

Unmanned Aircraft (drones) in Sediment and Erosion Control

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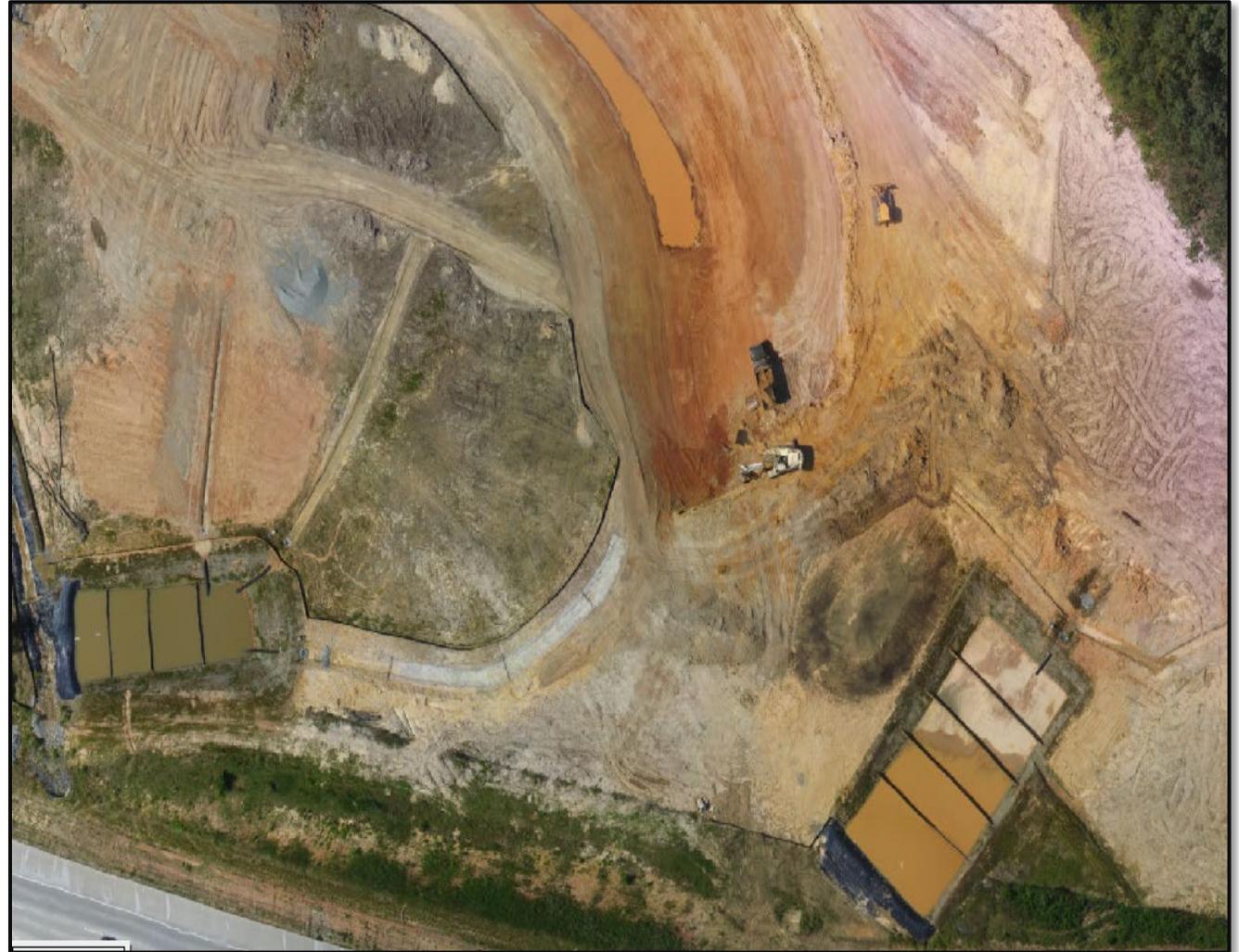


Why Drones in Sediment and Erosion Control?

