IMPLEMENTATION OF GNSS TECHNOLOGIES IN DRONE SURVEYING

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S&F Land Services

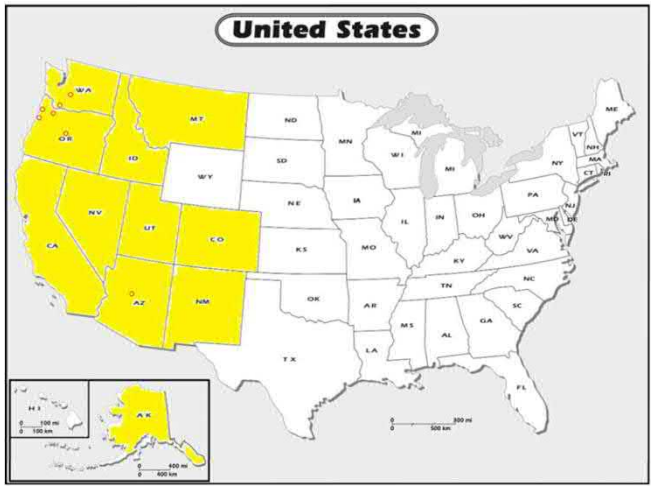
- Advanced Mapping Specialist- S&F Land Services
- Masters Certification in Remote Sensing and Earth Observations (Penn State)
- BS in Forestry, Concentration in GIS and Remote Sensing (University of Vermont)
- AAS in Geomatics (Clark College)
- Land Surveying Intern (Oregon)
- NSPS Certified Survey Technician
- FAA Part 107 Certified

COMPANY OVERVIEW

S&F Land Services

- Survey and Remote Sensing firm
- In business since 2016
- 6 office locations in OR, WA and AZ
- 9 field crews
- 43 total staff
- PLS in OR, WA, CA, ID, MT, NV, UT, CO, AZ, NM and AK

- 60% public sector and utilities
- 40% private development



PRESENTATION OBJECTIVE

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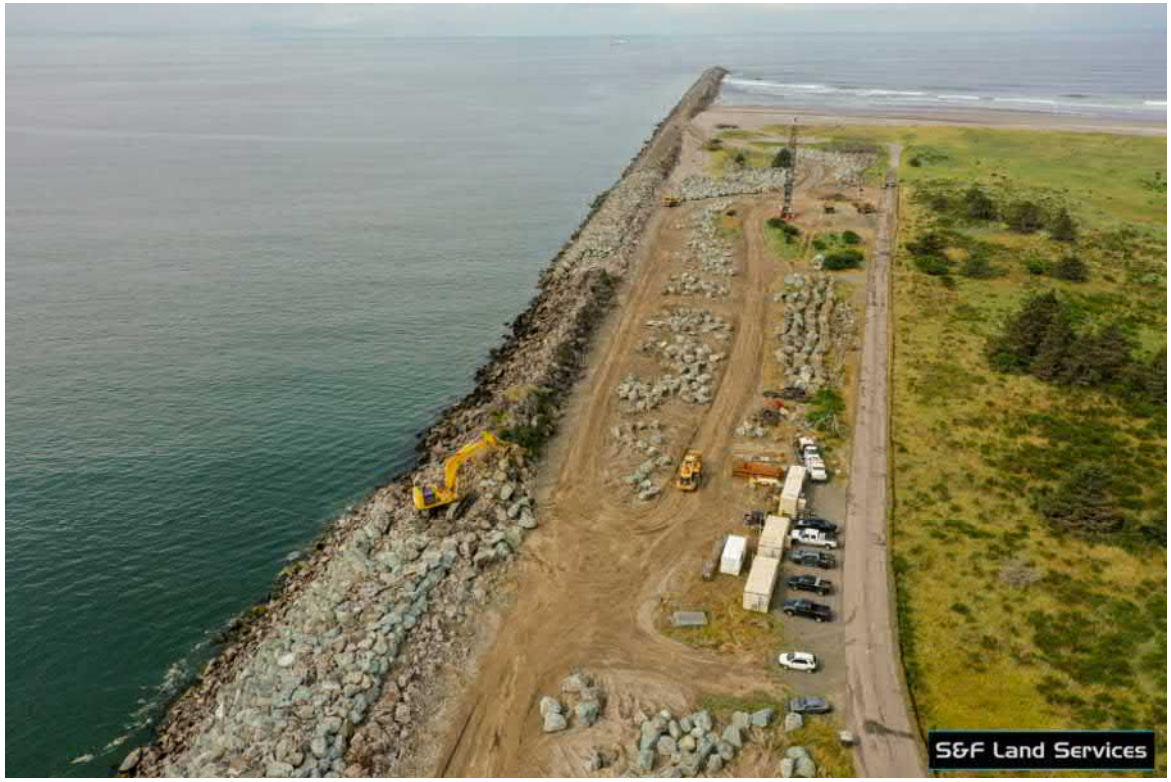
1. Commercial drone operations
2. Basic understanding of photogrammetry process and deliverables
3. Basic understanding of lidar process and deliverables
4. Role of GNSS in both workflows



