Aerial Mapping & Modeling using UAV

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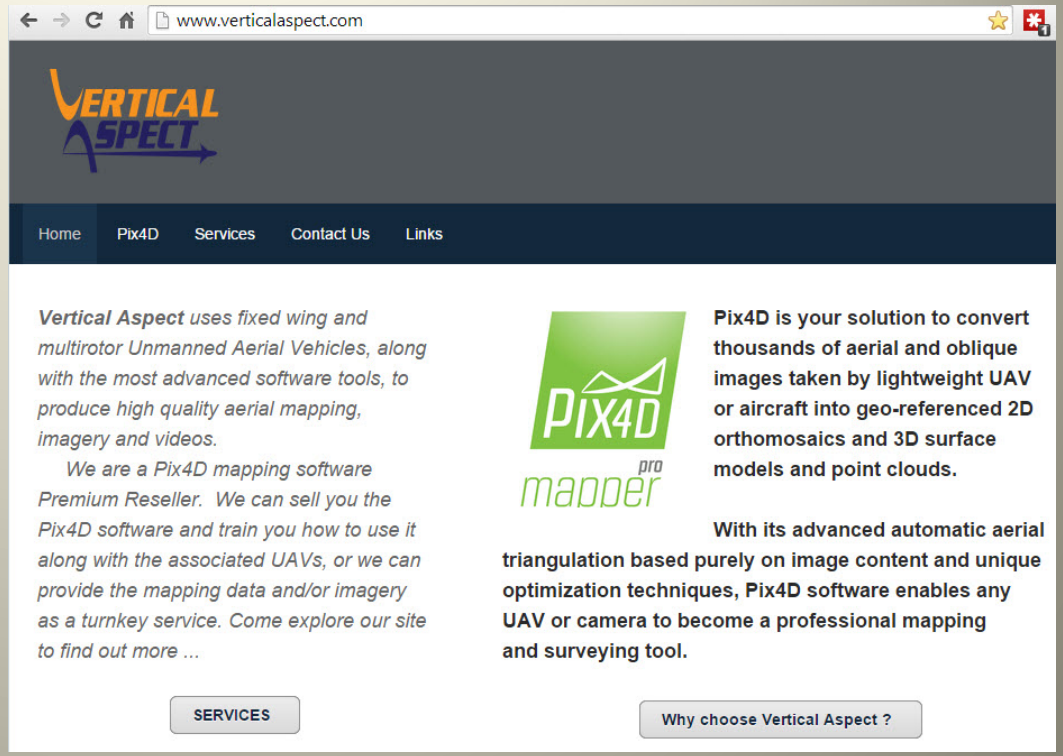
Vertical Aspect

- Services
  - Aerial mapping
  - Aerial Imagery
- Pix4D Software
  - Premium Reseller
  - Training
- UAV Training



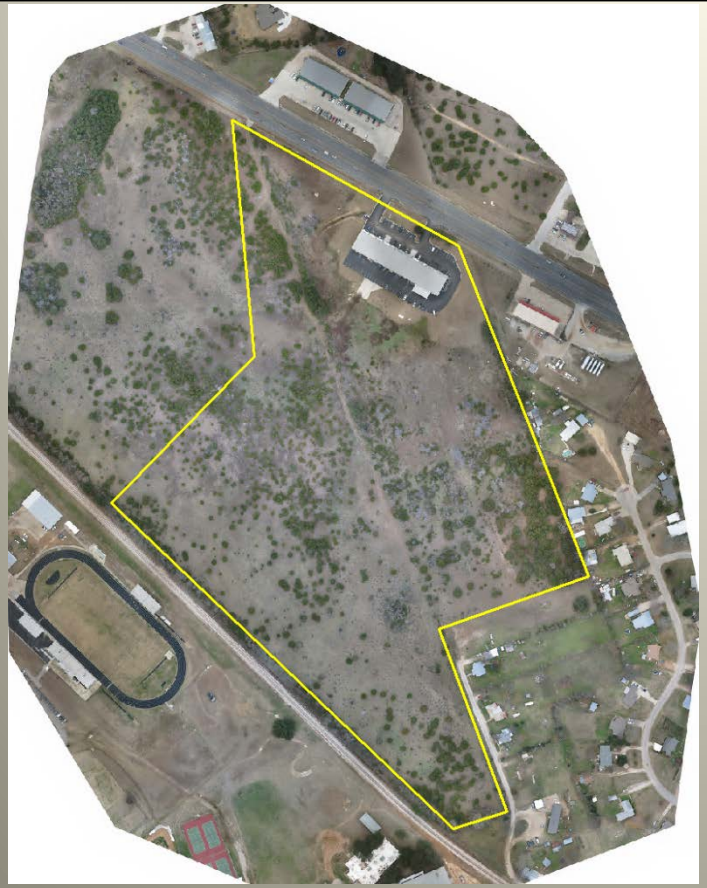
Mapping Theory / Techniques / Products

Graphical Map

BENEFITS:

- Good for navigation
- Inexpensive to produce
- Easy to interpret
- Non-technical
- No underlying data
- Not to scale / no accurate measurements

Orthomosaic Map



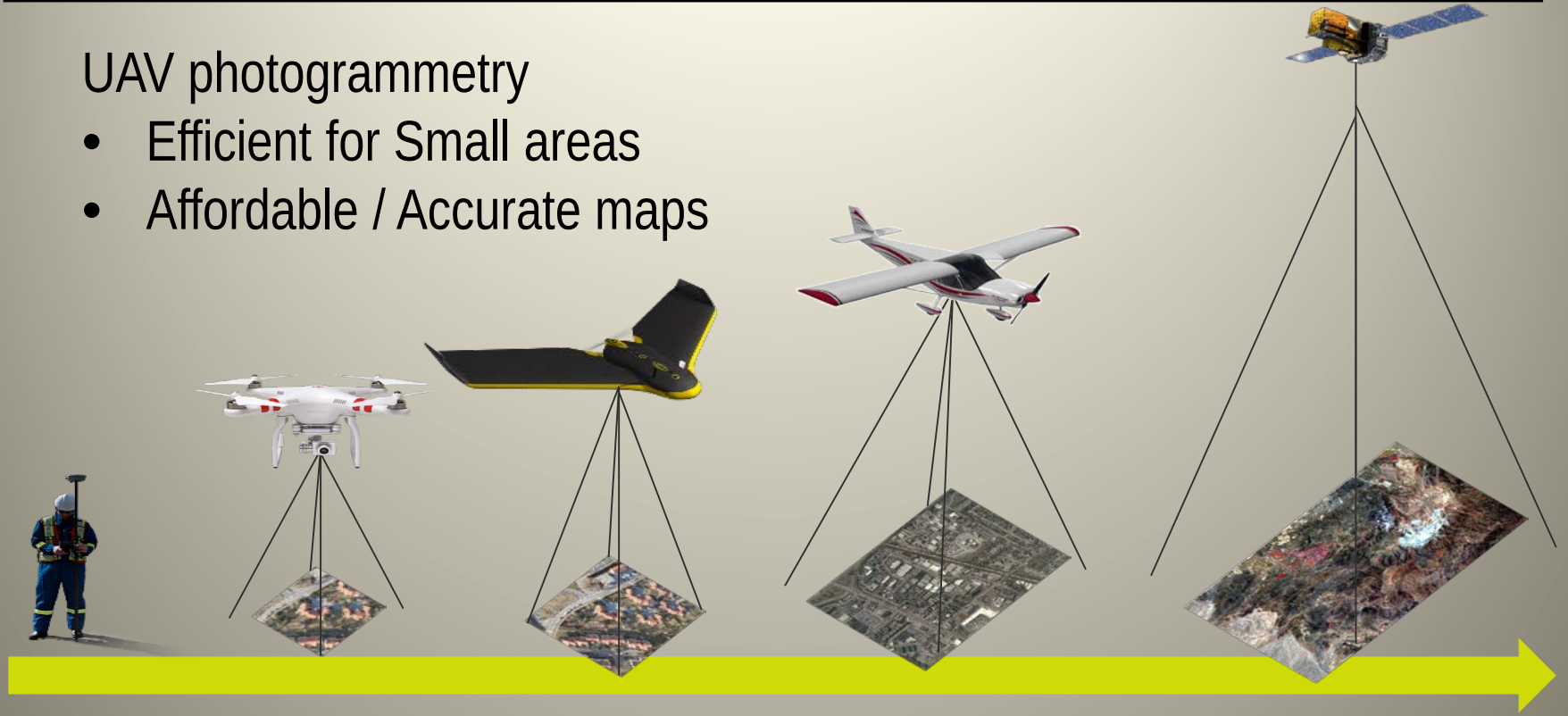
BENEFITS:

- Referenced to real world location
- Enables accurate measurements
- Rectified to 3D information
- Graphical representation of underlying data
- Underlying data easily exported / converted

Changing the mapping game

UAV photogrammetry

- Efficient for Small areas
- Affordable / Accurate maps

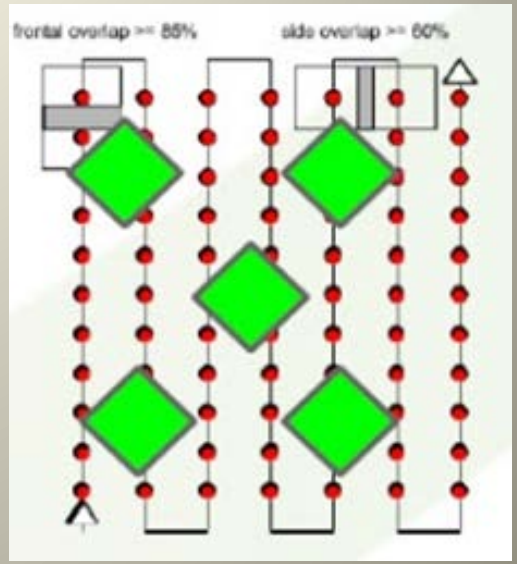


Survey efficiency with respect to Survey area

Ground Control Points (GCP)

