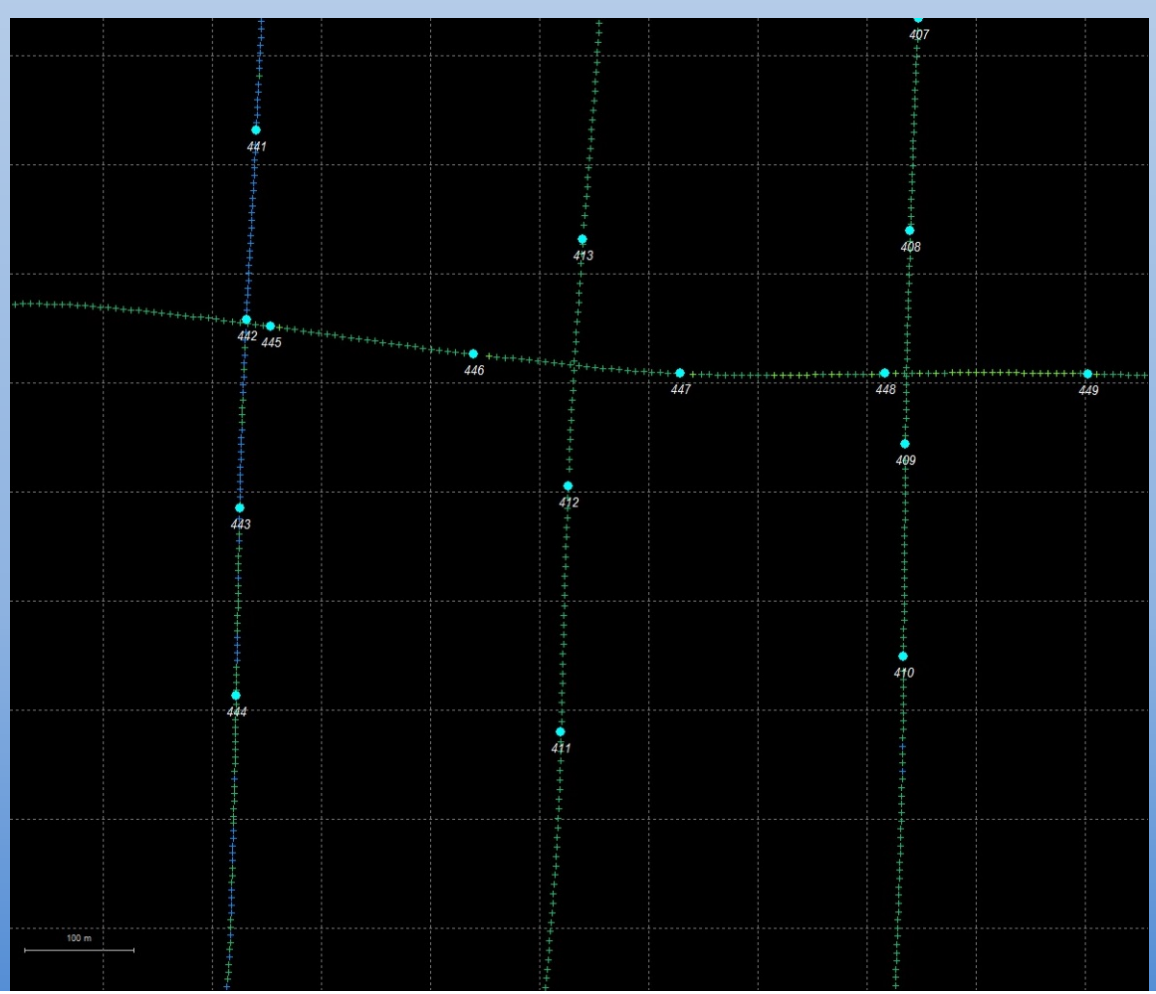


How it Works


laptop
Trigger box
GPS
Camera Monitor
Cameras and port
Aviatrix
Aviatrix 22nd MAY 2014 - DSLR Click & drag here to move
SETUP
NAV
MAP
OPTIONS
R28
3°
276.5° R28m
093° / 273°
Dist. to start: 297m
Time to start: 6s
RUN 2 0/15
Zoom +
Zoom -
Reset
North Up
Dir Up
#1
CamRanger
#2
CamRanger