ANOTHER TOOL IN THE TOOLBOX

S&F Land Services

GPS / RTK

Conventional (Robotic)

Data Collection GIS / Automation

Automatic Level

Terrestrial LiDAR

UAV/Drone

DJI M300RTK

S&F Land Services

- M300RTK
  - 55min flight (without payload)
  - Smart batteries (hot swappable)
  - 15km transmission range
  - Up to 3 payloads at a time
  - 6 directional sensing and positioning
  - Support for GPS, GLONASS, Beidou and Galileo satellite positioning systems
  - Dual RTK antennas
  - ADS-B receiver

DJI P1 & L1

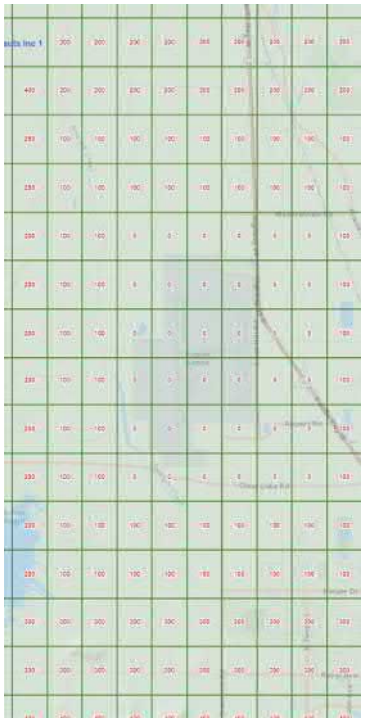
S&F Land Services

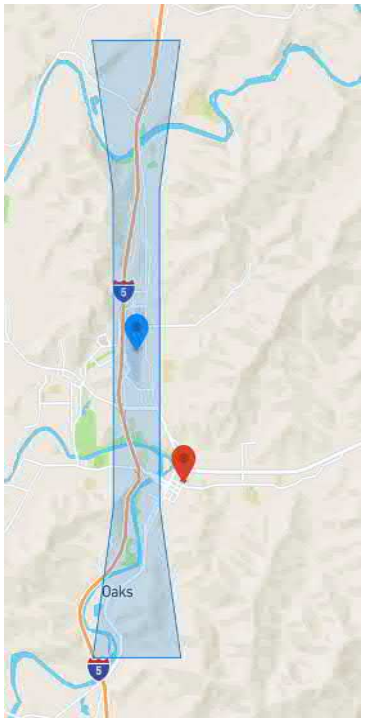
- P1
  - Lightweight
  - 45MP full frame sensor
  - Mechanical shutter
  - Smart obliques
- L1
  - Lidar + 1” RGB on a gimbal
  - 240,000pts/s
  - Sub 5cm vert accuracy from 60m AGL

COMMERCIAL OPERATIONS

S&F Land Services

- FAA Part 107
  - Certification/Testing
  - Operating Rules
  - FAA UAS Facility Map- https://arcg.is/1af5L8
- State/Local Laws
  - ORS 672.028- Practice of photogrammetric mapping without registration prohibited
    - (1)A person may not practice photogrammetric mapping in this state unless the person is registered and has a valid certificate to practice land surveying, engineering or photogrammetric mapping issued under ORS 672.002 (Definitions for ORS 672.002 to 672.325) to 672.325 (Civil penalties).
  - ORS 672.002- Definitions for ORS 672.002 to 672.325
    - (7)"Photogrammetric mapping" means an evaluating and measuring of land that is limited to the determination of the topography, area, contours and location of planimetric features, by using photogrammetric methods or similar remote sensing technology, including but not limited to using existing ground control points incidental to the photogrammetric or remote sensing mapping process.
- Manufacturer's restrictions
  - DJI FlySafe Geo Zone Map- https://www.dji.com/flysafe/geo-map
- Insurance





DRONE MAPPING

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Photogrammetry

Lidar

PHOTOGRAMMETRY: WHAT IS AN ORTHO?

S&F Land Services

An orthomosaic is a photogrammetrically orthorectified image product mosaicked from an image collection, where the geometric distortion has been corrected and the imagery has been color balanced to produce a seamless mosaic dataset.