Ground Control Points (GCP)

- Well distributed in dataset
- Visible on multiple images
- 5-8 sufficient for up to 1000 images
- Quality report shows reprojection error



Obtaining GCPs

- Traditional Survey Methods
- RTK GPS device
- Less accurate
  - Google Earth
  - Smartphone App
  - Handheld GPS device

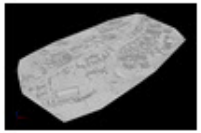
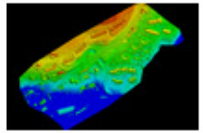
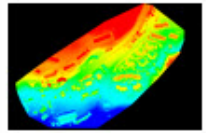
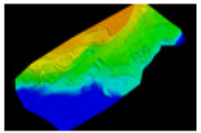
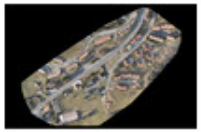
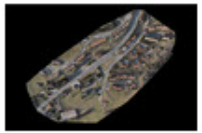
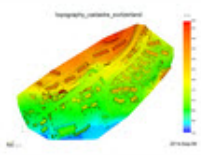
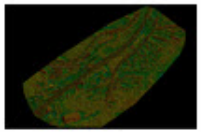
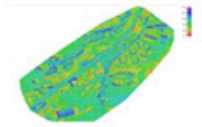
Without GCP

With GCP

Mapping Output & Potential Market

- Output
  - Orthomosaic
  - 3D Point Cloud
  - Topographic
  - Digital Surface Model
- Potential Customers

Output types

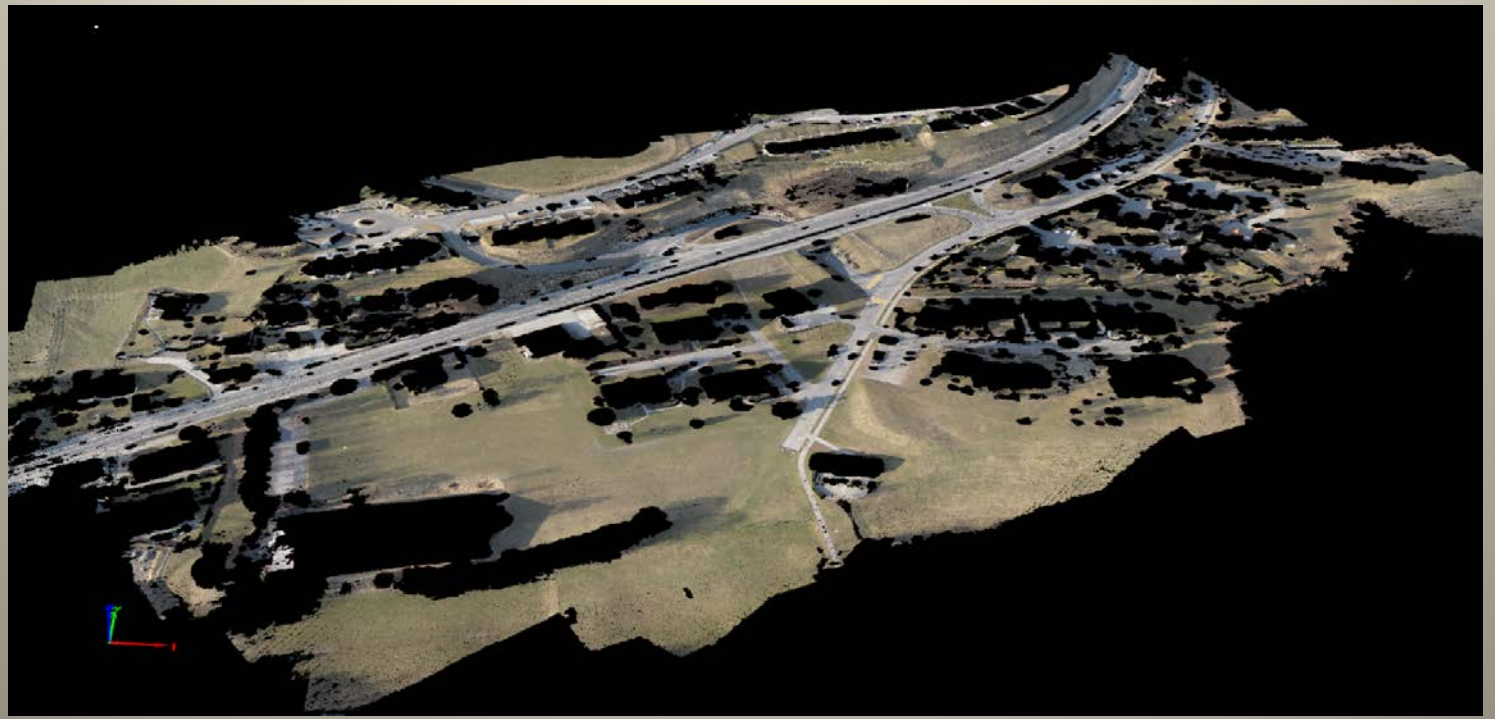
							
Densified Point Cloud	Triangle Mesh	3D Triangulated Mesh	3D Triangulated Point Cloud	Classified Point Cloud - Terrain	Classified Point Cloud - Objects	Raster DSM	Grid DSM
							
DTM	Orthomosaic	Triangle Model	Contour Lines	Contour Lines - DTM	3D PDF - ATT and Cameras	3D PDF - DSM	3D PDF - Orthomosaic
							
Reflectance Map	Index Grid	Colored Index Map	Google Maps Tiles	KML	Mapbox		

3D Models

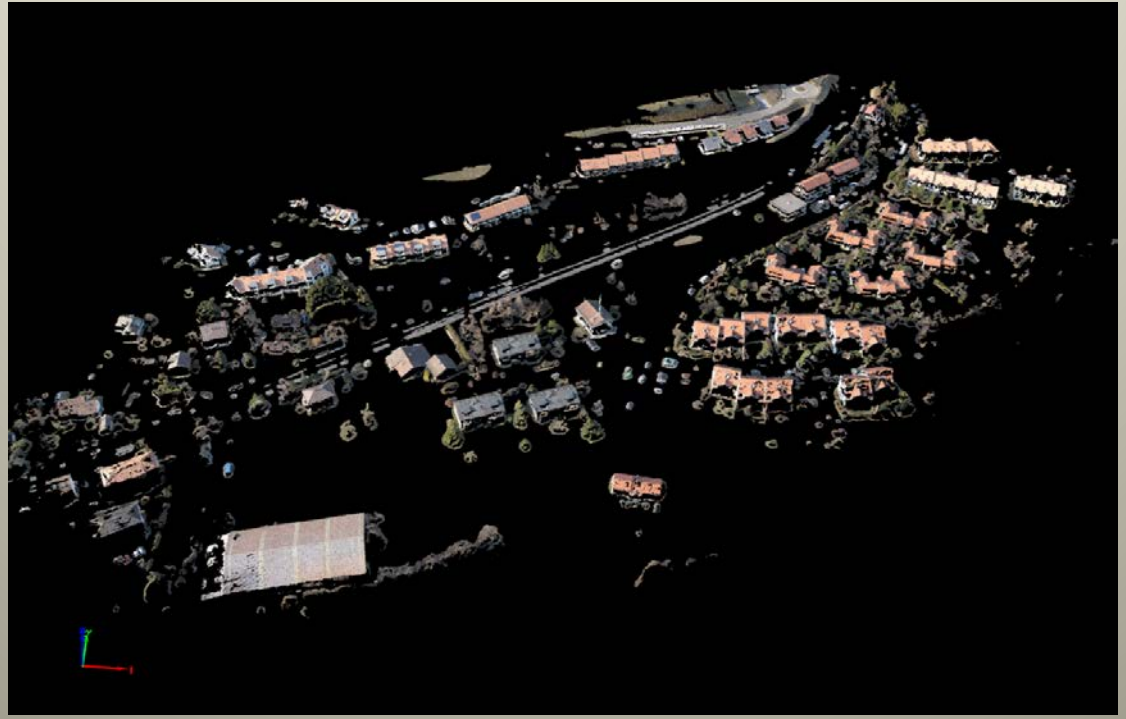
- Digital Surface Model
  - Everything
- Digital Terrain Model
  - “Bare Earth”
  - Used by engineers
- Oblique Models

