# U-2412A UCS-741A

## Summary of Project Area, Survey, & Flight

**Project**

- SR 1486/ SR 4121 (Jamestown Parkway) from I-74 to west of SR 1480 (Vickrey Road) in Guilford County

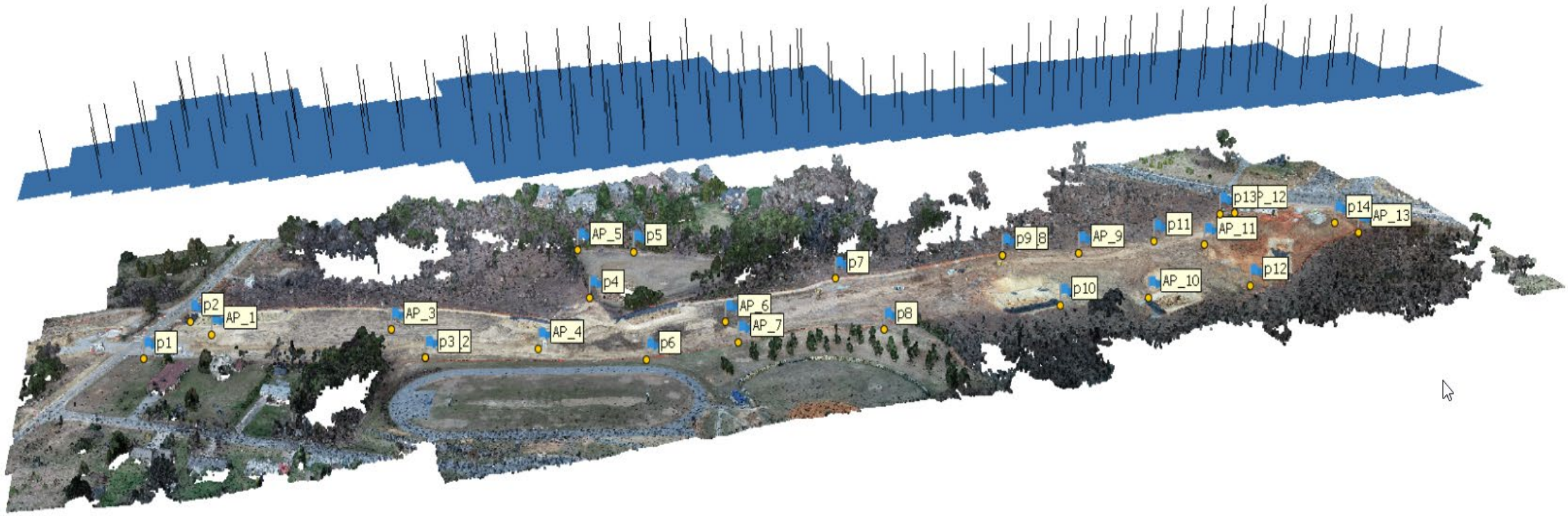
**Image Acquisition**

- ucs-741a, DOP 03/07/19, DJI Inspire 2 Drone, DGI Zenmuse X4s camera, FL 8.8 mm, flying height 400ft AMGL
- flown long axis with a west/east direction of flight with nominal 0.116 ft GSD
- weather conditions were overcast, cool, and minimal wind
- manned aircraft flight – cs-741a, DOP 03/07/19, Vexcel UltraCam Eagle M3 camera

**Survey/Control**

- GNSS exposure station data available via GeoCue Loki ASP system
- horizontal datum NAD 1983 (Conus), vertical datum NAVD 88, geoid G12NC, Hawthorne Reset localization point
- no control issues

# Project Graphic with Image Background




- March 07, 2019 UAS Flight (UCS-741A)
- Long axis (west/east) oriented nadir flight lines
- 143 images (planned 80% forward and side overlap)

# Ground Control Points and Checkpoints Locations


- Orthophoto with 6 field surveyed ground control points, 21independent checkpoints consisting of Aeropoints and field surveyed checkpoints, exposure stations, & original project boundary

# Classified Point Cloud Boundary

*( from 03-07-19 UAS Flight)*

Classified Point Cloud Boundary = 16.2 Acres

Void Areas are Indicated in Pink

# Image Alignment Results

## Independent Checkpoint Accuracy 6 GCP Only

| | Point ID | X error (ft) | Y error (ft) | Z error (ft) |
|---|---|---|---|---|
| No. Points = | | 21 | 21 | 21 |
| Min (ft) = | | -0.055 | -0.100 | -0.316 |
| Max (ft) = | | 0.121 | 0.120 | 1.139 |
| Mean (ft) = | | 0.041 | -0.004 | 0.329 |
| Std Dev (ft) = | | 0.045 | 0.053 | 0.478 |
| RMSE (ft) = | | 0.060 | 0.052 | 0.571 |
| FVA (ft) = | | | | 1.120 |
| RMSE R (ft) = | | 0.080 | | |
| Case 1 95% CE(ft) = | | 0.138 | | |
| Case 2 ~ CE(ft) = | | 0.137 | | |