Raw Image

- Corrected:
  - Topographic relief
  - Lens distortion
  - Camera tilt
  - Color balance
- Uniform scale
- Needed:
  - Raw imagery
  - Digital Elevation Model
  - Control points

Orthomosaic

PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

1. Flight Planning
   - DJI
   - Autel
2. Data Acquisition (Survey and Aerial)
   - Trimble
3. Pre-Process Raw Imagery
   - Adobe Lightroom
4. Process Imagery
   - Pix4D
5. Post-Process Orthomosaic
   - QGIS
6. Extract Planimetric and Topographic Data
   - Virtual Surveyor
   - Carlson Point Cloud
   - Trimble Business Center
7. Draft Final Deliverable
   - Autodesk Civil 3D

PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

1. Flight Planning
   - DJI
   - Autel









PHOTOGRAMMETRY: FLIGHT PLANNING

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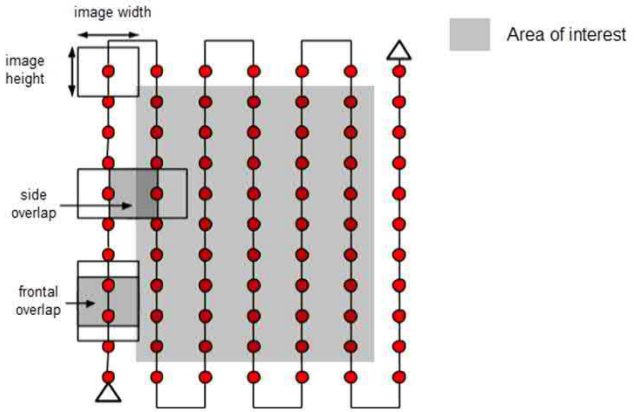
- Goal:
  - Ground Sample Distance (GSD)
  - Front/side overlap
- Known/Planned:
  - Altitude
  - Camera Parameters

H	|	height in meters
ImW	|	image width in pixels
GSD	|	ground sampling distance in centimeters/pixels
F	|	focal length in millimeters
SW	|	sensor width in millimeters



PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

2. Data Acquisition (Survey and Aerial)
   - Trimble





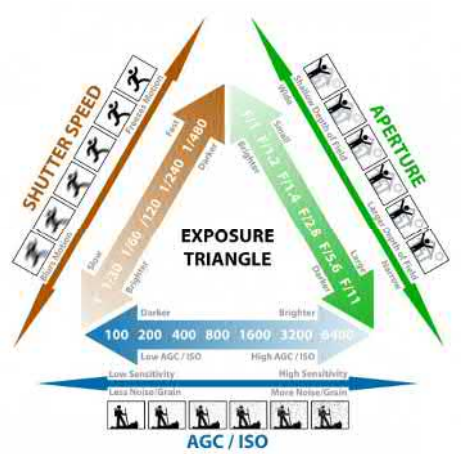


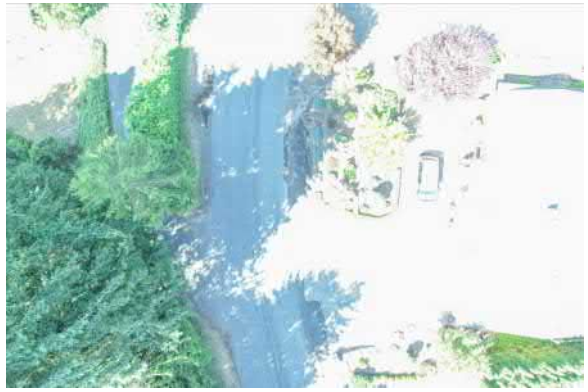


PHOTOGRAMMETRY: DATA ACQUISITION

S&F Land Services

- Photography Basics
  - Passive sensor
    - Ambient light
    - Minimize shadows
  - Exposure Triangle
    - Shutter speed
    - Aperture
    - ISO