1. New Perspective
2. Relatively low-cost
3. High Spatial Resolution
4. Greater Temporal Resolution
- Information 'On-Demand'

Specific To Erosion Control

- Greater Efficiency
- Self-documenting
- Increased Safety



Interstate 540 – Off Ramp

Data Products from Drones

UAV's collect data that ranges from **Single Photographs** and **Video** to **Aerial Surveys** and **Digital Surface Models**.

- Single Photographs

advantages: Simple and no processing of image required

disadvantages: Difficult to make measurements, Limited Spatial Extent



East End Connector: NC147 to US 70



Rock Check Dam

UAV Produced Aerial Survey's

Drones are able to produce aerial survey's of larger areas by collecting many overlapping images. The individual images are later aligned and stitched together using photogrammetric software.

After Post-Processing in the software the aerial survey are

- Georeferenced
- Orthorectified



Single, overlapping photos aligned to create a larger aerial survey

NOTE: Software is available that automates the collection of aerial survey's

- determines a systematic flight path
- Calculates when to take pictures based on flight altitude and proper image overlap
- Develops flight plan and carries out mission in fully- automatous mode



UAV Derived Digital Surface Models (DSM)

By using a process called '*Structure from Motion*' a collection of **overlapping 2-dimensional images** can be used to **develop a 3-dimensional model** of a photographed object or landscape.

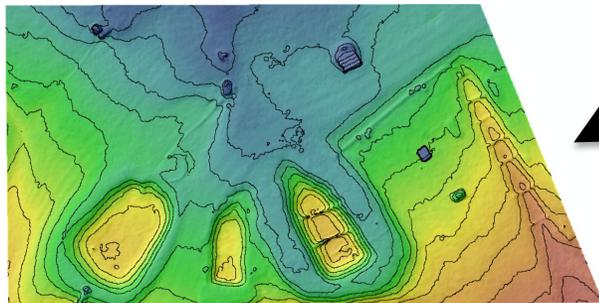
- Requires the same photogrammetric software as used in the development of aerial survey's



Set of 2D photographs



Resulting 3-D 'Point Cloud'



Digital Surface Model



UAV Applications: Documentation

- **Images** can act to **support** and **inform decisions**
 - what is happening when and where
 - Identify areas that require further inspection or maintenance
- Images as **Documentation**
 - Can provide legal protection or justification

*Images are geo-tagged,
but not georeferenced*



UAV Application: UAV-Aided Inspection of Sediment and Erosion Control Structures

- Weekly inspections (>1" rainfall)
- Quickly identify areas requiring a closer 'boot-on-the-ground' type inspection
- Provides real-time feedback
- Access hard-to-reach or 'hazardous' areas

Cover more area in less time, lower liability, improved documentation with greater legal protection