Unclassified 3D Point Cloud

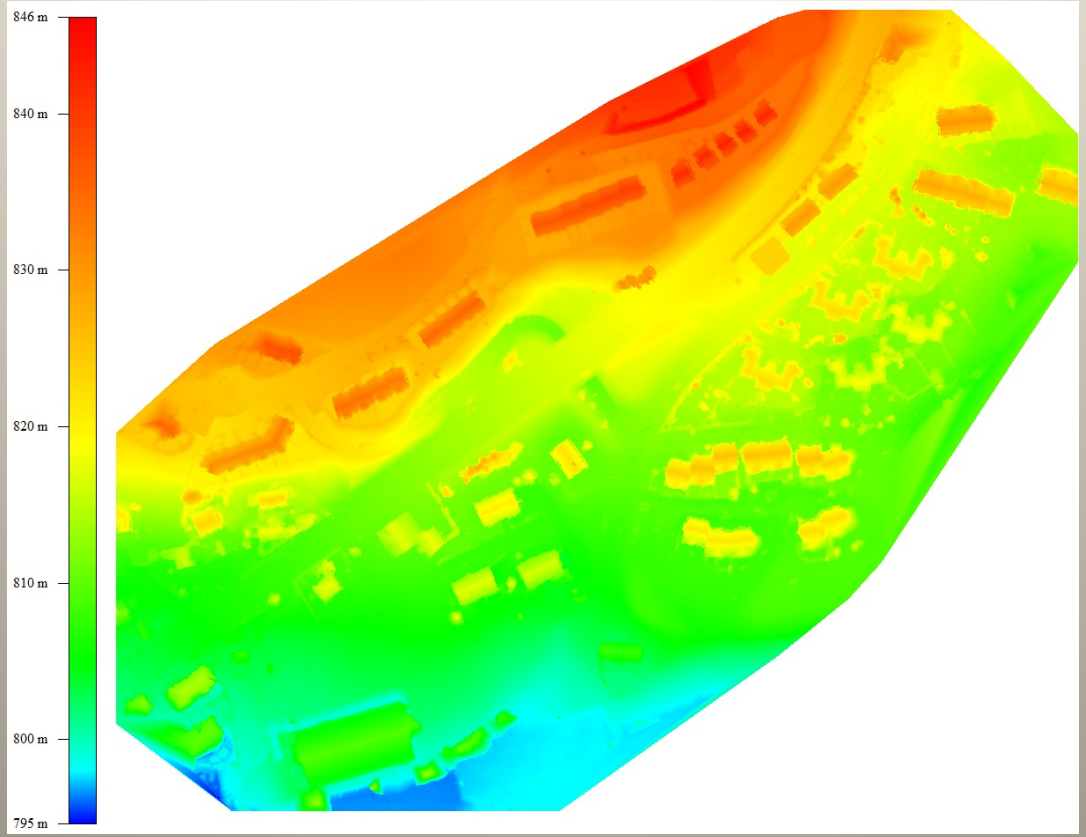
Classified Point Cloud-Terrain



Classified Point Cloud - Objects



Digital Surface Model (with scale)



Contour Lines

Contour Lines – (terrain only)

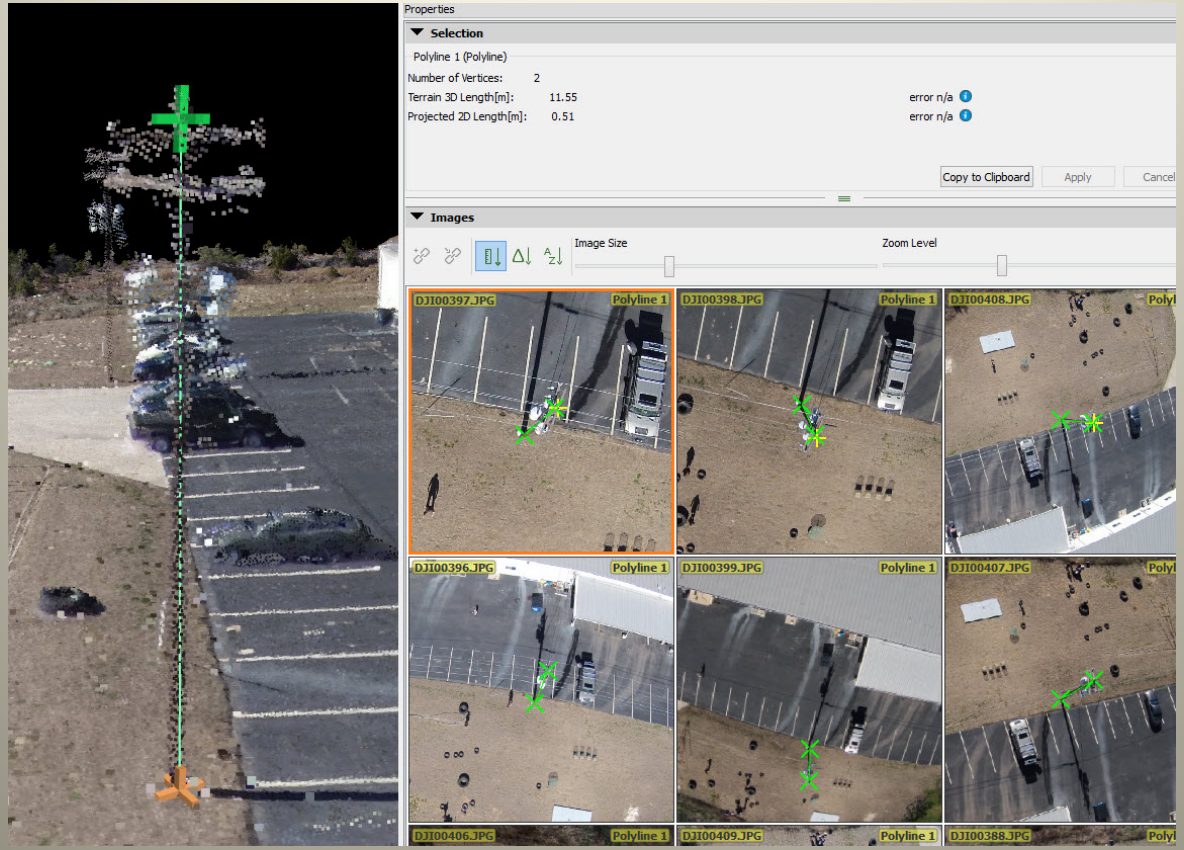
Planar vs. Orthomosaic

(Photo Stitching) *(Orthorectification)*

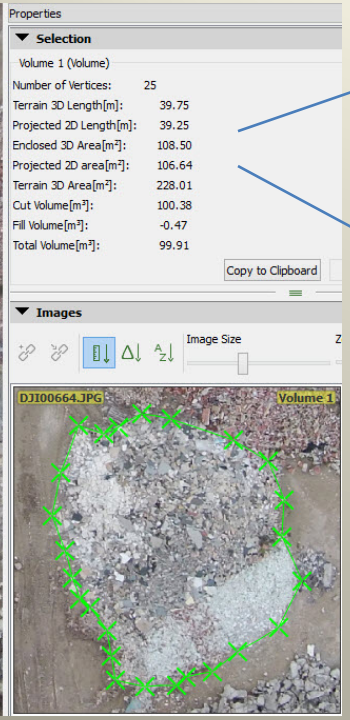
- Works only if terrain perfectly flat
- Only small datasets supported (due to error accumulation)
- No good georeference without GCP
- Distances (measurements) not accurate
- Requires only low number of matches / keypoints (>100)

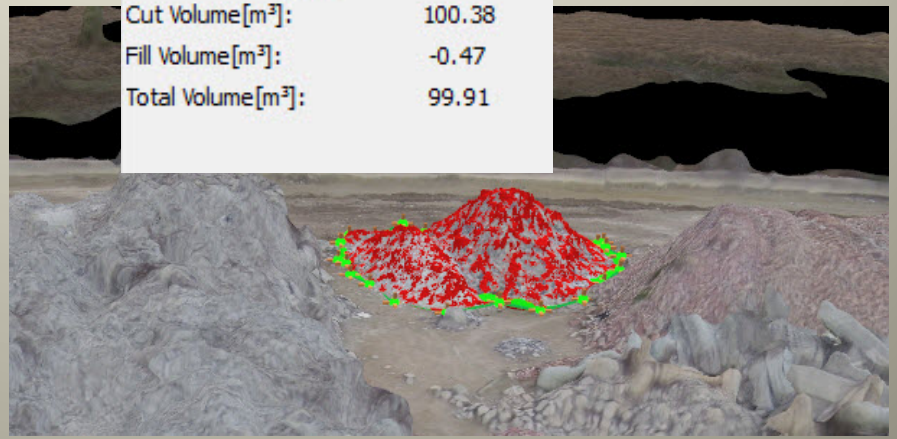
- Handles any terrain type
- Handles large datasets
- Supports Georeference perfectly
- Preserves distances & becomes measurable
- Requires high number of matches/keypoints (>1000) to generate the 3D model