Process Camera Positions and Ground Control Points

- GrafNav software is used to solve camera position using the event marker time stamp.
- Accuracy is typically < 2 cm



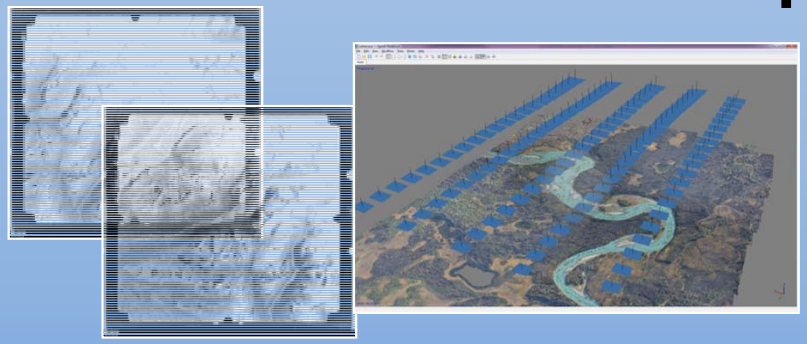
Structure From Motion (SfM)

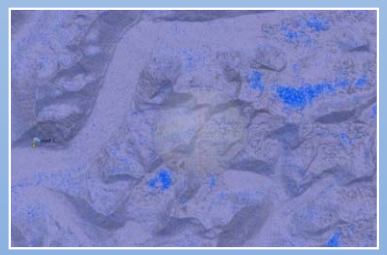
Photogrammetric software: Agisoft Photoscan

- Structure from Motion (SfM)

Similar to traditional photogrammetry… SfM uses multiple overlapping images to triangulate the position of points on the target surface

