

**NORTH CAROLINA**

Department of Transportation

# NCDOT UAS Calibration and Validation Site

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Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina

## **Presentation Outline**

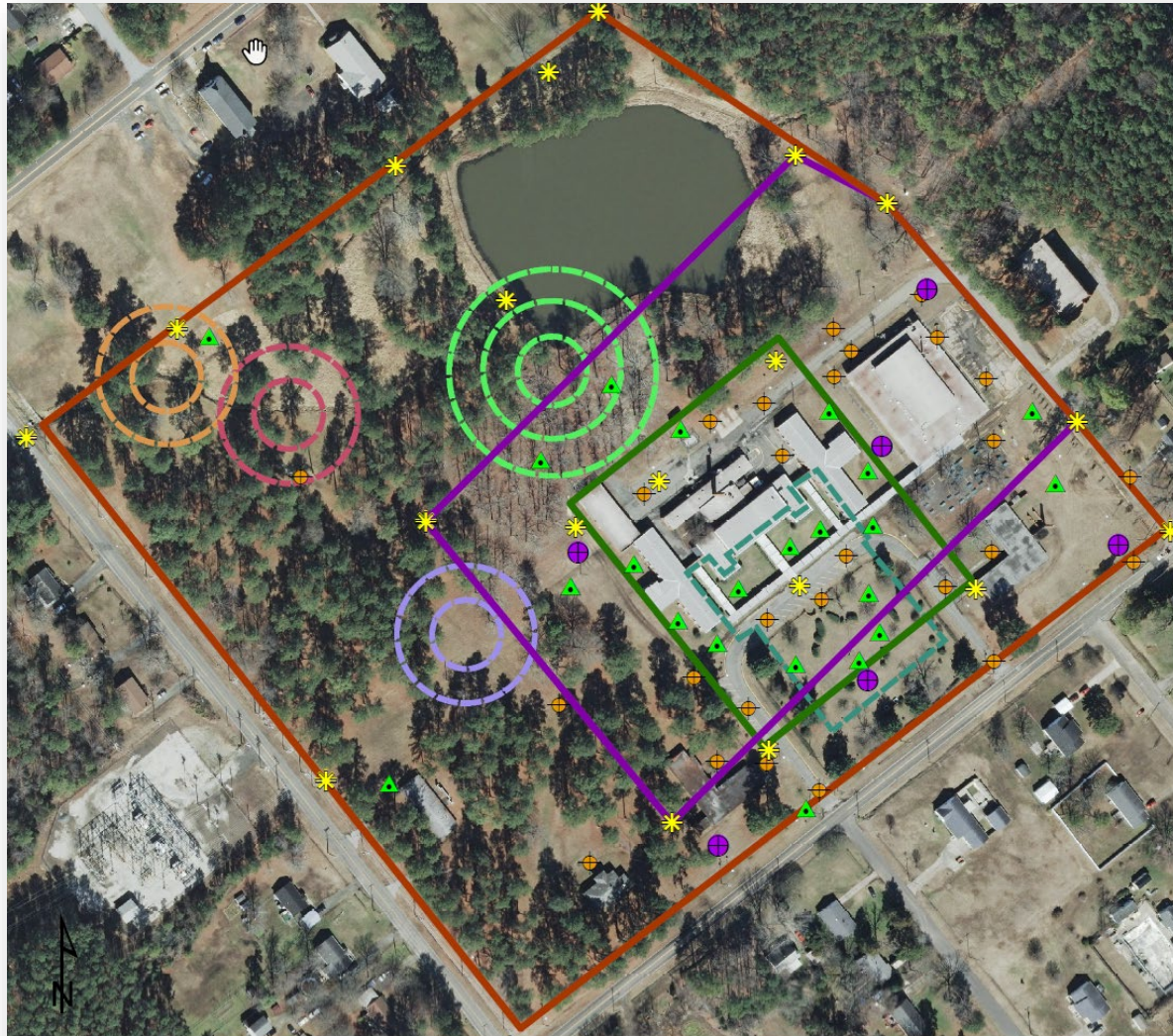
- Butner Test Site for UAS
  - Brief History
  - Site Layout
- Butner Use Cases
  - Calibration
  - Validation of hardware/software
- New Sanford Site
  - Butner Site – The end of an era
  - Site Layout and background
- Calibration, Validation, and Training
- Future Evaluation/Validation Sites
- Conclusion/Questions