Accurate Measurements



Stockpile Volume Calculations





UAV Image Capture

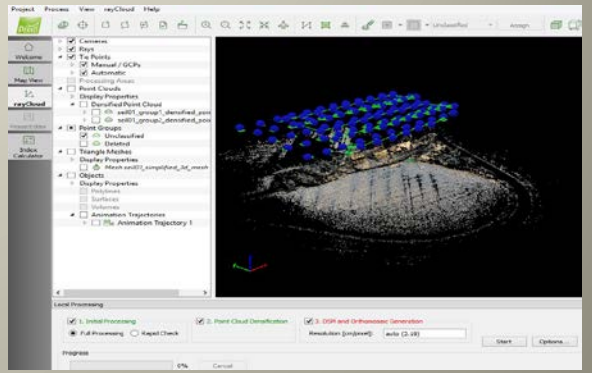
Fixed Wing & Multirotor

Workflow

Plan & Load the mission

Fly – Capture images

Process, Provide Output



Fixed Wing vs. Multirotor

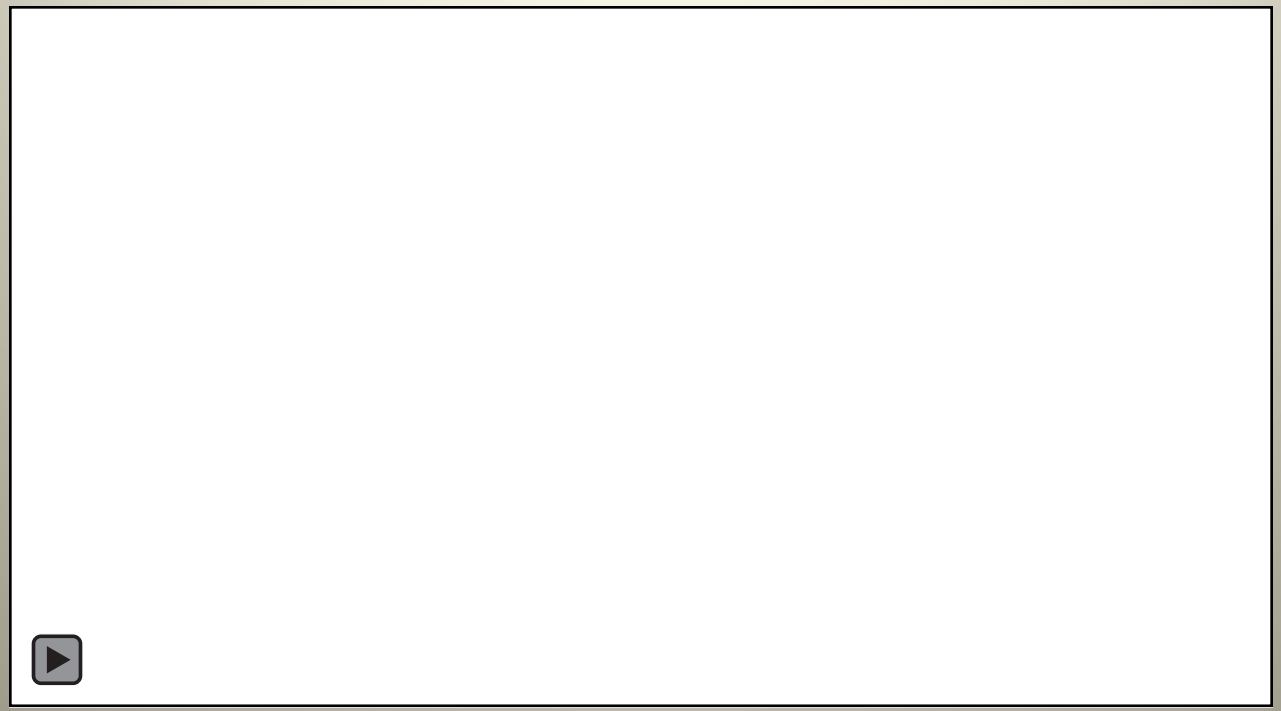
Fixed Wing

1. Larger area
2. Larger takeoff / landing area
3. Higher Altitudes / less detail
4. Longer Flight Time
5. More expensive

Multirotor

1. Smaller area
2. VTOL – much smaller takeoff / landing area
3. Lower altitudes / greater detail
4. Shorter Flight Times
5. Lower cost of entry

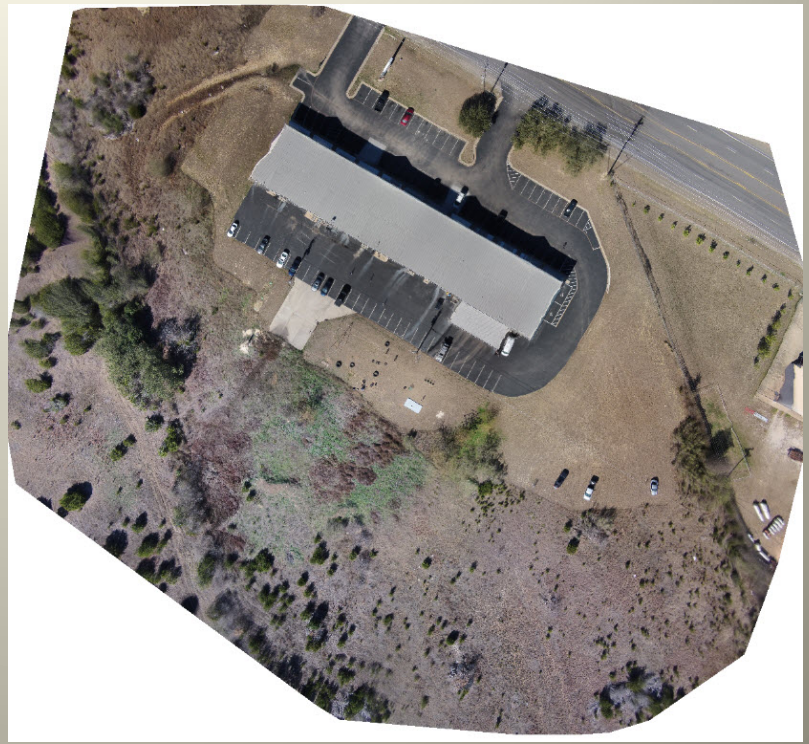
3D Flythrough Video



(Press "Play" Key to View Video) or view at https://www.youtube.com/watch?v=oDEIT1xvWyw

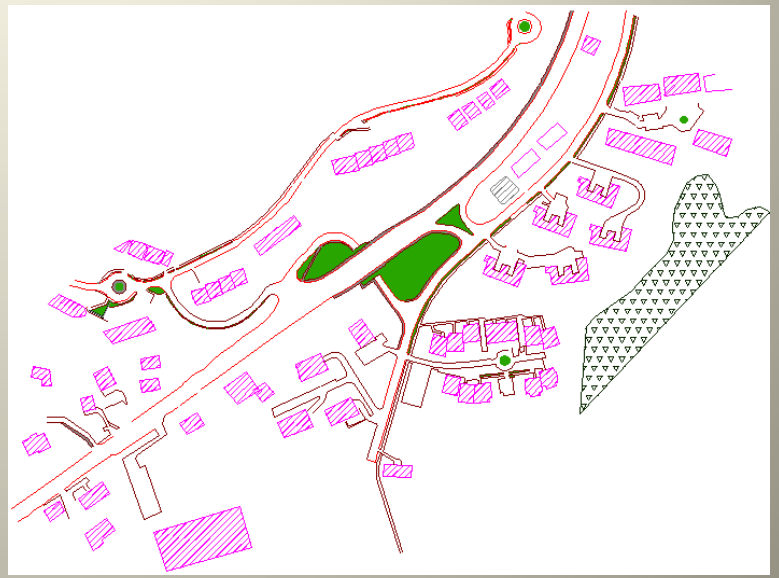
Fixed Wing vs. Multirotor

Larger Area, less resolution



Smaller Area, higher resolution

Digitized Orthomosaic



Generated Files

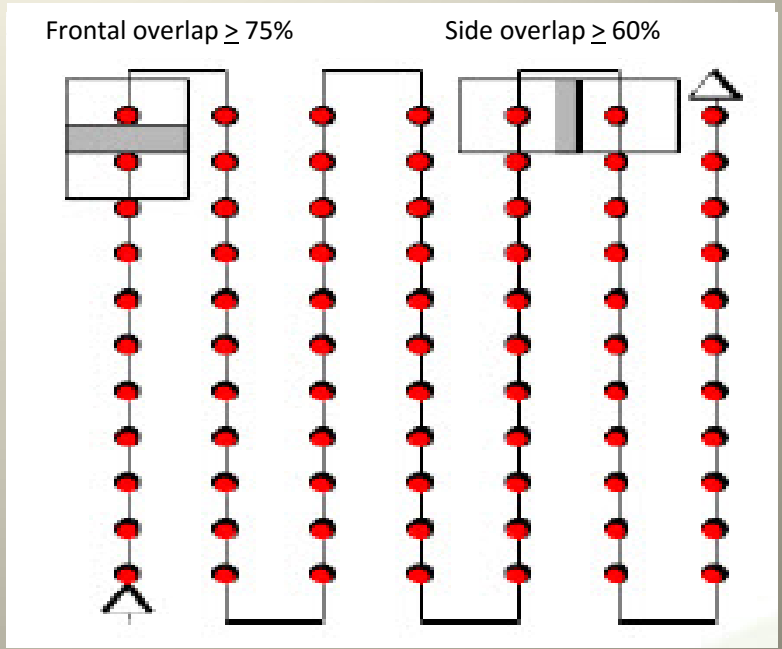
Pix4uav outputs	Format	Possible use	Examples of compatible software
Raster orthomosaic	geoTIFF (.tiff) KML tiles (.png/.kml)	Area overview Digitize buildings Annotate areas Overlay in GIS package Analyze spectral bands	ArcGIS Global Mapper QuantumGIS AutoCAD Google Earth
Undistorted images	TIFF (.tiff)	Stereo Viewing	LPS
Individual ortho/planar	geoTIFF (.tiff)	Seamline editing	OrthoVista
3D point cloud	.las, .ply, .ascii	Visualization Surface Editing DSM generation DTM generation	ArcGIS Global Mapper AutoCAD Quick Terrain Reader 3D Reshaper Trimble RealWorks Viewer
Raster digital surface model (DSM)	geoTIFF (.tiff)	Analyze surface Measure volumes Generate contour lines Draw breaklines	ArcGIS Global Mapper QuantumGIS Quick Terrain Reader
3D mesh with texture	Wavefront (.obj)	Render in animation package Visualize small projects	AutoCAD Bentley Pointools View CC Viewer 3D Reshaper

Methods of Capturing Images

- Fixed Wing
  - SenseFly eBee
  - eMotion flight planning / capture
- Multirotor
  - DJI Phantom Vision 2 +
  - Pix4D Capture App

Image Overlap

- High accuracy results
  - Requires high overlap between images
  - Consistent altitude
- Recommended Overlap
  - Frontal - ≥75%
    - *(with respect to flight direction)*
  - Side - ≥60%
    - *(between flight tracks)*