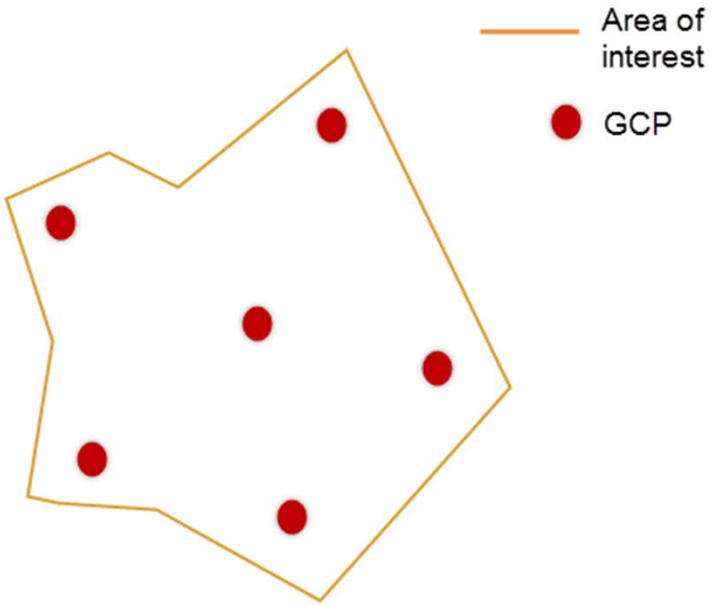


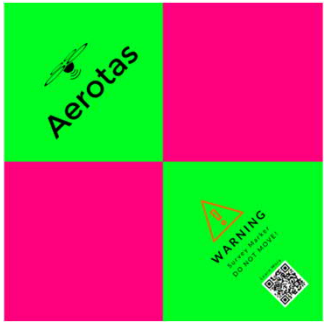


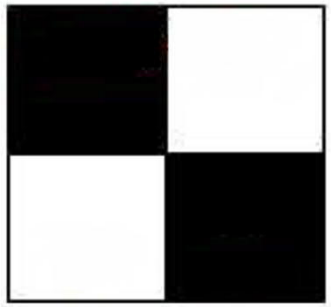
PHOTOGRAMMETRY: DATA ACQUISITION

S&F Land Services

- Ground Control Points







PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

3. Pre-Process Raw Imagery
   - Adobe Lightroom

PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

4. Process Imagery
   - Pix4D



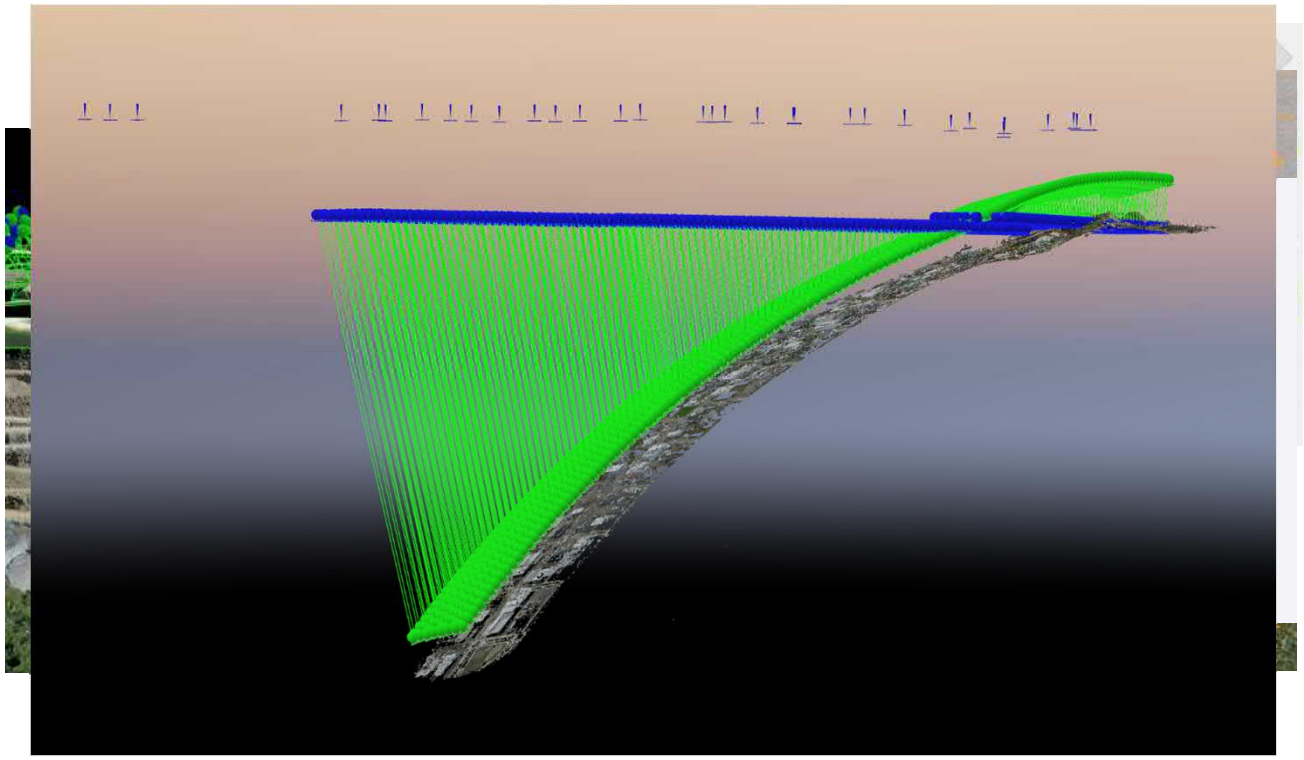





PHOTOGRAMMETRY: PROCESS IMAGERY

S&F Land Services

1. Initial Processing
   - Keypoints extraction
   - Keypoints matching
   - Camera model optimization
     - Internal Orientation
     - External Orientation
   - Geolocation (space)
2. Point cloud and mesh
   - Point densification