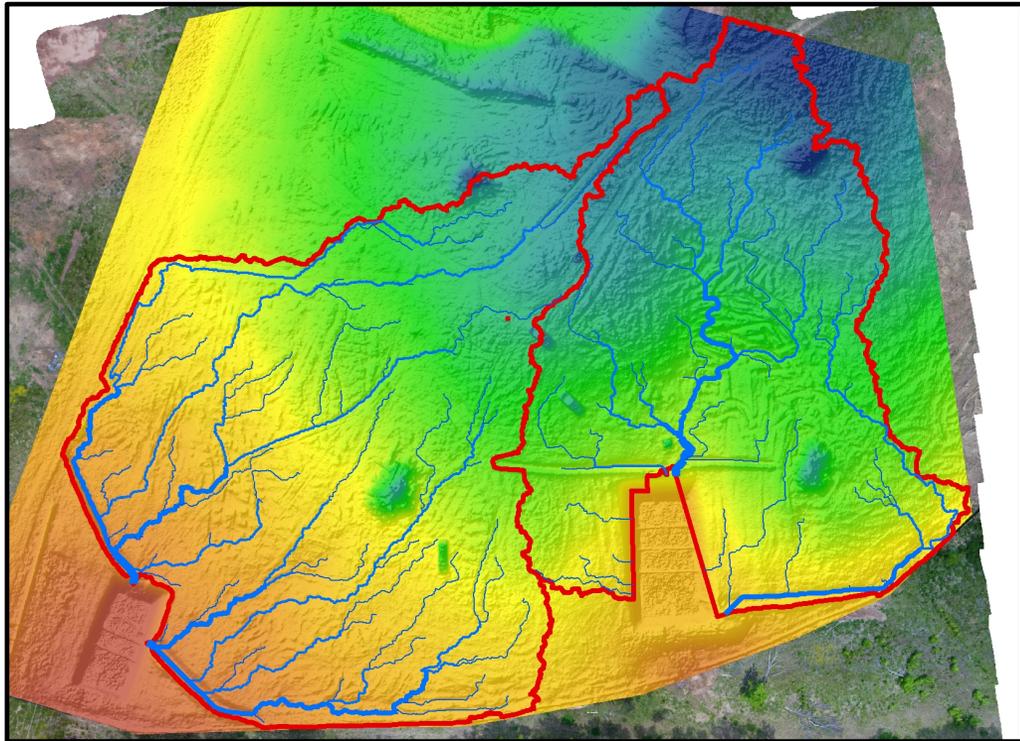
UAV Application: Monitoring Performance and Operation of Control Structures

- Monitor performance and operation over time
- Spot potential problems before violation
- Assign work orders and prioritize needs