Camera Considerations

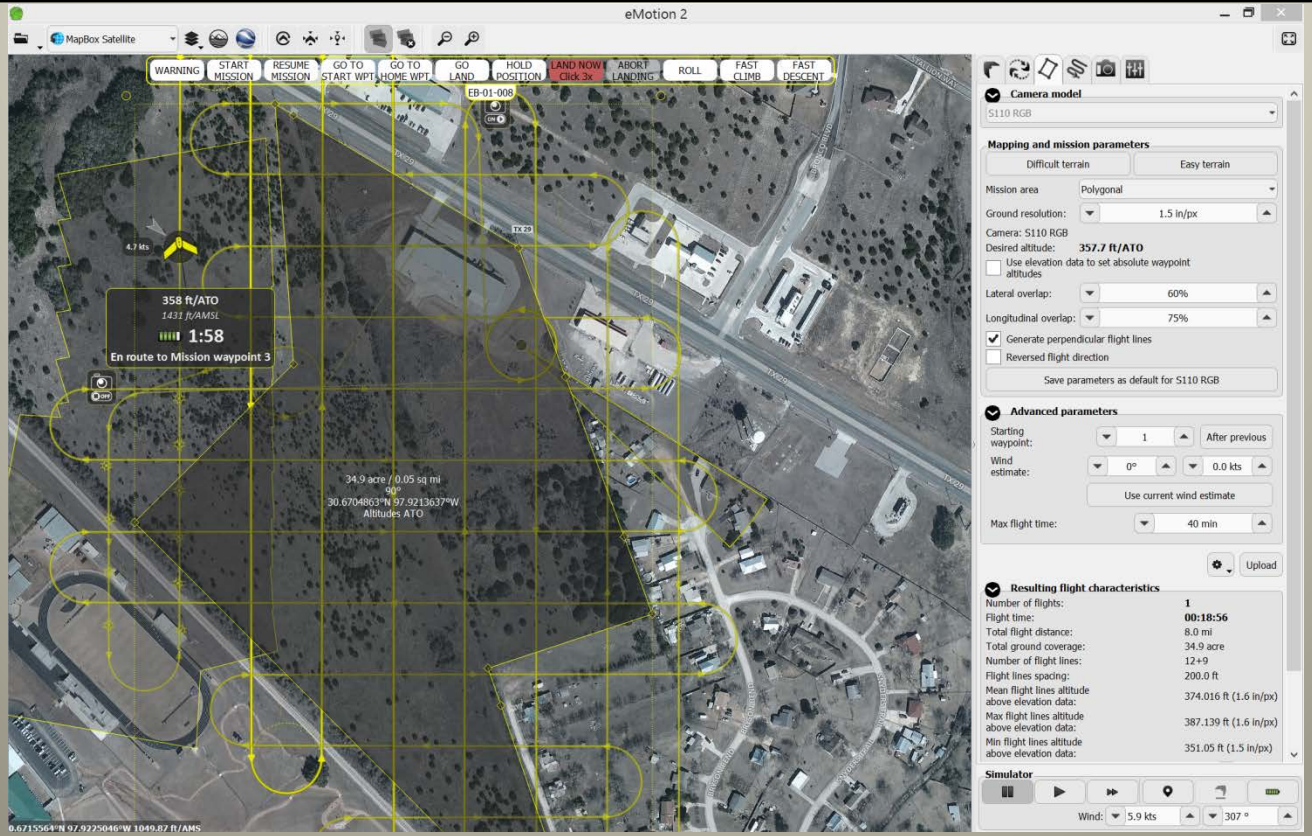
- Megapixel size less important than image overlap
- Sensor size determines area of coverage at given altitude
- Automated Flight Path necessary for reliability & accuracy

Safety Considerations

- Autonomous Flight Required for proper data collection
- DO's
  - Fly within Line of Sight
  - Remain below 400' AGL and outside of controlled airspace
  - Use spotter to handle people, have them keep their distance during takeoff and landing
  - Be prepared to take control of aircraft if autonomous flight fails
  - Give yourself a cushion on battery level
- BE PREPARED
  - For the possibility of the aircraft losing power
  - Fixed wing – more options & less weight than multirotor
- DO NOT
  - Fly linearly over major roads
    - Cross them at right angles
  - Allow people to distract you during flight
  - Fly over crowds of people

Sample Fixed Wing Capture (SenseFly eBee)

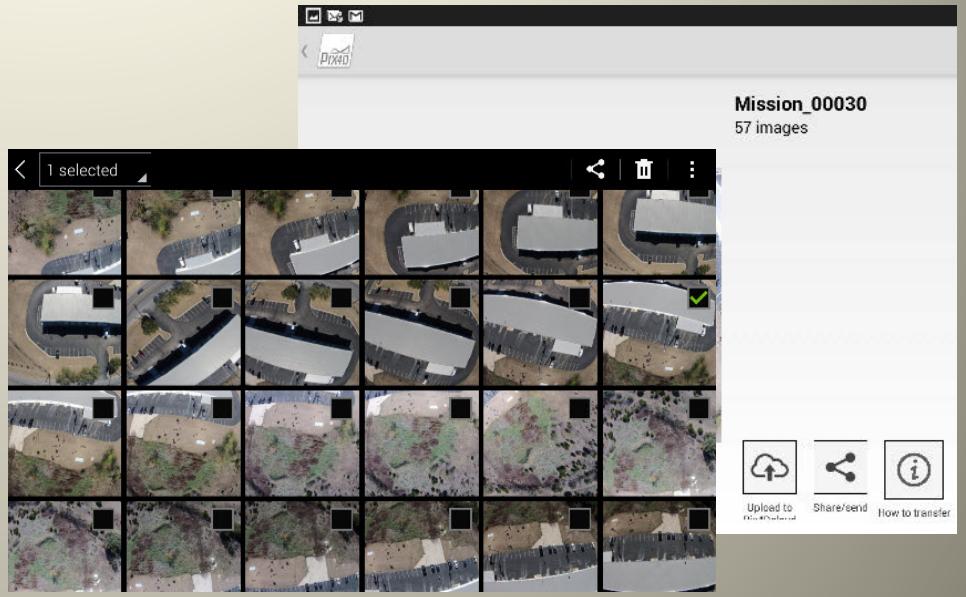
Sample eBee Mapping Flight



Post Flight Processing

Image Transfer

- Transfer to tablet
  - Annotates images with more accurate GPS geotags
  - Creates .p4d file
- Upload to PC for processing
  - Pix4D cloud (initial quality check) & later retrieval)
  - Dropbox
  - Manual transfer



Field Reporting (Optional)

From: Pix4D Cloud Services <cloud_services@mail133-7.atl131.mandrillapp.com> on behalf of Pix4D Cloud Services <cloud_services@pix4d.com> Sent: Tue 3/3/2015 1

To: Vertical Aspect Support

Cc:

Subject: Project Mission_00030 processed

Message | dsm_Mission_00030.png (226 KB) | ortho_Mission_00030.png (290 KB)

PIX4D simply powerful

Dear Vertical Aspect,

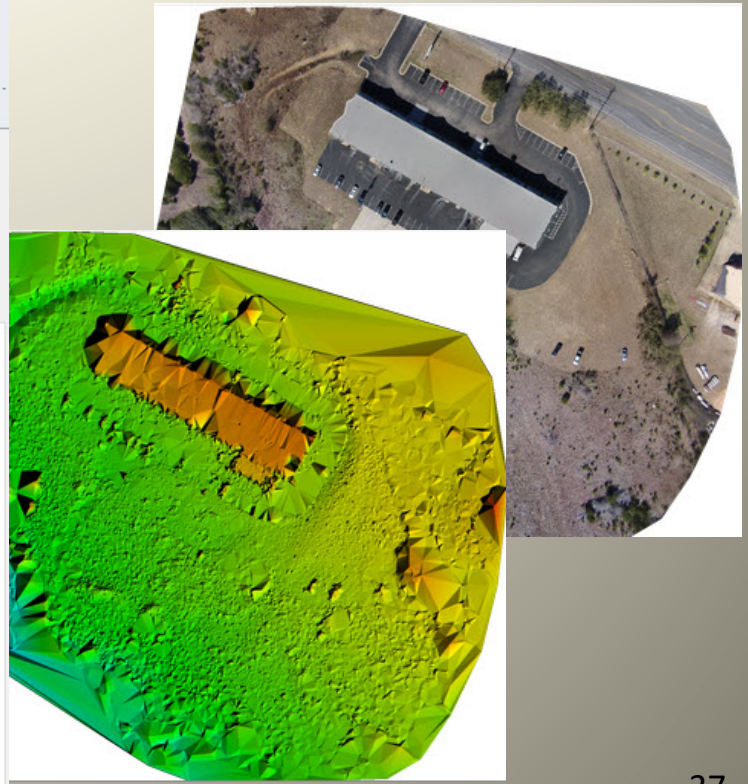
Good news! Mission_00030 has been processed. Find here attached a preview of the orthomosaic and DSM.

Go further!