Simplified Workflow

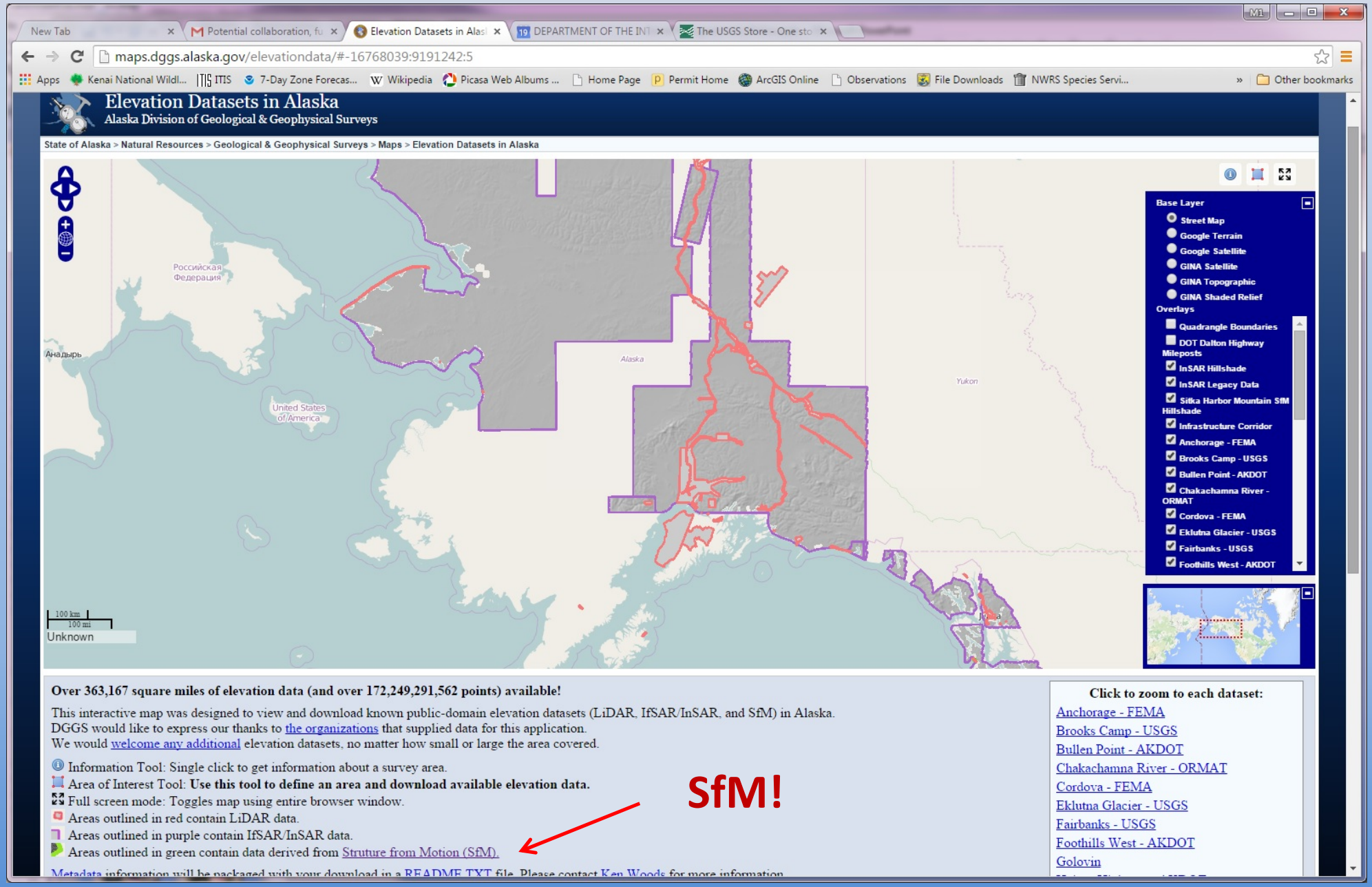




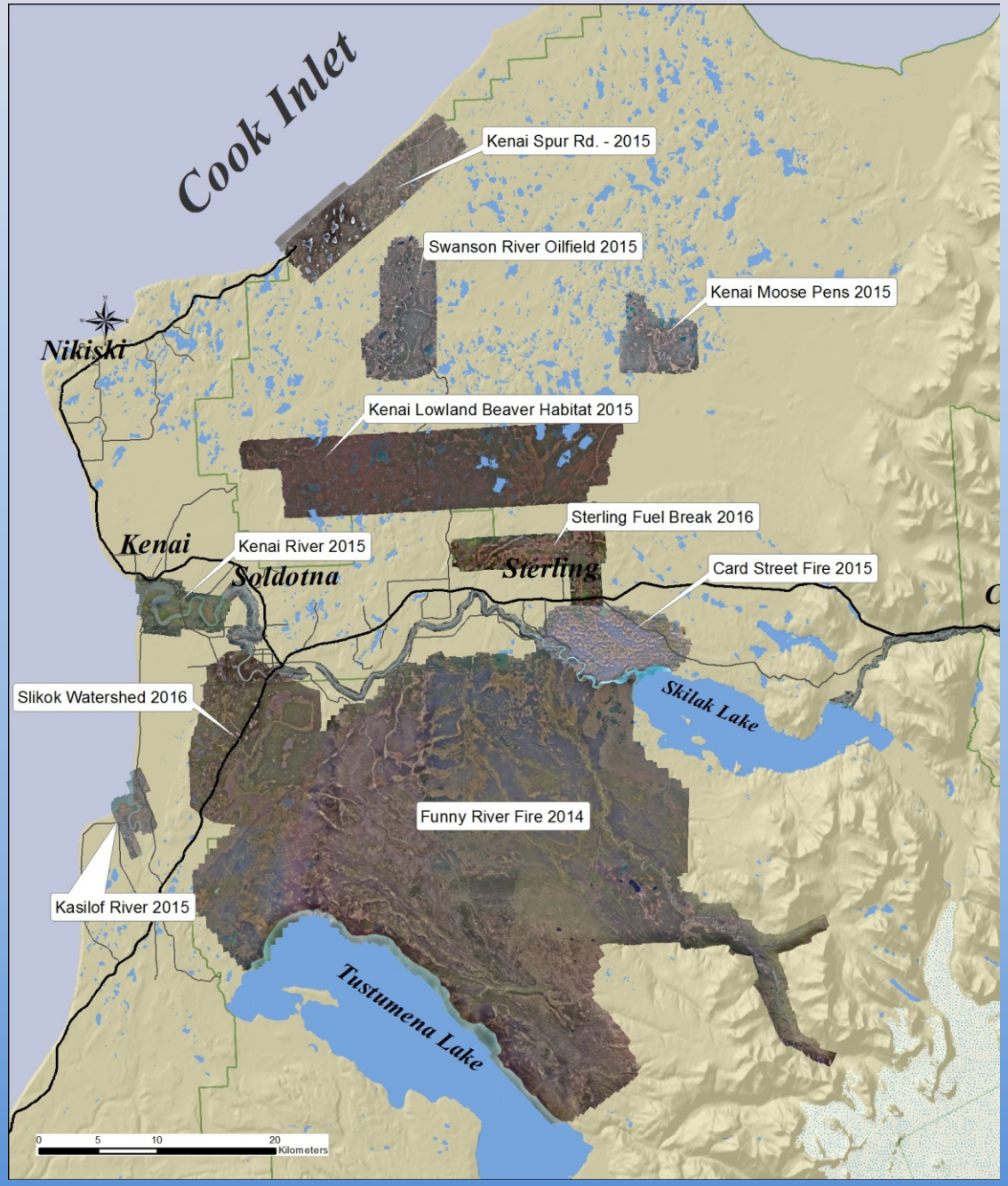
Align images → Build sparse point cloud & add GCPs → Build & edit dense point cloud → Build Mesh (TIN) → Export point cloud/DSM/ orthophotos