No GNSS Block Shift applied

## Independent Checkpoint Accuracy 6 GCP + Exposure Stations

| | Point ID | X error (ft) | Y error (ft) | Z error (ft) |
|---|---|---|---|---|
| No. Points = | | 21 | 21 | 21 |
| Min (ft) = | | -0.122 | -0.253 | -0.260 |
| Max (ft) = | | 0.177 | 0.111 | 0.313 |
| Mean (ft) = | | 0.029 | -0.019 | 0.039 |
| Std Dev (ft) = | | 0.095 | 0.081 | 0.153 |
| RMSE (ft) = | | 0.097 | 0.082 | 0.154 |
| FVA (ft) = | | | | 0.302 |
| RMSE R (ft) = | | 0.127 | | |
| Case 1 95% CE(ft) = | | 0.220 | | |
| Case 2 ~ CE(ft) = | | 0.219 | | |

GNSS Block Shift applied
(0.215 ft, -0.196 ft, -0.553 ft)

# Dense Point Cloud Accuracy Results

## Vertical RMS Summary Statistics for Check Points using Classified Point Cloud

The following table provides a summary of the vertical RMS statistics for all Check point measurements taken from the classified Point Cloud data.

| Check Point RMS Statistics | | | |
|---|---|---|---|
| **Parameter** | **X residual** | **Y residual** | **Z residual** |
| Number of Points | | | 15 |
| Maximum (ft.) | | | 0.178 |
| Minimum (ft.) | | | -0.226 |
| Mean (ft.) | | | -0.044 |
| Standard Deviation (ft.) | | | 0.120 |
| RMSE (ft.) | | | 0.123 |
| 95% Accuracy (ft) | | | 0.242 |
| 99.74% Accuracy (ft) | | | 0.370 |

76,123,580 points for 16.2 acres

Classified Point Cloud Boundary from 03-07-20 UAS Flight

Point Cloud Generation Process is fully automated so whatever is shown in imagery is captured

# 1-Foot DEM Accuracy Results

## Vertical RMS Summary Statistics for Check Points using 1-foot DEM

The following table provides a summary of the vertical RMS statistics for all Check point measurements taken from the 1-foot DEM data.

| Check Point RMS Statistics | | | |
|---|---|---|---|
| Parameter | X residual | Y residual | Z residual |
| Number of Points | | | 15 |
| Maximum (ft.) | | | 0.153 |
| Minimum (ft.) | | | -0.187 |
| Mean (ft.) | | | -0.034 |
| Standard Deviation (ft.) | | | 0.105 |
| RMSE (ft.) | | | 0.107 |
| 95% Accuracy (ft) | | | 0.209 |
| 99.74% Accuracy (ft) | | | 0.320 |

647,213 points for 16.2 acres

Classified Point Cloud Boundary from 03-07-19 UAS Flight

Point Cloud Generation Process is fully automated so whatever is shown in imagery is captured

# 2.5-Foot DEM Accuracy Results

## Vertical RMS Summary Statistics for Check Points using 2.5-foot DEM

The following table provides a summary of the vertical RMS statistics for all Check point measurements taken from the 2.5-foot DEM data.

| Check Point RMS Statistics | | | |
|---|---|---|---|
| **Parameter** | **X residual** | **Y residual** | **Z residual** |
| Number of Points | | | 15 |
| Maximum (ft.) | | | 0.261 |
| Minimum (ft.) | | | -0.165 |
| Mean (ft.) | | | 0.037 |
| Standard Deviation (ft.) | | | 0.126 |
| RMSE (ft.) | | | 0.127 |
| 95% Accuracy (ft) | | | 0.250 |
| 99.74% Accuracy (ft) | | | 0.382 |

103,523 points for 16.2 acres

Classified Point Cloud Boundary from 03-07-19 UAS Flight

Point Cloud Generation Process is fully automated so whatever is shown in imagery is captured

# Summary of Earthwork Quantities

*(Volume Boundary with Voids from 03-07-19 UAS Flight)*

**Summary of Earthwork Quantities**

U-2412A ucs-741a Cut Quantities for 13.94 Acre Terrain Data Boundary

(as Compared to Original DTM collected from Manned Aircraft Mission)

| Comparison DTM | Mission Date | Point Spacing (ft) | Voided Areas Excluded | Cut (cubic yards) |
|---|---|---|---|---|
| UAS Mission UCS-741A | 03/07/2019 | 2.5 | Yes | 804.385 |
| UAS Mission UCS-741A | 03/07/2019 | 1 | Yes | 809.426 |

