UAS to GIS
Utilizing a low-cost Unmanned Aerial System (UAS) for Coastal Erosion Monitoring

esri

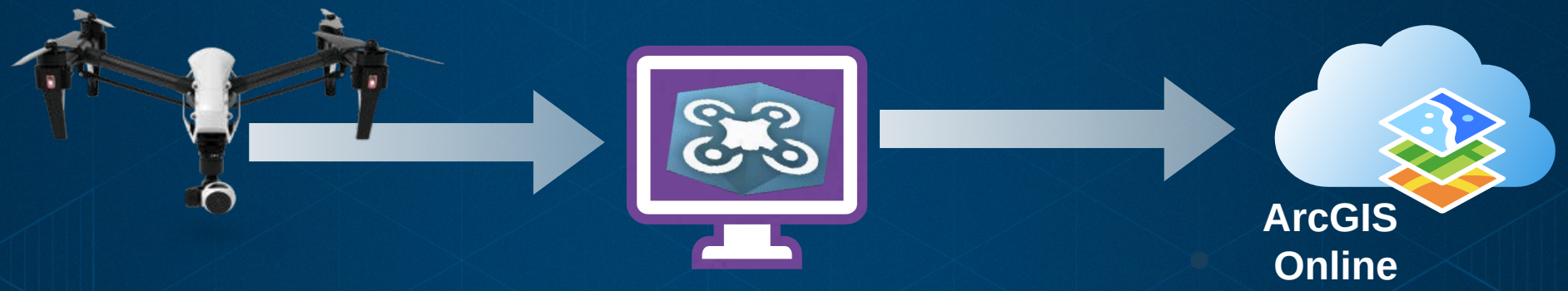
McKIM&CREED

A New Window on the World

Personal Mapping for Micro-Geographies

Drone2Map for ArcGIS

Accurate 2D & 3D Map Products



Fly Drone **Run App** **Get Map**

Implementation:

- Is a Windows App running on a PC or Surface Tablet
- Does not require ArcGIS for Desktop
- Publishes output directly to ArcGIS Online & Portal
- Intuitive workflow oriented interface

Drone2Map Processing

Produces three primary image products

Overlapping
Static Aerial Photos

2D Image Maps (Ortho Mosaics):

- Map Accurate
- Seamless stitched for base mapping
- Files or tile Cache
- Can be used for analytics

3D Elevation Products:

- Digital Surface Model (DSM)
- Point Cloud (LAS)
- 3D Mesh Models
- 3D Site Models (PDF)

Smart Inspection Photos:

- Non-Distorted but Map Accurate
- Works for vertical and oblique photos
- Complete 3D Measurements
- Cataloging for site inventories

Project Objectives

Low-Cost UAS Evaluation for Wilmington District

- Beach renourishment surveys
- Volumetric Calculations – Dredge Disposal Site
- Construction Monitoring – Masonboro Inlet Jetties
- Accuracy and use of 2D & 3D products for other applications
- Environmental and community impacts

