



# NORTH CAROLINA

Department of Transportation



# NCDOT: Hurricane Florence UAS Response Debrief and 2019 Planning Meeting

NCDOT Division of Aviation

July 2019



# Welcome

- Housekeeping
- Purpose
- Introductions
- Agenda



Purpose – Learn from the past and plan for the future



# Agenda Morning

0830 – 0900 Welcome, Introductions

0900 - 1030 Overview of NCDOT Hurricane  
Florence UAS Response

1030 – 1040 Break

1040 – 1120 – Teams Overview/Feedback

1120 – 1200 – Customer Feedback/Open  
Discussion

1200 – 1300 – Lunch - Photos

An aerial photograph of a flooded agricultural field. A road with a yellow dashed center line and white edge lines runs through the center of the field. The water is dark and reflects the sky. The surrounding area is green, suggesting crops. The sky is overcast and grey.

# Agenda Afternoon

1200 – 1300 – Lunch – Photos

1300 - 1320 – Overview of DPS Aviation/UAS  
Response Structure

1320 – 1350 – Safety Overview

1350 – 1435 – Data Management and Sharing

1435 – 1500 – Open Discussion & NC Drone  
Summit Overview

1500 – 1515 – Break – Conclusion for non-  
contractors

1515 – 1600 – Contracts Overview

# NC Team Awards & Recognition



# Hurricane Florence Response in the News

FEATURE

## DRONES AND DISASTERS: USING EYES IN THE SKY IN THE RIGHT WAY

By Brett Davis and Brian Sprowl



A week out from the arrival of Hurricane Florence in the Carolinas in September 2018, state officials knew they wanted to use drones to help deal with the flooded aftermath, but they didn't want to create chaos in the air. NCDOT has about 20 drone pilots with varying degrees of experience. Other state agencies have their own drones, including police and firefighters, and private support was also going to be called in from partners including Dronescope, North State Engineering, PrecisionHawk and SM&E. Then there was coordination with the National Guard, FEMA and the Federal Aviation Administration.

"The major thing for us was coordination," says Darshan Divakaran, the UAS program engineer at the North Carolina Department of Transportation's aviation division.

Divakaran's office became what he calls the "UAS champion," a sort of air boss coordinating the efforts of all these disparate players.

“THIS ISN'T A RIVER, IT'S A HIGHWAY” - NCDOT

UAS CORNER

## USING DRONES IN DISASTERS: NCDOT Hurricane Florence Response

By Darshan Divakaran, UAS Program Engineer, North Carolina Department of Transportation, Division of Aviation

The North Carolina Department of Transportation (NCDOT) tweet went viral: "This isn't a river, it's a highway."

The Sept. 17, 2018, Twitter post featured drone-captured video of a flooded interstate 40 near Wallace, NC. Spreading across social and news media outlets around the world, it revealed the extent and urgency of the crisis posed by Hurricane Florence.

Drones, or unmanned aircraft systems, are revolutionizing disaster response efforts and helping save lives and protect property. Aerial views of disaster areas have always been critical for disaster response. For the past several decades, manned aircraft and satellites have provided the vital images. But manned aircraft and satellites present several limitations, including cost, real-time update concerns, data sharing restrictions, cloud cover, and the operating time needed

to acquire images. In contrast, UAS can capture aerial imagery at a higher resolution, more quickly, more efficiently and lower cost.

North Carolina was devastated by Hurricane Florence in 2018. Cities were inaccessible by road. The state estimated \$1.7 billion in property damage and economic loss. North Carolina Governor Roy Cooper declared a state of emergency in anticipation of the hurricane's arrival. The severity of the predictions played a role in compelling NCDOT to launch its first drone response before Hurricane Florence made landfall. The event also marked the first time the area's public and private sector worked together in disaster response operations.

Unmanned aircraft technology proved to make a significant difference before, during and after the hurricane. The NCDOT Division of Aviation UAS Program Office clearly demonstrated its value, deploying 15 drone teams for more than 260 missions, providing more than 8,000 videos and images and live streaming data, and supporting agencies like the Federal Aviation Administration, NC Emergency Management, National Guard and FEMA.

The team provided other emergency response groups the following services:

- Communicated conditions to the public to navigate people off the roads.
- Monitored evacuation routes and



Flooded Interstate 40 near Wallace, NC

42 AIRBEAT MAGAZINE | May/June | 2019



December 12, 2018

### How Did the NCDOT Use Drones to Help Plan for and Recover from Hurricane Florence?

Jeremiah Karpowicz

Emergency Response & Search and Rescue



All images courtesy of NCDOT.

North Carolina Governor Roy Cooper declared a state of emergency on September 7, 2018, in anticipation of arrival of Hurricane Florence. The severity of the situation is part of what compelled the North Carolina Department of Transportation (NCDOT) to launch its UAS response well before Hurricane Florence reached the North Carolina coast. The difference the technology made before, during and after the hurricane proved to be substantial.

The difference UAV technology can make during these sorts of emergency situations is evident, since drones provide a unique capability of approaching, hovering, and observing transportation infrastructure from much closer distances than manned aircrafts. Much of the damage



# **NORTH CAROLINA**

Department of Transportation



# **NCDOT Hurricane Florence**

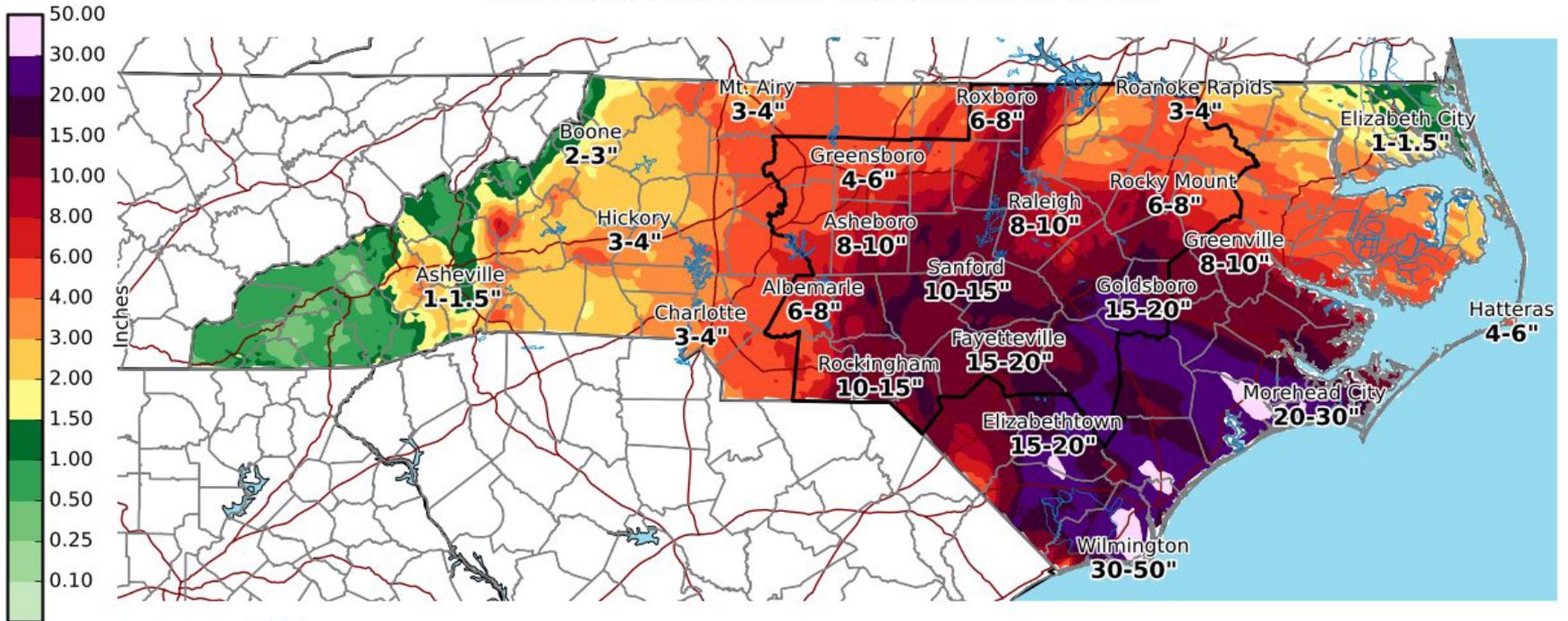
House Select Committee

Strategic Transportation Planning and Long Term Funding

10/3/2018

# Total Estimated Rainfall

**Radar-Estimated Florence Total Rainfall**  
Valid: 09/13/2018 08:00 AM - 09/17/2018 08:00 PM EDT



National Weather Service  
Raleigh, North Carolina  
09/18/2018 04:10 AM EDT

Follow Us:     
[weather.gov/raleigh](https://weather.gov/raleigh)

# For Reference

- Estimated 8 trillion gallons of rain = Over 1 trillion cubic feet
- Jordan Lake approx. 2 billion cubic feet in volume
- **Could fill Jordan Lake over 536 times**
- Current N.C. population = 10.27 million
- **Rained almost 779,000 gallons / person**



# NORTH CAROLINA

Department of Transportation



# NCDOT: Hurricane Florence UAS Response Debrief and 2019 Planning Meeting

NCDOT Division of Aviation

July 2019

# Division of Aviation Core Functions

As the State's Aviation Authority:

1. Inform and Promote Aviation and Aerospace Development
2. Administer State and Federal Airport Grants and Programs
3. Conduct Aviation Safety and Education Programs
4. Manage the Unmanned Aircraft Systems (UAS) Program
5. Provide Air Transportation for all State Agencies



# Division of Aviation's Capabilities

During an Emergency Response the Division:

- Provides Air Transportation for all State Agencies
  - King Air B200
- Operate aircraft for Photogrammetry missions
- Monitors and provides airport infrastructure updates
  - Airport status tracking of fuel, runway open, electricity, etc..
- Conducts and manages Unmanned Aircraft Systems (UAS) Operations
  - Deploys UAS teams, collects and disseminates photos/videos, coordinates UAS operations

# UAS Program Office Role



## Regulatory

Permitting commercial N.C. UAS operators



## Education

Safety, opportunity



## Research

Technology benefiting state



## Flight Services

NCDOT, other state agencies, local governments



## Government Agency Integration

UAS program development and support



# Public Information Campaign



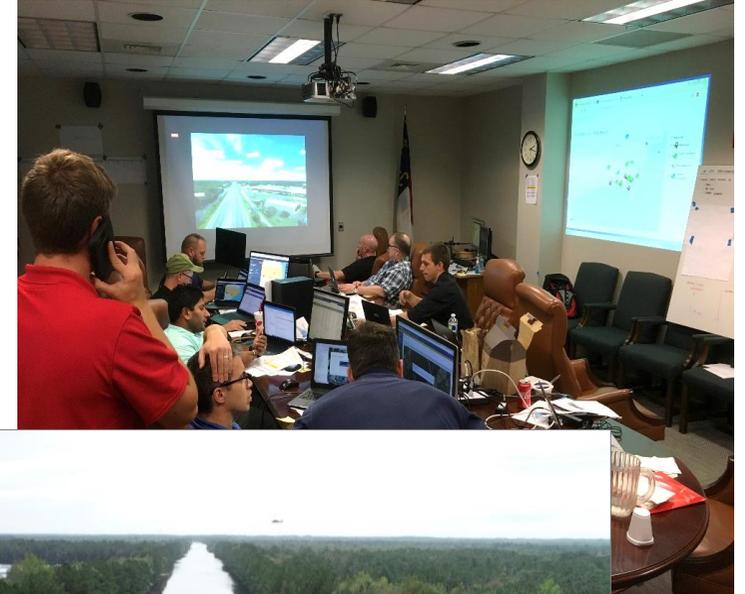
- **179,000** people in NC reached via Facebook
- **5,700** comments, shares and reactions
- **0 reported incidents** of civilian drones interfering with response/recovery operations

# NCDOT Pre-hurricane Assessment Flights



# Hurricane Florence Response

- NCDOT Led 15 UAS Teams
- Over 260 missions flown
- Over 8,000 videos/photos uploaded to statewide map
- Over 45 live streaming events
- >515 Gigabytes of Video and Photo taken
- Coordinated response with zero incidents

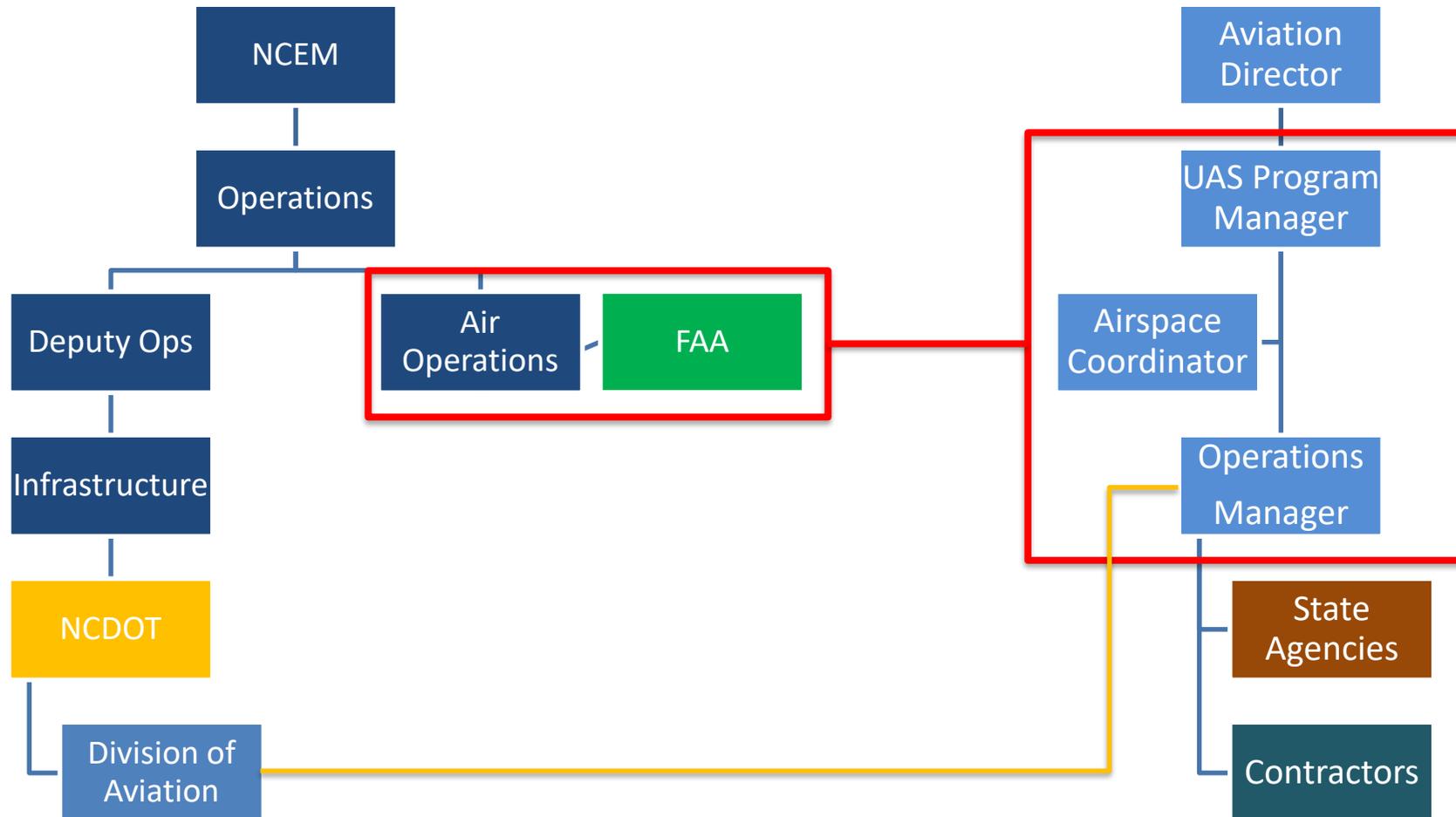


# NCDOT Fleet

- Over 30 UAS within the Dept.
- Contracts with unlimited UAS and team access
- Quadcopters, fixed wing
- Products
  - Imagery/Video (thermal included)
  - Live Streaming Capabilities