# Manned Flight DTM Accuracy Results

## Vertical RMS Summary Statistics for Check Points using Manned Flight DTM

The following table provides a summary of the vertical RMS statistics for all Check point measurements taken from the Manned Flight DTM data.

| Check Point RMS Statistics | | | |
|---|---|---|---|
| **Parameter** | **X residual** | **Y residual** | **Z residual** |
| Number of Points | | | 15 |
| Maximum (ft.) | | | 0.421 |
| Minimum (ft.) | | | -0.380 |
| Mean (ft.) | | | 0.053 |
| Standard Deviation (ft.) | | | 0.220 |
| RMSE (ft.) | | | 0.219 |
| 95% Accuracy (ft) | | | 0.429 |
| 99.74% Accuracy (ft) | | | 0.657 |

Manned flight DTM has break lines and a 10’ grid spacing for points

# Vertical RMS Summary Statistics for Check Points using ISDM Stereo View at 60 Degrees

The following table provides a summary of the vertical RMS statistics for all check point stereoscopic measurements using a base to height ratio near 0.30 for manned flight stereo pairs with a 60% overlap.

| Check Point RMS Statistics | | | |
|---|---|---|---|
| **Parameter** | **X residual** | **Y residual** | **Z residual** |
| Number of Points | | | 15 |
| Maximum (ft.) | | | 0.076 |
| Minimum (ft.) | | | -0.113 |
| Mean (ft.) | | | -0.010 |
| Standard Deviation (ft.) | | | 0.059 |
| RMSE (ft.) | | | 0.058 |
| 95% Accuracy (ft) | | | 0.113 |
| 99.74% Accuracy (ft) | | | 0.174 |

# Summary Table of RMSE & 95% FVA

| Platform | Camera Size & Type | No. of Images | Date of Photography | Product | No. of Independent Check Points | RMSE Z (ft) | FVA (ft) |
|---|---|---|---|---|---|---|---|
| UAS | 20 Mpixel non-metric | 160 | 2/4/2020 | AT (GCP only) | 21 | 0.571 | 1.120 |
| | | | | AT (GCP+ GNSS) | 21 | 0.154 | 0.302 |
| UAS | 20 Mpixel non-metric | 160 | 2/4/2020 | **2 Image Stereo Measurement (80% FOL) | 15 | N/A | N/A |
| | | | | **2 Image Stereo Measurement (60% FOL) | 15 | N/A | N/A |
| Manned Aircraft | 450 Mpixel metric | 4 | 1/28/2020 | 2 Image Stereo Measurement (60% FOL) | 15 | 0.058 | 0.113 |
| UAS | 20 Mpixel non-metric | 160 | 2/4/2020 | Dense Point Cloud | 15 | 0.123 | 0.242 |
| | | | | 1 feet DEM* | 15 | 0.107 | 0.209 |
| | | | | 2.5 foot DEM* | 15 | 0.127 | 0.250 |
| Manned Aircraft | 450 Mpixel metric | 4 | 1/28/2020 | DTM* ( breaklines & 10 foot spaced points) | 15 | 0.219 | 0.429 |

*Standard delivery products (note 2.5 foot DEM may exceed CADD software limits due to number of points)

** AgiSoft Metashape software was used to process the UAS data and it has no 2 image stereo measurement capabilities

# U-2412A Original Flight

## Conclusions

- Target RMSE accuracy values are an X and Y (Easting & Northing) of 0.12 ft and Z (Elevation) of 0.18 ft. The image alignment (aerotriangulation) results using 6 ground control points and GNSS PPK camera station positions yielded RMSE values of 0.097 ft in X, 0.082 ft in Y, and 0.154 ft in Z, all well below the target accuracy values.
- The 1 ft DEM contains 625% more points than the 2.5 ft DEM, thus making the 2.5 ft DEM file size much smaller and more manageable. With a cut difference of only 5.04 cubic yards between the 1 ft DEM and 2.5 ft DEM over 16.2 acres one can conclude that the 2.5 ft DEM is dense enough data to provide for accurate volumetric calculations and comparisons and the 1 ft DEM is not necessary.
- The 2.5 ft UAS DEM has a lower RMSE Z and FVA than the DTM collected from the Manned flight. The denser 2.5 ft DEM point interval captures the overall terrain better than the break lines and 10 ft point interval of the DTM.
- Since there is a limit to the amount of data that can be input into our CADD software, UAS imagery projects are not ideal for larger mapping areas.
- Projects best suited for utilizing UAS imagery should have cleared ground with little to no vegetation.