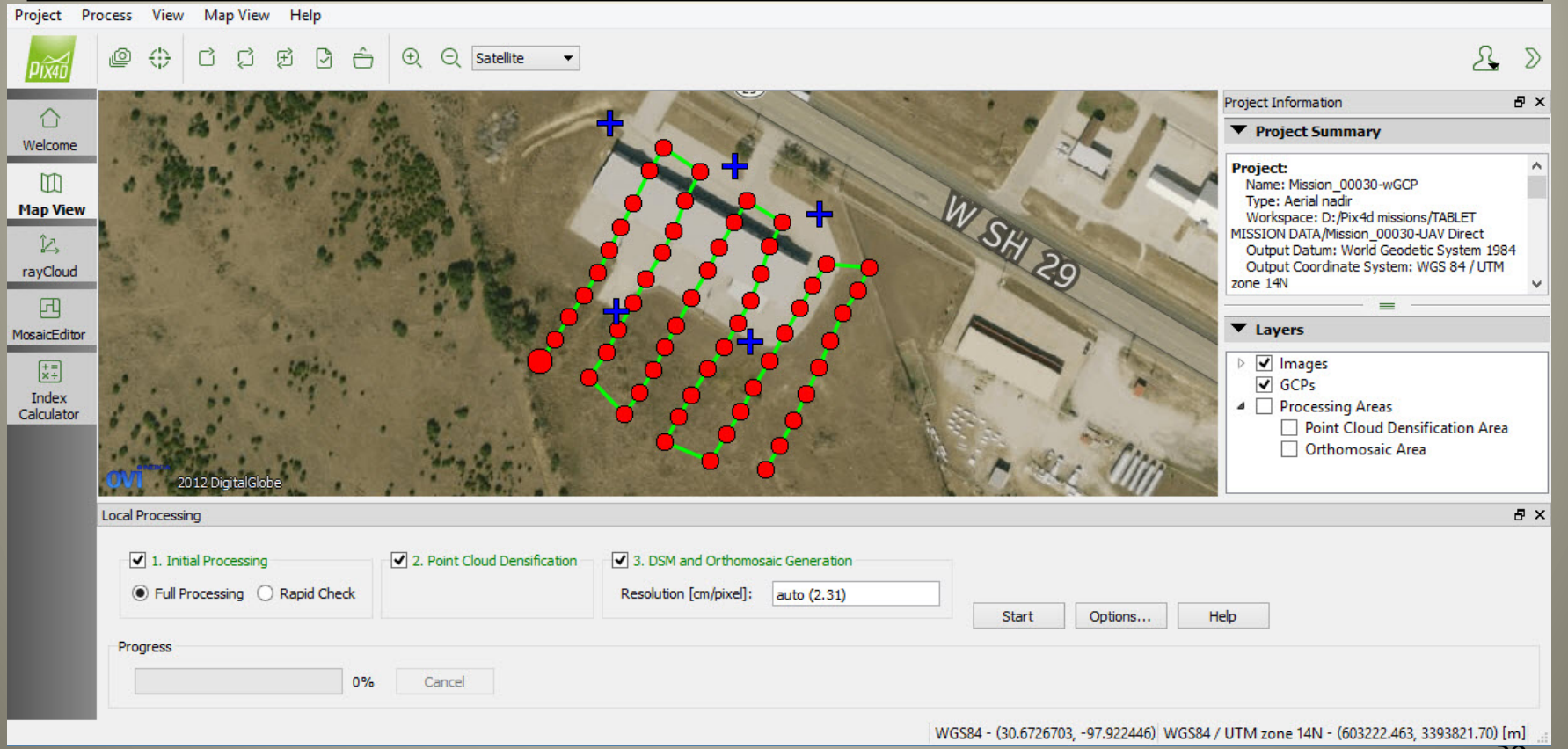
Want to assess your project in detail, improve it with many edition features, perform precise measurements directly in the software and save output results such as point clouds, vector objects, contour lines, DTMs, meshes and more? Just download your project and open it on your desktop computer with **Pix4Dmapper Pro**.

Thanks for choosing Pix4Dmapper and lots of success with your projects.

The Pix4D team



Initial Processing



Quality Report

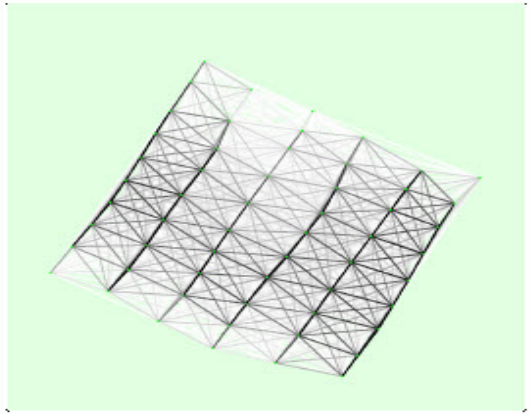
Summary

Project	Mission_00030-wGCP
Processed	2015-Mar-02 14:10:46
Camera Model Name	PHANTOMMISIONFC200_5.0_4608x3456-UAVDirect (RGB)
Average Ground Sampling Distance (GSD)	2.28 cm / 0.89 in
Area Covered	0.0222 km^2 / 2.2177 ha / 0.0086 sq. mi. / 5.483 acres
Image Coordinate System	WGS84
Ground Control Point (GCP) Coordinate System	WGS84
Output Coordinate System	WGS84 / UTM zone 14N
Processing Type	full Aerial nadir
Feature Extraction Image Scale	1
Camera Model Parameter Optimization	optimize externals and all internals

Quality Check

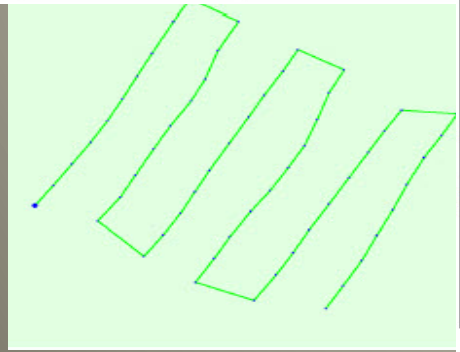
Images	median of 39147 keypoints per image	✓
Dataset	57 out of 57 images calibrated (100%), all images enabled	✓
Camera Optimization	0.63% relative difference between initial and final focal length	✓
Matching	median of 11314.1 matches per calibrated image	✓
Georeferencing	no 3D GCP	⚠