   - 3D textured mesh
3. DSM & Orthomosaic
   - Digital Surface Model (DSM)
   - Orthomosaic



PHOTOGRAMMETRY: WORKFLOW

S&F Land Services

5. Post-Process Orthomosaic
   - QGIS

PHOTOGRAMMETRY: POST-PROCESS ORTHO

S&F Land Services

- Clipping to Area of Interest (AOI)
  - Clean finished product
- Compressing geotiff
  - 70% reduction in file size

PHOTOGRAMMETRY: WORKFLOW

S&F Land Services





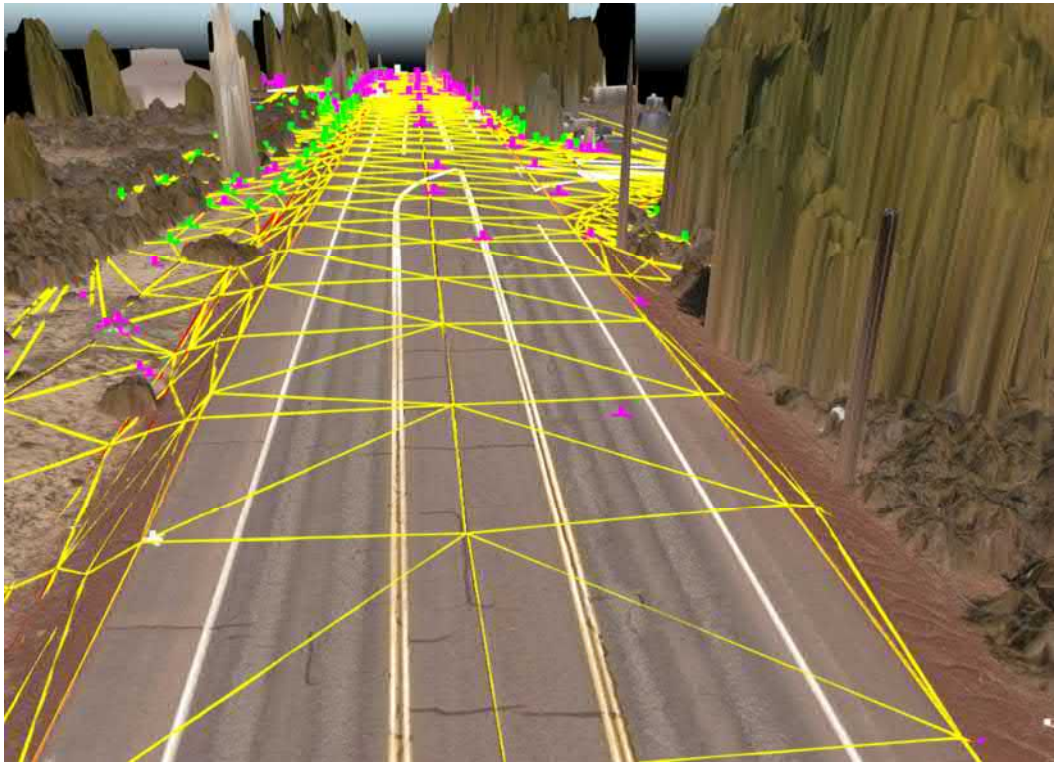

6. Extract Planimetric and Topographic Data
   - Virtual Surveyor
   - Carlson Point Cloud
   - Trimble Business Center



PHOTOGRAMMETRY: EXTRACT DATA

S&F Land Services

- Points
  - .csv in PNEZD
- Lines/Breaklines
  - .dxf on correct layers
- Surfaces
  - .xml