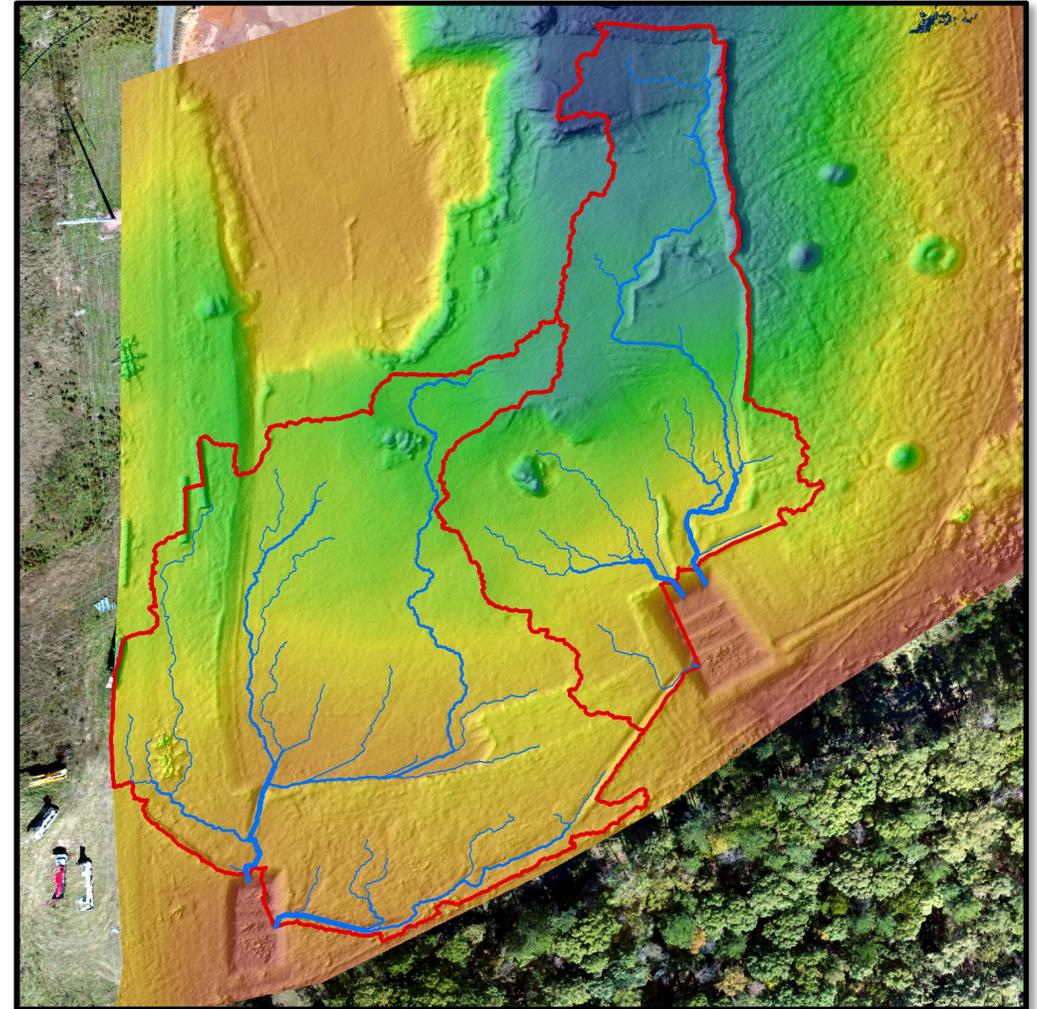


Modeling Overland Flow

- Monitor Changes During Construction
- Identify improper offsite discharge
- Direct efforts to high risk areas



April 2017



August 2017

Applications: Assessing Vegetation Establishment

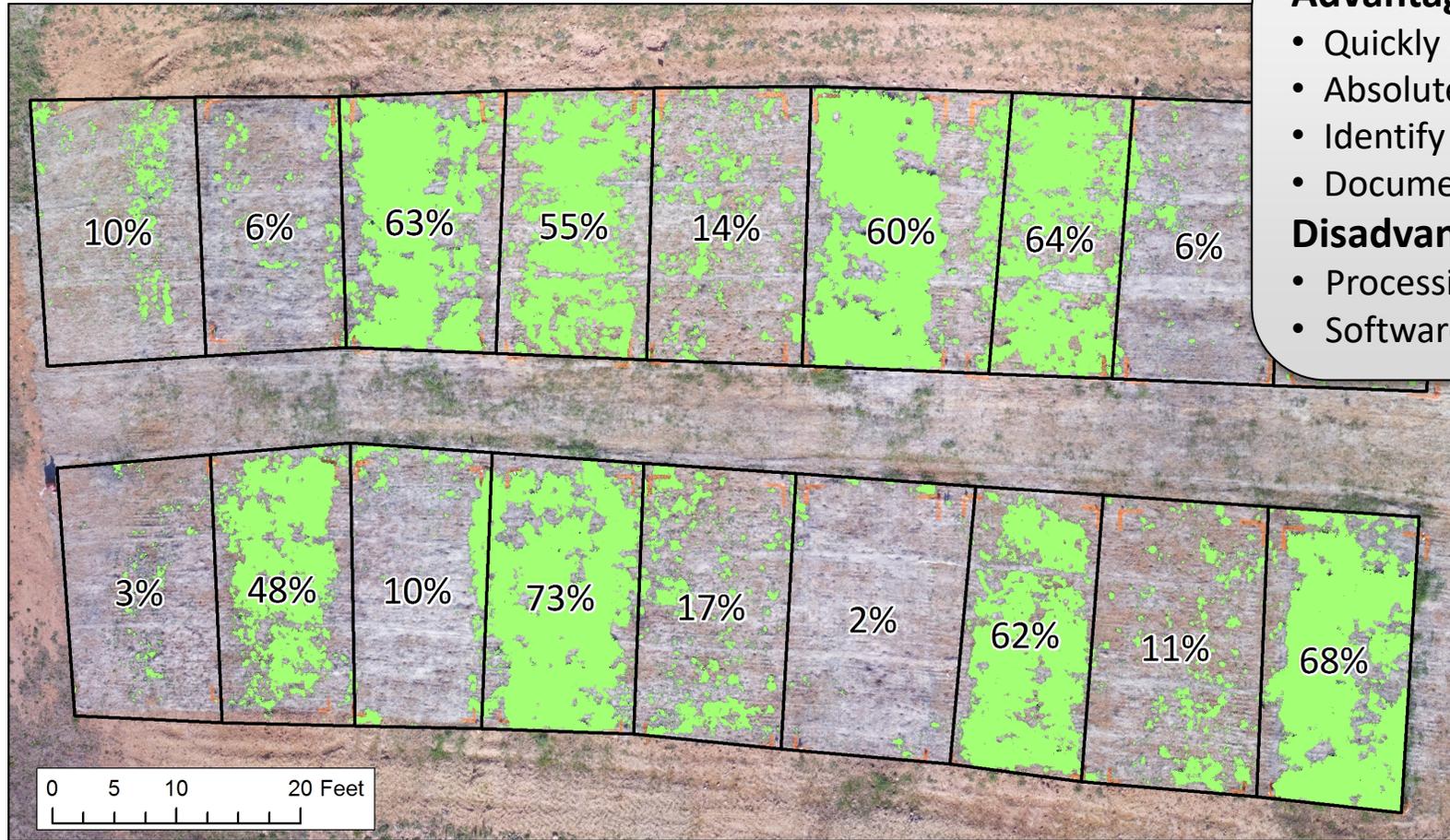
- Stabilize areas not brought to grade within 21 days.
 - 70% cover required within 14 days