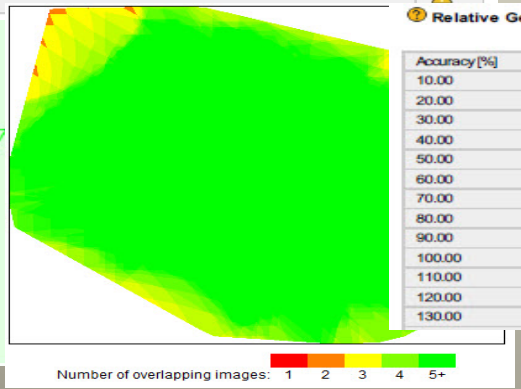
3D Points from 2D Keypoint Matches



Number of matches

25 222 444 666 888 1111 1333 1555 1777 2000

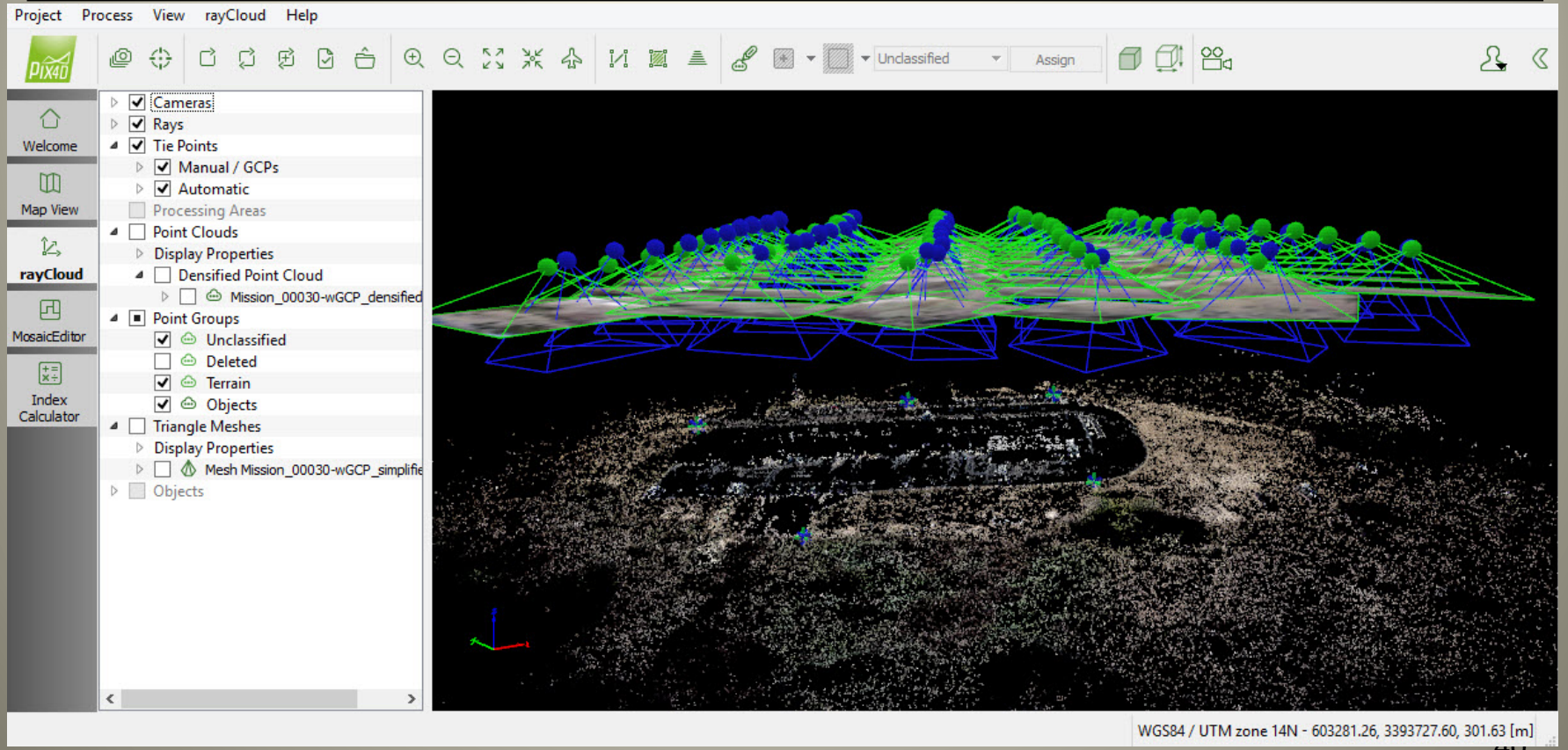




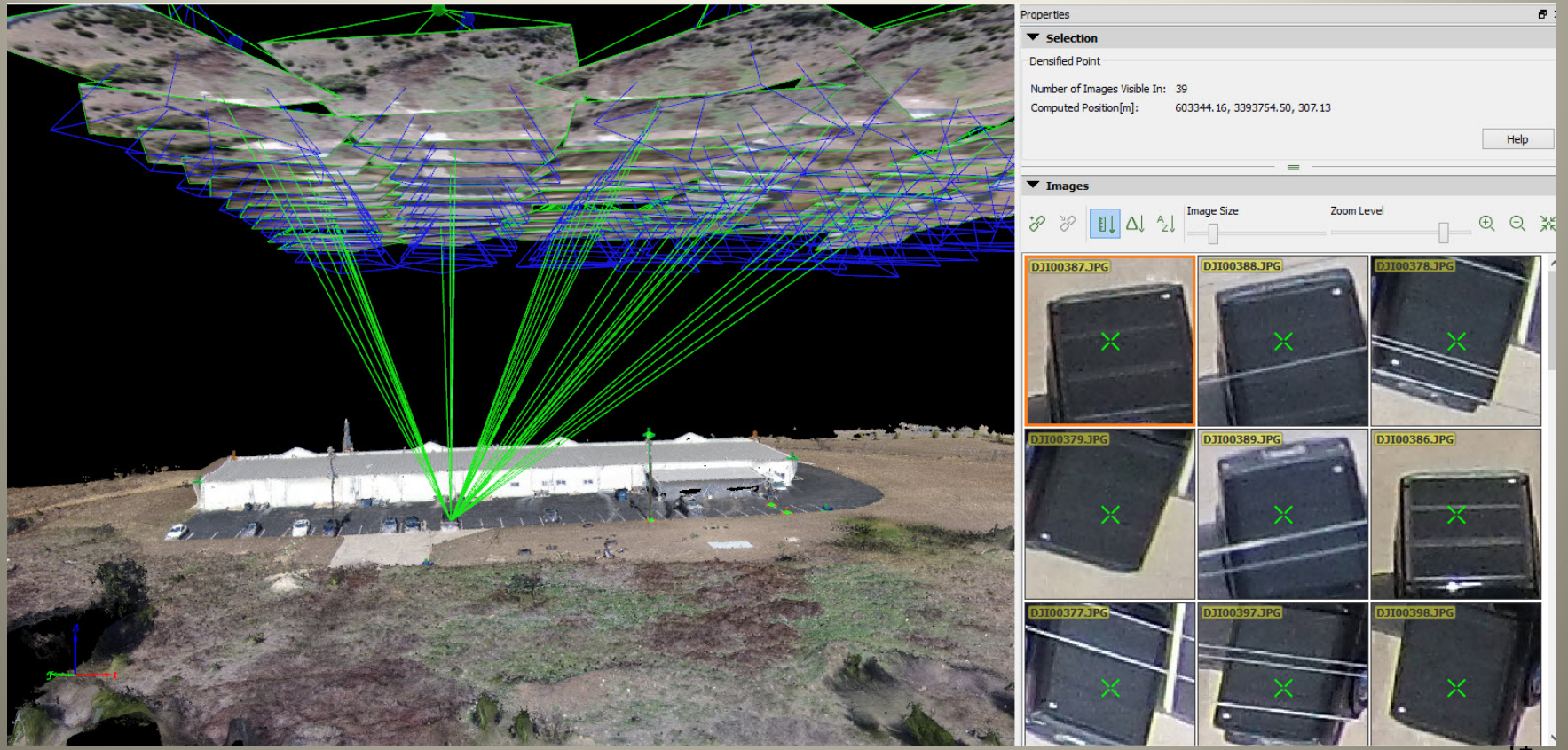
Relative Geolocation Variance

Accuracy [%]	Images X [%]	Images Y [%]	Images Z [%]
10.00	1.75	5.26	54.39
20.00	10.53	17.54	94.74
30.00	26.32	45.61	100.00
40.00	45.61	61.40	100.00
50.00	57.89	71.93	100.00
60.00	71.93	85.96	100.00
70.00	82.46	94.74	100.00
80.00	87.72	98.25	100.00
90.00	98.25	100.00	100.00
100.00	100.00	100.00	100.00
110.00	100.00	100.00	100.00
120.00	100.00	100.00	100.00
130.00	100.00	100.00	100.00

Initial Point Cloud



Ray Cloud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Selection
Densified Point
Number of Images Visible In: 39
Computed Position[m]: 603344.16, 3393754.50, 307.13
Help
Images
Image Size
Zoom Level
DJI00387.JPG
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DJI00378.JPG
DJI00379.JPG
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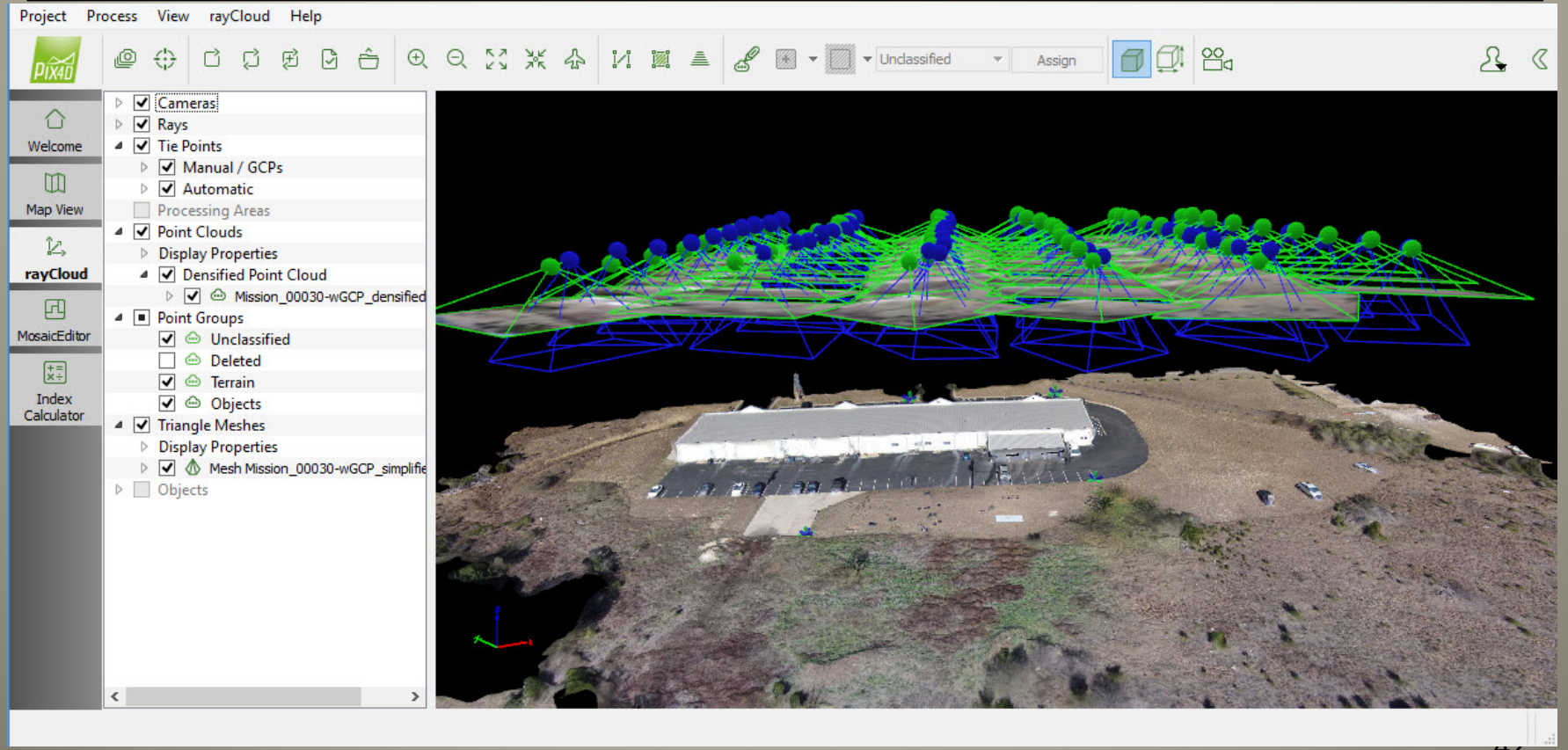
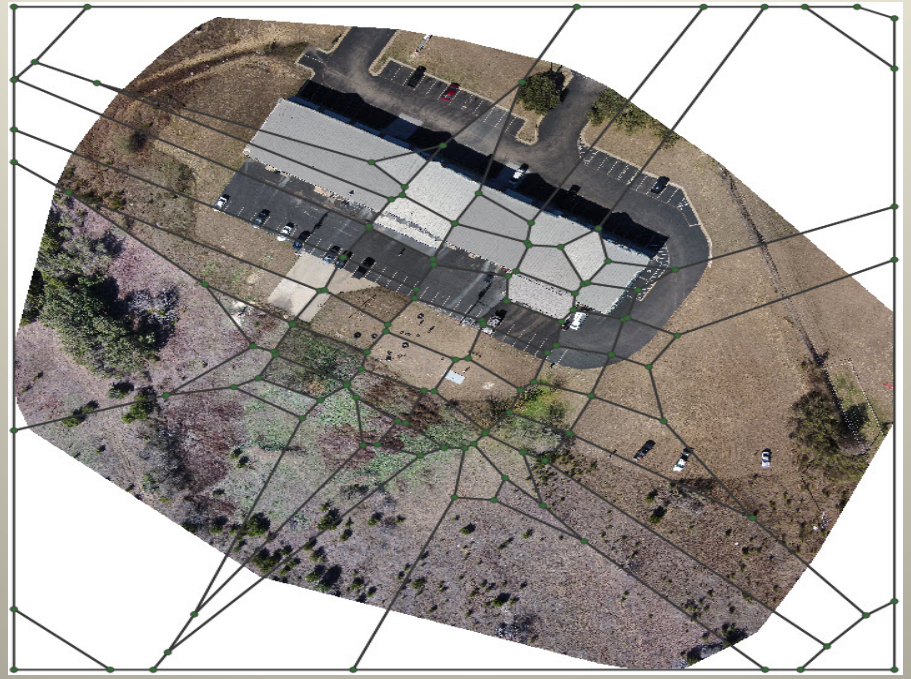
DJI00398.JPG