PHOTOGRAMMETRY: WORKFLOW

S&F Land Services





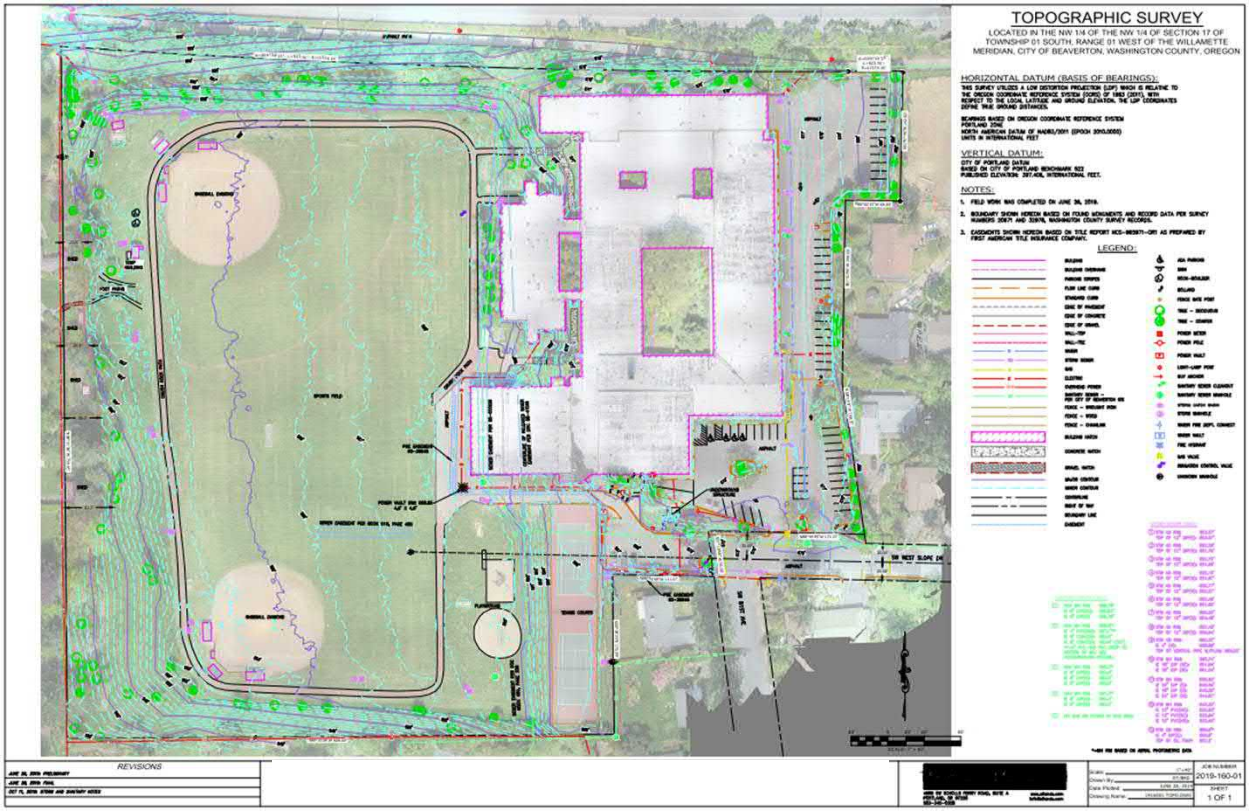




7. Draft Final Deliverable
   - Autodesk Civil 3D

PHOTOGRAMMETRY: FINAL DELIVERABLE

S&F Land Services



LIDAR: WORKFLOW

S&F Land Services

1. Flight Planning
   - DJI
2. Data Acquisition (Survey and Aerial)
   - Trimble
3. Process Raw Data
   - DJI Terra
4. Process Point Cloud
   - Terrasolid
5. Extract Planimetric and Topographic Data
   - Virtual Surveyor
   - Carlson Point Cloud
   - Trimble Business Center
6. Draft Final Deliverable
   - Autodesk Civil 3D