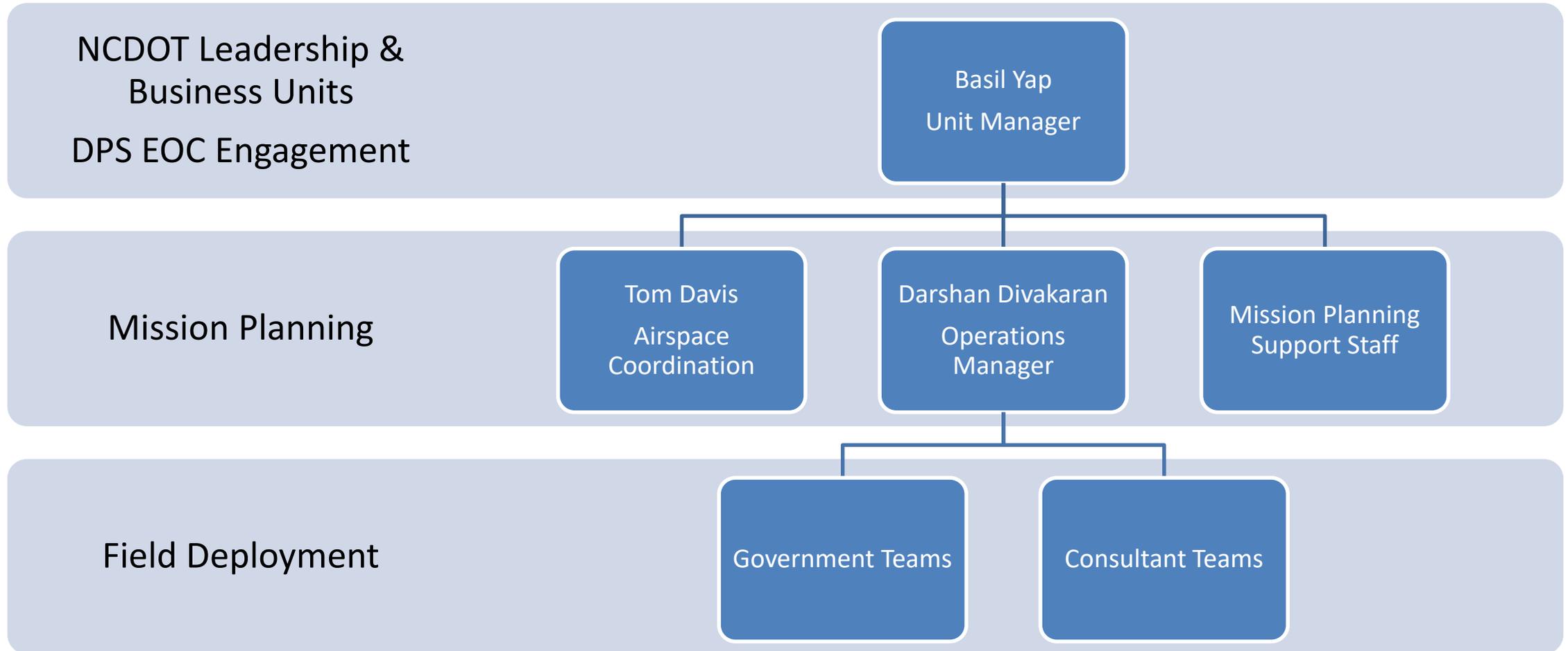
# NC UAS Response Team



# DoA UAS Command Center



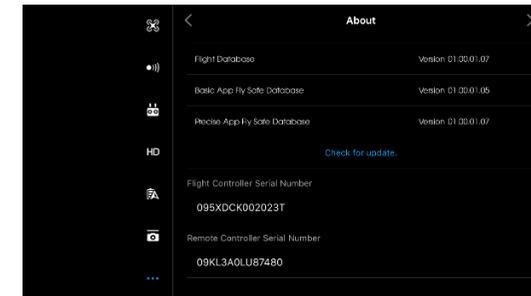
# DoA Command Center



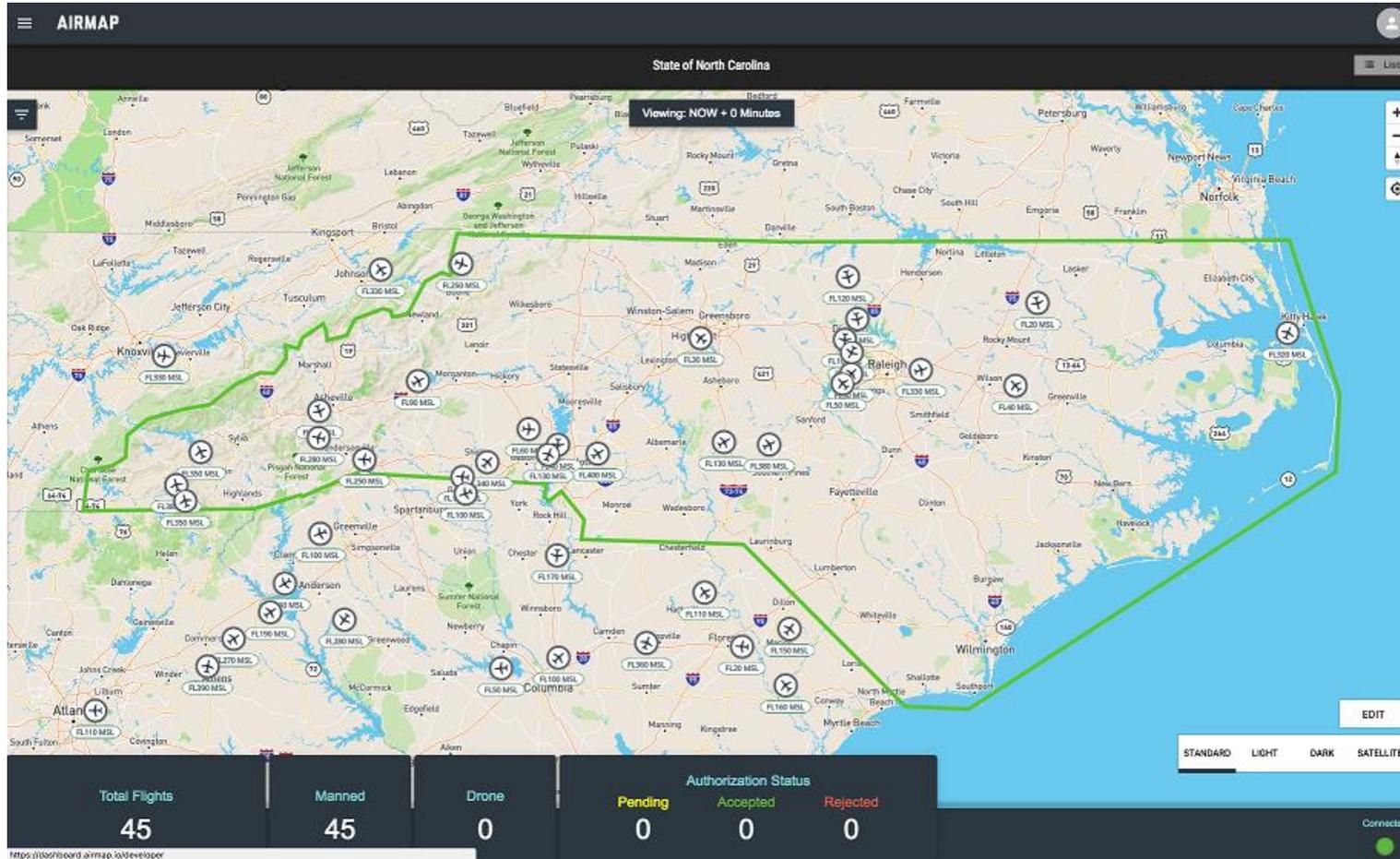
# Getting our Pilots ready

We asked our pilots to –

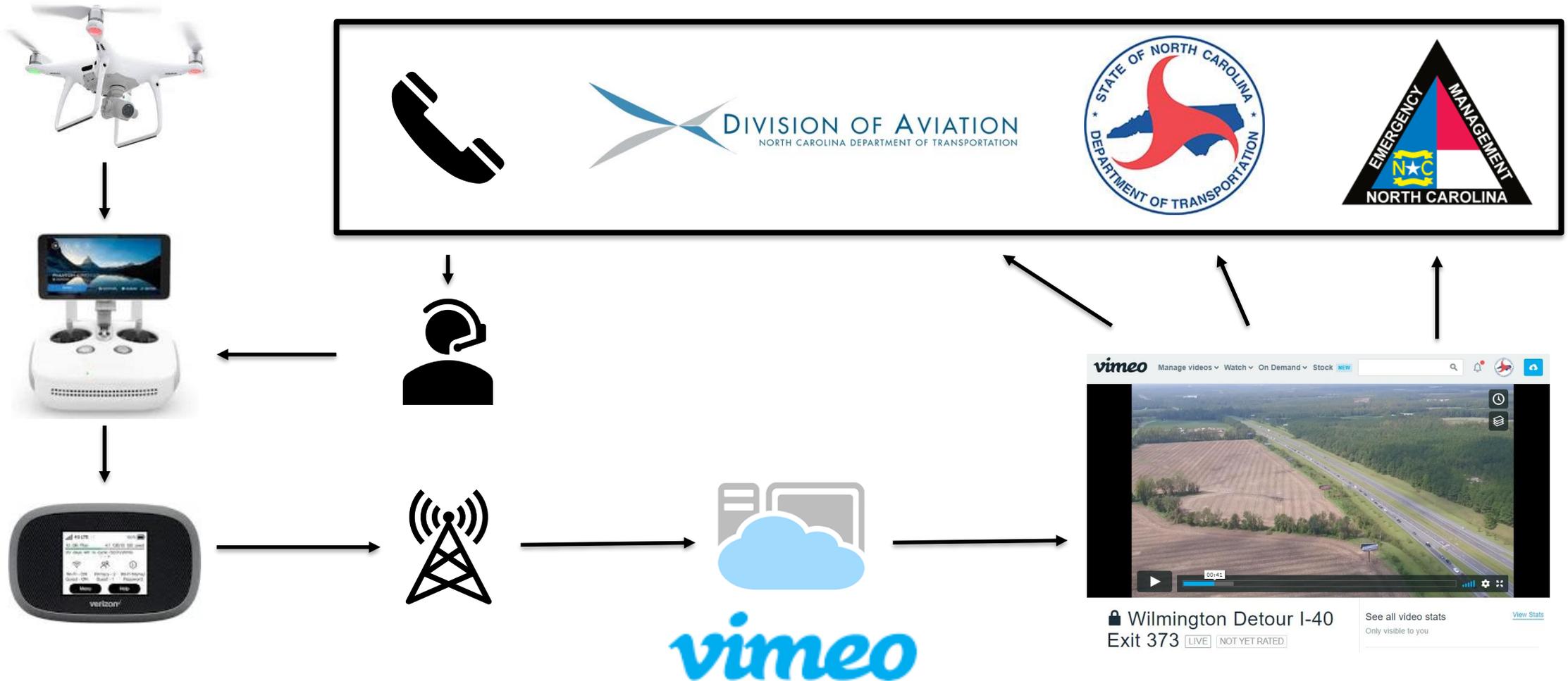
- Download the Airmap app on their phones.
- Create a DJI account.
- Get the drones updated and all batteries charged
- Be prepared for overnight operations
- Send-
  - Personal and emergency contact information
  - FAA license number
  - NC UAS permit number
  - Flight controller Serial Number.



# Unmanned Traffic Management



# Live Streaming Video



# Live Streams



# UAS Mission Workflow/Process

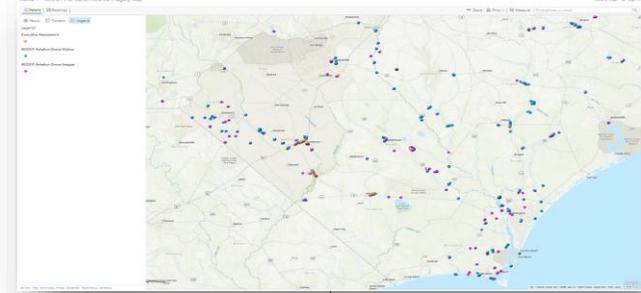
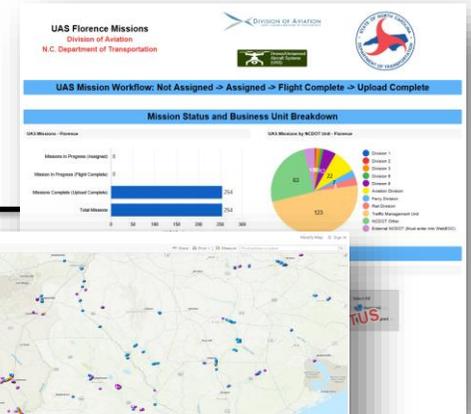


NCDOT  
Divisions /  
Business Units



Stakeholders

Dashboard,  
Content Retrieval



Form

smartsheet

**Hurricane Florence Airport Status**

Please provide status updates for your airport. This information is critical and is used for many purposes at the Emergency Operations Center prior to, during, and post-storm. Please update this form as your situation changes due to closures, fuel supply changes, etc. Please fill in the form out in its entirety.