Advantages:

- Quickly assesses large areas of vegetative cover
- Absolute measure versus qualitative estimate
- Identify harsh site conditions (mulching)
- Documented

Disadvantages:

- Processing time and effort
- Software cost and expertise

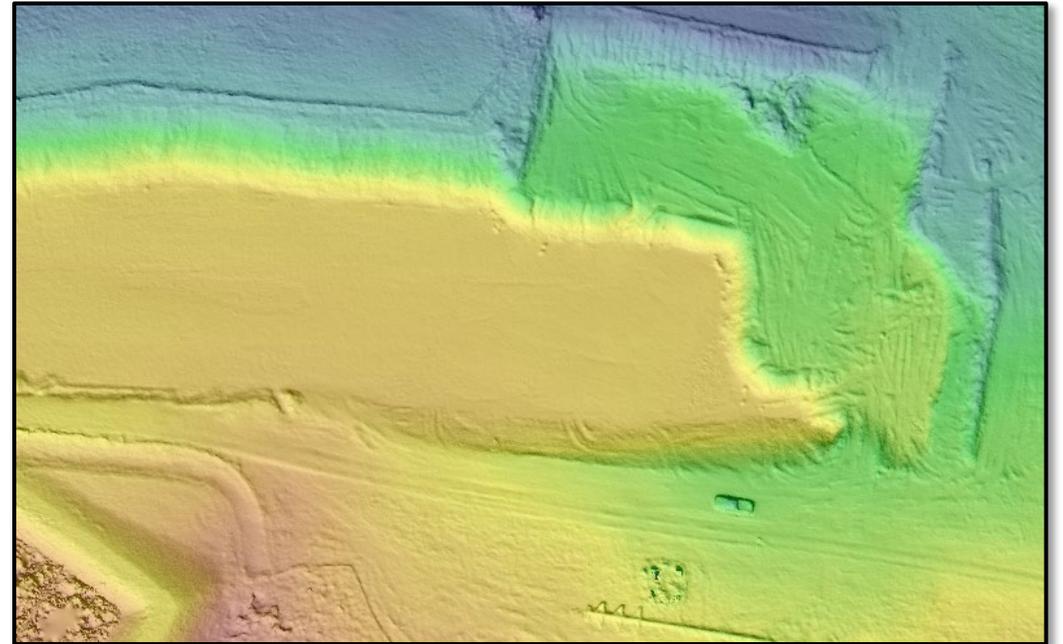


Material Volume Estimates

- Material in Stockpiles and Borrow pits
- Haul and Transport estimates



Borrow pits



Surface Elevation

Applications: Measuring Turbidity

- Sampling sediment turbidity basin using a drone



Part 107 Summary

Framework of regulations that would allow routine use of certain small unmanned aircraft systems (UAS) in today's aviation system. (finalized June 2016)