## Butner Test Site

- Begin to establish Butner UAS Test Site in 2017
  - Site owned by the Department of Corrections
  - Coordination with NCDOT Photogrammetry, Location & Surveys, Aviation, and NCEM
  - Extensive ground surveys for evaluating geospatial products generated from non-metric cameras & LiDAR systems on UAS platforms



# Butner Test Site



## UAS Butner Test Site

- Control
- Project\_Control
- PHOTO\_ID\_XYZ\_Control
- Paneled\_XYZ\_Control

## Photogrammetry Missions Boundaries

- PH\_100ft
- PH\_200ft
- PH\_400ft

## Terrestrial Lidar

- Intersection of hydrologic features
- Ornamental Brick Structures and Building Facade
- Small stream feature
- Swale
- deciduous canopy with slope



## Butner Test Site

UAS Butner Test Site Check Point RMS Statistics  
NCDOT- 400 foot Flight Height  
Loki Exterior Orientation Only ( XYZ Wt. = 0.06')

Parameter	X residual	Y residual	Z residual
No. Points	67	67	73
Maximum (ft.)	0.876	0.079	1.622
Minimum (ft.)	-0.232	-0.843	-0.308
Mean (ft.)	0.299	-0.380	0.633
STD DEV (ft.)	0.241	0.211	0.409
RMSE (ft.)	0.383	0.434	0.752
95% Accuracy (ft.)	1.000	1.000	1.474
99.74% Accuracy (ft.)	1.500	1.500	2.256

UAS Butner Test Site Check Point RMS Statistics  
NCDOT- 400 foot Flight Height  
Loki Exterior Orientation Only ( XYZ Wt. = 0.06')  
Ground Control Points (Wt. = 0.03')  
(C301,C304, c311, C314, PID200)

Parameter	X residual	Y residual	Z residual
No. Points	62	62	68
Maximum (ft.)	0.380	0.152	1.245
Minimum (ft.)	-0.329	-0.801	-0.117
Mean (ft.)	0.058	-0.151	0.663
STD DEV (ft.)	0.130	0.174	0.305
RMSE (ft.)	0.141	0.229	0.729
95% Accuracy (ft.)	0.277	0.449	1.428
99.74% Accuracy (ft.)	0.424	0.686	2.186

400 foot AMGL

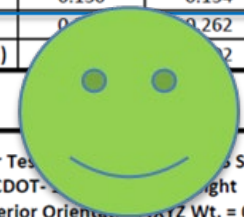
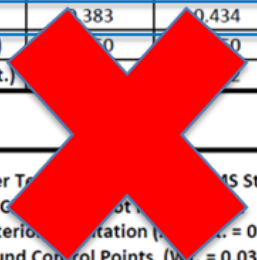
UAS Butner Test Site Check Point RMS Statistics  
NCDOT- 100 foot Flight Height  
Loki Exterior Orientation Only ( XYZ Wt. = 0.06')

Parameter	X residual	Y residual	Z residual
No. Points	33	33	35
Maximum (ft.)	0.116	0.248	0.529
Minimum (ft.)	-0.305	-0.310	-0.209
Mean (ft.)	-0.086	0.003	-0.030
STD DEV (ft.)	0.099	0.136	0.156
RMSE (ft.)	0.130	0.134	0.157
95% Accuracy (ft.)	0.260	0.262	0.307
99.74% Accuracy (ft.)	0.390	0.392	0.470

UAS Butner Test Site Check Point RMS Statistics  
NCDOT- 100 foot Flight Height  
Loki Exterior Orientation Only ( XYZ Wt. = 0.06')  
Ground Control Points (Wt. = 0.03')  
(C307,C308, c309, C316, C319)

Parameter	X residual	Y residual	Z residual
No. Points	28	28	30
Maximum (ft.)	0.018	0.253	0.425
Minimum (ft.)	-0.150	-0.105	-0.164
Mean (ft.)	-0.072	0.047	-0.019
STD DEV (ft.)	0.045	0.087	0.114
RMSE (ft.)	0.084	0.097	0.113
95% Accuracy (ft.)	0.165	0.191	0.222
99.74% Accuracy (ft.)	0.253	0.292	0.340