Airport?   
 Select airport from the dropdown list.   
 [Dropdown]

Back to Normal Operations (Post Florence)?   
 Select Yes only if your airport is back to Pre-Hurricane Florence conditions (All Runways Open, Not Flooding on Runways, No NOTAMS issued due to hurricane, etc.)   
 Yes No

If you submit yes here, you do not need to re-submit a form unless unforeseen flooding has occurred.   
 Yes No

Are you commercial service?   
 Check for yes.   
 [Form]

Person Submitting Form   
 Please provide the name of the person updating the data.   
 [Form]

Best Contact   
 Please provide your best contact method (i.e. Phone number, email address, or both)   
 [Form]

General Airport Status   
 Is your runway open for use?   
 Check for yes.   
 [Form]

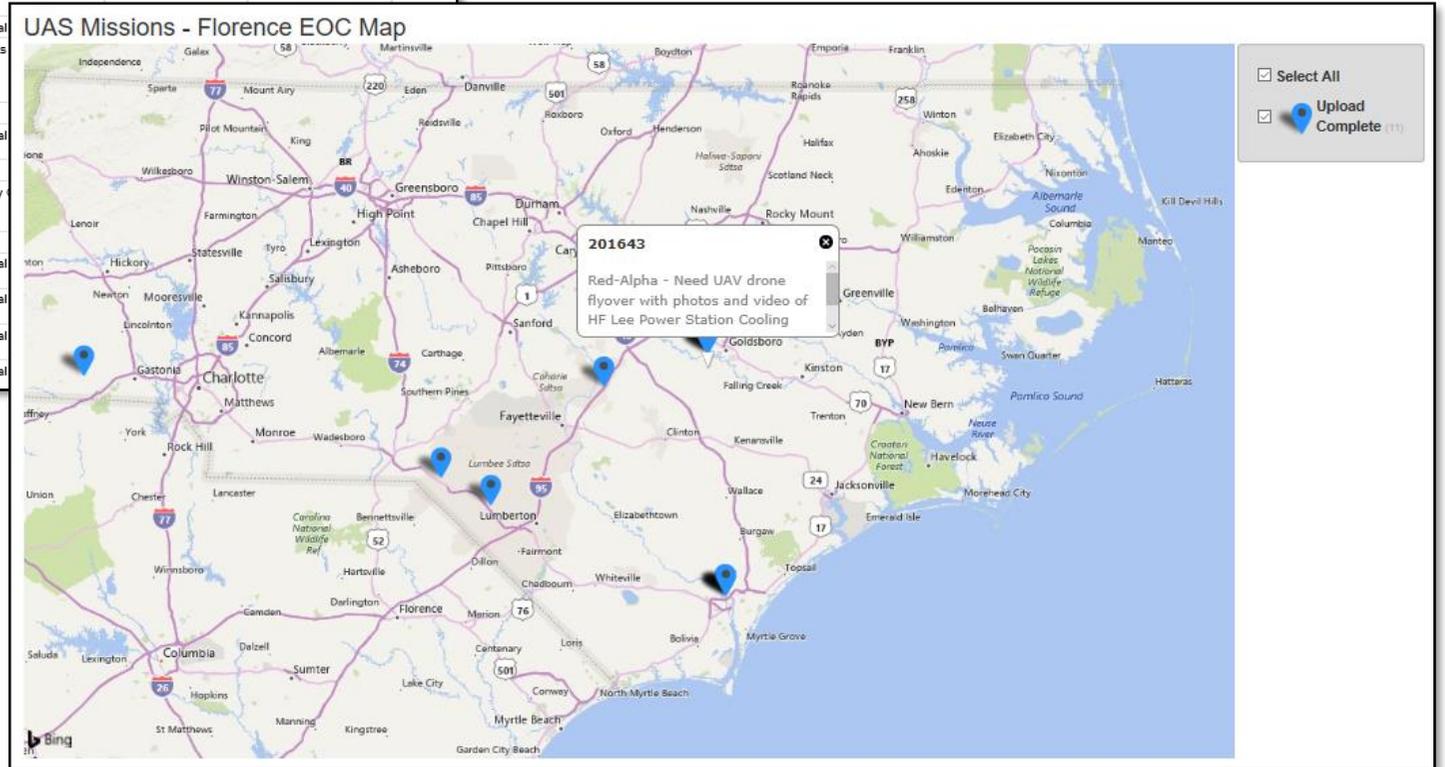
Reports, Mapping

Mission Request ID	Complete_Flag	Mission Objective	Requesting Division/Unit	Contact Name	Contact Email	Mission Location (Div#-City#-CityName)	Mission Location (Latitude (D) Longitude (W))
HF187	Upload Complete	Road closure location (Teal Hill Road)	Aviation Division	n/a	n/a	10-004-Arson	
HF190	Upload Complete	Road closure due to flooding/washed out	Aviation Division	n/a	n/a	10-004-Arson	
HF211	Upload Complete	Look into traffic situation at US17 and NC43 in Vanceboro. Livestream if possible.	Aviation Division	Internal	n/a	2-028-Craven	
HF203	Upload Complete	Red Charlie flew East Bolling Spring Rd next to Lake	Aviation Division	Internal	n/a	2-028-Craven	
HF202	Upload Complete	Red Charlie flew East Bolling Spring Rd next to Pine	Aviation Division	Internal	n/a	2-028-Craven	
HF204	Upload Complete	Drone fly-over to Duke Energy Sutton Plant (1671 Ac Basin, 1994 Ash Basin, and Sutton Lagoon during pass conditions on Saturday, September 22, 2018. Object take photos and videos of the affected area.	Aviation Division	Internal	n/a	2-028-Craven	
HF189	Upload Complete	Hammock Beach road flood area	Aviation Division	Internal	n/a	2-028-Craven	
HF272	Upload Complete	Observe traffic and road conditions on US 17 through Hamstead. Livestream if possible.	Aviation Division	Internal	n/a	2-028-Craven	
HF236	Upload Complete	Flooded Road	Aviation Division	Internal	n/a	2-028-Craven	
HF145	Upload Complete	Take photo and video of ACC Henderson Field. Take base with FBO fuel and let them know you are there behalf of the NCDOT Division of Aviation.	Aviation Division	Internal	n/a	2-028-Craven	
HF171	Upload Complete	road flooded	Aviation Division	Internal	n/a	2-028-Craven	
HF275	Upload Complete	Record conditions on NC 53 in Kelly. Photos and vid Livestream if possible.	Aviation Division	Internal	n/a	2-028-Craven	
HF274	Upload Complete	Check on conditions on NC 53 just east of Kelly and record pictures and video. Livestream if possible.	Aviation Division	Internal	n/a	2-028-Craven	
HF273	Upload Complete	Take pictures/video of road conditions on 210 before near Kelly. Livestream if possible.	Aviation Division	Internal	n/a	2-028-Craven	
HF200	Upload Complete	Capture photos/video of road conditions on NC-73 at Kelly, NC	Aviation Division	Internal	n/a	2-028-Craven	

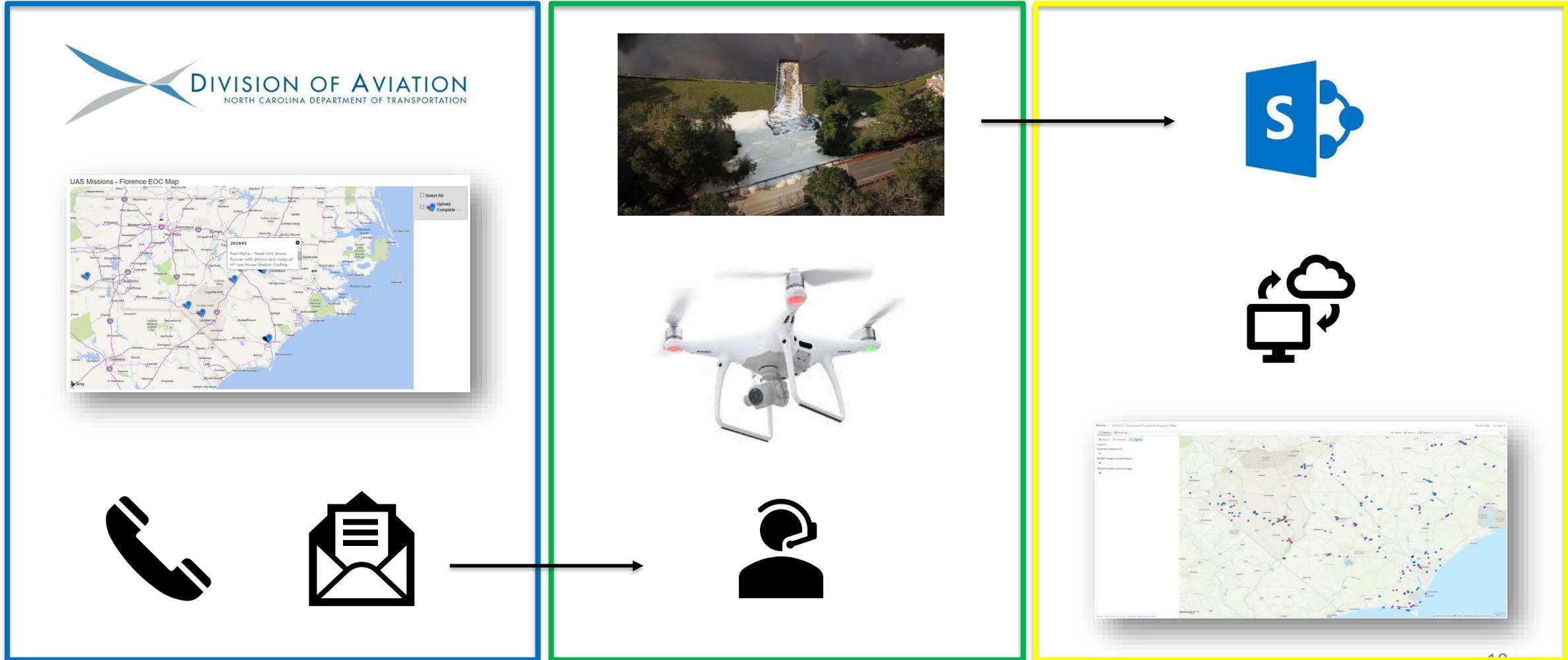


# UAS Mission Reporting

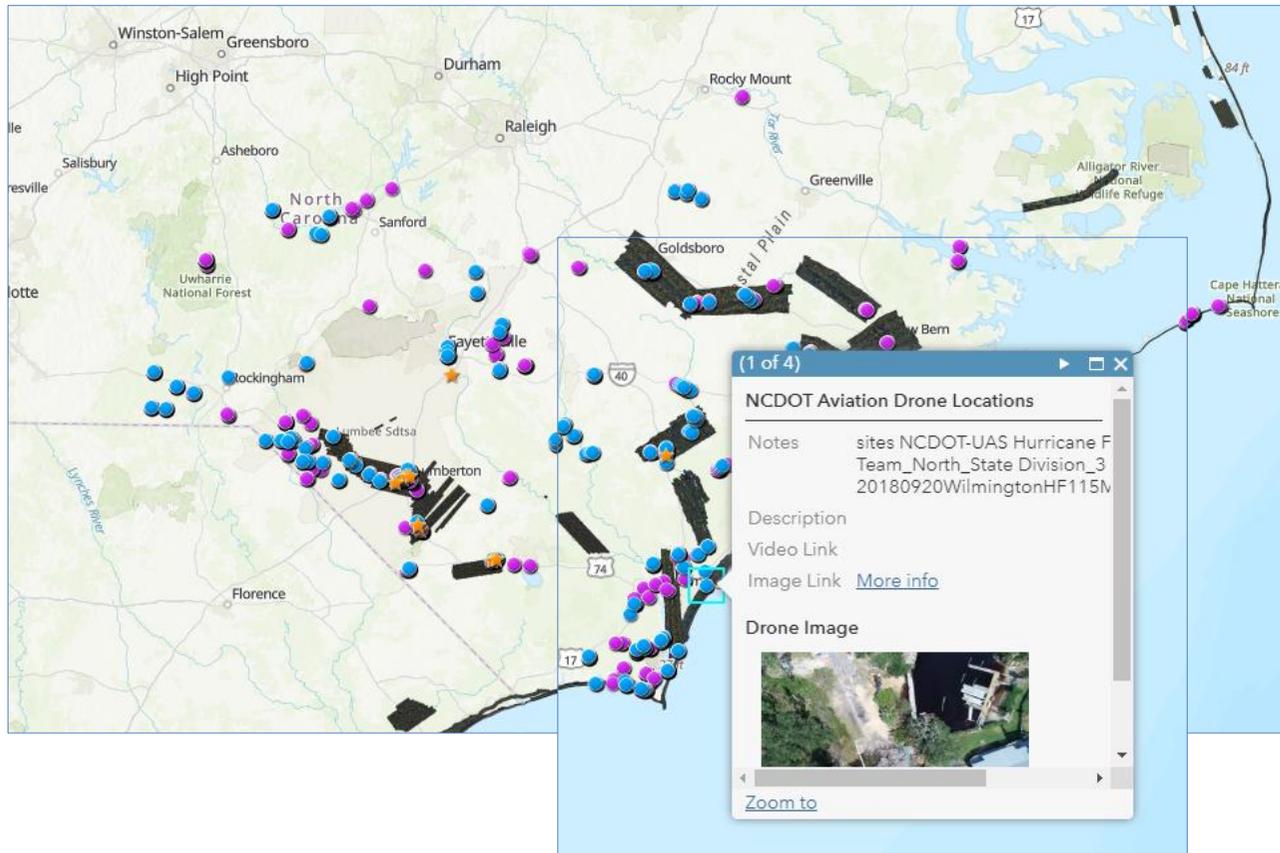
Mission Request ID	Complete_Flag	Mission Objective	Requesting Division/Unit	Contact Name	Contact Email	Mission Location (Div#-Cnty#-CntyName)	Mission Lo Latitude (D Degrees)
HF187	Upload Complete	Road closure location (Teal Hall Road)	Aviation Division	n/a	n/a	10-004-Anson	
HF186	Upload Complete	Road closure due to flooding/washed out	Aviation Division	n/a	n/a	10-004-Anson	
HF271	Upload Complete	Look into traffic situation at US17 and NC43 in Vanceboro. Livestream if possible.	Aviation Division	Internal	na	2-025-Craven	
HF203	Upload Complete	Red Charlie captured East Boiling Spring Rd next to Pine Lake	Aviation Division	Internal	na	3-010-Brunswick	
HF202	Upload Complete	Red Charlie flew East Boiling Spring Rd next to Pine Lake	Aviation Division	Internal			
HF254	Upload Complete	Drone fly-over to Duke Energy Sutton Plant (1971 Ash Basin, 1984 Ash Basin, and Sutton Lake) during peak conditions on Saturday, September 22, 2018. Objective to take photos and videos of the affected area.	Aviation Division	Francis			
HF189	Upload Complete	Hamock Beach road flood area	Aviation Division	n/a			
HF272	Upload Complete	Observe traffic and road conditions on US 17 through Hamstead. Livestream if possible.	Aviation Division	Internal			
HF236	Upload Complete	Flooded Road	Aviation Division	n/a			
HF145	Upload Complete	Take photo and videos of ACZ Henderson Field. Touch base with FBO first and let them know you are there on behalf of the NCDOT Division of Aviation.	Aviation Division	Ashley			
HF171	Upload Complete	road flooded	Aviation Division	n/a			
HF275	Upload Complete	Record conditions on NC 53 in Kelly. Photos and video. Livestream if possible.	Aviation Division	Internal			
HF274	Upload Complete	Check on conditions on NC 53 just East of Kelly and record pictures and video. Livestream if possible.	Aviation Division	Internal			
HF273	Upload Complete	Take pictures/video of road conditions on 210 between 53 near Kelly. Livestream if possible.	Aviation Division	Internal			
HF286	Upload Complete	Capture photos/video of road conditions on NC-73 around Kelly, NC	Aviation Division	Internal			