Courtesy of Gabriel Wolken, ADGGS

Archive Point Cloud and Orthophotographs



Completed Projects

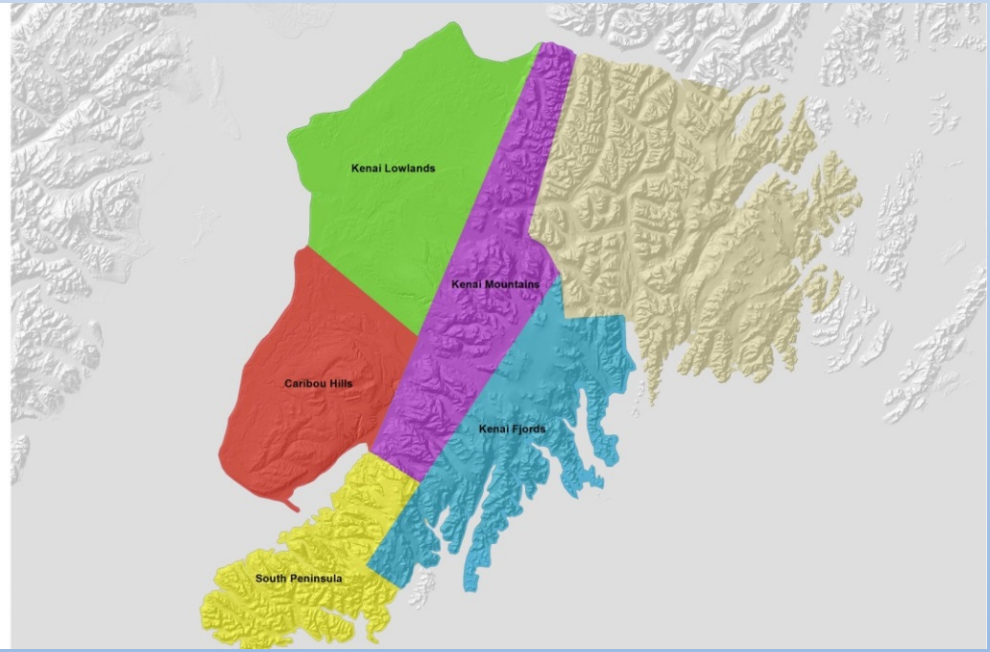


- Fire Monitoring (1,000 Km^2)
  - Funny River
  - Sterling Fuel Break
  - Card Street
- Habitat (950 Km^2)
  - Kenai Lowlands
  - Moose Pens
  - Slikok Watershed
  - Kenai River
  - Kasilof River
  - Yukon Flats NWR*
- Wetland Monitoring
  - Tetlin NWR* (1,100 Km^2)
- Urban Interface (160 Km^2)
  - Kenai Spur Road
  - Swanson Oilfields