100 foot AMGL



## Butner Test Site

**Butner UAS Test Site Check Point RMS Statistics -  
NCDOT - Software #1  
(Acquisition Date: September 11, 2019)**

Parameter	X residual	Y residual	Z residual
No. Points	45	45	51
Maximum (ft)	0.243	0.458	0.596
Minimum (ft)	-0.266	-0.195	-0.246
Mean (ft)	0.014	0.060	0.177
STD DEV (ft)	0.095	0.132	0.190
RMSE (ft)	0.095	0.144	0.258
95% Accuracy (ft)	0.186	0.282	0.506
99.74% Accuracy (ft)	0.285	0.432	0.775

**Butner UAS Test Site Check Point RMS Statistics -  
NCDOT - Software #2  
(Acquisition Date: September 11, 2019)**

Parameter	X residual	Y residual	Z residual
No. Points	46	46	52
Maximum (ft)	0.350	0.334	0.336
Minimum (ft)	-0.544	-0.309	-0.383
Mean (ft)	-0.087	0.008	-0.105
STD DEV (ft)	0.160	0.148	0.160
RMSE (ft)	0.181	0.147	0.190
95% Accuracy (ft)	0.354	0.288	0.373
99.74% Accuracy (ft)	0.542	0.440	0.571

# Butner Test Site

## Unmanned Aircraft System (UAS) Sensor Validation for Land Surveying and LiDAR Butner Test Site

### Request for Unmanned Aircraft System (UAS) Sensor Validation

1. Vendor shall submit a written request (via email) for Unmanned Aircraft System (UAS) Sensor Validation to Keith Johnston (kjohnston@ncdot.gov) or Dale Burton (jburton@ncdot.gov) and provide the following information:
  - a. Company name
  - b. Requested date and time of test session
  - c. Type of Sensor Validation being requested
    - i. Camera Sensor
    - ii. LiDAR Sensor
    - iii. Camera and LiDAR Sensor
  - d. Pilot in Command (PIC) information
    - i. Full name
    - ii. Driver license's number and State issued
    - iii. FAA-issued Remote Pilot Certificate ID or other FAA-recognized Airman's Certificate ID with Small UAS Remote Pilot Rating
    - iv. UAS Knowledge Test Certificate ID
  - e. Aircraft information
    - i. Type of Aircraft
    - ii. N-number or FAA-issued UAS registration number
  - f. Sensor information
    - i. Make of Sensor
    - ii. Model of Sensor
  - g. Acknowledgement that the company has the proper credentials and insurance to pilot an Unmanned Aerial Vehicle (UAV)
    - i. Minimum General Liability Insurance \$1 Million per Incident