# UAS Mission Workflow/Process



# GIS Map of UAS Missions



## Supported Agencies

- NC Dept. of Transportation
  - Highway Divisions
  - Traffic and Mobility
  - Rail Division
  - Ferry Division
- NC Dept. of Public Safety
  - Emergency Mgmt
  - NC State Highway Patrol
- NC Dept. of Environ Quality
  - Dam Safety
- NC National Guard
- US Coast Guard
- FEMA

# US 70 & US 258 in Kinston on 9-21-18



# Boiling Springs Dam Breach



# Railroad Crossing in Fayetteville



# Ferry Terminal on Ocracoke Island



# Hwy 13 & South River



# Post Hurricane Drone Video



# Post Hurricane Success

NCDOT's UAS Program Office clearly demonstrated its value in its first test in a disaster situation:

- Communicate conditions to the public to get people off the road.
- Monitor evacuation routes and traffic.
- Gather and push real-time information on infrastructure and road conditions.
- Post-storm damage assessment to plan for repairs.
- Coordinate with both state agencies and private sector UAS teams for efficient and safe operations

# Roles/Capabilities of Manned/Unmanned

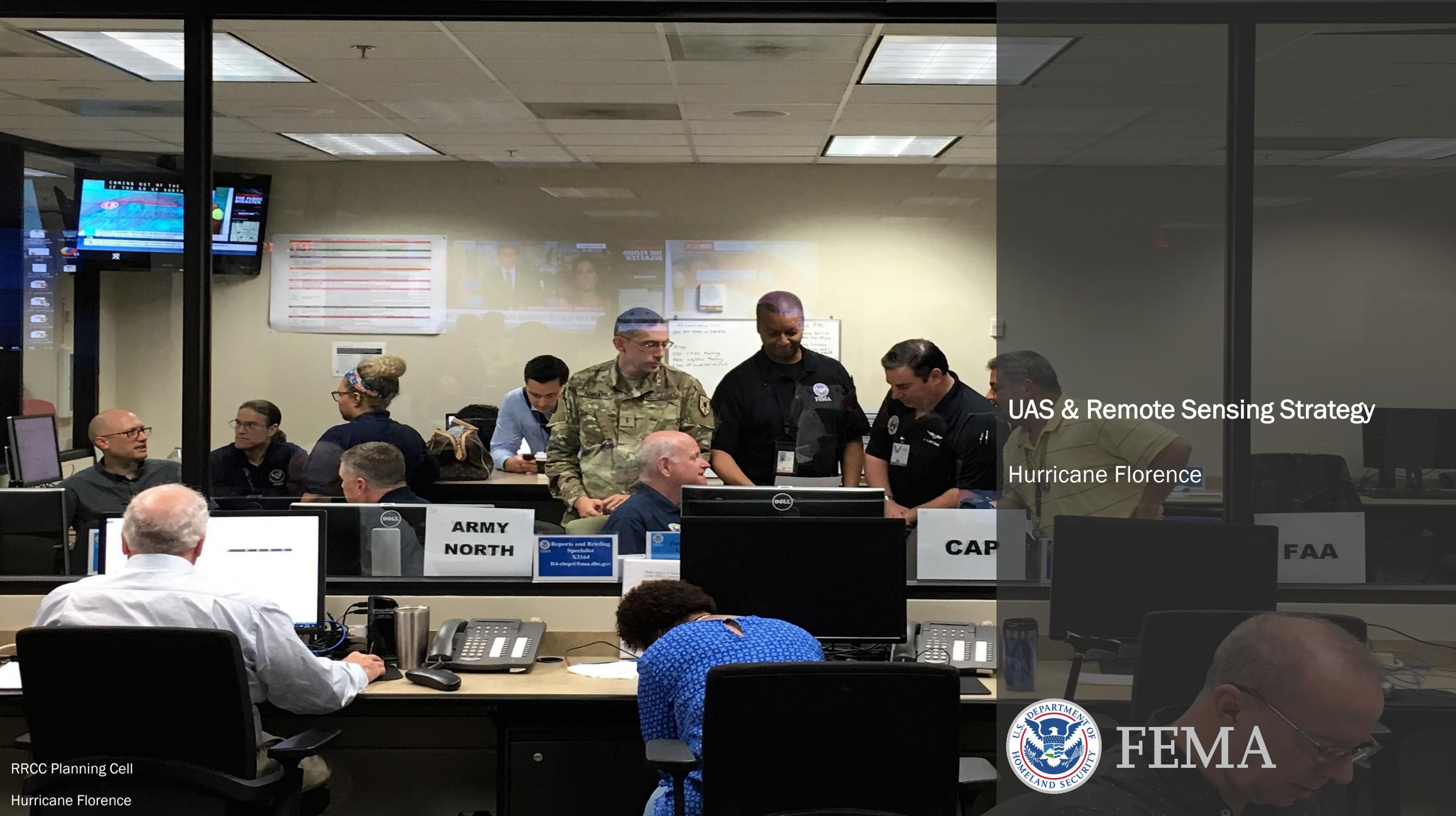


## Manned Aircraft

- Can fly in poor weather than our current drone fleet
- Covers larger areas of the state quicker
- Transports drone crews to areas where roadways are cut off

## Unmanned Aircraft

- Cost-effective way to deploy to multiple locations
- Crews can typically drive to location
- Can fly in hard-to-reach areas, (i.e. under bridges)
- Live streaming capabilities



# UAS & Remote Sensing Strategy

Hurricane Florence

**ARMY  
NORTH**

Reports and Briefing Specialist  
X3164  
R4-ramp@fema.dhs.gov

**CAP**

**FAA**



# FEMA

# FEMA Region IV Remote Sensing Cell



Hurricane Florence



Hurricane Michael

AFNORTH, ARNORTH, Civil Air Patrol, FAA, CISA, FEMA\State AIR OPS, CSEPP, NGB UPAD

# Local, State, Federal & Private Sector Coordination

## Pre-Landfall UAS Coordination Calls



**ESFs**



**FEMA**



**Law Enforcement**



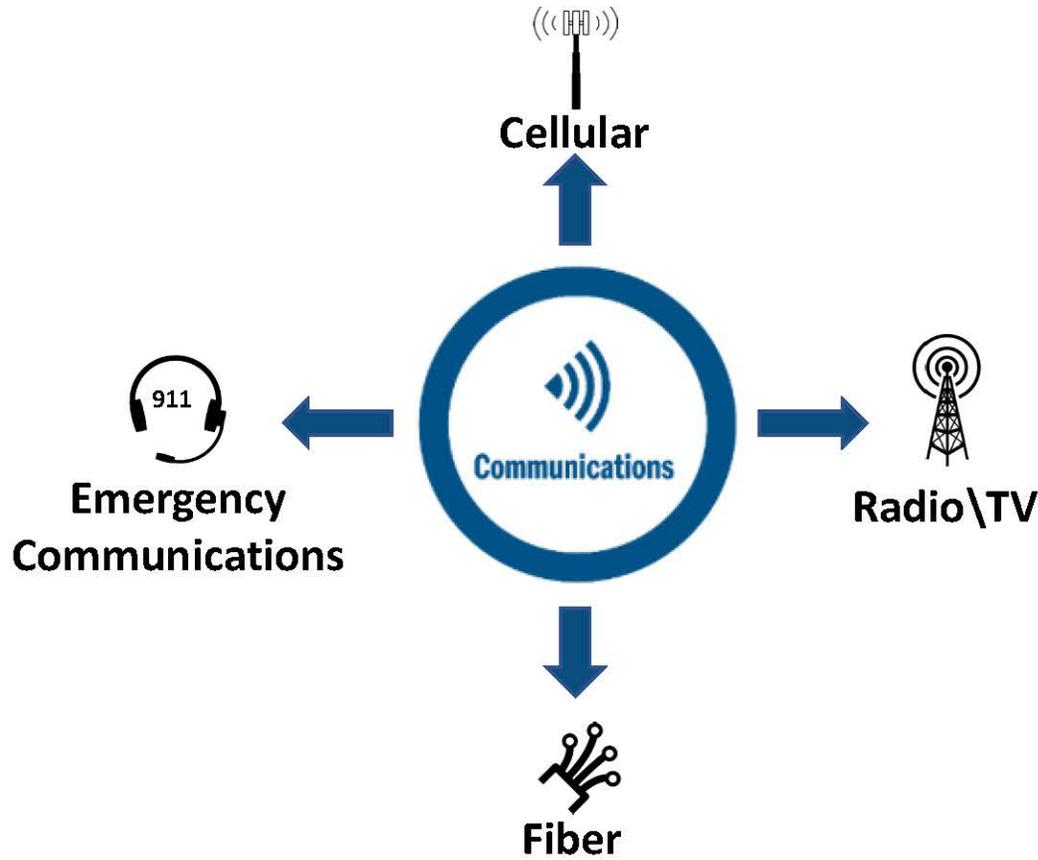
**Insurance**



**Utilities**



**Media**



**Resources**

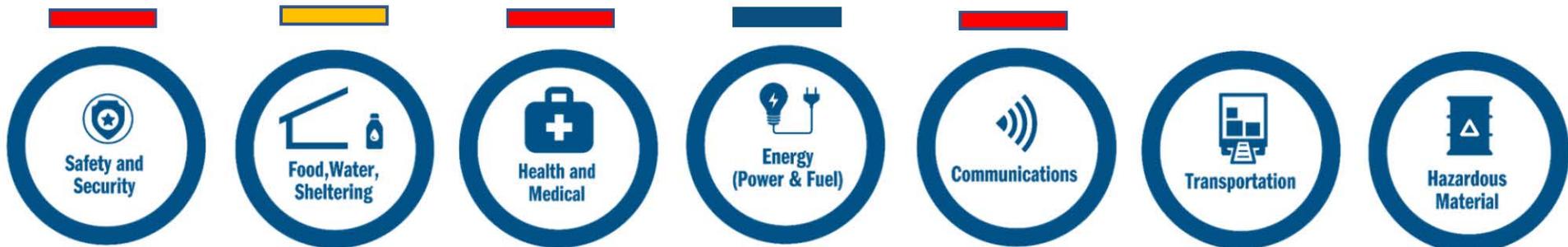
- Civil Air Patrol
- NOAA
- NASA
- Loc\Reg\Priv UAS
- Contracted Agents
- Crowd Sources

**Customers**

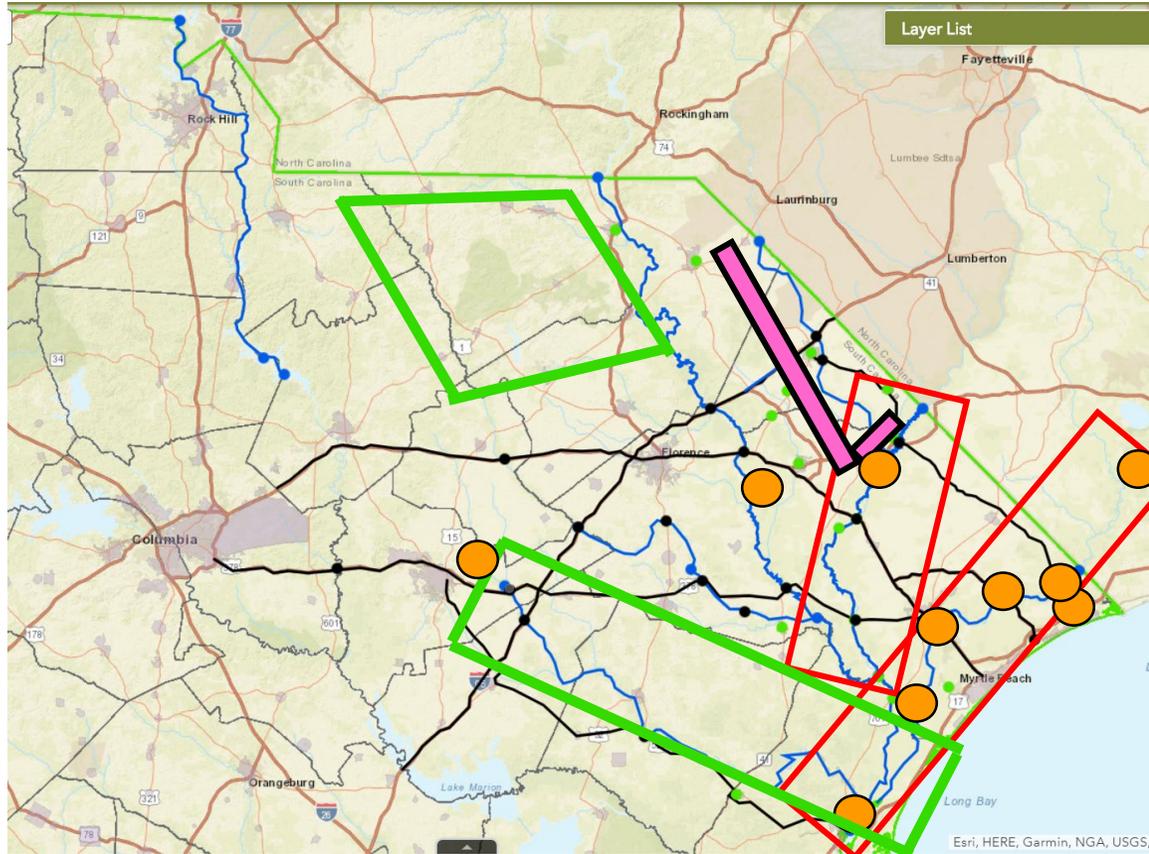
- ESF 2, 13,8,6
- FCO
- State EMA
- IMAT
- Federal Partners
- FEMA HQ

**Impact**

A legend box with a blue border containing three colored bars: a red bar labeled "Major", a yellow bar labeled "Minor", and a blue bar labeled "Affected".