LIDAR:
WORKFLOW

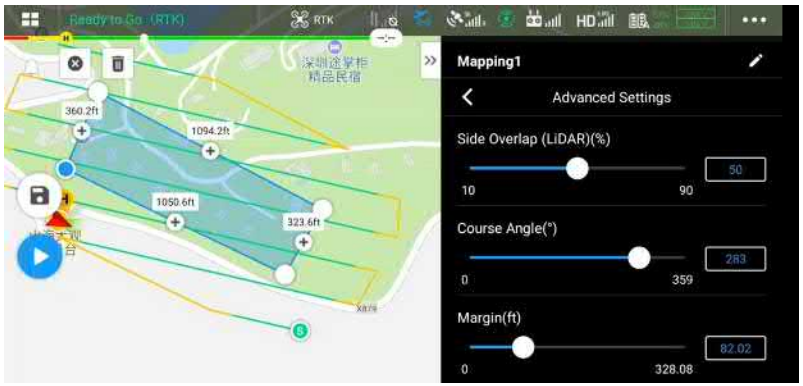
S&F Land Services

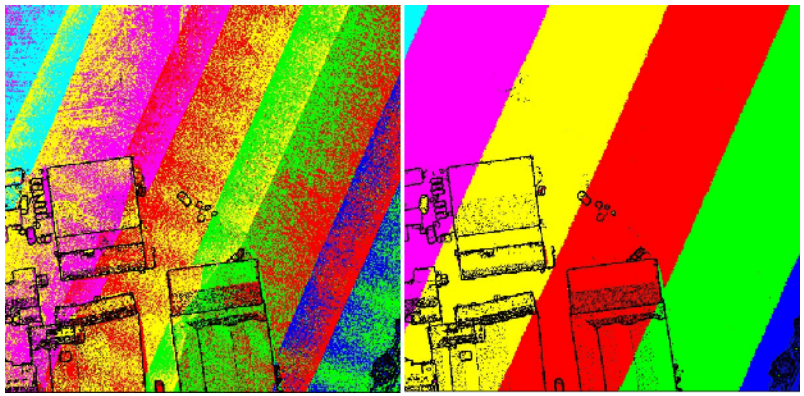
1. Flight Planning
   - DJI

LIDAR:
FLIGHT PLANNING

S&F Land Services

- Goal:
  - Point Density
  - Side overlap
- Known/Planned:
  - Altitude
  - Sensor Parameters





LIDAR:
WORKFLOW

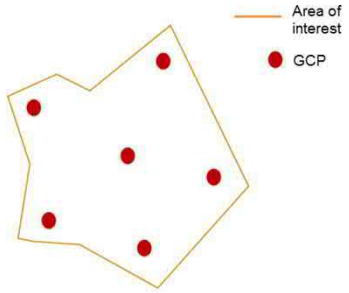
S&F Land Services

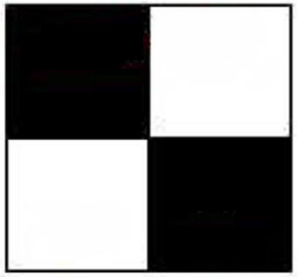
2. Data Acquisition (Survey and Aerial)
   - Trimble

LIDAR:
DATA ACQUISITION

S&F Land Services

- Ground Control Points
- GNSS base data (PPK)
- ORGN (RTK)