Hardware and Software

SiteScan

The Leading Aerial Analytics Platform

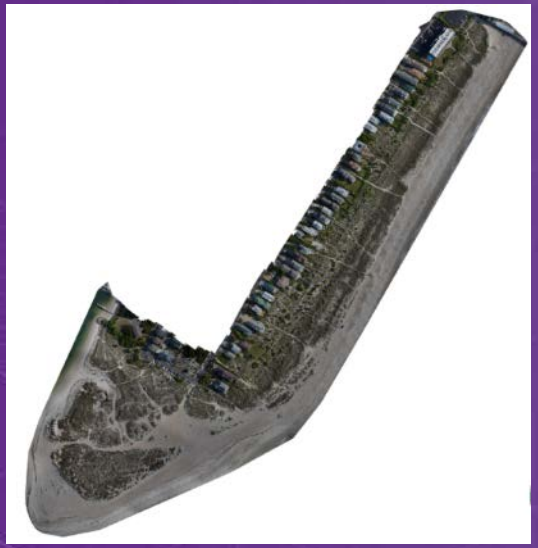
3DR

esri

Wrightsville Beach

Summary

Total Area Processed

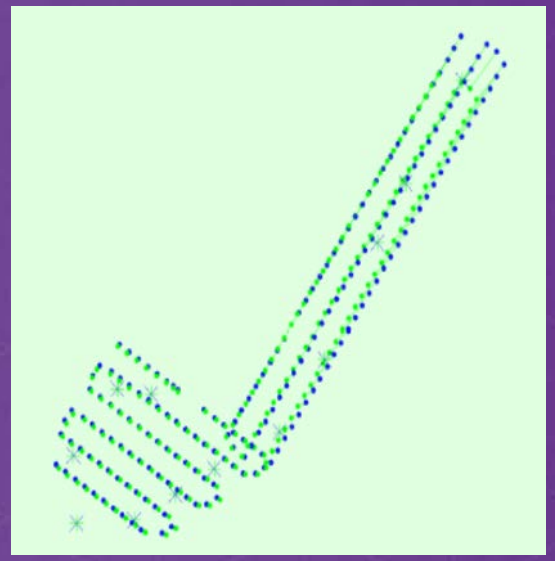


Oceanic Pier to
Masonboro Inlet
71.62 Acres

Ground Control Used

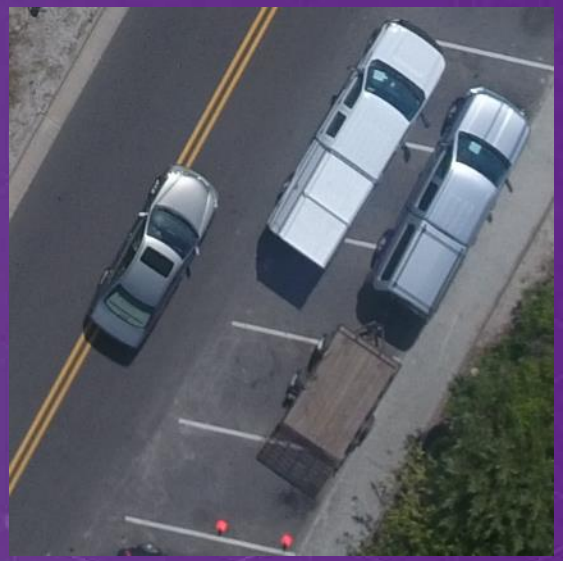
14 Points
Fully Surveyed

Photos Collected



Sony R10C
Total 195 / 1.25GB
Collection Time < 1hr / 2flts

Output Parameters



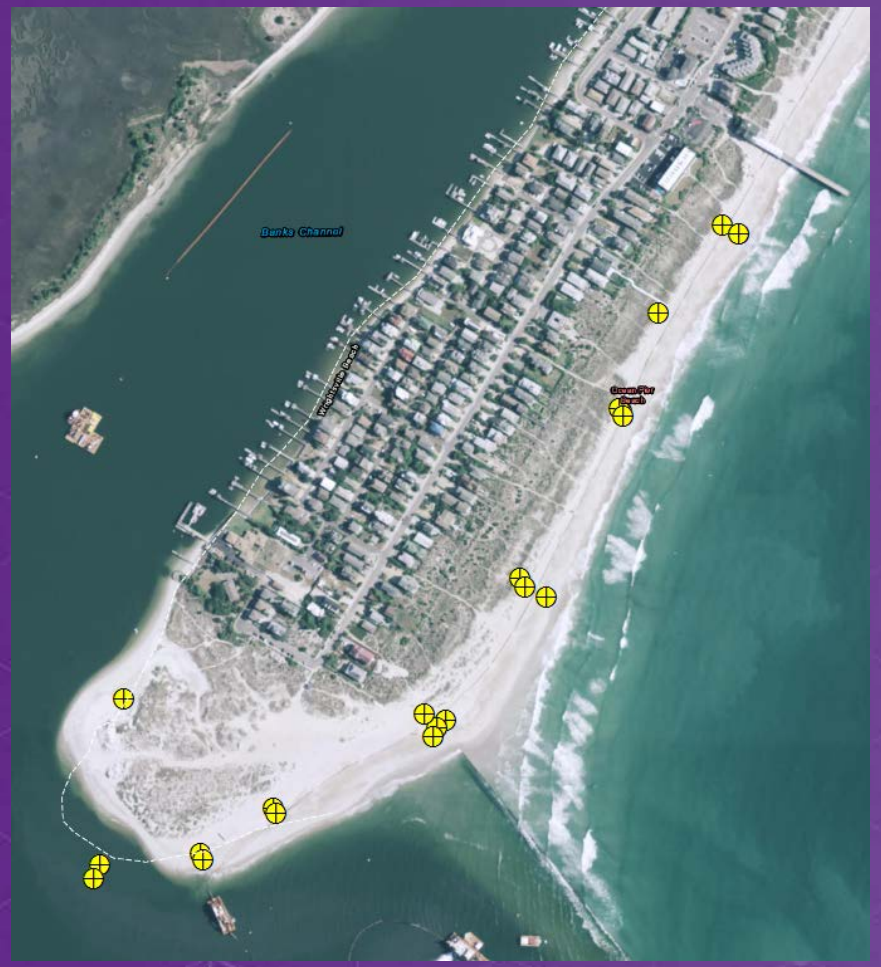
Horizontal GSD – 1.21 in
3D Points / Meter - 104

Processing Time: 4 hrs 32 mins
Products Produced: Orthos, DSM, Point Cloud, 3D Mesh
Overall Accuracy: Mean RMS 1.27 inches

Products Produced

OrthoMaps, DSMs, Point Cloud, Visualization Mesh

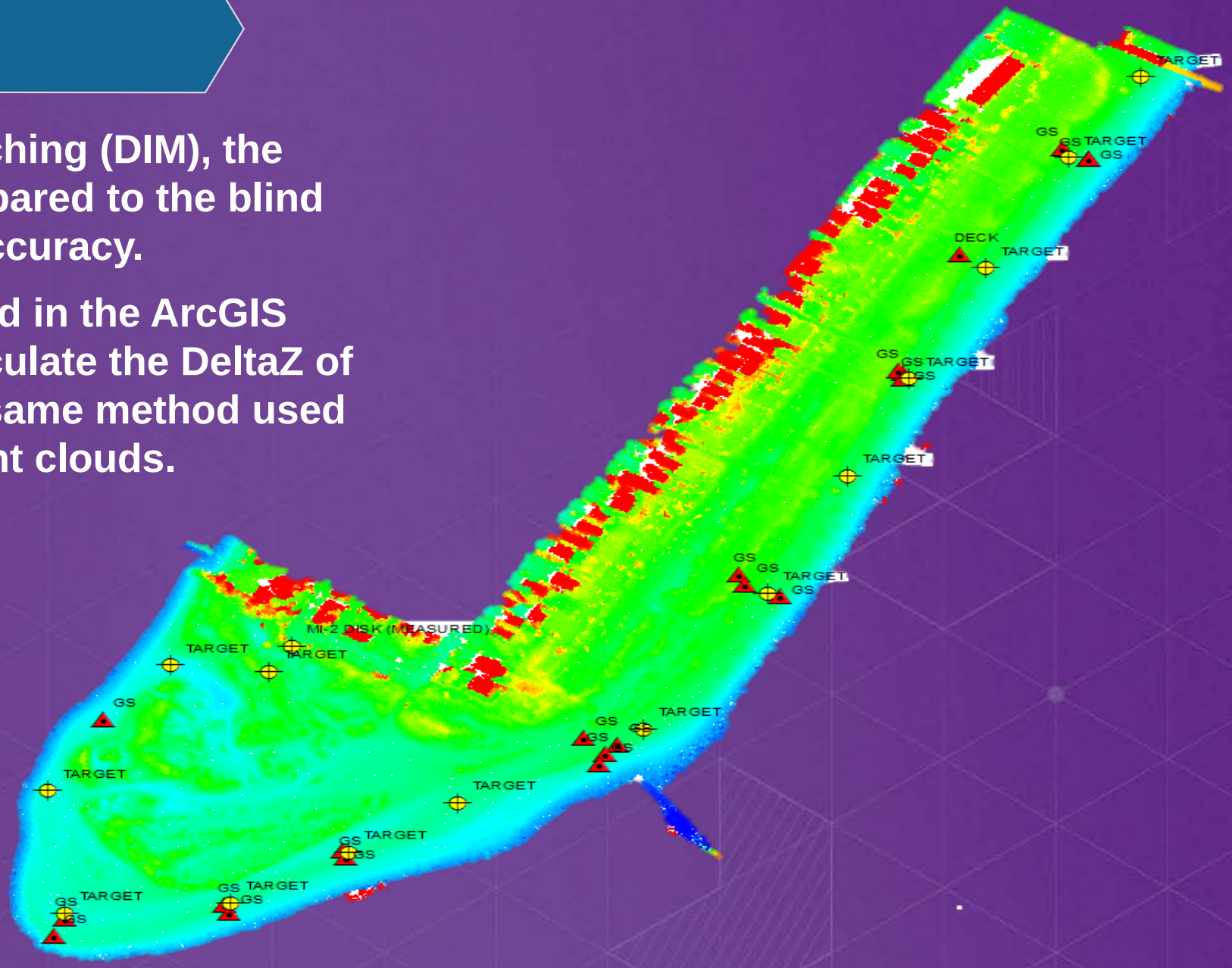
Wrightsville Beach Flight



- McKim & Creed placed 14 survey targets on the beach
- 22 Blind check shots were collected randomly
- 2 Flights were flown with the Solo / R10C setup (400 Ft. AGL 1.21 Inch GSD)
- 1 Flight was flown using the Solo / GoPro setup (400 Ft. AGL 2.44 Inch GSD)
- 1 Flight was flown with a Phantom 4 (200 Ft. AGL 1.01 Inch GSD)

Accuracy Reporting

- After Dense Image Matching (DIM), the Point clouds were compared to the blind checkpoints to verify accuracy.
- A TIN model was created in the ArcGIS extension LP360 to calculate the DeltaZ of each point. This is the same method used for verifying LiDAR point clouds.