# Hurricane Florence Collection Plan 23 SEP 2018



ZULU	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4
EDT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RC – 26																								
UH – 72																								
CAP Cessna 172																								
CAP FMV																								
CAP VERB																								
EPA Aspect																								
Raven																								

**RC – 26:** Rising Flood Waters, damage to dams, log jams and river debris, bridges, roadways, HAZMAT contamination (PIR 1, PIR 2, PIR 4) Support to SAR,

**UH – 72:** Rising Flood Waters, damage to dams, bridges, roadways, HAZMAT contamination (PIR 1, PIR 2, PIR 4) SAR

**CAP Cessna 172:** Rising Flood Waters, damage to dams, log jams and river debris, bridges, roadways, Urban damage assessment, damage to Crit Infra., HAZMAT contamination (PIR 1, PIR 2, PIR 3, PIR 4) Support to SAR,

**CAP FMV:** Rising Flood Waters, damage to dams, bridges, roadways, HAZMAT contamination (PIR 1, PIR 2, PIR 4) SAR (Lynches River)

**CAP VIRB:** Mosaic imagery along the Lumber and Little Pee Dee Rivers to include the Great Grainger Coal Ash Pond and Conway Waste Water Treatment Plant (PIR 1, PIR 2, PIR 3, PIR 4)

**EPA ASPECT:** HAZMAT contamination (PIR 1, PIR 2, PIR 4).

\* = On/Off Station Time



# FEMA Region IV Remote Sensing Cell Collection Summary 11 Oct 2018



**Georgia EMAC:** Four counties were requested; Damage to HWY 91 Albany to Colquite, HWY 27 Colquite to Bainbridge, service road to Joseph M. Marley Nuclear Power Plant

**Florida National Guard:** Request the collection of Five Airports, eight bridges on Major LOCs and Tyndall AFB; Wind damage, flooding damage to bridges and LOCs

**CBP:** Critical infrastructure will be flown for damage assessment of Ash ponds, Bridges Dams and Nuclear Power plants

EST	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
CAP (FL)	Pending Flight Times																							
CAP (GA)																								
CBP (P-3)	Pending Flight Times																							

# DOMOPS Awareness and Assessment Response Tool

The screenshot shows the DAART Suite Landing Page in a web browser. The browser address bar displays <https://daart.us/>. The page title is "DAART DOMOPS Awareness and Assessment Response Tool".

**Left Sidebar (Links):**

- Support**
  - DAART Suite 1.1.0
  - 8am - 5pm Central Time weekdays:
  - 256-955-2750
  - DSN: 645-2750
  - After Hours:
  - 256-690-8612
  - 256-783-4578
  - 256-679-4347
  - support@daart.us
  - @DAART\_NGB
  - Bugs/Suggestions/Incidents
  - Manage Users
  - FAQ's
  - DAART User Access Process
  - Contact Help
  - DAART Quick Start Guide
  - DAART Fact Sheet
- Documents** (+)
- Training** (+)
- Downloads** (+)
- Other Suite Tools** (+)

**Main Content Area (Grid of Awareness Cards):**

- CA IAA Wildfire 2019**
  - Created: 6/2/2019
  - Views: 33
  - Created By: skil.dangerfield
- VA-JFHQ (Steady State)**
  - Created: 6/5/2019
  - Views: 4
  - Created By: jpackley
- CAP22SP**
  - Created: 5/29/2019
  - Views: 250
  - Created By: william.drake.1@us.af.mil
- WI-JFHQ (Steady State)**
  - Created: 4/9/2019
  - Views: 176
  - Created By: jpackley
- Hurricane FLORENCE**
  - Created: 9/10/2018
  - Views: 949
  - Created By: thomas.merrill.civ
- SAREX 19-T-4879**
  - Created: 5/7/2019
  - Views: 38
  - Created By: rwill1107
- Hurricane Michael LANDFALL**
  - Created: 10/6/2018
  - Views: 2446
  - Created By: SWEB.STC
- NORFOLK HARBORFEST**
  - Created: 5/29/2019
  - Views: 37
  - Created By: jrafols
- 181 IW Tornado Training**
  - Created: 5/28/2019
  - Views: 26
  - Created By: keaton.l.robertson
- GUAM PAKYO Exersise**
  - Created: 1/29/2019
  - Views: 18
  - Created By: joseph.s.santiago
- CAP ND James river flooding 2019**
  - Created: 4/2/2019
  - Views: 37
  - Created By: matthew.brugger
- LISP**
  - Created: 6/23/2018
  - Views: 44
  - Created By: jim.whitesell

**Bottom Right:** DAART News

# NGB UPAD Analysis Product



Hurricane Florence – CAP Image 18 SEP 2018  
Richmond Pond Dam, Laurel Hill, NC  
GEO: 344914N0793149W  
MGRS: 17SPU3439054135



**UNCLASSIFIED//FOUO**

(U) Domestic imagery obtained IAW NC Proper Use Memorandum 14-3; U.S. person(s) information deemed necessary for intended recipient to understand, assess, or act on the information provided IAW DoDM 5240.01 and E.O. 12333. This domestic imagery may only be used IAW the PUM

Analysis revealed no damage or flooding along the bridge. Bubbles from rushing water filled the area and observed along the bridge. Imagery cannot confirm the structural integrity of the bridge. Recommend on-ground inspection for further analysis and confirmation.



Courtesy of North Carolina – Department of Transportation



Courtesy of North Carolina – Department of Transportation

**UNCLASSIFIED//FOUO**

# Remote Sensing Cell Product



FEMA R-IV  
Remote Sensing Cell

Donalsonville Polling Site  
200 S. Knox Ave.  
Donalsonville, Ga.

DOI: 15 October 2018  
31.0297 -84.8849



UNCLASSIFIED

ATTENTION: This document contains U.S. persons information which has been included consistent with all applicable laws, directives, and policies.



**Assessor Comment:** Referencing the criteria from the FEMA Damage Classification Charts 2014. Primary structure roof appears intact. Ingress & Egress routes are clear. Noted area Affected by debris. JB 17 OCT 2018.

Remote sensing for dams in Hurricane Florence - Message (HTML)

File Message Help Adobe PDF Tell me what you want to do

Ignore Delete Archive Reply Reply Forward Meeting  
Junk Delete All More

Accolade To Manager  
Team Email Done  
Reply & Delete Create New

Move OneNote  
Actions

Assign Mark Categorize Follow  
Policy Unread Tags Up

Translate Find  
Related Select

Read Aloud Zoom  
Speech Zoom



Wed 10/10/2018 10:55 AM

**Goolsby-Brown, Katy**  
Remote sensing for dams in Hurricane Florence

To: Potter, Travis  
Cc: Plisich, John  
You forwarded this message on 10/10/2018 2:32 PM.

Travis,

Thank you for your help with the UAS/remote sensing for dams in the RRCC during Hurricane Florence. It helped us and the states improve situational awareness for dams. We look forward to working with you for USA/remote sensing for dams in the RRCC during future events and plan to work on a white paper on this topic to better prepare for the next event.

Thank you!

Katy Goolsby-Brown, PE(GA), CFM  
Civil Engineer  
Risk Analysis Branch  
Mitigation Division  
FEMA Region 4- Atlanta  
770-220-8811 (O)  
678-218-2110 (M)  
<mailto:Katy.Goolsby-Brown@fema.dhs.gov>

Windows taskbar showing icons for File Explorer, Edge, Outlook, Word, PowerPoint, Excel, and Adobe Reader. System tray shows the date and time: 10:00 AM 5/19/2019.

**From:** [Agvent, Greg](#)  
**To:** [Potter, Travis](#); [matt@skyfireconsulting.com](mailto:matt@skyfireconsulting.com); [David Merrick](#); [Peter Acevedo](#); [Strouse, Philip](#)  
**Subject:** RE: Manned and unmanned aircraft operations during Hurricane Michael response and recovery efforts  
**Date:** Wednesday, October 17, 2018 2:08:10 PM

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All,

I wanted to take a moment to let you know how valuable I thought last week's meeting was. I hope that this can become a regular feature when FEMA and the news media find ourselves flying in close quarters, as we so often do.

Best,

**Greg Agvent**

Senior Director, CNN Aerial Imagery & Reporting

**CNN Worldwide**

O: 404.878.1726

C: 678.642.2981





FEMA

# Questions & Discussion

*FEMA Region IV  
UAS & Remote Sensing Strategy*

Travis Potter  
UAS & Remote Sensing Coordinator  
404.909.1400  
[travis.potter@fema.dhs.gov](mailto:travis.potter@fema.dhs.gov)

# Hurricane Florence Airspace Operations

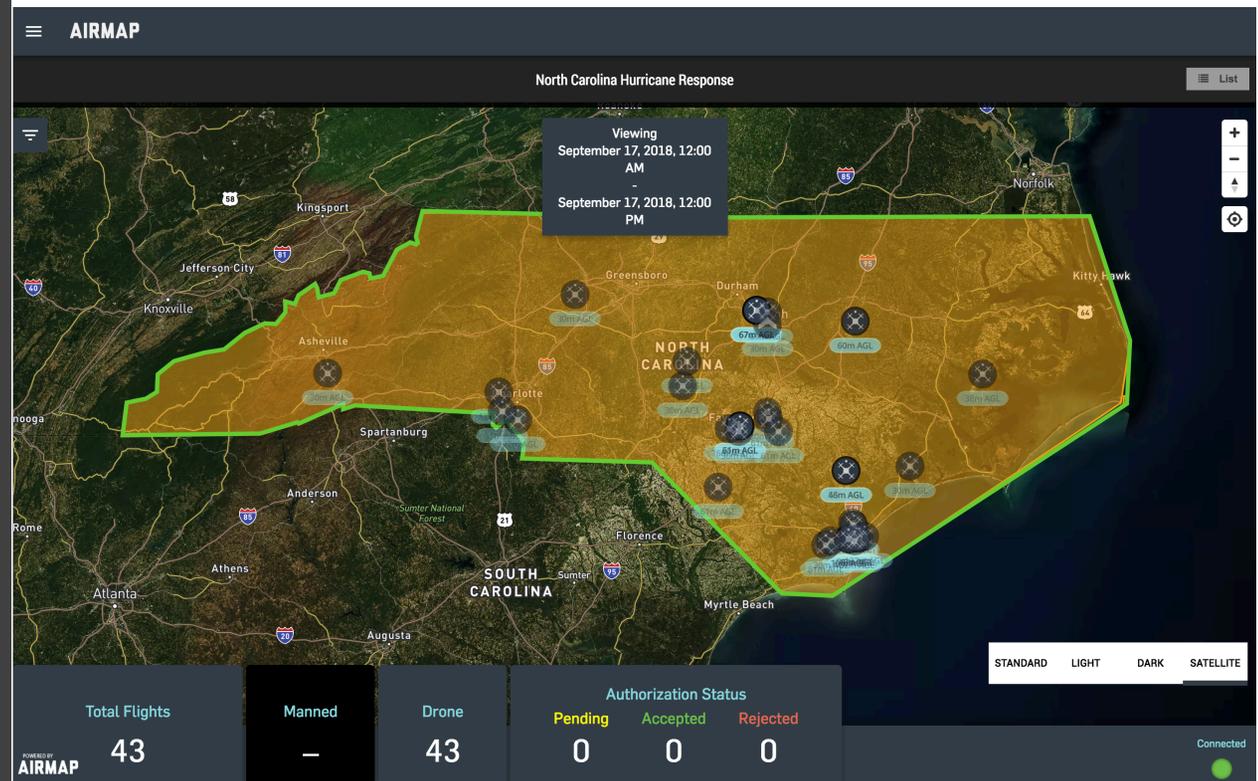
Objective: Utilizing UAS, conduct robust inspection missions in Eastern NC to assess Hurricane Florence damage, ingress/egress routes, flooding and infrastructure status

- Conduct complex missions in coordination with FAA to maximize impact
- Most flights (~95%) could be executed within Visual Line of Sight (VLOS) and easily handled without waivers to airspace rules
- Some missions required waivers and/or special permission from FAA
  - Beyond Visual Line of Sight (BVLOS) to assess extent of damage (e.g. I-40 approaching Wilmington)
  - Operations in/around airports or controlled airspace
  - Temporary flight restrictions (TFRs) were needed in some cases to fence off operations from manned aircraft
  - FAA imposed some statewide temporary restrictions (e.g. no UAS above 200 ft for all of North and South Carolina)...and then later lifted them
  - FAA disabled some critical infrastructure (Low Altitude Authorization and Notification Capability (LAANC)) for UAS flights early in the response...and then reinstated them



# Prototype NC Statewide UTM for Coordination

- Airspace Awareness (manned & unmanned)
- Information sharing with FAA
- Publication of restrictions
- Messaging portal to pilots
- Enforcement of restrictions
- Confirmation of flight activity
- Roll up of daily flight data for reporting



# Process for Authorization of Complex Operations

## eCOA Request to FAA

**FAA REQUEST FORM FOR EXPEDITED SGI WAIVER OR AUTHORIZATION FOR UAS OPERATION**

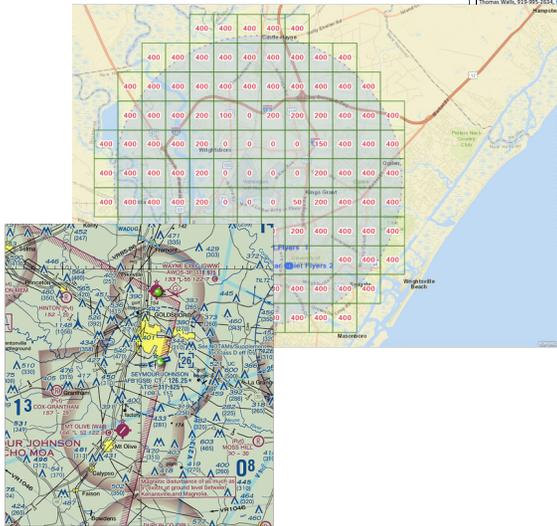
**Basic Qualifications**

- The requesting operator must possess a Certificate of Waiver or Authorization (COA) or Part 107 Pilot License
- The UAS operator must support an emergency response or other effort being conducted to address urgent requirements and that will benefit the public good
- The requested FAA approval cannot be secured via normal processes in time to meet urgent operational needs

**Operator Information**

Operator Organization (i.e., Name or Address): North Carolina Dept. of Transportation, Division of Aviation  
 Operator Address: 8200 Mountain Drive, Morrisville, NC 27560  
 Operator Phone Number (include area code, state number, and extension): 919-995-3034, Email: tmwalls@dot.nc.gov  
 Operator Email Address: tmwalls@dot.nc.gov  
 Operator UAS Type: DJI Phantom 4

## Airspace Analysis



## eCOA Approval

FAA FORM 7713-1 (7-74) 1975 C.F.D.

DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

**CERTIFICATE OF WAIVER OR AUTHORIZATION**

Issued To: North Carolina Dept. of Transportation / c/o Thomas Walls  
 Address: 1050 Meridian Drive, Morrisville, NC 27560  
 Phone: 919-995-3034, Email: tmwalls@dot.gov

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

**Operations Authorized:** Infrastructure Inspection NOTE: Operations under this certificate of authorization are limited to the maximum altitude listed below. This altitude is an absolute value and it shall not be added to the height of any structures.  
 UAS Type: DJI Phantom 4 Pro & DJI Inspire 2  
 Location and Class of Airspace: 25 NMR either side of a line from 344354N0775642W to 344290N0775645W - Class G  
 Alt. or Below: 150 AGL  
 Under the Jurisdiction of: Washington ARTCC (ZDC)

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE: 14 CFR 107.41 107.47

**STANDARD PROVISIONS**

- A copy of the application made for this certification shall be attached to and be:
- The certificate shall be presented for inspection upon the request of any authorized Administrator of the Federal Aviation Administration, or of any State or municipal corporation enforcing local laws or regulations.
- The holder of this certificate shall be responsible for the strict observance of the contained herein.
- This certificate is nontransferable.