Vendor ID	Location	Point ID	Panel Type	SURVEY Easting NAD 83(2011) US Survey Feet (GRID)	SURVEY Northing NAD 83(2011) US Survey Feet (GRID)	SURVEY Orthometric Height NAVD88 US Survey Feet (GRID)	DATEM Stereo Easting NAD 83(2011) US Survey Feet	DATEM Stereo Northing NAD 83(2011) US Survey Feet	DATEM Stereo Orthometric Height NAVD88 US Survey Feet	X residual (ft)	Y residual (ft)	Z residual (ft)
NCDOT	Butner	P401	Paneled	2069107.400	867256.718	358.808	2069107.437	867256.837	358.319	-0.037	-0.119	0.489
NCDOT	Butner	P402	Paneled	2069045.566	867344.739	359.366	2069045.657	867344.851	359.188	-0.091	-0.112	0.178
NCDOT	Butner	P403	Paneled	2069399.525	867409.830	363.007	2069399.586	867409.946	362.753	-0.061	-0.116	0.254
NCDOT	Butner	P404	Paneled	2069384.548	867478.893	363.320	2069384.386	867478.932	363.002	0.162	-0.039	0.318
NCDOT	Butner	P405	Paneled	2069375.044	867196.954	361.156	2069375.199	867196.998	361.329	-0.155	-0.044	-0.173
NCDOT	Butner	P406	Paneled	2069279.614	867198.464	359.568	2069279.686	867198.548	359.498	-0.072	-0.084	0.070
NCDOT	Butner	P407	Paneled	2069196.347	867309.467	361.874	2069196.403	867309.455	361.549	-0.056	0.012	0.325
NCDOT	Butner	P408	Paneled	2069270.742	867371.397	362.268	2069270.883	867371.531	362.378	-0.141	-0.134	-0.110
NCDOT	Butner	P409	Paneled	2069315.537	867395.705	362.698	2069315.588	867395.63	362.434	-0.051	0.075	0.264
NCDOT	Butner	P410	Paneled	2069399.696	867245.532	361.914	2069399.8	867245.57	361.829	-0.104	-0.038	0.085
NCDOT	Butner	P411	Paneled	2069623.825	867565.855	367.131	2069623.921	867565.924	367.137	-0.096	-0.069	-0.006
NCDOT	Butner	P412	Paneled	206842								
NCDOT	Butner	P413	Paneled	206965								
NCDOT	Butner	P414	Paneled	206868								
NCDOT	Butner	P415	Paneled	206928								
NCDOT	Butner	P416	Paneled	206916								
NCDOT	Butner	P417	Paneled	206938								
NCDOT	Butner	P418	Paneled	206911								
NCDOT	Butner	P419	Paneled	206932								
NCDOT	Butner	P420	Paneled	206901								
NCDOT	Butner	P421	Paneled	206891								
NCDOT	Butner	P422	Paneled	206895								
NCDOT	Butner	PID200	Photo ID	206897								
NCDOT	Butner	PID201	Photo ID	206931								
NCDOT	Butner	PID202	Photo ID	206923								
NCDOT	Butner	PID203	Photo ID	206916								
NCDOT	Butner	PID204	Photo ID	206921								
NCDOT	Butner	PID205	Photo ID	206913								
NCDOT	Butner	PID206	Photo ID	206893								
NCDOT	Butner	PID207	Photo ID	206923								
NCDOT	Butner	PID208	Photo ID	2069216.069	867294.039	365.186	2069316.068	867293.974	365.12	0.063	0.065	0.066
NCDOT	Butner	PID209	Photo ID	2069251.879	867356.882	362.495	2069352.076	867356.921	362.486	-0.197	-0.039	0.009
NCDOT	Butner	PID210	Photo ID	2069495.471	867310.288	364.072	2069495.467	867310.199	364.207	0.004	0.089	-0.135
NCDOT	Butner	PID211	Photo ID	2069566.087	867203.470	365.091	2069565.928	867203.413	365.431	0.159	0.057	-0.340
NCDOT	Butner	PID212	Photo ID	2069563.452	867362.312	366.205	2069563.398	867362.106	366.076	0.054	0.206	0.129
NCDOT	Butner	PID213	Photo ID	2069769.394	867347.040	368.576	2069769.263	867346.936	368.72	0.131	0.104	-0.144
NCDOT	Butner	PID214	Photo ID	2069764.288	867470.304	369.705	2069764.269	867470.286	369.611	0.019	0.018	0.094
NCDOT	Butner	PID215	Photo ID	2069566.183	867523.250	366.703	2069566.143	867523.361	366.816	0.040	-0.111	-0.113
NCDOT	Butner	PID216	Photo ID	2069555.279	867613.735	364.984	2069555.303	867613.709	364.871	-0.024	0.026	0.113
NCDOT	Butner	PID217	Photo ID	2069484.638	867673.284	365.258	2069484.707	867673.42	365.345	-0.069	-0.136	-0.087
NCDOT	Butner	PID218	Photo ID	2069333.229	867685.095	356.899	2069333.202	867685.37	357.351	0.027	-0.275	-0.452
NCDOT	Butner	PID219	Photo ID	2069461.914	867735.203	359.891	2069461.978	867734.975	359.862	-0.064	0.228	0.029
NCDOT	Butner	PID220	Photo ID	2069359.329	867653.874	358.909	2069359.461	867653.655	358.818	-0.132	0.219	0.091
NCDOT	Butner	PID221	Photo ID	2069334.667	867616.686	364.922	2069334.581	867616.762	365.08	0.086	-0.076	-0.158
NCDOT	Butner	PID222	Photo ID	2069232.714	867577.216	361.870	2069232.809	867577.321	361.864	-0.095	-0.105	0.006
NCDOT	Butner	PID223	Photo ID	2069259.190	867501.462	362.774	2069259.137	867501.568	362.418	0.053	-0.106	0.356
NCDOT	Butner	PID224	Photo ID	2069154.618	867551.490	362.822	2069154.611	867551.533	362.673	0.007	-0.043	0.149

	No. Points			
	43		43	49
Max (ft)	0.162		0.446	0.610
Min (ft)	-0.222		-0.275	-0.452
Mean (ft)	-0.045		-0.011	0.062
Std Dev (ft)	0.092		0.138	0.200
RMSE (ft)	0.101		0.137	0.207
95% Accuracy	0.199		0.268	0.406
99.74% Accuracy	0.304		0.410	0.621

