

# R-2530B Cyberdyne Pit

## Summary of Project Area, Survey, & Flight

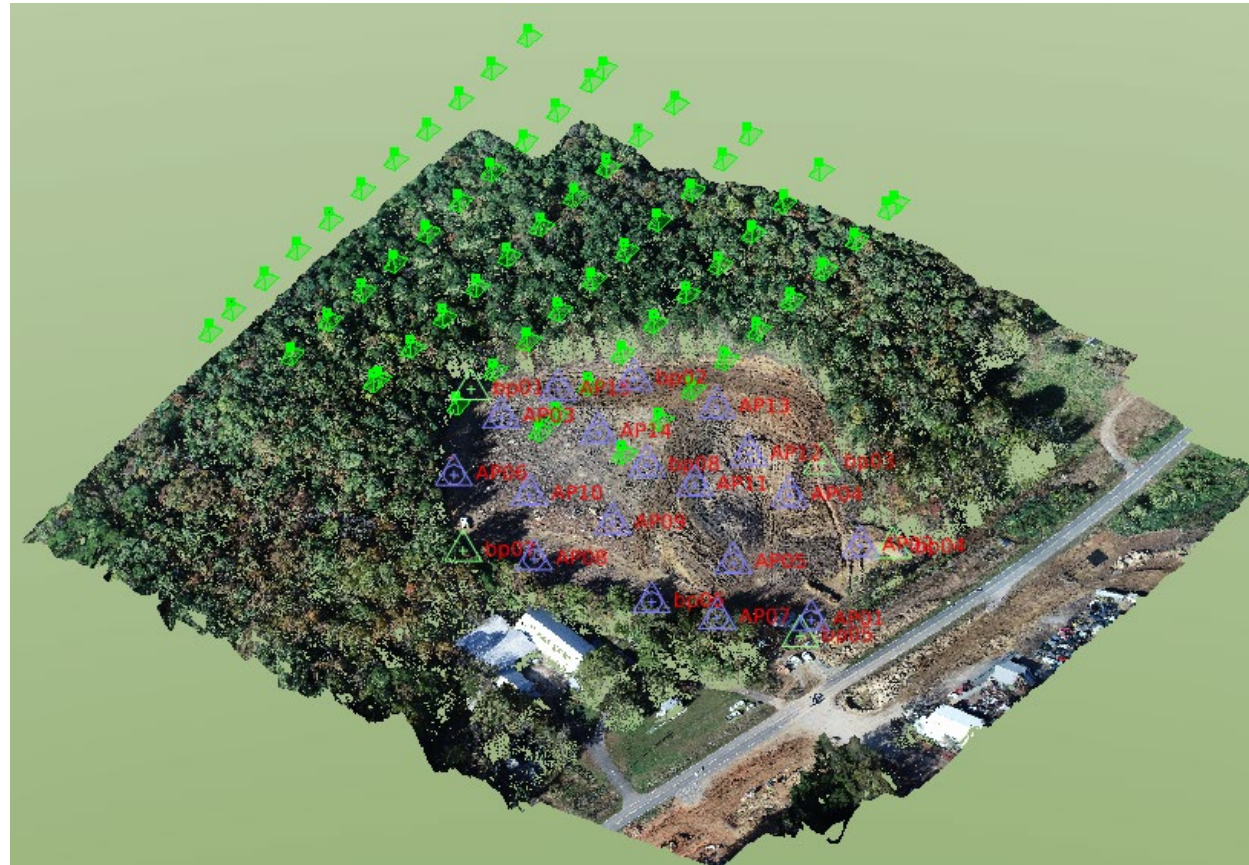
### Project

- Description: NC 24/27 Widening NC 740 to East of Pee Dee River in Stanly and Montgomery Counties.  
Cyberdyne Pit Original Flight