NOTE - This certificate constitutes a waiver of those Federal rules or regulations referred to above. It does not constitute a waiver of any State law.

**SPECIAL PROVISIONS**

Special Provisions Nos. 1 to 4, inclusive, are set forth on following page

This certificate is effective from 09/20/2018 inclusive, and is subject to time upon notice by the Administrator or his/her authorized representative.

BY DIRECTION OF THE ADMINISTRATOR

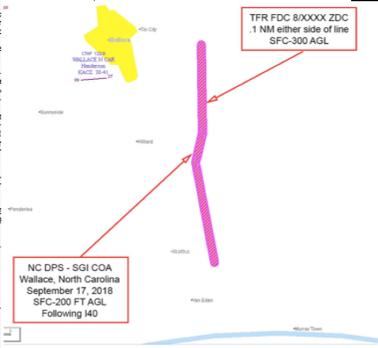
FAA Headquarters - AJP-2 (Region)  
 September 19, 2018 (Date)  
 Gary W. Miller, Manager, Tactical Operations



## Actual Operation

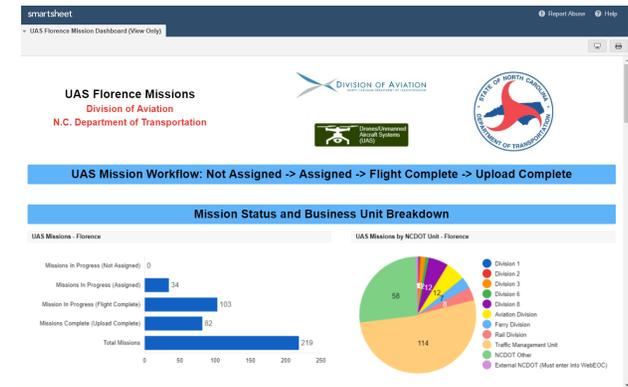


## TFR



# Characterization of Complex Operations

- 13 Missions requested, 9 approved, 1 withdrawn
  - 3 Beyond-Visual-Line-of-Sight (BVLOS)
  - 6 operations in controlled airspace, required coordination with Tower
  - 1 Search & Rescue – withdrawn as helicopter arrived on scene
  - 2 denied due to volume of manned operations at Kinston Airport, 1 denied due to coordination with Camp Lejeune
- Types of missions
  - Inspections of flooded roadways, waste management plants, bridges & waterways
- Time to approval
  - Less than 1 hour to overnight (S&R would have happened in less than 5 min)
- Typical duration – 3-5 hours



Date	Location	Description	Duration	Approval	Details
17-Sep	Wallace/140	BVLOS flights over I-40 to inspect flooding, Class G, 200 ft, 4 nmi x .25 nmi	5 hrs	17-Sep 3 hrs, TFR over I-40, 200 ft	
18-Sep	Cherry Point	VLOS flight to inspect bridge/waterway, Class D, 200 ft, 400 ft radius	5 hrs	18-Sep 4 hrs, coordinate w/ Cherry Pt. ATCT	
19-Sep	Wilmington Airport (ILM)	Inspect areas near ILM, Class D, 150 ft, 5 locations, 300 ft radius ea	5 hrs	19-Sep 5 hrs, coordinate w/ ILM ATCT, Compliance with LAANC altitude grid incl. some restrictions down to 0 ft AGL at airport	
19-Sep	Wallace/140	BVLOS flights over I-40 to re-inspect flooding, Class G, 150 ft, 4 nmi x .25 nmi	6 hrs	20-Sep 6 hrs, TFR over I-40, 150 ft	
19-Sep	Lumberton/I-95	BVLOS flights over I-95 to inspect flooding, Class G, 150 ft, .25 nmi wide along I-95	7 hrs	19-Sep 7 hrs, TFR along I-95, 150 ft	
19-Sep	New Bern (EWN)	VLOS flight to inspect road, bridge & waterway S of New Bern, NC (Hurricane surge pd within 0 ft LAANC restriction 2 nmi N or EWN, Class D, 150 ft, .25 nmi radius,	4.5 hrs	19-Sep 4.5 hrs, coordinate w/ EWN ATCT	
20-Sep	Goldboro/Seymour Johnson AFB (GSB)	VLOS flight to inspect Neuse River flooding and Goldboro Water Waste Treatment Plant, Class D, 150 ft, .75 nmi radius	5 hrs	20-Sep 2 hrs, coordinate w/ GSB ATCT, restricted to NW Neuse River and Arrington Bridge	
20-Sep	Goldboro/Seymour Johnson AFB (GSB)	VLOS flight to inspect Neuse River flooding, Class D, 150 ft, .75 nmi radius	3.5 hrs	20-Sep 3 hrs, Approval direct from ATCT	
20-Sep	Goldboro/Seymour Johnson AFB (GSB)	Search & Rescue, Driver stranded on truck, Class D, 200 ft, .5 nmi radius	5 hrs	Immediate action by FAA to approve, withdrawn within minutes as helicopter arrived on scene	
20-Sep	Jacksonville, NC/New River Marine Corps Station (NCA)	Bridge inspection, Class G, 150 ft, 500 ft radius		Not approved due to Marine Corps restrictions	
21-Sep	Kinston Airport (ISO)	ISO Airport infrastructure inspection, Class D, 200 ft	8 hrs	Not approved due to ISO activity and workload	
21-Sep	Fayetteville Airport (FAY) area	Infrastructure inspection, Class D, 400 ft within 0 ft LAANC restriction	5 hrs	21-Sep 5 hrs, coordinate w/ FAY ATCT	
21-Sep	Kinston Airport (ISO)	Proposed for 10/12/2019		Not approved - outside window of Hurricane Ops	

# Lessons Learned – Airspace Operations

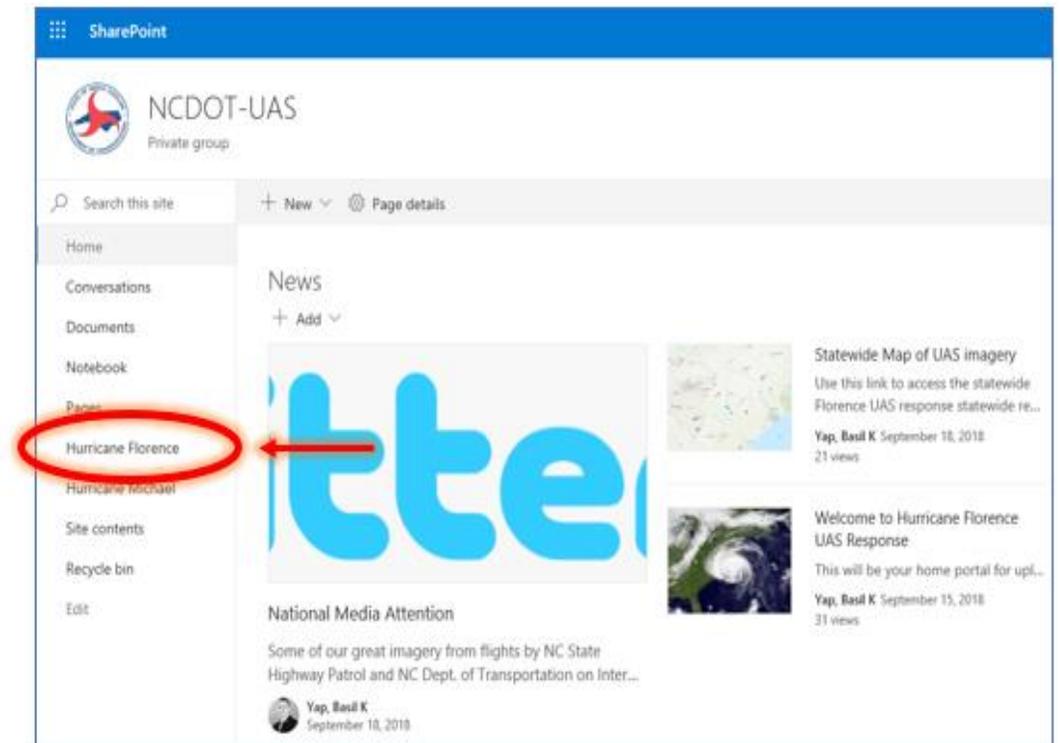
- We learned a lot along the way – we will be more efficient next time
  - Integration of airspace operations into Response Center will enable more collaborative requests and more timely response
  - Need better integration with National Guard operations
  - Credibility was gained and should ease future operations
- UTM Dashboard and data collection will be more streamlined
  - Requirements already feeding into Statewide UTM design
  - IPP data requirements are improving and streamlining data collection
- FAA is more likely to keep LAANC operating around airports from the beginning, enabling near real-time approvals



# Data Management

## Media and data upload and SharePoint

- All media will be uploaded to the NCDOT-UAS SharePoint site. Navigate to <https://ncconnect.sharepoint.com/sites/NCDOT-UAS>
- Locate and click on the appropriate page on the far-left side of the site.



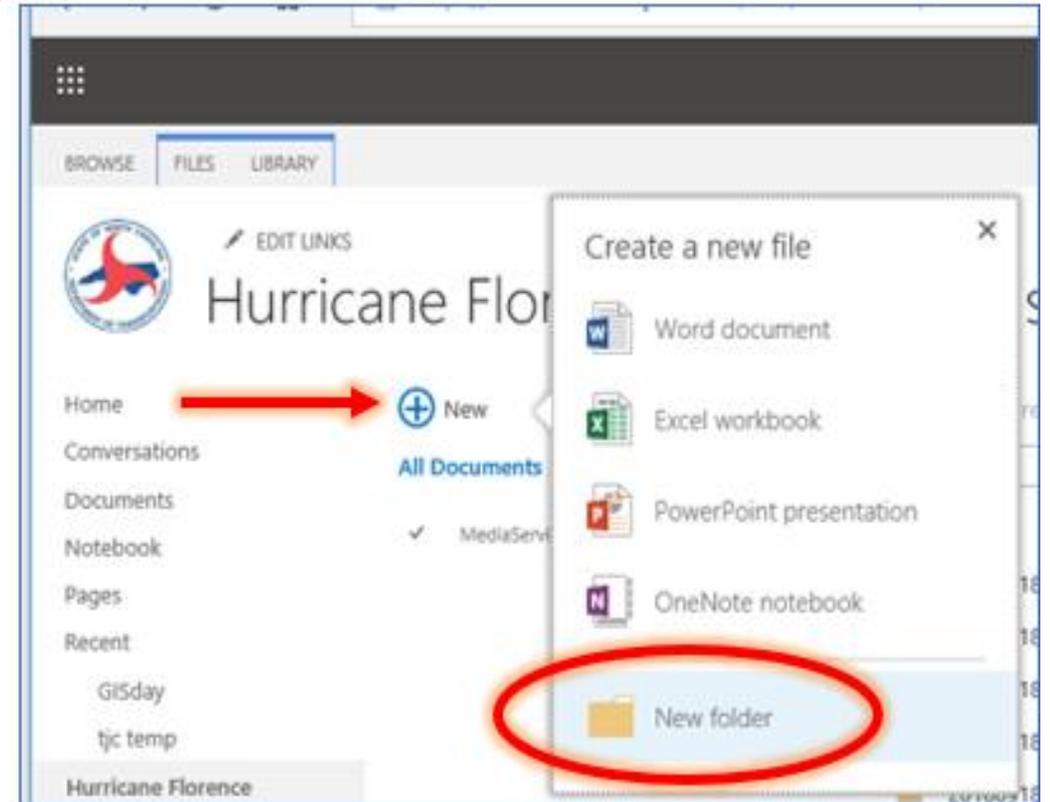
# Data Management

- Navigate to the appropriate Team Folder



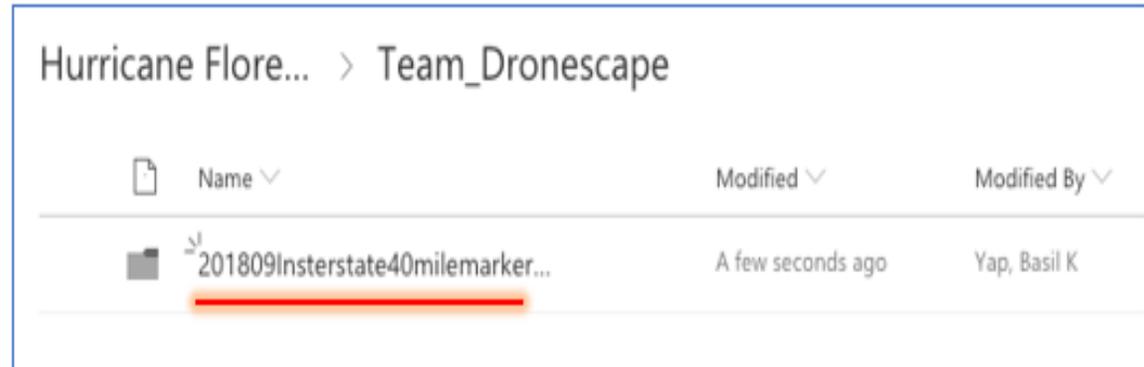
# Data Management

- For each unique mission location, create a new folder with the naming convention: YYYYMMXXDescription (e.g., 20180917Interstate40mm36).
- **\*\*NOTE\*\*** Please do not change the name of the folder once the photos/videos have been uploaded. This will disrupt the connection between SharePoint and ArcGIS Online.



# Data Management

- Upload all appropriate photos and video from the flight. Keep the browser open during the upload process. If there is a weak internet connection, upload photos first, then videos.
- Once completed, email [bkyap@ncdot.gov](mailto:bkyap@ncdot.gov) indicating the files have been uploaded.



Hurricane Flore... > Team\_Dronescape

 Name ▾	Modified ▾	Modified By ▾
 <u>201809Insterstate40milemarker...</u>	A few seconds ago	Yap, Basil K

# Data Collection Standards for Photo Imagery

JPEG

No bracketed files for HDR creation

Enable GPS/location services; this assures collection of appropriate metadata

Take as many photos that are necessary to fully understand the extent of the damage, while still being cognizant of upload time

Be diligent culling out low quality, poor images

Any relevant imagery that contains personal identification information or potentially controversial material should be forwarded to the UAS program manager (i.e., picture of a face)

All photos will be geo-referenced and displayed within a statewide map available to NCDOT staff

# Data Collection Standards for Video Imagery

.MP4 (issues with .MOV files)

2 minutes maximum

1080p or smaller

30fps or 24fps

Before flight: **disable** audio

Before flight: **enable** video subtitles/video captions within video settings

Have a plan of how the video will look prior to takeoff

**Minimize** takeoff and landing footage; **maximize** damage assessment

If necessary, trim videos to minimize uploading time (< 2 min)

# Data Management Standards and Privacy



ALL UAS TEAMS CONTRACTED BY NCDOT WILL BE OPERATING UNDER PART 107 RULES UNLESS ADDITIONAL AUTHORIZATION IS GRANTED. DO NOT TAKE ANY UNNECESSARY RISKS TO GET A BETTER PHOTO OR VIDEO.