## Butner Test Site





## **Search for a new Test Site**

- Preferred New Site Criteria
  - Controlled access
  - Central to NC
  - Ability to visit site often
  - Maintenance of site
  - Diversity of features (buildings, towers, sheds, utilities, etc.), vegetation, road surface types (BST, concrete, gravel), & terrain relief
  - Large for fixed wing testing and evaluation

## Sanford Test Site

- Emergency Services Training Center
  - The Emergency Services Training Center is committed to providing accessible, high quality, and cost-effective emergency responder training in Emergency Medical Services, Firefighting, Technical Rescue, and Law Enforcement. Our programs strive to develop skilled responders, empowering them to act more effectively in emergency situations.
- Coordination with NCDOT Photogrammetry, Location & Surveys, Aviation, and NCEM

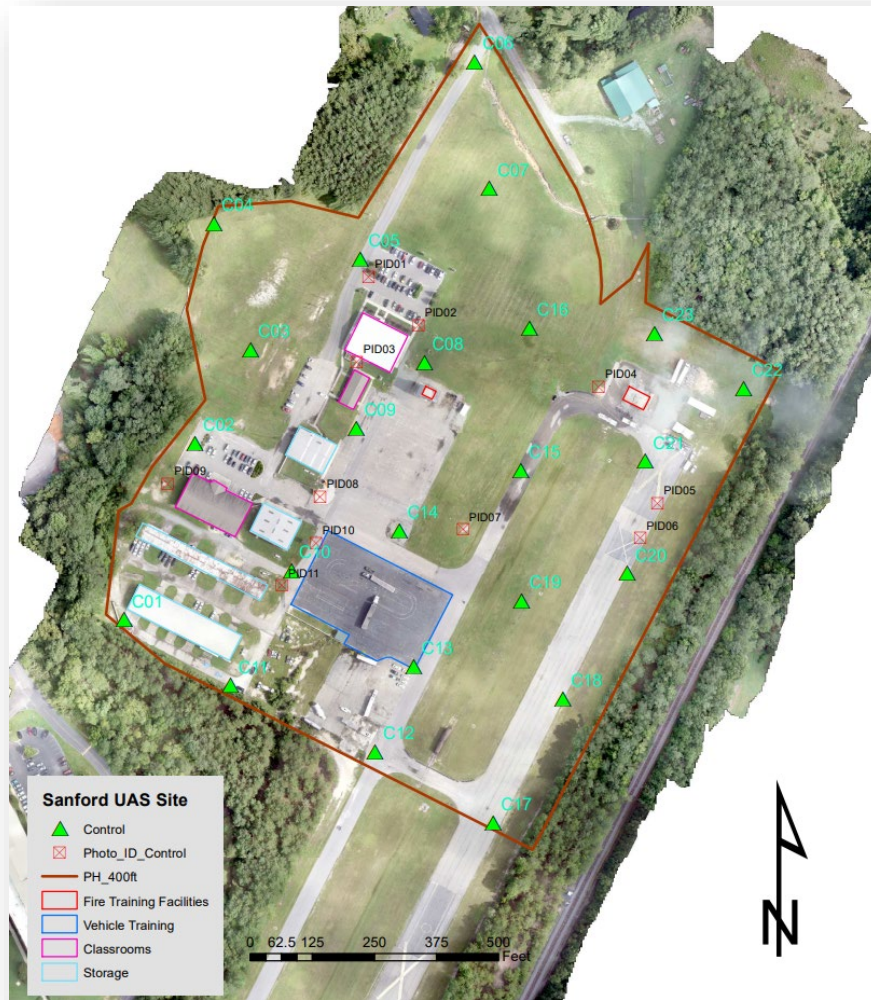


**Emergency Services Training  
Center (ESTC)**

## NEW Sanford Test Site



# NEW Sanford Test Site



## **NEW Sanford Test Site**

- Future Evaluation/Validation Sites
- Testing and Evaluation of new sensors and UAS platforms
- Testing of new geospatial products
- Artificial Intelligence and Machine Deep Learning
- Datasets from scanned mobile lidar, manned/crewed aircraft photogrammetry and lidar, terrestrial lidar, etc.
- Base line for instrument calibration

# Contact Us


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