Results

DJI Results

```
--------- Report Summary ---------

X Error Mean:                    0.000
X Error Range:                   [0.000,0.000]
X Skew:                          0.000
X RMSE:                      0.000
X NMAS/VMAS Accuracy (90% CI):    ±0.000
X ASPRS/NSSDA Accuracy (95% CI):    ±0.000
X Accuracy Class:    ------


Y Error Mean:                    0.000
Y Error Range:                   [0.000,0.000]
Y Skew:                          0.000
Y RMSE:                      0.000
Y NMAS/VMAS Accuracy (90% CI):    ±0.000
Y ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Y Accuracy Class:    ------


Planimetric Error Mean:                0.000
Planimetric Error Range:               [0.000,0.000]
Planimetric Skew:                      0.000
Planimetric RMSE:                  0.000
Planimetric NMAS/VMAS Accuracy (90% CI):    ±0.000
Planimetric ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Planimetric Accuracy Class:    ------


Vertical Error Mean:                 -0.000
Vertical Error Range:                [-0.839,1.481]
Vertical Skew **:                     1.173
Vertical RMSE:                 0.527
Vertical NMAS/VMAS Accuracy (90% CI):    ±0.867
Vertical ASPRS/NSSDA Accuracy (95% CI):    ±1.034
Vertical Accuracy Class:    0.53
Vertical Min Contour Interval:    1.59
```

GoPro Results

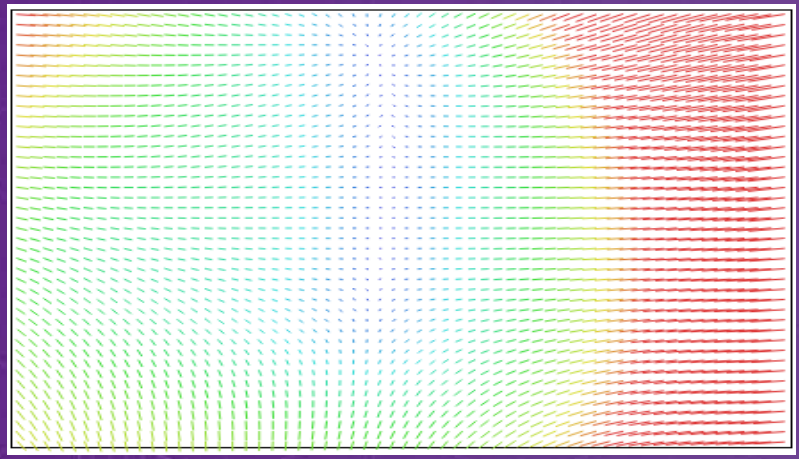
```
--------- Report Summary ---------

X Error Mean:                    0.000
X Error Range:                   [0.000,0.000]
X Skew:                          0.000
X RMSE:                      0.000
X NMAS/VMAS Accuracy (90% CI):    ±0.000
X ASPRS/NSSDA Accuracy (95% CI):    ±0.000
X Accuracy Class:    ------


Y Error Mean:                    0.000
Y Error Range:                   [0.000,0.000]
Y Skew:                          0.000
Y RMSE:                      0.000
Y NMAS/VMAS Accuracy (90% CI):    ±0.000
Y ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Y Accuracy Class:    ------


Planimetric Error Mean:                0.000
Planimetric Error Range:               [0.000,0.000]
Planimetric Skew:                      0.000
Planimetric RMSE:                  0.000
Planimetric NMAS/VMAS Accuracy (90% CI):    ±0.000
Planimetric ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Planimetric Accuracy Class:    ------


Vertical Error Mean *:               -0.221
Vertical Error Range:                [-0.535,0.171]
Vertical Skew:                       0.037
Vertical RMSE:                 0.310
Vertical NMAS/VMAS Accuracy (90% CI):    ±0.510
Vertical ASPRS/NSSDA Accuracy (95% CI):    ±0.608
Vertical Accuracy Class:    0.32
Vertical Min Contour Interval:    0.96
```

R10C Results

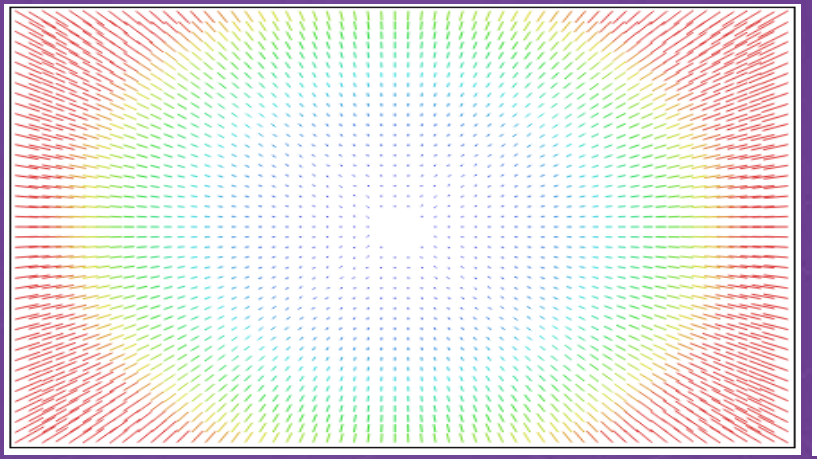
```
--------- Report Summary ---------

X Error Mean:                    0.000
X Error Range:                   [0.000,0.000]
X Skew:                          0.000
X RMSE:                      0.000
X NMAS/VMAS Accuracy (90% CI):    ±0.000
X ASPRS/NSSDA Accuracy (95% CI):    ±0.000
X Accuracy Class:    ------


Y Error Mean:                    0.000
Y Error Range:                   [0.000,0.000]
Y Skew:                          0.000
Y RMSE:                      0.000
Y NMAS/VMAS Accuracy (90% CI):    ±0.000
Y ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Y Accuracy Class:    ------


Planimetric Error Mean:                0.000
Planimetric Error Range:               [0.000,0.000]
Planimetric Skew:                      0.000
Planimetric RMSE:                  0.000
Planimetric NMAS/VMAS Accuracy (90% CI):    ±0.000
Planimetric ASPRS/NSSDA Accuracy (95% CI):    ±0.000
Planimetric Accuracy Class:    ------


Vertical Error Mean *:               -0.062
Vertical Error Range:                [-0.258,0.190]
Vertical Skew:                       0.098
Vertical RMSE:                 0.137
Vertical NMAS/VMAS Accuracy (90% CI):    ±0.225
Vertical ASPRS/NSSDA Accuracy (95% CI):    ±0.268
Vertical Accuracy Class:    0.14
Vertical Min Contour Interval:    0.42
```