OPERATIONAL

- Aircraft less than 55 lbs
- **Visual Line of Sight only**
- Daylight only
- Max airspeed: 100 mph
- **Max altitude: 400' AGL**
- Requires preflight inspection
- No careless and reckless operations
- Visual Observer is optional
- 1 aircraft per 1 operator
- Aircraft registration # required

AIRCRAFT

- **Aircraft must not operate over anyone not involved in the operation**
- **Can fly in Class B,C,D and E airspaces with ATC permission**
- Can fly in Class G airspace without ATC permission
- No transportation of hazardous materials
- Transportation of products for compensation are allowed, under some stipulation

OPERATOR

- **Operator must pass an aeronautical knowledge test for small UAS**
- Operator is vetted by TSA
- Operator must report accident within 10 days
- Operator must be 16 years old minimum

Becoming a Remote Pilot in Command

Step 1: Schedule an appointment with a Knowledge Testing Center (KTC), which administers initial and recurrent FAA knowledge exams

Step 2: Study and Pass the test...
(study resources are available for free download from the FAA and many other sources)

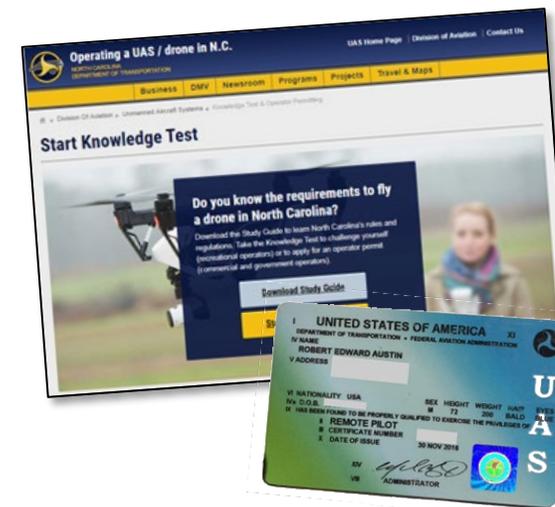
Step 3: Complete FAA Form 8710-13 for a remote pilot certificate using the electronic FAA Integrated Airman Certificate system (IACRA)

Step 4: TSA performs security background check and will send email to print a copy of the temporary remote pilot certificate from IACRA.

Step 5: Obtain your North Carolina License and Register your Drone with the FAA.



UAS Topics	Percentage of Items on Test
I. Regulations	15 – 25%
II. Airspace & Requirements	15 - 25%
III. Weather	11 – 16%
IV. Loading and Performance	7 – 11%
V. Operations	35 – 45%
Total Number of Questions	60



PART II: The Accuracy and Use of Unmanned Aircraft in Sediment and Erosion Control Inspections

By: Jalen Hairston

Background

- Under the Federal Water Pollution Control Act of 1972, construction sites have to provide erosion and sediment control systems.
- An Inspector document erosion and sediment controls and storm water discharge/devices every seven days.
- During inspection it can be difficult to document erosion and sediment controls (E&SCs) because of terrain, traffic, or environmental conditions.