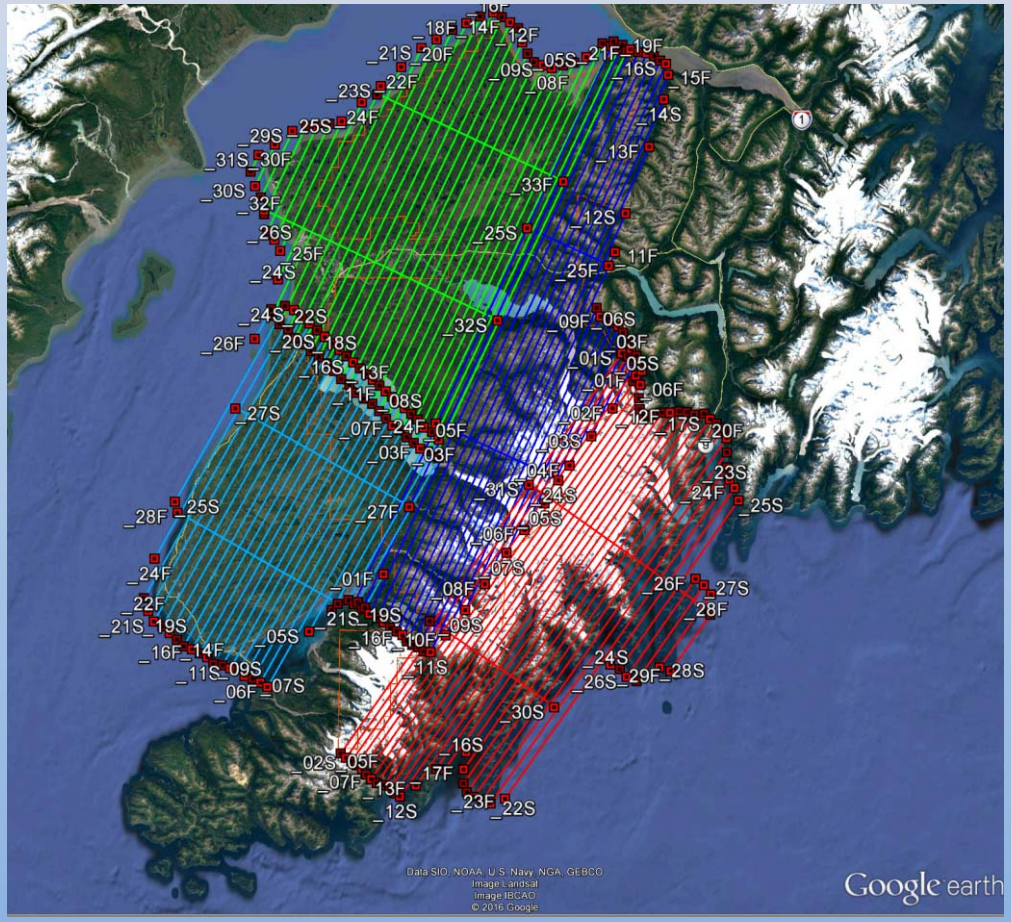
*not pictured

Kenai Peninsula Landcover Classification

Goal: Photograph 17,500 square Kilometers at a resolution of 75 cm.



Completed 15,000 Km sq. in 5 days



- Aircraft: Aero Commander
- Altitude: 4,000 meters
- Speed: 250 knots (480 Kmh)
- Acquisition cost: $3.6/Km sq.