Distortion Plots

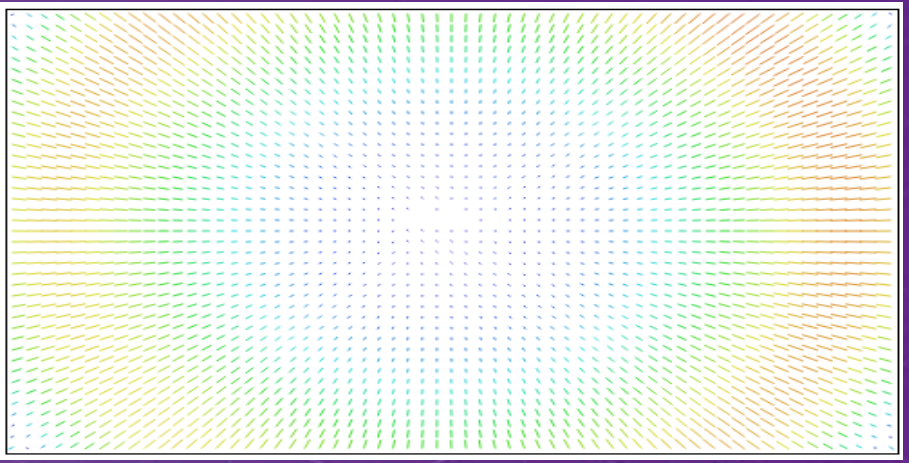
DJI Phantom 4



GoPro Hero 4 Black



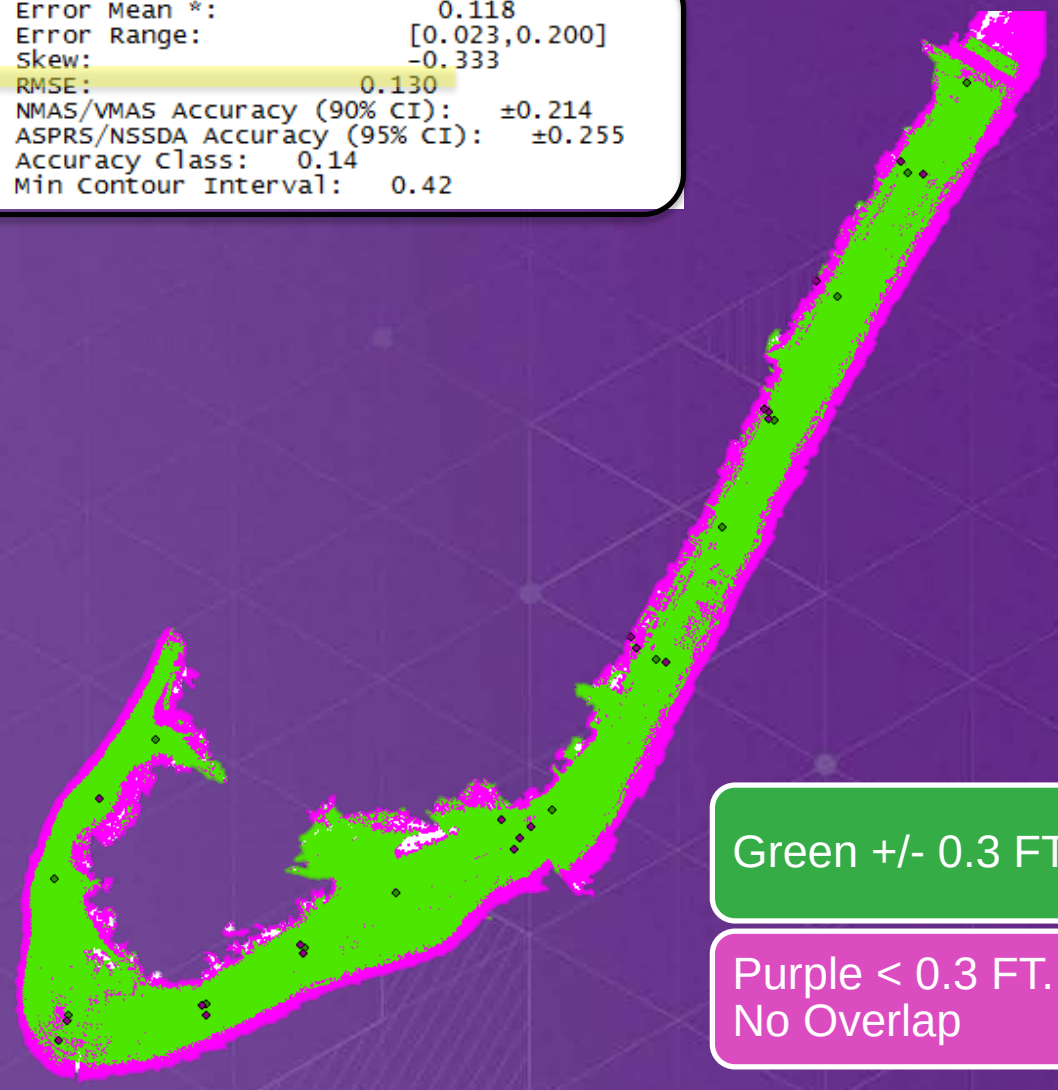
R10C 16mm



Terrestrial LiDAR Analysis

- Terrestrial LiDAR was collected the same day by the Charleston USACE district
- The Terrestrial LiDAR was off by almost the same amount as the R10C data from the blind checkpoints.
- The error however was in the opposite direction creating an offset between the two datasets by 3 – 5 tenths
- By normalizing the terrestrial LiDAR surface to the UAS surface we were able to compare the overall fit of the two surfaces relative to each other
- The two surfaces matched well in most areas. The terrestrial data extended further out than the UAS data due to time of collection.

```
Vertical Error Mean *:                    0.118
Vertical Error Range:                   [0.023,0.200]
Vertical Skew:                          -0.333
Vertical RMSE:                    0.130
Vertical NMAS/VMAS Accuracy (90% CI):   ±0.214
Vertical ASPRS/NSSDA Accuracy (95% CI):   ±0.255
Vertical Accuracy Class:   0.14
Vertical Min Contour Interval:   0.42
```



Green +/- 0.3 FT.