Traffic issues while inspecting



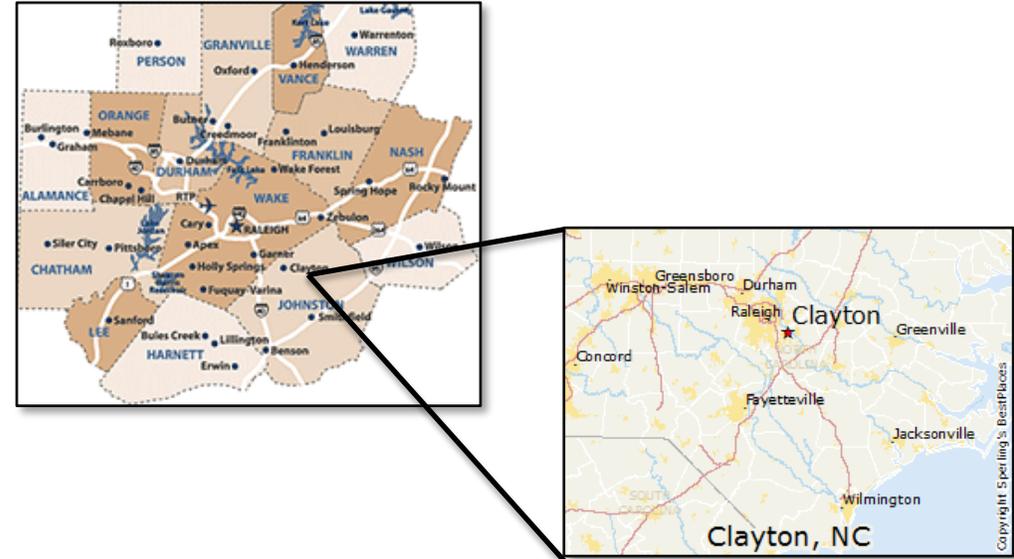
Storm drain outlet pipe discharge

Objectives

- Can unmanned aerial vehicles (UAVs) be an effective tool for site inspection?
- UAVs could aid on-foot and aerial inspection at a lower cost.
- Investigate UAVs applications that include estimating cut/fill volumes, flow directions, and sediment control device maintenance needs.
- *Accuracy of 'consumer-grade' UAVs vs. those with more advanced positioning technology (i.e. RTK) (and cost)?*

Study Site: NC Highway 42 East

- N.C. Department of Transportation (DOT) widening N.C. 42 to a four-lane highway.
- Initial area used for testing UAV accuracy and UAV-aided inspections.



Road Widening along NC Highway 42 East (June 05, 2019)

Testing UAV Accuracy: Ground Control Points

- A total of 15 control points were distributed throughout the site.
 - 7 check points were surveyed by DOT.
 - 8 check points were located using RTK-GPS.



Locating a control point using RTK-GPS



8 Checkered panels (2'x2') set at GPS surveyed locations and used into test accuracy of UAV aerial surveys



DOT survey location: spray paint used as identifying mark for visual identification in UAV imagery

Testing UAV Accuracy: UAV Platform and Survey Factors

- UAV-based aerial surveys conducted using **Mavic Pro Platinum** UAV.



