UAS to GIS
Utilizing a low-cost Unmanned Aerial System (UAS) for Coastal Erosion Monitoring
Agenda
Scope of today’s presentation

Demonstration Objectives
Wrightsville Beach Test Area
Masonboro Inlet Jetties
Eagle Island Disposal Site
Conclusions
McKim & Creed Company Background

- Founded in 1978
- 350 + Employees
- 21 Office Locations
- McKim & Creed has completed projects in 38 US states
- Staff with survey and/or engineering licensure in 29 states
- Can deploy data assets to any region of US and beyond
- One of the top engineering, design and geomatics firms in the country
McKim & Creed’s UAS Focus

- Small Drones, Big Sensors
- Imagery for orthophotography and photogrammetric extraction
- Autocorrelation for point cloud generation
- Adapting our current mapping production processes to UAS collected data

Applications
- Small/Medium site mapping
- Volumetric Measurements
- Inspections
- Construction Site Monitoring
- Damage assessment
UAS as a tool for Survey and Mapping

- Clients expect to receive mapping products that are familiar and consistent with their design process
  - Planimetric and topographic mapping
  - Orthophotography
  - Classified point clouds
  - DTM/DEM
  - Contours
  - Video
Demonstration Objectives
Wrightsville Beach Demonstration

Evaluate the use of low-cost commercial drones for:

• Production of accurate high-resolution 2D and 3D geospatial products
• Specifically evaluate the use of drones for:
  - Beach Renourishment Surveys
  - Volumetric Measurements
  - Construction Site Monitoring
• Better understand UAS operational use patterns
• Environmental/community impacts of using drones
Hardware and Software

Drone2Map for ArcGIS
What Will Your Drone Do For You?
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
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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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<tbody>
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<tr>
<td>X Error Range</td>
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<td>0.000</td>
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<tr>
<td>X NMAS/VMAS Accuracy (95% CI)</td>
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<tr>
<td>X ASPRS/NSDDA Accuracy (95% CI)</td>
<td>±0.000</td>
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<td>X Accuracy Class</td>
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<td>Y Error Mean</td>
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<td>Y Error Range</td>
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<tr>
<td>Y Accuracy Class</td>
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### Planimetric Error Mean: 0.000
### Planimetric Error Range: [0.000, 0.000]
### Planimetric Skew: 0.000
### Planimetric RMSE: 0.000
### Planimetric NMAS/VMAS Accuracy (95% CI): ±0.000
### Planimetric ASPRS/NSDDA Accuracy (95% CI): ±0.000
### Accuracy Class: ------

### GoPro Results

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<tr>
<td>X RMSE</td>
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<tr>
<td>X NMAS/VMAS Accuracy (95% CI)</td>
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<td>X ASPRS/NSDDA Accuracy (95% CI)</td>
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<tr>
<td>Y Skew</td>
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<tr>
<td>Y RMSE</td>
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<tr>
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</tr>
<tr>
<td>Y ASPRS/NSDDA Accuracy (95% CI)</td>
<td>±0.000</td>
</tr>
<tr>
<td>Y Accuracy Class</td>
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### Planimetric Error Mean: 0.000
### Planimetric Error Range: [0.000, 0.000]
### Planimetric Skew: 0.000
### Planimetric RMSE: 0.000
### Planimetric NMAS/VMAS Accuracy (95% CI): ±0.000
### Planimetric ASPRS/NSDDA Accuracy (95% CI): ±0.000
### Accuracy Class: ------

### R10C Results

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<tr>
<td>X Skew</td>
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<tr>
<td>X RMSE</td>
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<tr>
<td>X NMAS/VMAS Accuracy (95% CI)</td>
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<tr>
<td>X ASPRS/NSDDA Accuracy (95% CI)</td>
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<td>X Accuracy Class</td>
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<td>Y Skew</td>
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<tr>
<td>Y ASPRS/NSDDA Accuracy (95% CI)</td>
<td>±0.000</td>
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<tr>
<td>Y Accuracy Class</td>
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### Planimetric Error Mean: 0.000
### Planimetric Error Range: [0.000, 0.000]
### Planimetric Skew: 0.000
### Planimetric RMSE: 0.000
### Planimetric NMAS/VMAS Accuracy (95% CI): ±0.000
### Planimetric ASPRS/NSDDA Accuracy (95% CI): ±0.000
### Accuracy Class: ------