### Image Acquisition

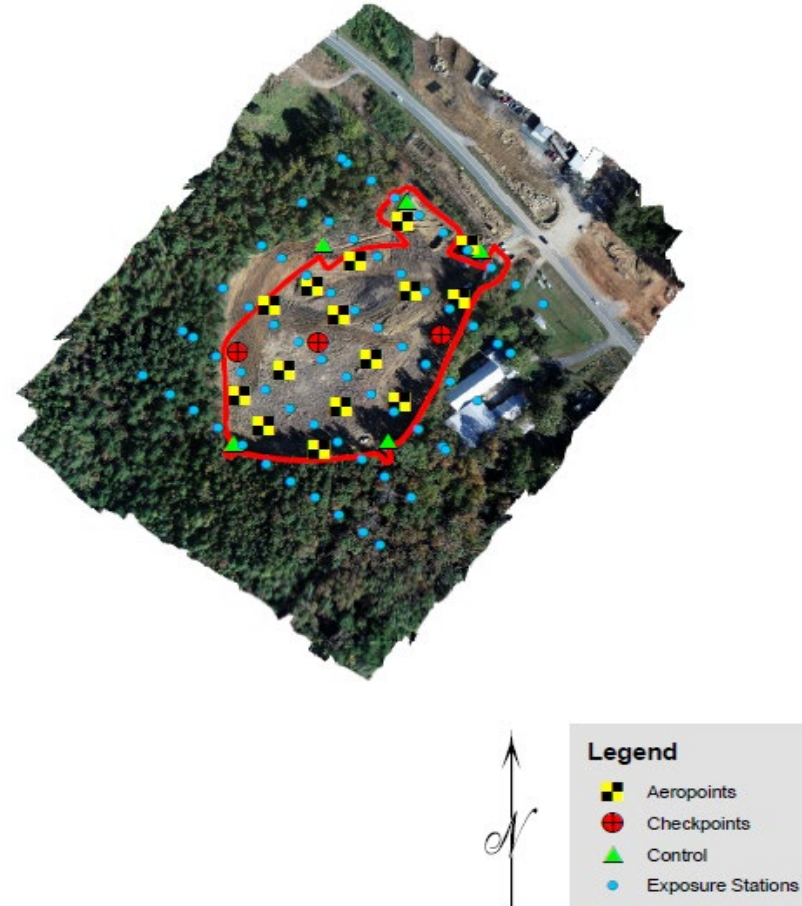
- ucs-748cp, DOP 10/20/20, DJI Inspire 2 Drone, DGI Zenmuse X4s camera, FL 8.8 mm, flying height 400ft AMGL
- short axis flown with a south/north direction of flight with nominal 0.117 ft GSD
- weather conditions were about 70 degrees, minimal clouds, winds about 5 mph
- manned aircraft flight – fi-748, DOP 10/19/20, 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 Geoid18 (Conus), R2527-6 localization point
- no control issues

## Project Graphic with Image Background



- October 20, 2020 UAS Flight (UCS-748CP)
- Short axis (south/north) oriented nadir flight lines
- 63 images (planned 80% forward and side overlap)

# Ground Control Points and Checkpoints Locations



- Orthophoto with 5 field surveyed ground control points, 18 independent checkpoints consisting of Aeropoints and field surveyed checkpoints, exposure stations, & original project boundary

## Classified Ground Boundary (*from 10-20-20 UAS Flight*)



Classified Ground Boundary = 4.21 Acres

Void Areas are Indicated in Pink

# Image Alignment Results

## Independent Checkpoint Accuracy 5 GCP Only

	Point ID	X error (ft)	Y error (ft)	Z error (ft)
<b>No. Points =</b>		18	18	18
<b>Min (ft) =</b>		-0.116	-0.134	-0.548
<b>Max (ft) =</b>		0.076	0.001	-0.010
<b>Mean (ft) =</b>		0.011	-0.082	-0.167
<b>Std Dev (ft) =</b>		0.050	0.034	0.132
<b>RMSE (ft) =</b>		0.050	0.089	0.211
<b>FVA (ft) =</b>				0.413
<b>RMSE R (ft) =</b>		0.102		
<b>Case 1 95% CE(ft) =</b>		0.176		
<b>Case 2 ~ CE(ft) =</b>		0.170		

## Independent Checkpoint Accuracy 5 GCP + Exposure Stations

	Point ID	X error (ft)	Y error (ft)	Z error (ft)
<b>No. Points =</b>		18	18	18
<b>Min (ft) =</b>		-0.239	-0.113	-0.414
<b>Max (ft) =</b>		-0.043	0.084	0.044
<b>Mean (ft) =</b>		-0.096	-0.015	-0.127
<b>Std Dev (ft) =</b>		0.052	0.047	0.108
<b>RMSE (ft) =</b>		0.108	0.048	0.165
<b>FVA (ft) =</b>				0.324
<b>RMSE R (ft) =</b>		0.119		
<b>Case 1 95% CE(ft) =</b>		0.205		
<b>Case 2 ~ CE(ft) =</b>		0.192		

No GNSS Block Shift applied



# 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			18
Maximum (ft.)			0.159
Minimum (ft.)			-0.506
Mean (ft.)			-0.146
Standard Deviation (ft.)			0.163
RMSE (ft.)			0.216
95% Accuracy (ft)			0.423
99.74% Accuracy (ft)			0.647

21,998,078 points for 4.21 acres

Classified Point Cloud Boundary  
from 10-20-20 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			I 18
Maximum (ft.)			0.163
Minimum (ft.)			-0.505
Mean (ft.)			-0.136
Standard Deviation (ft.)			0.161
RMSE (ft.)			0.207
95% Accuracy (ft)			0.406
99.74% Accuracy (ft)			0.622