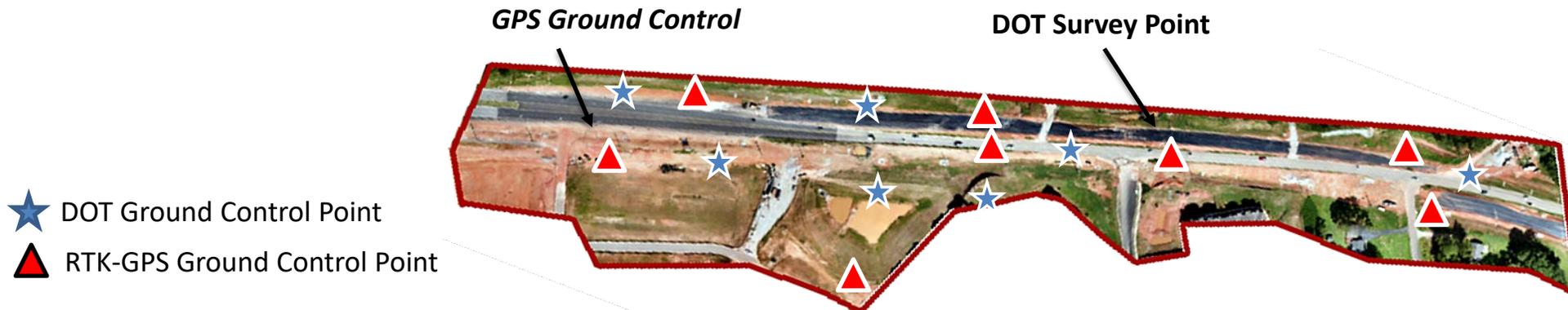
Mavic Pro Platinum flying over the site

- Missions setup to test the effects of **image overlap** and the inclusion/exclusion of **ground control points** during post-processing of the UAV-based aerial surveys

- Additional tests included 120m altitude and an RTK-enabled platform

Platform (UAV)	Altitude (meters)	Front x Side Overlap (%)
Mavic Pro Platinum	60	20%x20% 75%x60%

Flight Missions created to survey study site.



**UAV-based aerial survey
September 07, 2019.**

Preliminary Results: Accuracy of UAV-based Aerial Survey

- Photogrammetric software used to post process the aerial photos
- Software setup to process **with** or **without** the surveyed locations of the Ground Control Targets
 - Run with no Ground Control Targets
 - Run with either DOT, GPS, or both sets of Ground Control Targets
- Average Distance between the surveyed location and that of the Ground Control Targets used to determine the horizontal (and vertical) accuracy of aerial surveys. (*Root Mean Square Error*)
- Both surveyed or GPS located check points greatly improved the accuracy.

			UAV Platform: Mavic Pro Platinum				
			Ground Control Points	<i>DOT Survey</i>	<i>0</i>	<i>6</i>	<i>0</i>
			<i>GPS</i>	<i>0</i>	<i>0</i>	<i>8</i>	<i>8</i>
Check Points used in RMSE			<i>DOT Survey</i>	<i>6</i>	<i>0</i>	<i>6</i>	<i>6</i>
			<i>GPS</i>	<i>8</i>	<i>8</i>	<i>0</i>	<i>8</i>
Height 60m	Overlap 75%x60%	Check Point RMSE	Horizontal Accuracy (ft)	2.1	0.4	0.4	0.1
			Vertical Accuracy (ft)	46.1	0.9	0.3	0.4

Comparison between on-foot and UAV-aided Inspection

- Weekly on-foot inspections were compared to UAV-aided aerial inspections (photo reviews) .
- The erosion control plans were used to identify control structures in photos collected by the UAV



Objective: Identify failing or potential future failures using photographs from a UAV

Station	On-Foot Inspection Review(s)	Discrepancy captured via UAV (Yes/NO)	Comments
28+50	Sediments on rock-lined ditch	Yes	
29+80	Residents's driveway needs to be cleaned	Yes	
49+25	Dress area off of Fox Ridge Road	Yes	
29+75	Damaged rock inlet	Yes	
29+75	Clogged Slope Drain	No	UAV was unable to identify clogged slope drain.

Summary and Future

- Either surveyed or GPS-derived control points greatly reduced the error for the consumer-type UAV-derived check points.
 - Inspections by UAV appears to be feasible, with a number of advantages and disadvantages. Additional testing is needed with different inspectors on different sites.
 - Testing is underway to use Phantom 4 RTK* to determine if a higher technology (and cost) UAV can produce even greater accuracy.
 - Different flight paths at higher altitude will be implemented to see if higher coverage and reduced images can obtain similar results.
-
- *Real Time Kinematic surveying capability.

Questions?

North Carolina Erosion and Sediment Control Design Workshop

December 3, 2019



Please Remember to Complete the End of Workshop Evaluation

(separate from the PDH sponsor evaluation)

bit.ly/Raleigh2019-ESC-Eval