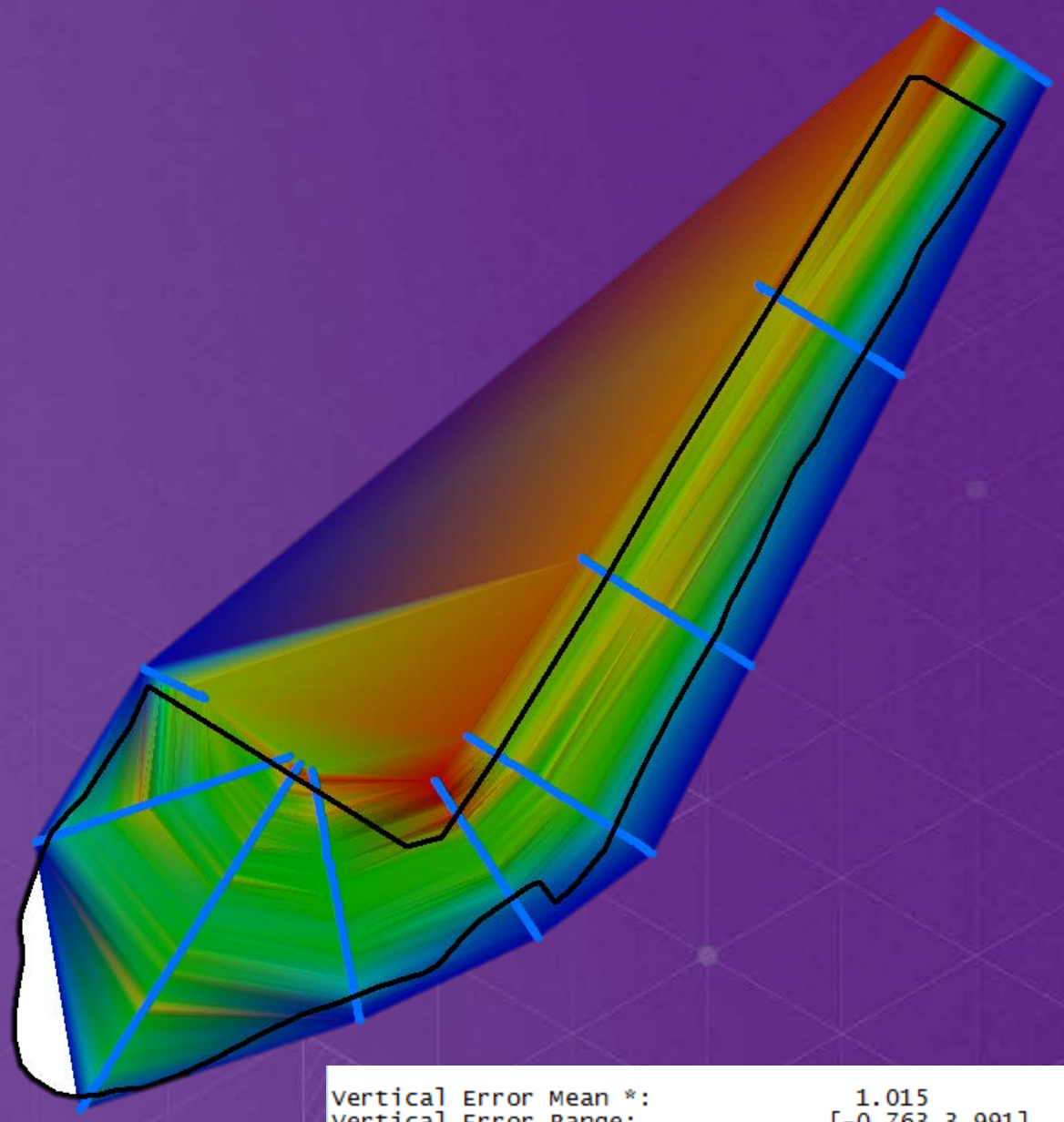
Purple < 0.3 FT. or No Overlap

Beach Profiles

- Transects were collected of the beach earlier in the year.
- Beach profiles are spaced at 1,000 ft. To each other and 3 ft. downline.
- Both profiles and UAS data match well.

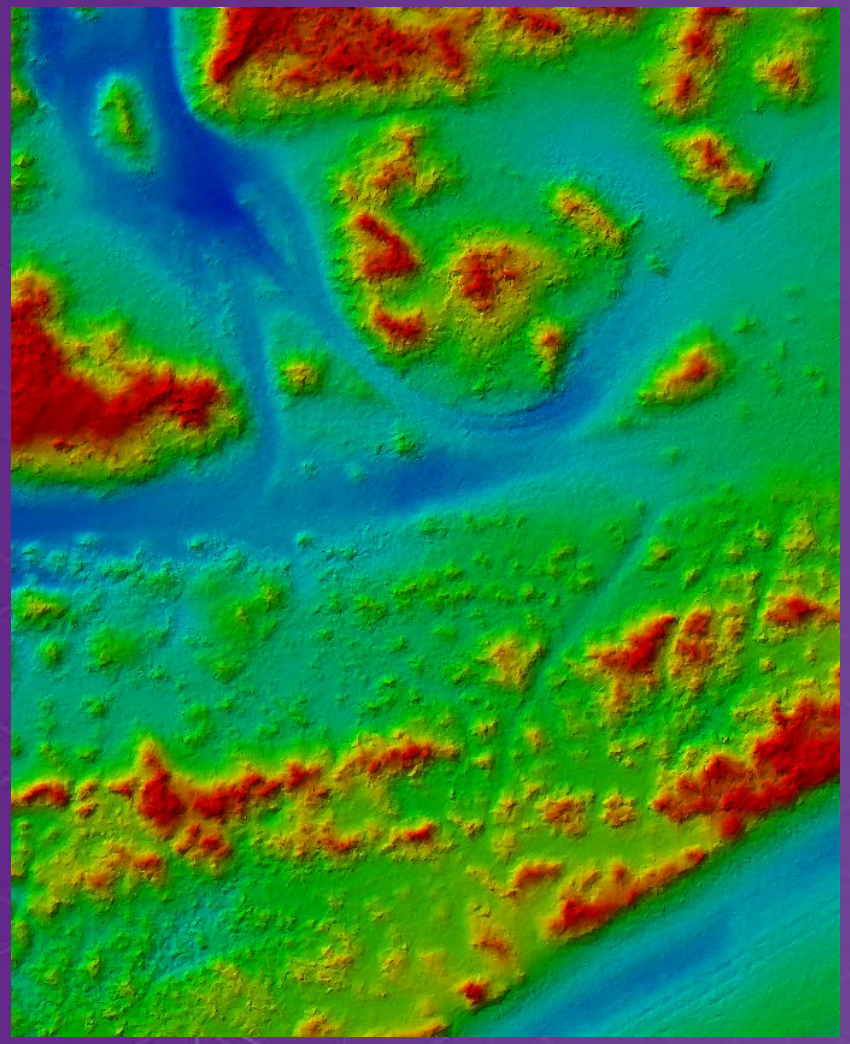
Beach Profiles

Surface	# Points	Cut (Cu. Ft.)	Fill (Cu. Ft.)	Net Diff. (Cu. Ft.)
Profile Lines	7,589	4207225.611	2016795.71	2190429.905
Drone2Map	445,492,843	6285711.208	475396.716	5810314.492
Variance	5870144.34%	49.40%	-76.43%	165.26%



```
Vertical Error Mean *:                    1.015
Vertical Error Range:                   [-0.763,3.991]
Vertical Skew:                          0.456
Vertical RMSE:                        1.723
Vertical NMAS/VMAS Accuracy (90% CI):   ±2.835
Vertical ASPRS/NSSDA Accuracy (95% CI):   ±3.377
Vertical Accuracy Class:   1.73
Vertical Min Contour Interval:   5.19
```

Business Comparison



- 5 mile Beach Profile:
- UAS vs. Conventional Survey
  - Accuracy - UAS is within 4 cm on control points
  - Cost - UAS is 30% less expensive for competitive project
  - Time - UAS captures greater detail in less time
- UAS vs. Terrestrial LiDAR
  - Accuracy - UAS is within 2 cm of LiDAR specifications
  - Cost - UAS is 15% less expensive for competitive project
  - Time - Similar mobilization & coverage, faster collect & processing
- UAS vs. Aerial LiDAR
  - Accuracy - UAS is within 2 cm of LiDAR specifications
  - Cost - UAS is 60% less expensive for competitive project
  - Time - Similar coverage, faster mobilization & processing