### Vertical Error Mean: 1.59
### Vertical Error Range: [-0.839, 1.481]
### Vertical Skew: 1.173
### Vertical RMSE: 0.527
### Vertical NMAS/VMAS Accuracy (95% CI): ±0.867
### Vertical ASPRS/NSDDA Accuracy (95% CI): ±1.084
### Vertical Accuracy Class: 0.53
### Vertical Min Contour Interval: 1.59

### Vertical Error Mean: -0.021
### Vertical Error Range: [-0.335, 0.171]
### Vertical Skew: 0.057
### Vertical RMSE: 0.310
### Vertical NMAS/VMAS Accuracy (95% CI): ±0.510
### Vertical ASPRS/NSDDA Accuracy (95% CI): ±0.608
### Vertical Accuracy Class: 0.32
### Vertical Min Contour Interval: 0.96

### Vertical Error Mean: -0.062
### Vertical Error Range: [-0.258, 0.100]
### Vertical Skew: 0.098
### Vertical RMSE: 0.132
### Vertical NMAS/VMAS Accuracy (95% CI): ±0.223
### Vertical ASPRS/NSDDA Accuracy (95% CI): ±0.268
### Vertical Accuracy Class: 0.14
### Vertical Min Contour Interval: 0.42
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.
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.
<table>
<thead>
<tr>
<th>Surface</th>
<th># Points</th>
<th>Cut (Cu. Ft.)</th>
<th>Fill (Cu. Ft.)</th>
<th>Net Diff. (Cu. Ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile Lines</td>
<td>7,589</td>
<td>4207225.611</td>
<td>2016795.71</td>
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<td>Drone2Map</td>
<td>445,492,843</td>
<td>6285711.208</td>
<td>475396.716</td>
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<tr>
<td>Variance</td>
<td>5870144.34%</td>
<td>49.40%</td>
<td>-76.43%</td>
<td>165.26%</td>
</tr>
</tbody>
</table>
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

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

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
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.
Business Comparison

• Jetty Profile:
  - UAS vs. Conventional Survey
    - Accuracy - Unattainable through conventional survey methods
    - Cost - N/A
    - Time - N/A
  
  • UAS vs. Terrestrial LiDAR on a Survey boat
    - Accuracy - UAS is within 2 cm of LiDAR specifications
    - Cost - UAS is ~300% less expensive for competitive project
    - Time - Similar coverage, faster mobilization, collect & processing

• UAS vs. Aerial LiDAR
  - Accuracy - UAS is within 2 cm of LiDAR specifications
  - Cost - UAS is ~400% less expensive for competitive project
  - Time - Similar coverage, faster mobilization & processing
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.
Business Comparison

• **Cell Profile:**

  • UAS vs. Conventional Survey
    - **Accuracy** - UAS is within 4 cm on control points
    - **Cost** - UAS is 80% less expensive for competitive project
    - **Time** - UAS captures greater detail in less time

  • UAS vs. Terrestrial LiDAR with internal setups
    - **Accuracy** – N/A (Inadequate ground stability)
    - **Cost** – N/A
    - **Time** – N/A

• **UAS vs. Aerial LiDAR**

  - **Accuracy** - UAS is within 2 cm of LiDAR specifications
  - **Cost** - UAS is ~200% less expensive for competitive project (size)
  - **Time** - Similar coverage, faster mobilization & processing
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
The Grand Conceptor Award was presented for a proof of concept (POC) by McKim & Creed and Esri. The purpose was to determine if unmanned aerial system technology (UAS/drones) can provide coastal communities with a faster, more cost-effective way to produce beach monitoring surveys. These surveys are typically conducted twice a year—before and after hurricane season—and are used to 1) analyze a beach’s performance in terms of erosion and accretion, 2) plan and predict maintenance and renourishment activities and 3) secure emergency funding for restoration. The POC showed that municipalities can save up to 60% in time and money by using UAS for data collection.