Great Accuracy without GCPs

Error (pixel) = 0.364

High Quality Orthomosaics

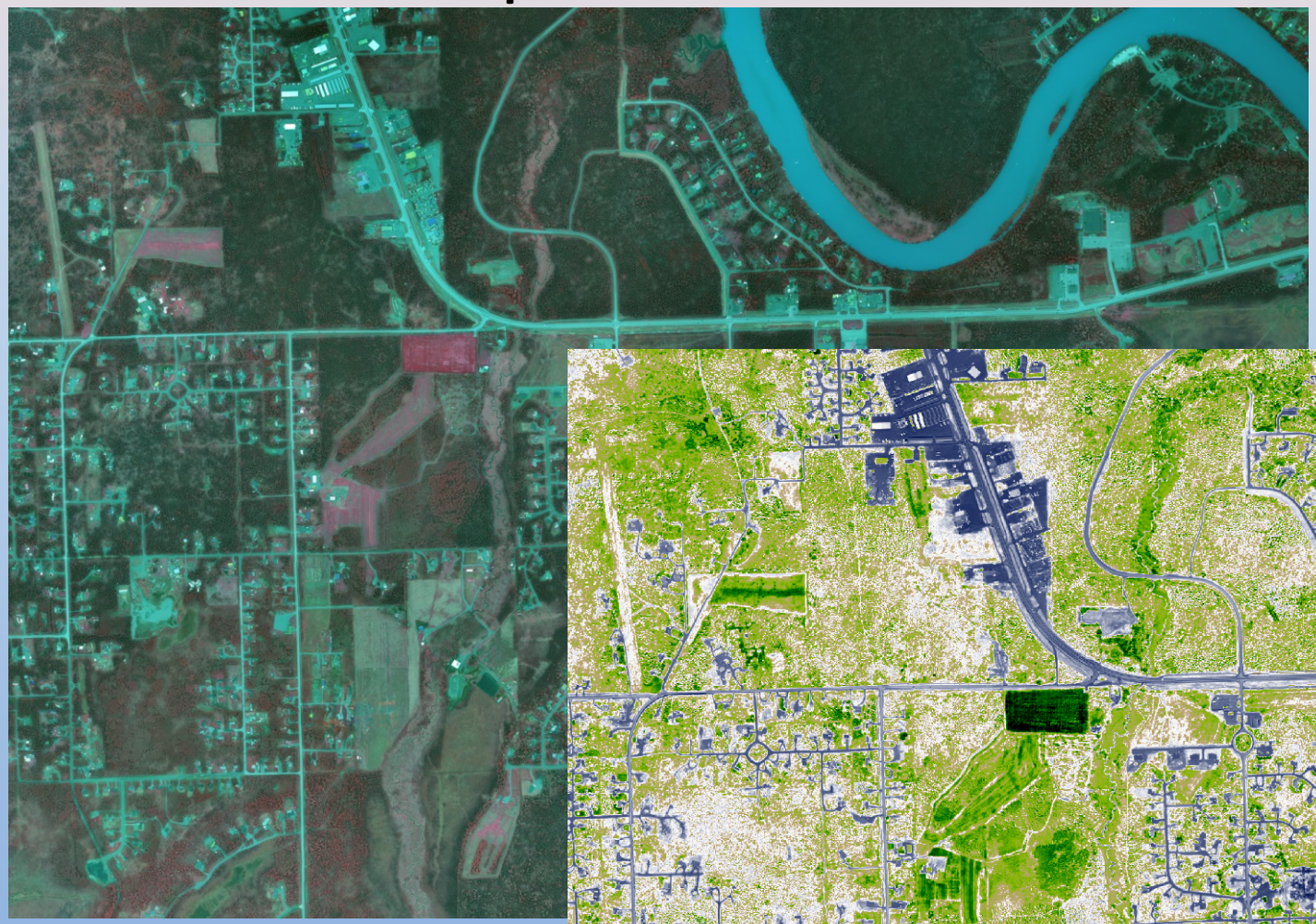
Very Dense and Accurate Point Clouds

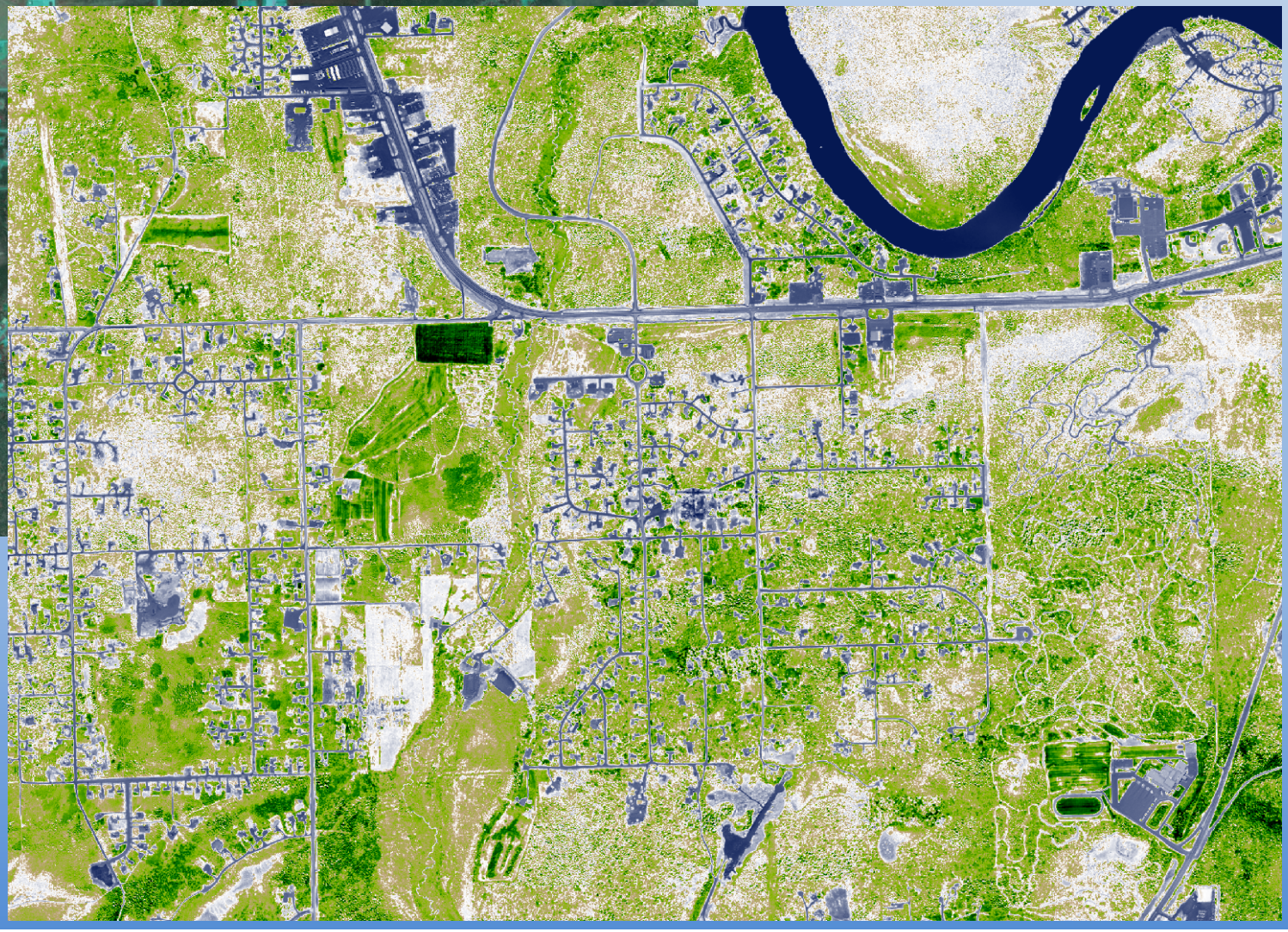
Density:

- About 15 million points per square kilometer (15cm) resolution
- Denser than LiDAR, each pixel is an overlap of 15 photos.

The accuracy is the same as the orthomosaic. Error is smaller than Ground Sample Distance with precise camera positions.