Masonboro Inlet N. Jetty

Summary

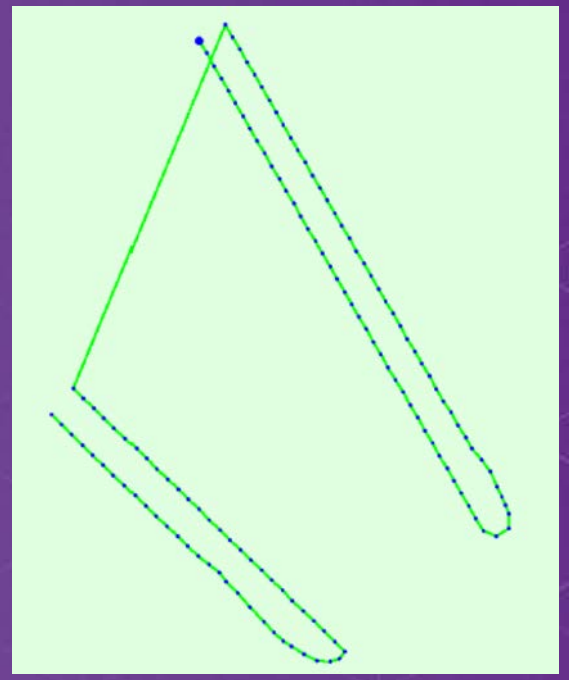
Total Area Processed

Masonboro Inlet
North Jetty
71.62 Acres

Ground Control Used

No Surveyed Points
3 Map Derived Points
X,Y Only

Photos Collected



Sony R10C
Total 123 / .89 GB
Collection Time < 1hr / 1 flts

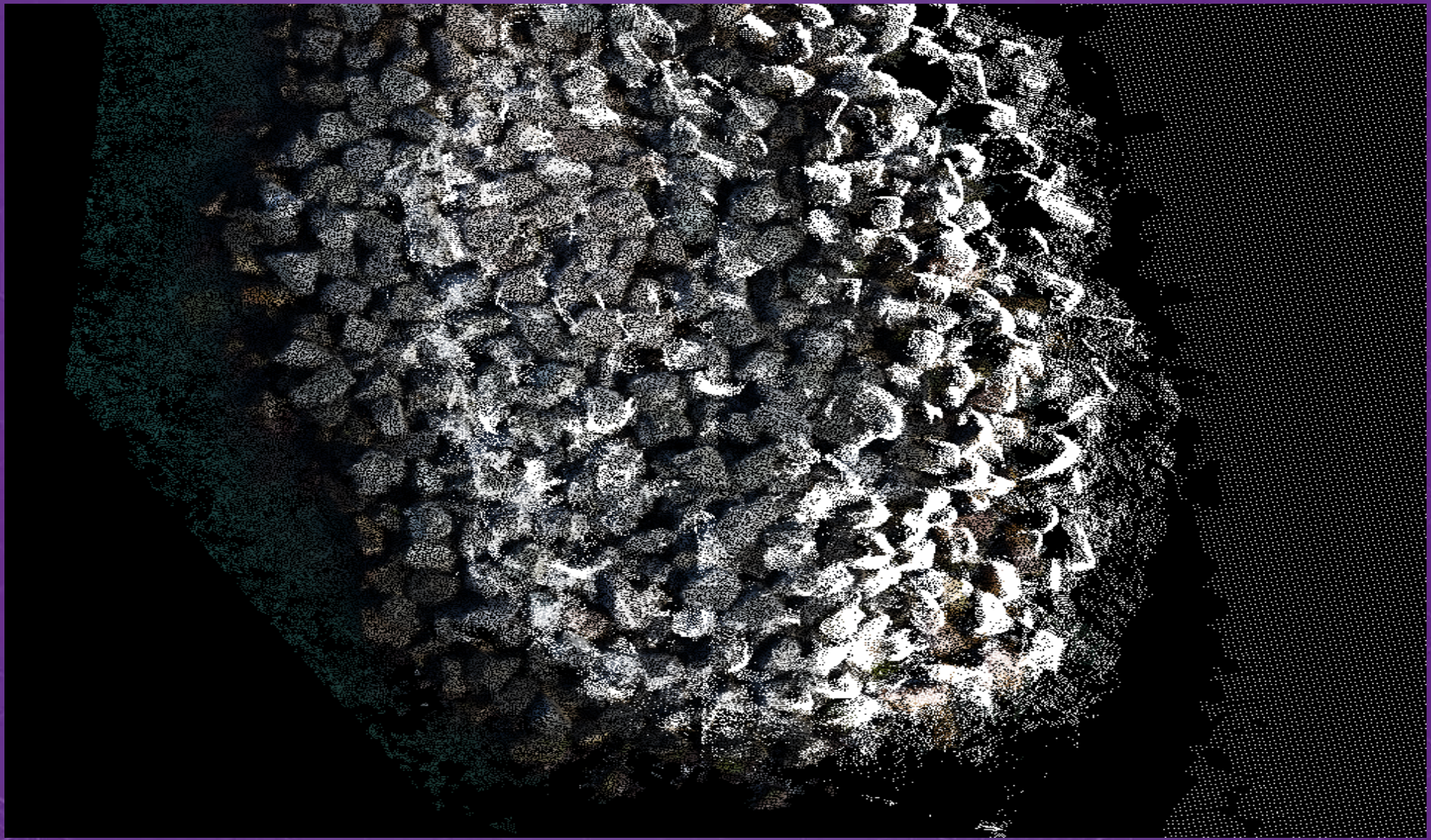
Processing Time: 21 mins
Products Produced: Orthos, DMS
Overall Accuracy: N/A

Masonboro Inlet N. Jetty

Masonboro Inlet N. Jetty

- No Control was collected for the Masonboro Inlet Jetties however LiDAR had been collected previously.
- Due to lack of control, the two scans did not line up however similar features could be identified in both scans.