LIDAR:
WORKFLOW

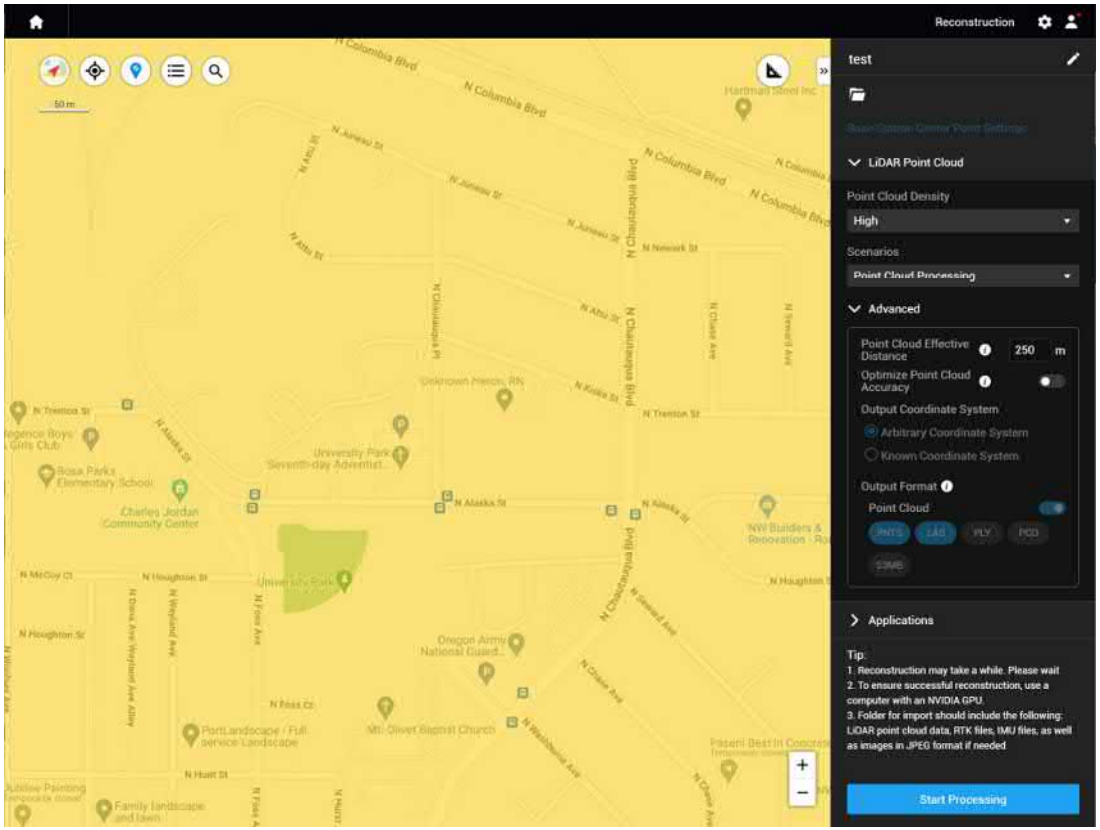
S&F Land Services

3. Process Raw Data
   - DJI Terra

LIDAR:
PROCESS RAW DATA

S&F Land Services

- Proprietary software
  - DJI Terra
- Input:
  - Raw lidar data
  - Raw imagery
  - GNSS data
  - IMU data
- Output:
  - Colorized .las file
  - **Smoothed Best Estimate of Trajectory (SBET)**



LIDAR:
WORKFLOW

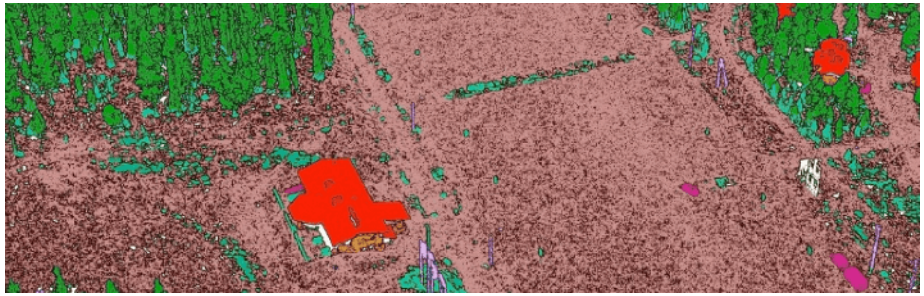
S&F Land Services

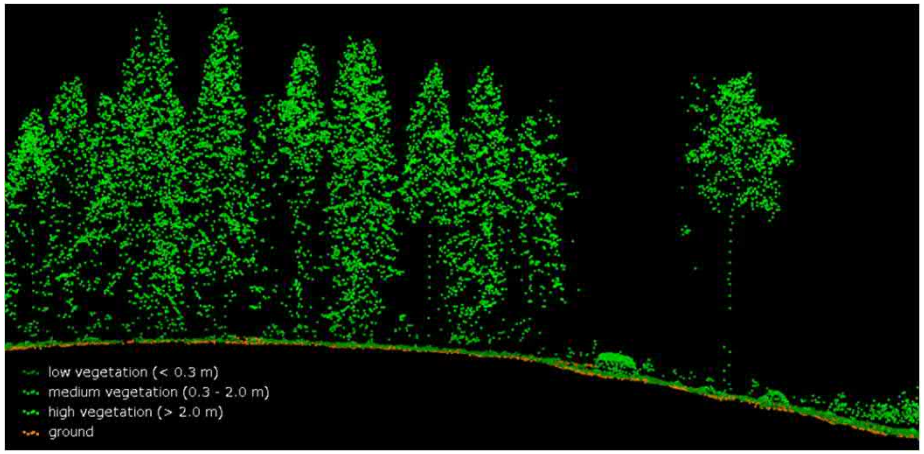
4. Process Point Cloud
   - Terrasolid

LIDAR:
PROCESS POINT CLOUD

S&F Land Services

- Cleanup
  - **High/low**
- **Classification**
  - **Auto/manual**
  - **Number of returns**
- **Output:**
  - **Classified point cloud**
  - **Digital Terrain Model (DTM)**





LIDAR:
WORKFLOW

S&F Land Services

5. Extract Planimetric and Topographic Data
   - Virtual Surveyor
   - Carlson Point Cloud
   - Trimble Business Center
6. Draft Final Deliverable
   - Autodesk Civil 3D

ACCURACY ASSESSMENT

S&F Land Services

- American Society for Photogrammetry and Remote Sensing
  - ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014)
- Is UAV as accurate as traditional field survey? Depends…
  - Final error = Control error + Imagery/resolution error + Mapping error
    - Field survey procedures
    - GCP quality in imagery
    - Camera specs and settings
    - Data extraction techniques
  - Checkpoints/Confidence shots
  - Level of Accuracy
    - Discuss the balance of accuracy and cost with clients

THANK YOU

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