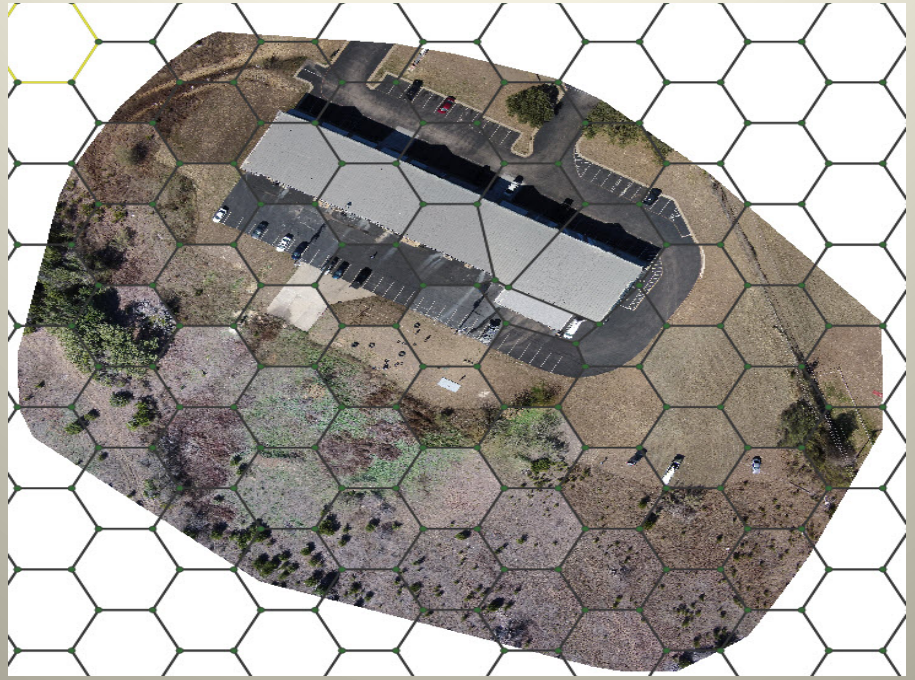
Densified Point Cloud



Mosaic Mesh – Initial

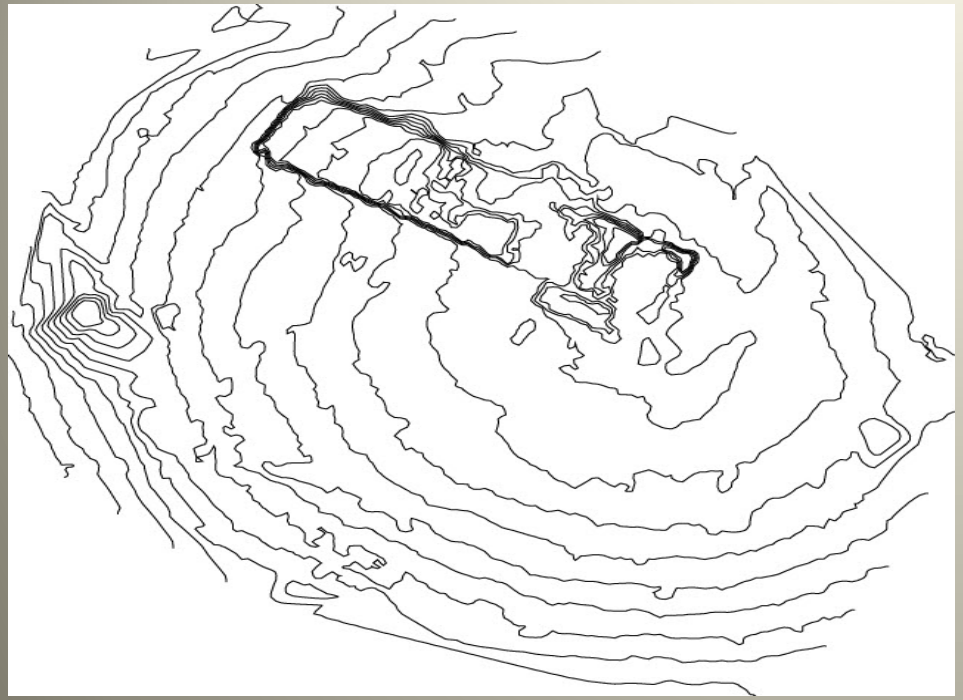


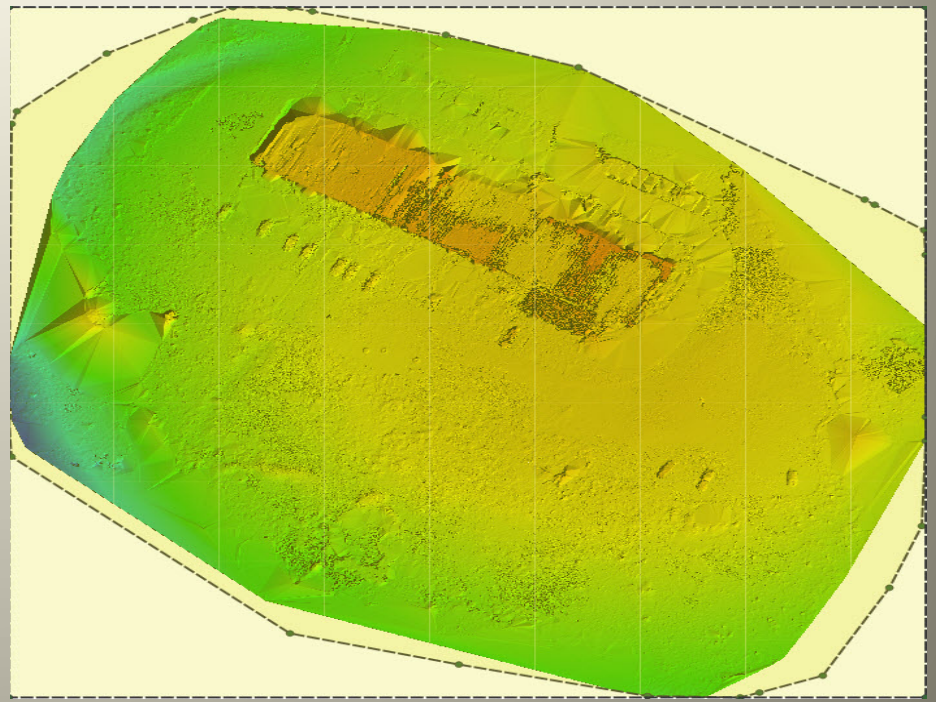
Mosaic Mesh – Reset



Mosaic - Blended

Contour and DSM

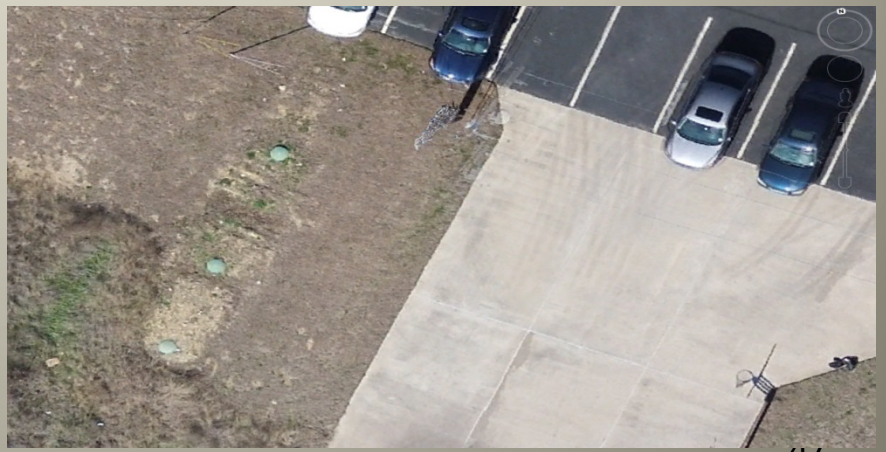




Google Earth & Pix4D

Google Earth

Pix4D Overlay



Questions?

Jeff Campbell

(202) 494-8410

www.verticalaspect.com

or e-mail us at

support@verticalaspect.com