ALL MEDIA AND ASSOCIATED METADATA (PHOTO AND VIDEO) COLLECTED DURING FLIGHTS ARE PROPERTY OF THE NCDOT. THE NCDOT HAS SOLE DISTRIBUTION RIGHTS OF SAID DATA. THE CONSULTANT SHALL REQUEST IN WRITING PRIOR APPROVAL TO USE ANY DATA COLLECTED UNDER THIS CONTRACT (TO INCLUDE PHOTOS, VIDEOS, ETC.) FROM THE UAS PROGRAM MANAGER.

# Data Management Standards and Privacy

Questions regarding specific data management policy, collection practice, storage, handling, and dissemination are covered under the Statewide Data Classification and Handling Policy document.



That document can be found at the following address.

<https://it.nc.gov/documents/statewide-data-classification-and-handling-policy>

# Information



All information presented in the preceding slides is available on the NCDOT UAS Emergency Response Media Guidelines document.

Please contact Basil Yap [bkyap@ncdot.gov](mailto:bkyap@ncdot.gov) to request access.



All UAS response teams should have access to NCDOT-UAS an Office 365 group and Microsoft SharePoint site: <https://ncconnect.sharepoint.com/sites/NCDOT-UAS>.

Contact Basil Yap [bkyap@ncdot.gov](mailto:bkyap@ncdot.gov) to request access.



NCDOT and UAS teams' goal is to capture photos and video that showcase the extent of the damage during a hurricane or other natural disaster.



**NORTH CAROLINA**  
Department of Transportation

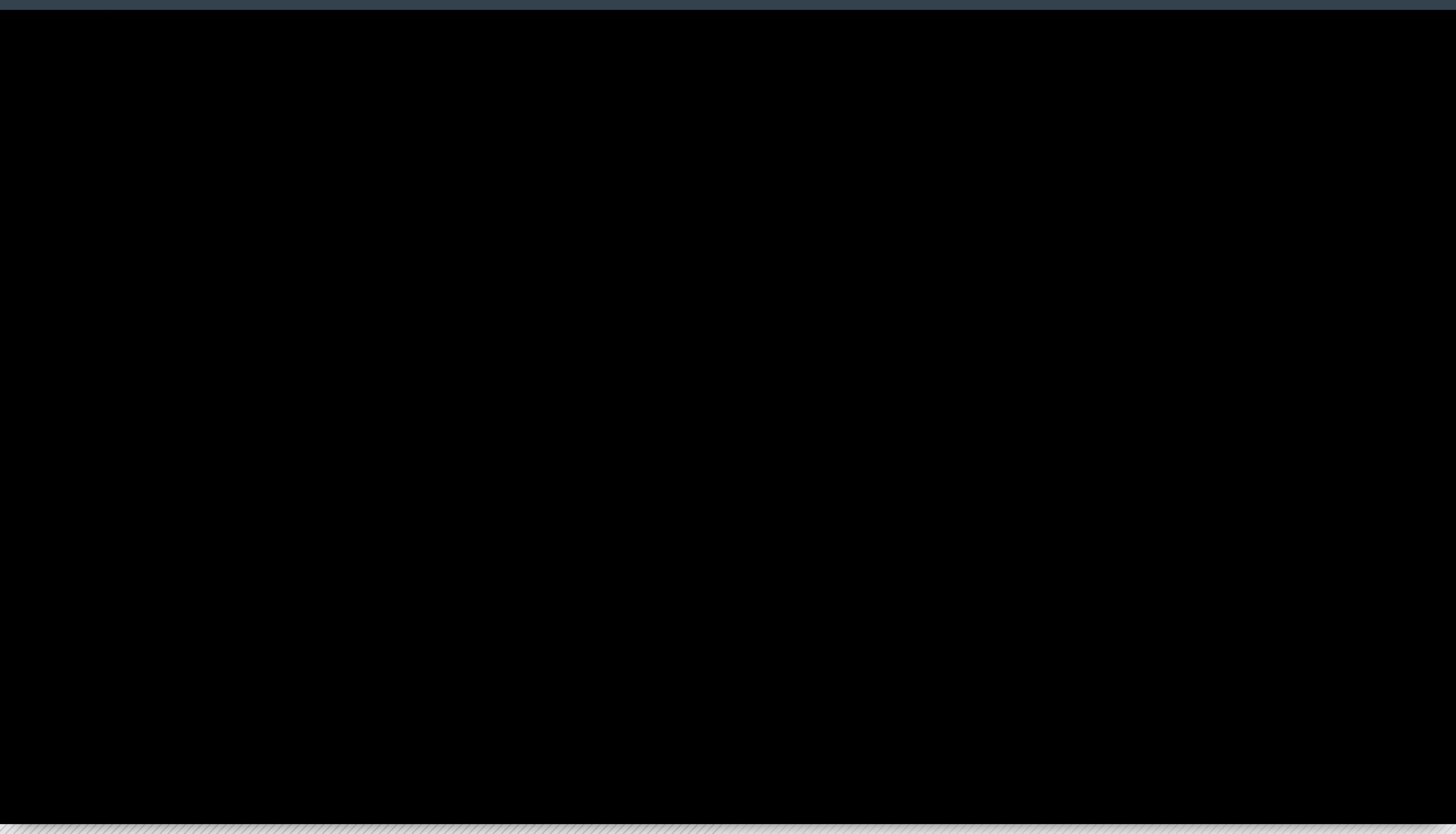


# UAS Hurricane Response Safety

Wade Baily, CSP

John Cala, CIH

July 11, 2019

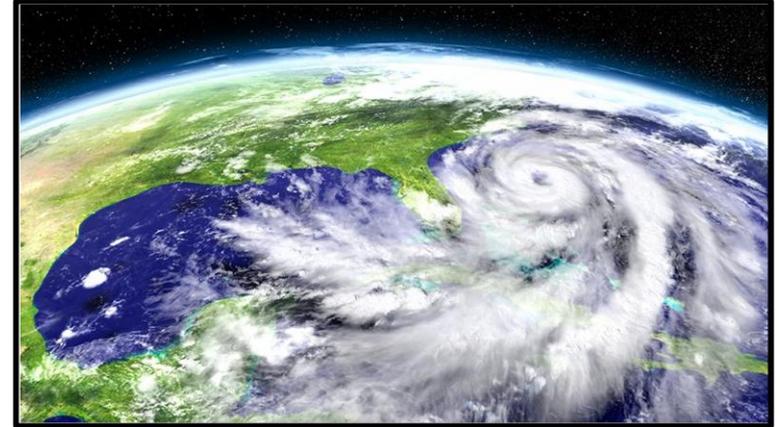


# Statistics

- Atlantic hurricane season

\*June 1 – November 30\*

- 1.2 million Americans live in hurricane-prone areas
- Annual estimated hurricane damage: \$28 billion
- Effects expected to increase



# Hazard Assessment

- Scope of work dictates applicable hazards
  - Command structure
  - Location permission/restriction
  - Elimination



# Flooding

## HAZARDS

- Unknown depth of standing water
- Changing accessibility of routes
- Damage to infrastructure

## CONTROLS

- Elimination
- PFDs



# Electrical

## HAZARDS

- Downed/submerged power lines
- Water conducts electricity

## CONTROLS

- Remain in vehicle
- Keep safe distance
- Never drive over downed lines



# Physical Hazards

## HAZARDS

- Heat-related illness
- Lacerations
- Noise
- Falls

## CONTROLS

- Shade/Hydration
- Elimination
- PPE
- First Aid



# Hazardous/Infectious Agents

## HAZARDS

- Chemical releases
- Building materials
- Biological hazards

## CONTROLS

- Use your senses
- Elimination
- Bug spray



# Conclusion

- Communication is key
- Prioritize responder safety
- Be proactive in safety controls
- Continuous improvement





# Disaster Response Air Operations Center (AOC)

Chris Bailey  
SAR Coordinator, NCEM





# SERT AIR OPERATIONS MISSION

- Plans, Organizes, Directs, Manages, and Controls State and Regional Disaster Airlift (SARDA)