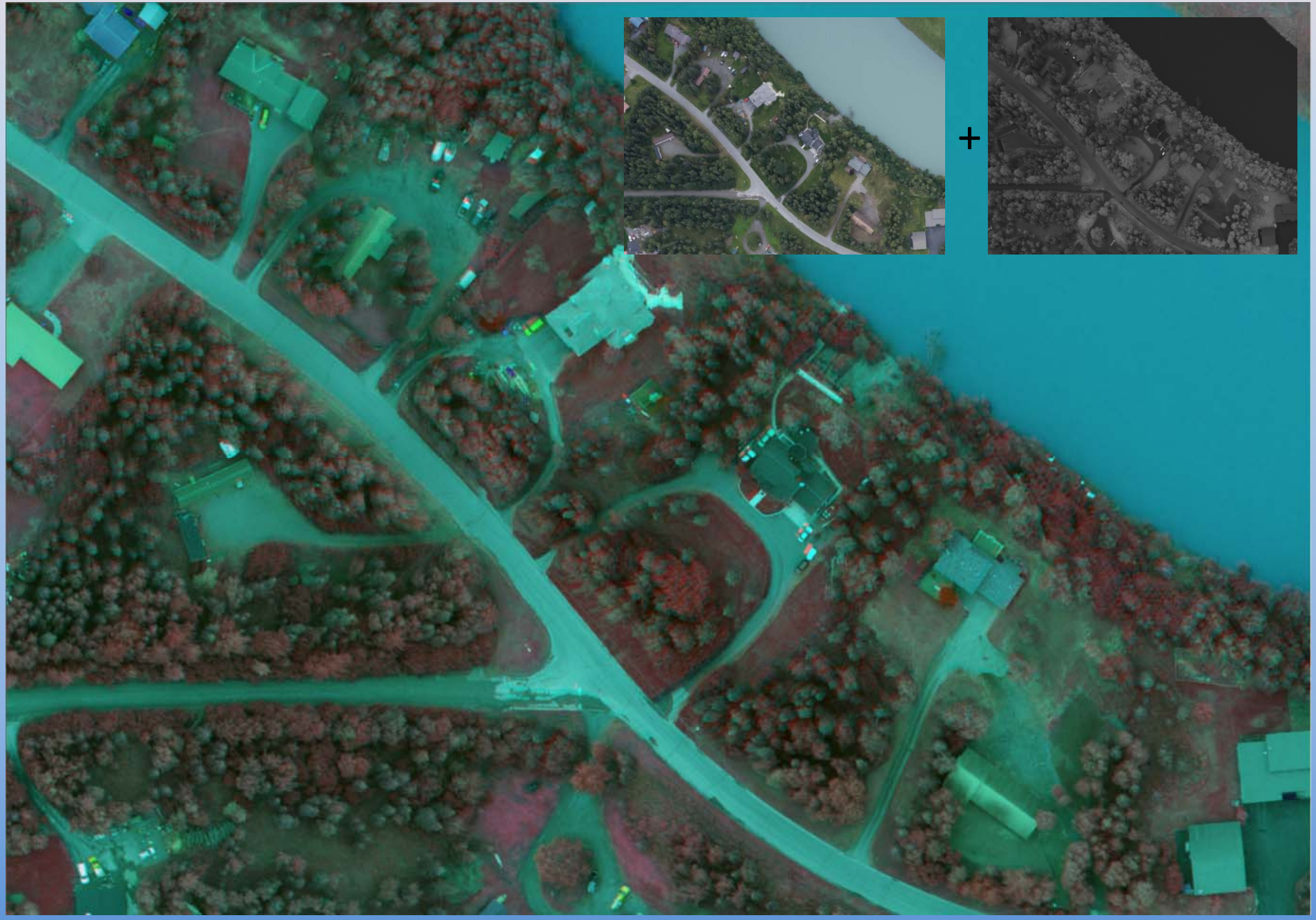
Multispectral Results – Relatively Good





The modified camera did an excellent job of capturing near infrared

Some Issues with Image Co-registration



Summary

- Cost Effective
  - $25,000 to $75,000 for equipment (not including plane)
  - 15 cm SFM orthomosaic and DSM: $20/Square Km
  - 30 cm SFM orthomosaic and DSM: $10/Square Km
  - 80 cm SFM orthomosaic and DSM: $5/Square Km
- Relatively Simple
- Does not work on moving objects
- Orthomosaic, Point Cloud and DSM exceeded expectations
- Multispectral needs improvement, but still hopefull

Acknowledgments

- Bureau of Land Management: Seth Kiester (Cadastral Survey Group) and Tommy Noble.
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