182,925 points for 4.21 acres

Classified Point Cloud Boundary  
from 10-20-20 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			18
Maximum (ft.)			0.175
Minimum (ft.)			-0.529
Mean (ft.)			-0.122
Standard Deviation (ft.)			0.175
RMSE (ft.)			0.209
95% Accuracy (ft)			0.409
99.74% Accuracy (ft)			0.626

29,287 points for 4.21 acres

Classified Point Cloud Boundary  
from 10-20-20 UAS Flight

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



## Vertical RMS Summary Statistics for Check Points using UASMaster Stereo View at a Base to Height Ratio Near 0.15

The following table provides a summary of the vertical RMS statistics for all check point stereoscopic measurements using a base to height ratio of 0.15 or less for UAV stereo pairs with an 80% overlap (sensor dependent). A small base to height ratio demonstrates weakness in stereo measured vertical accuracies.

Check Point RMS Statistics			
Parameter	X residual	Y residual	Z residual
Number of Points			18
Maximum (ft.)			-0.635
Minimum (ft.)			1.142
Mean (ft.)			0.071
Standard Deviation (ft.)			0.482
RMSE (ft.)			0.474
95% Accuracy (ft)			0.929
99.74% Accuracy (ft)			1.421

## Vertical RMS Summary Statistics for Check Points using UASMaster Stereo View at a Base to Height Ratio Near 0.60

The following table provides a summary of the vertical RMS statistics for all check point stereoscopic measurements using a base to height ratio of, or very near 0.60 for UAV stereo pairs with an 20% overlap (sensor dependent), may include cross strip stereo pairs. A large base to height ratio demonstrates greater stereo measured vertical accuracies.

Check Point RMS Statistics			
Parameter	X residual	Y residual	Z residual
Number of Points			18
Maximum (ft.)			0.100
Minimum (ft.)			-0.447
Mean (ft.)			-0.166
Standard Deviation (ft.)			0.136
RMSE (ft.)			0.212
95% Accuracy (ft)			0.416
99.74% Accuracy (ft)			0.637

# Summary of Earthwork Quantities

*(Volume Boundary with Voids from 10-20-20 UAS Flight)*

R-2530B Cyberdyne Cut Quantities for 2.81 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-748CP	10/20/2020	2.5	Yes	354.337
UAS Mission UCS-748CP	10/20/2020	1	Yes	381.076

\*\*\*The original dtm from manned aircraft has a 10' grid spacing\*\*\*

Manned Aircraft Flight Mission (Fi-748) Date: 10-19-2020

UAS Flight Mission (UCS-748CP) Date: 10-20-2020



# 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			18
Maximum (ft.)			0.190
Minimum (ft.)			-0.614
Mean (ft.)			-0.067
Standard Deviation (ft.)			0.230
RMSE (ft.)			0.233
95% Accuracy (ft)			0.458
99.74% Accuracy (ft)			0.700

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			18
Maximum (ft.)			0.010
Minimum (ft.)			-0.310
Mean (ft.)			-0.163
Standard Deviation (ft.)			0.096
RMSE (ft.)			0.188
95% Accuracy (ft)			0.369
99.74% Accuracy (ft)			0.564

## 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)	18	0.211	0.413
				AT (GCP+ GNSS)	18	0.165	0.324
UAS	20 Mpixel non-metric	160	2/4/2020	**2 Image Stereo Measurement (80% FOL)	18	0.474	0.929
				**2 Image Stereo Measurement (20% FOL)	18	0.212	0.416
Manned Aircraft	450 Mpixel metric	4	1/28/2020	2 Image Stereo Measurement (60% FOL)	18	0.188	0.369
UAS	20 Mpixel non-metric	160	2/4/2020	Dense Point Cloud	18	0.216	0.423
				1 feet DEM*	18	0.207	0.406
				2.5 foot DEM*	18	0.209	0.409
Manned Aircraft	450 Mpixel metric	4	1/28/2020	DTM* ( breaklines & 10 foot spaced points)	18	0.233	0.458

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



# R-2530B Cyberdyne Borrow Pit

## 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 5 ground control points and GNSS PPK camera station positions yielded RMSE values of 0.108 ft in X, 0.048 ft in Y, and 0.165 ft in Z, all below the target accuracy values.
- On this project, the 2 image stereo measurements at 60% forward overlap taken on the Manned flight imagery indicate better RMSE Z and FVA values than both the 80% and 20% forward overlap image stereo measurements taken on the UAS imagery. Testing on other UAS project imagery also indicates 2 UAS image stereo measurements are not reliably accurate for earthwork determination.
- 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 26.74 cubic yards between the 1 ft DEM and 2.5 ft DEM over 2.1 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.