Masonboro Inlet N. Jetty



Eagle Island Disposal Site

Summary

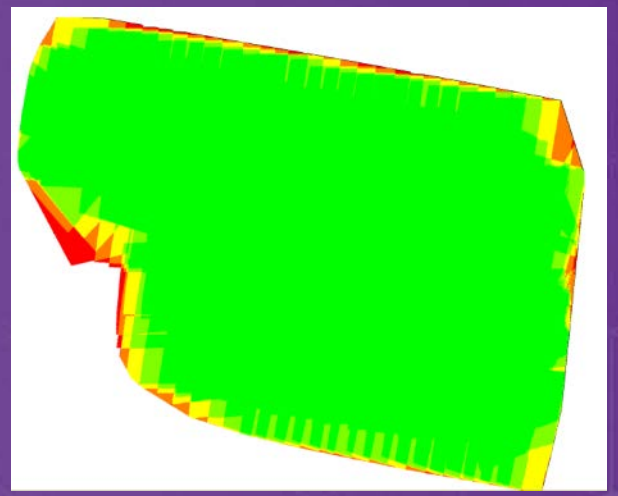
Total Area Processed

Partial Cells 1 & 2
106 Acres

Ground Control Used

7 Points
Fully Surveyed

Photos Collected



Sony R10C
Total 214 / 1.34GB

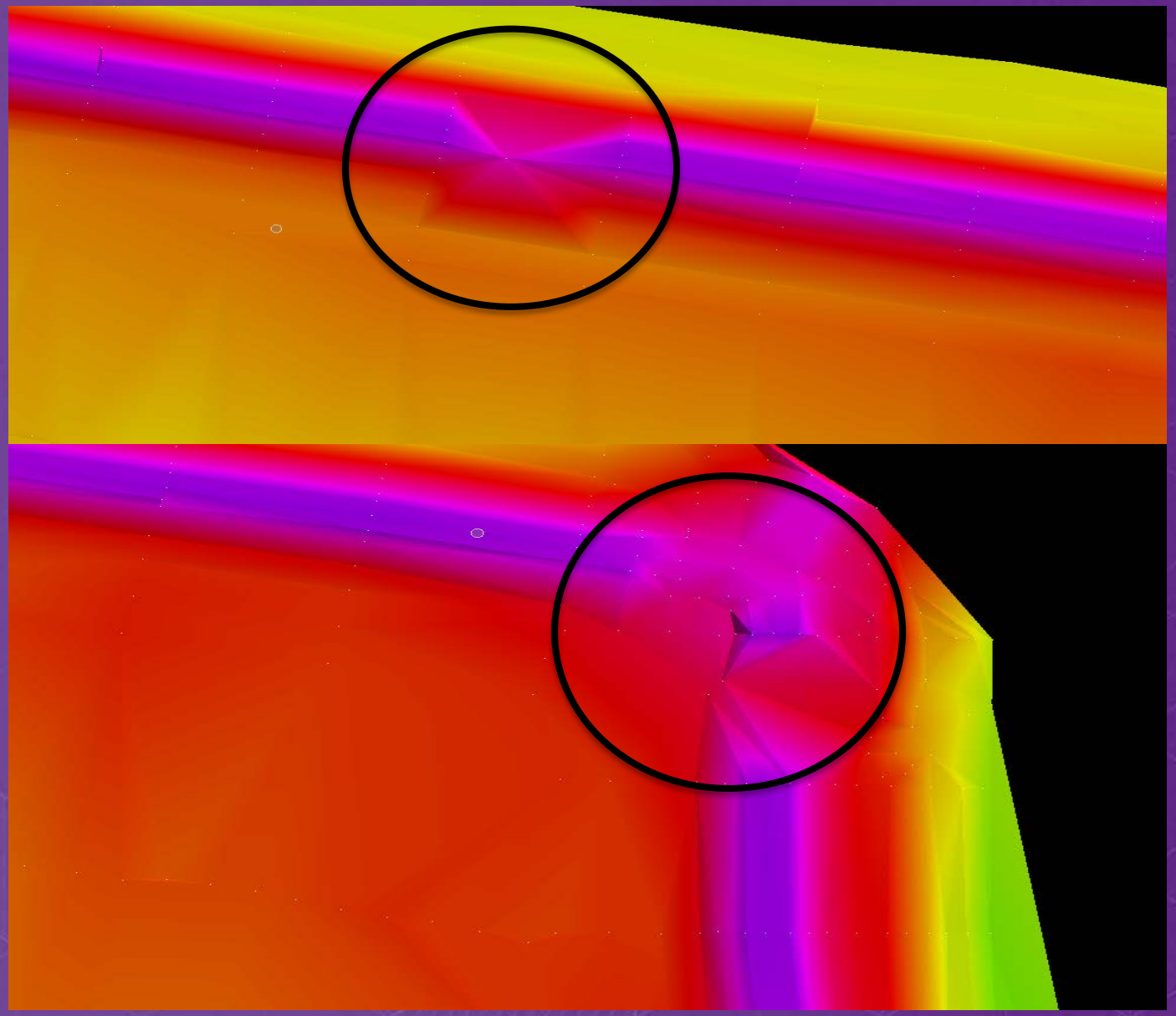
Output Parameters

Horizontal GSD – 1.32 in
3D Points / Meter - 104

Processing Time: 5 hrs 7 mins
Products Produced: Orthos, DSM, Point Cloud, 3D Mesh
Overall Accuracy: Mean RMS 2.64 inches

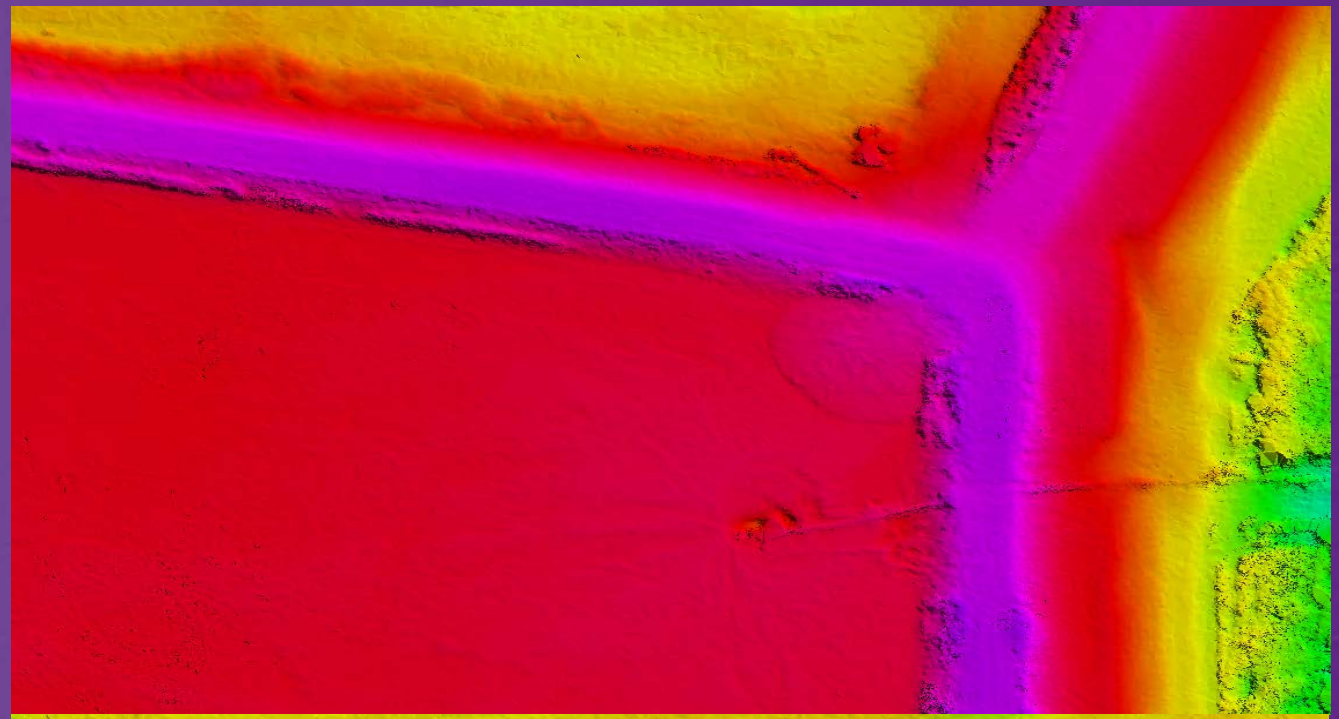
Traditional Survey Data

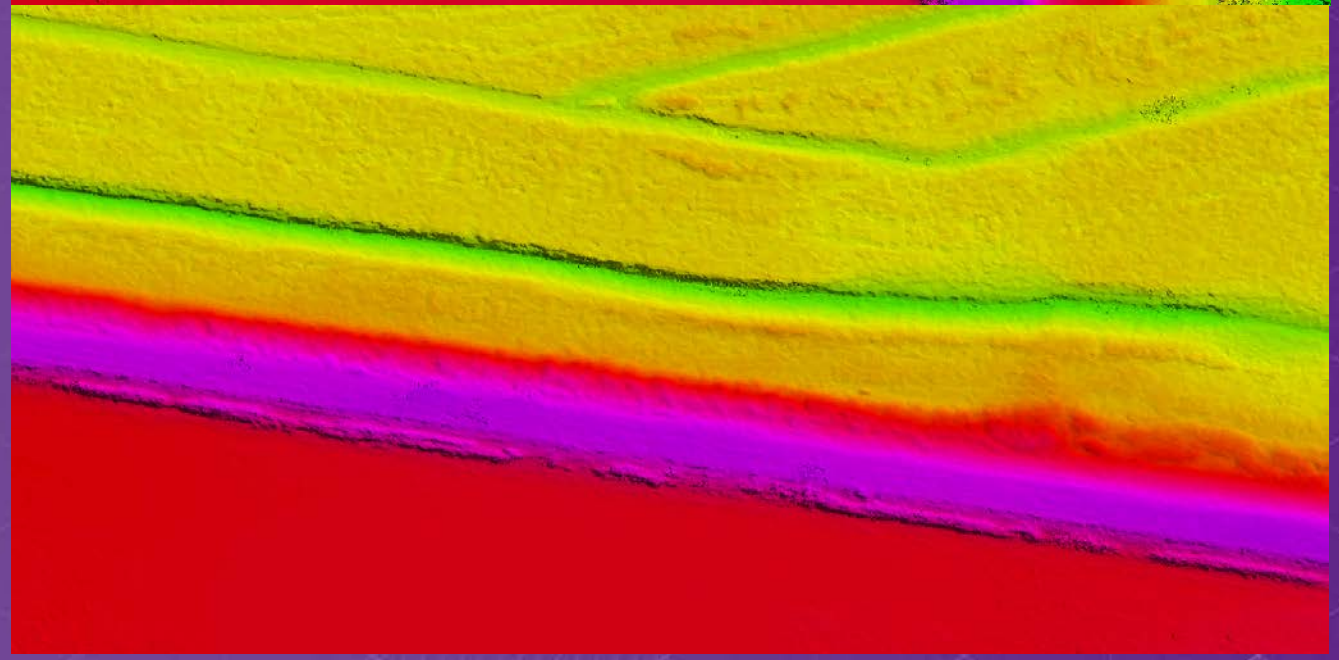
- Cell 1 (280 Acres approx.) was previously surveyed using conventional.
- 3642 individual survey shots were collected (2 weeks of work approx.)
- Irregularities in the surface model existed due to either bad elevations or incorrect triangulation



UAS Survey

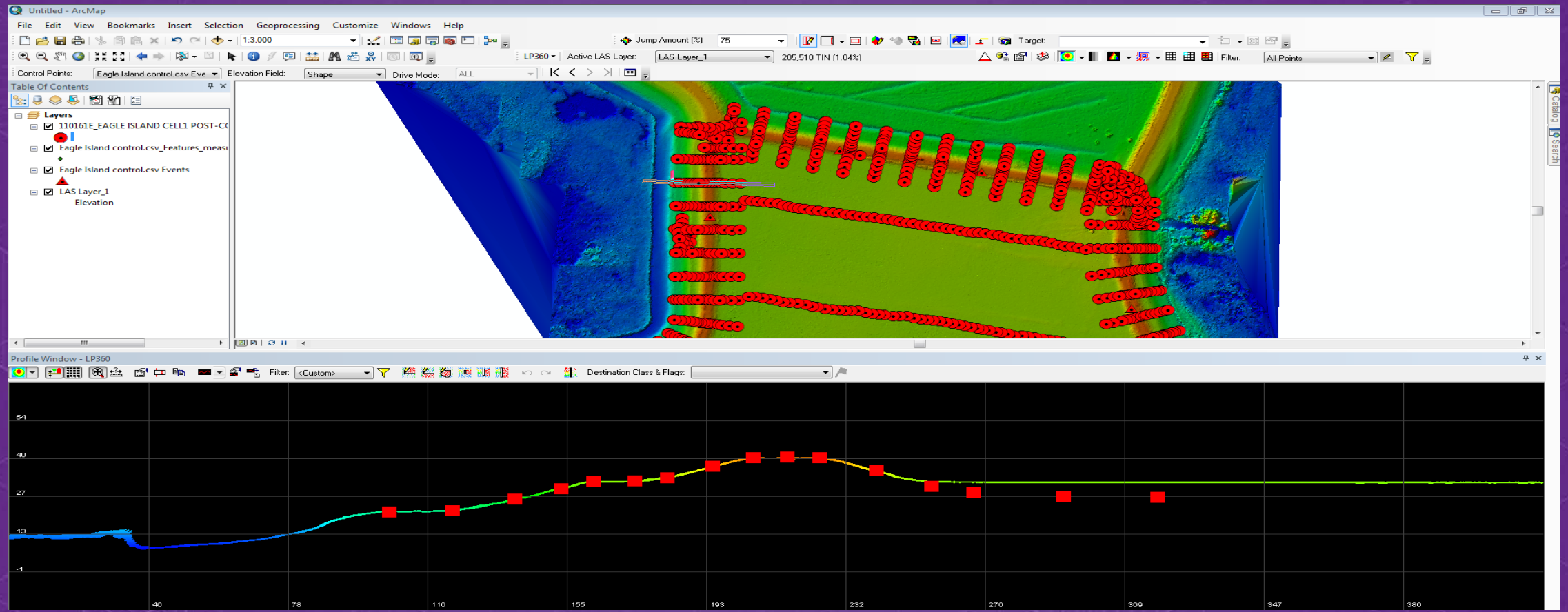
- Portions of Cell 1 and Cell 2 were collected in two 15 minute flights.
- 5 flights would be required to collect all of Cell 1 (half a day of flight and target survey approx.)
- 104 points per square meter vs. 0.07 (averaged from survey)





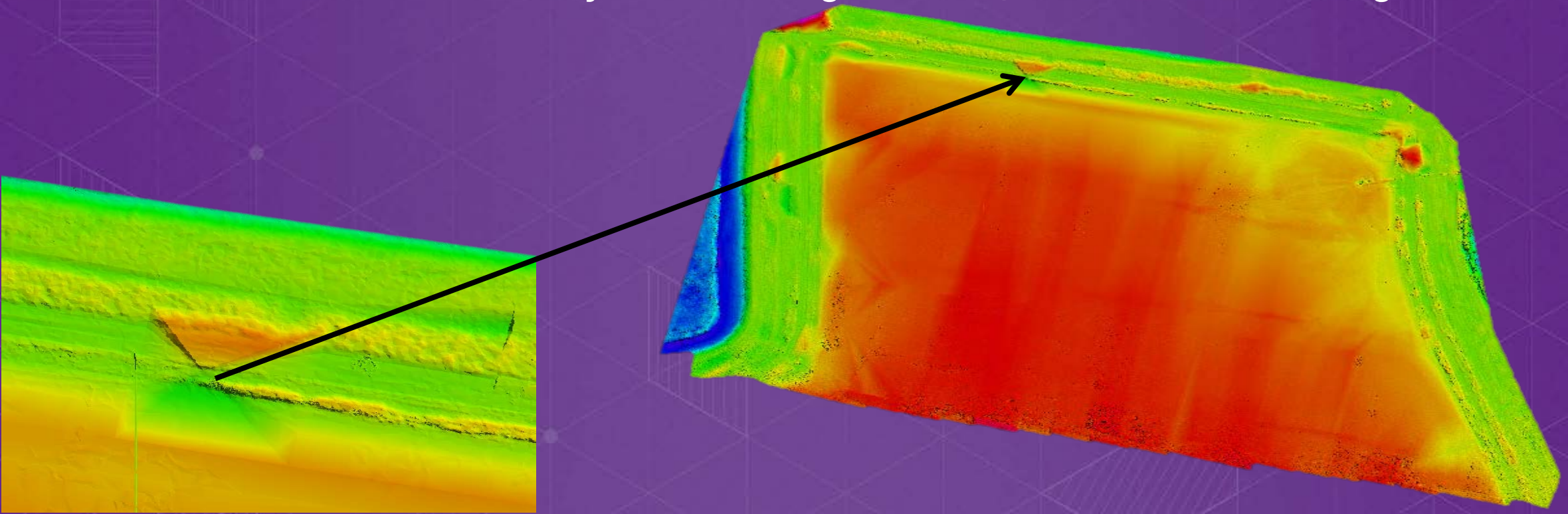
Accuracy Reporting

- No blind checkpoints were collected only control points.
- UAS and survey lined up very well on the dikes. The volume inside had changed however since the survey.



Surface Comparison

- The difference between data collections were normalized to visualize differences between datasets
- Most locations on the dike were less than 0.1 ft. up to 0.02 ft. difference between surfaces.
- In Places where the survey did not triangulate well, the differences were greater.



Conclusions

- Business 101
  - Cost
  - Quality
  - Speed

- Esri's Drone2Map coupled with 3DR's Solo and Site Scan equate to a business paradigm shift that allows civil engineering and land surveyors to take advantage of the advancing drone industry.
- Advantages:
  - Less people
  - Greater safety
  - More accurate
  - Faster deliverable

Community Effort

Corps, City of Wrightsville Beach, UNC-W, NC Coastal Land Trust, Audubon

Thank You!