# SERT AVIATION PARTNERS



DIVISION OF AVIATION  
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION





# NORTH CAROLINA STATE CHAIN OF COMMAND

Governor  
Commander and Chief

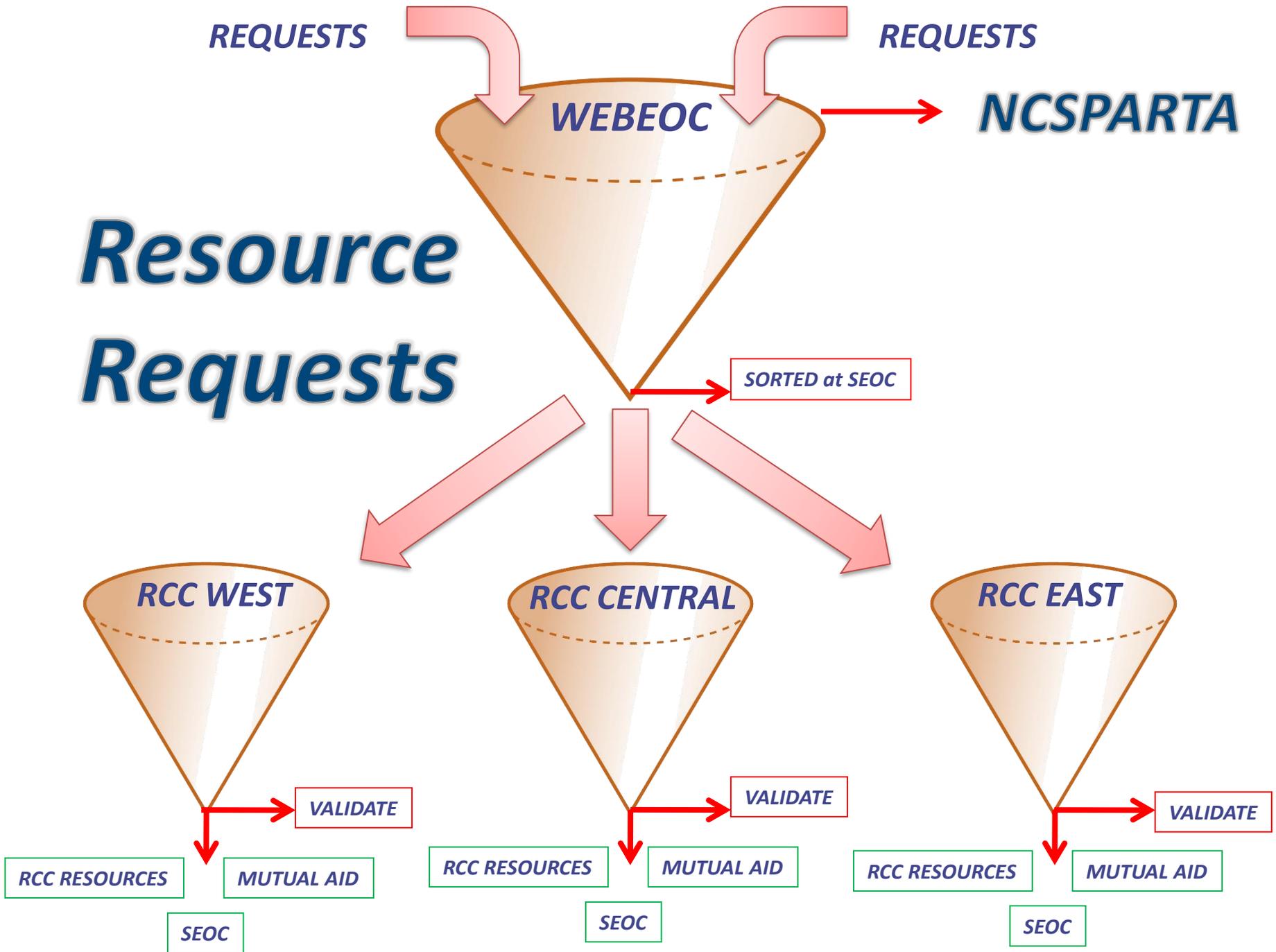
Secretary Department of  
Public Safety

Director of Emergency  
Management

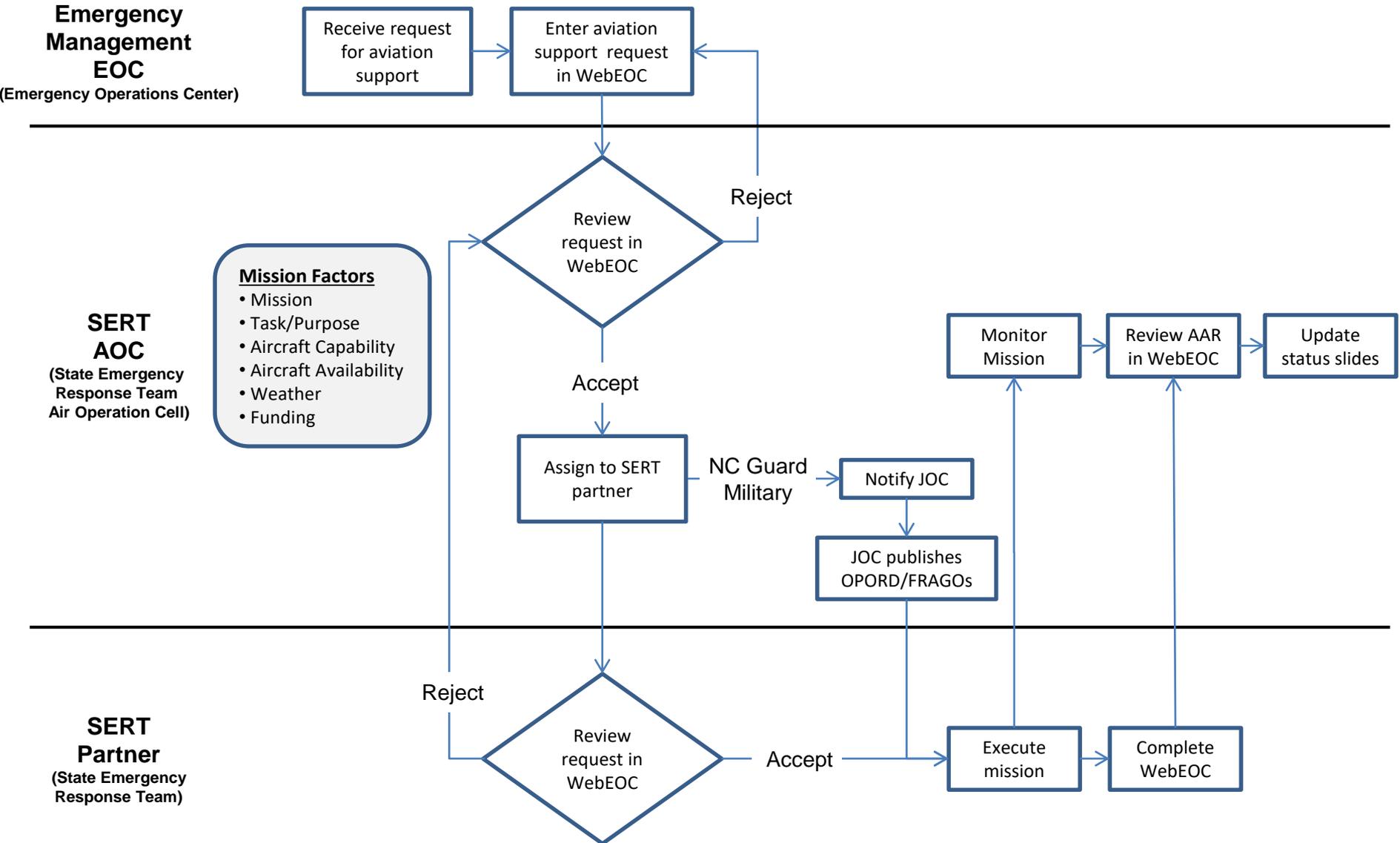
Air Boss  
SERT Air Ops



# Resource Requests



# State Emergency Response Team Air Operations Cell Mission Receipt and Partner Tasking Process





## NORTH CAROLINA Department of Transportation



# NCDOT Photogrammetry Unit Activities during Hurricane Florence

Matt Macon and Donald Early  
NCDOT Photogrammetric Engineers

July 11, 2019

# Presentation Outline

- Manned Flights for Hurricane Florence
- Support for US 421 (both UAS imagery & manned imagery)
  - Post Hurricane Florence at US 421- Manned Imagery
  - Post Hurricane Florence at US 421 – UAS Nadir Imagery
- Manned Flight Preparations for Future Events
  - Pre Hurricane Flights over NCDOT Facilities
  - Pre Planned Missions in Event of Hurricane Landfall
  - Coordination with NCDOT GIS Unit
- Preparations to Process nadir or block UAS Imagery for Future Events

# Manned Flights for Hurricane Florence

- I-40
  - I-95
  - US 17
  - US 70
  - US 74
  - US 421
  - NC 210
- US 421 was used for design and construction

<http://arcg.is/1WOquq>

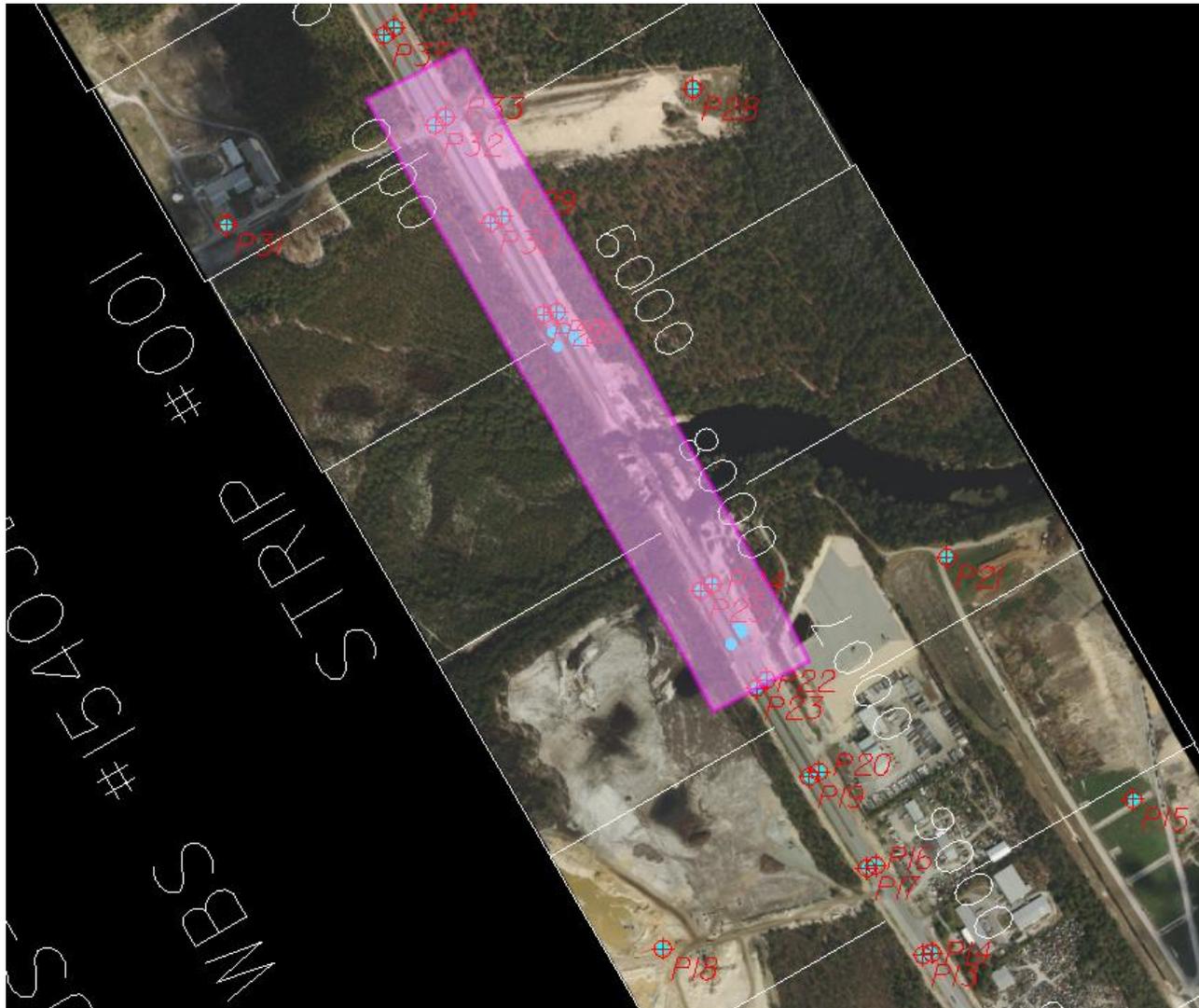
<http://arcg.is/0emjqf0>

# Support for US 421 (UAS & manned Imagery )

- Manned imagery was used for
  - Design and construction in a MicroStation environment
    - Collecting planimetric, DTM, and field surveyed data
      - Pavement
      - Hydro
      - Property
- UAS imagery was used for
  - Construction monitoring purposes

# Post Hurricane Florence at US 421

## Fishing Creek at New Hanover/Pender County Line



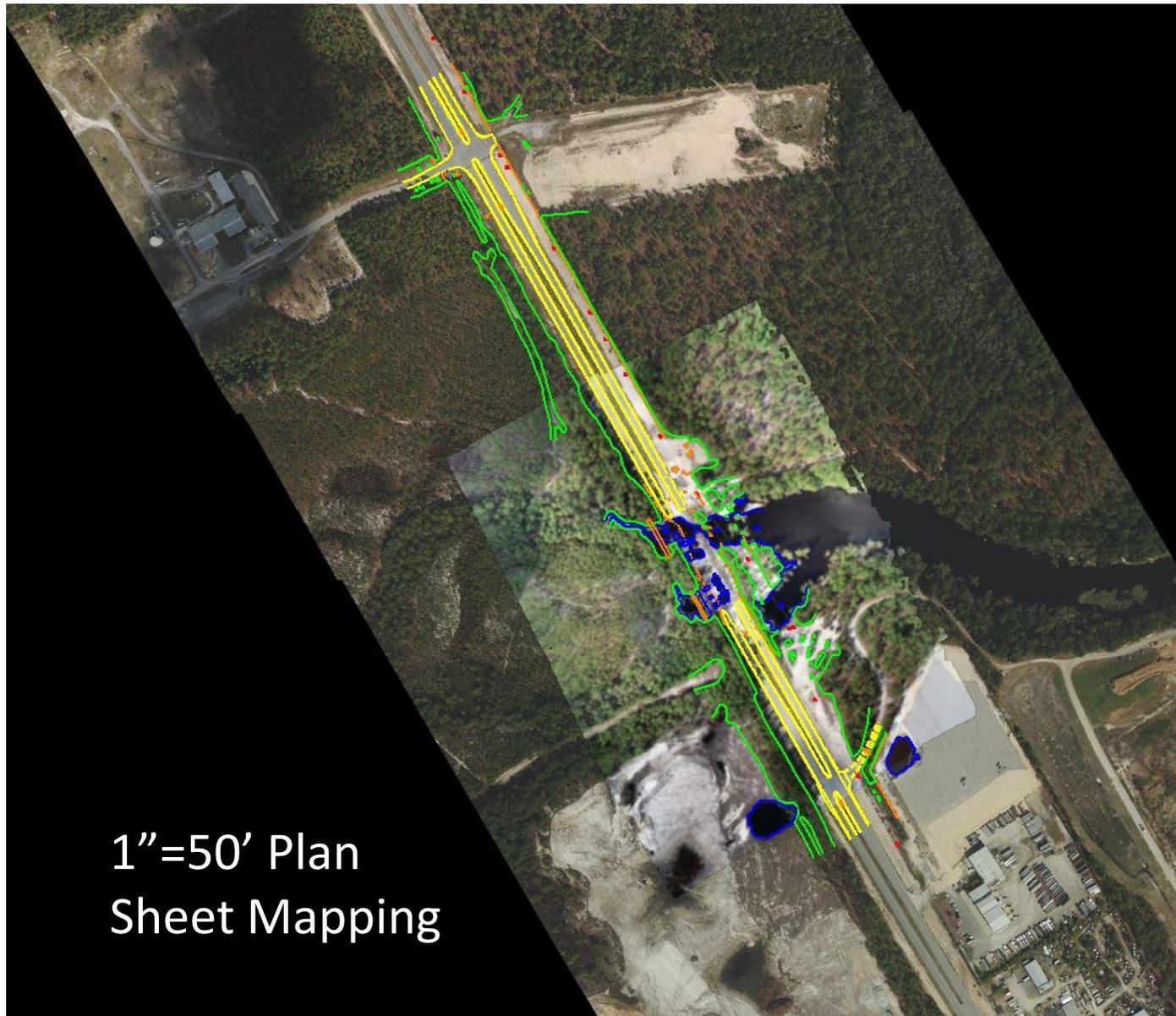
1"=50' Plan Sheet  
Mapping with DTM

Location & Surveys  
Unit to use to  
produce Final  
Surveys

Red Points – GCPs  
for manned aircraft  
imagery

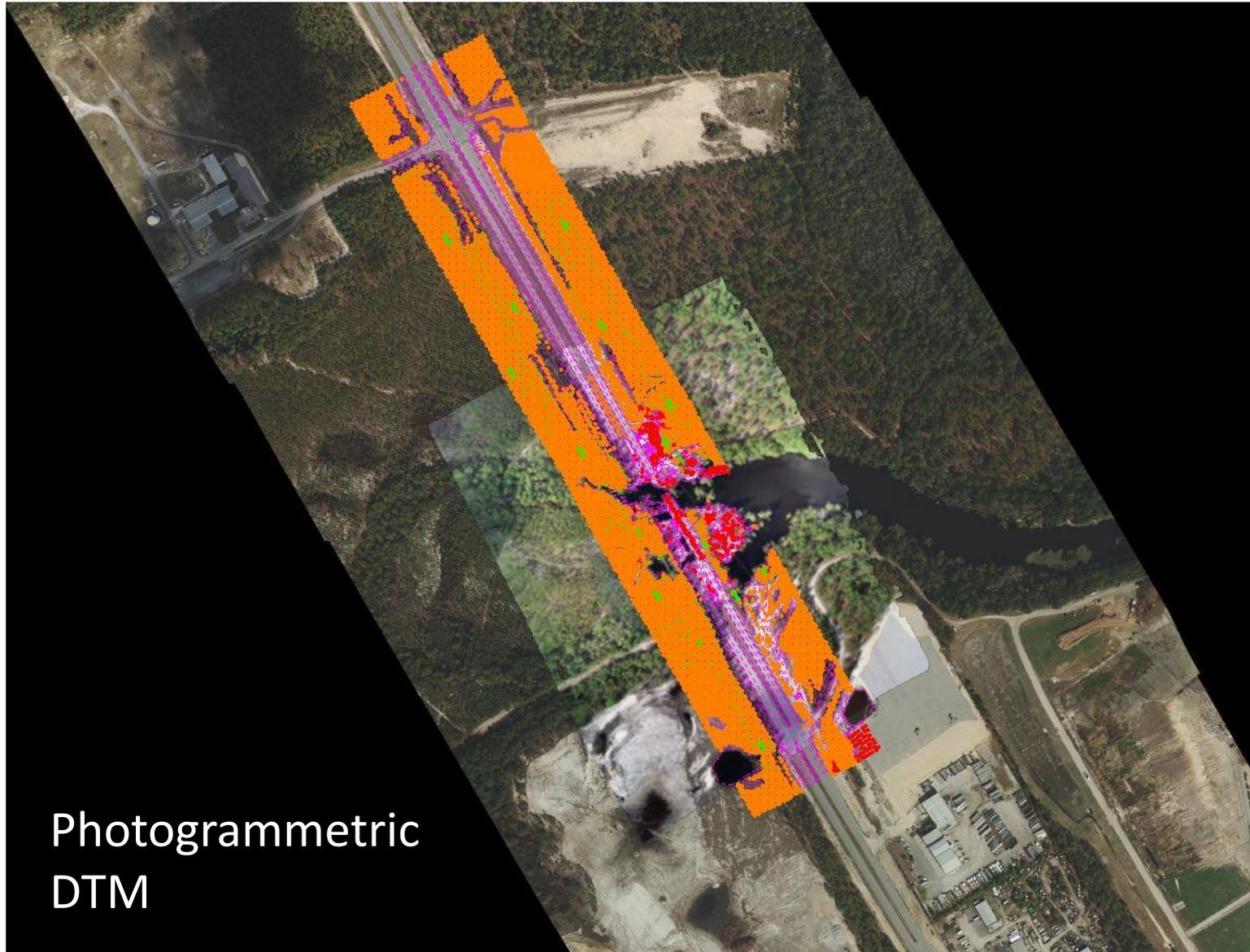
Blue Points w/o  
Red ID – GCPs for  
UAS nadir imagery

# Post Hurricane Florence at US 421



1"=50' Plan  
Sheet Mapping

## Post Hurricane Florence at US 421



Photogrammetric  
DTM

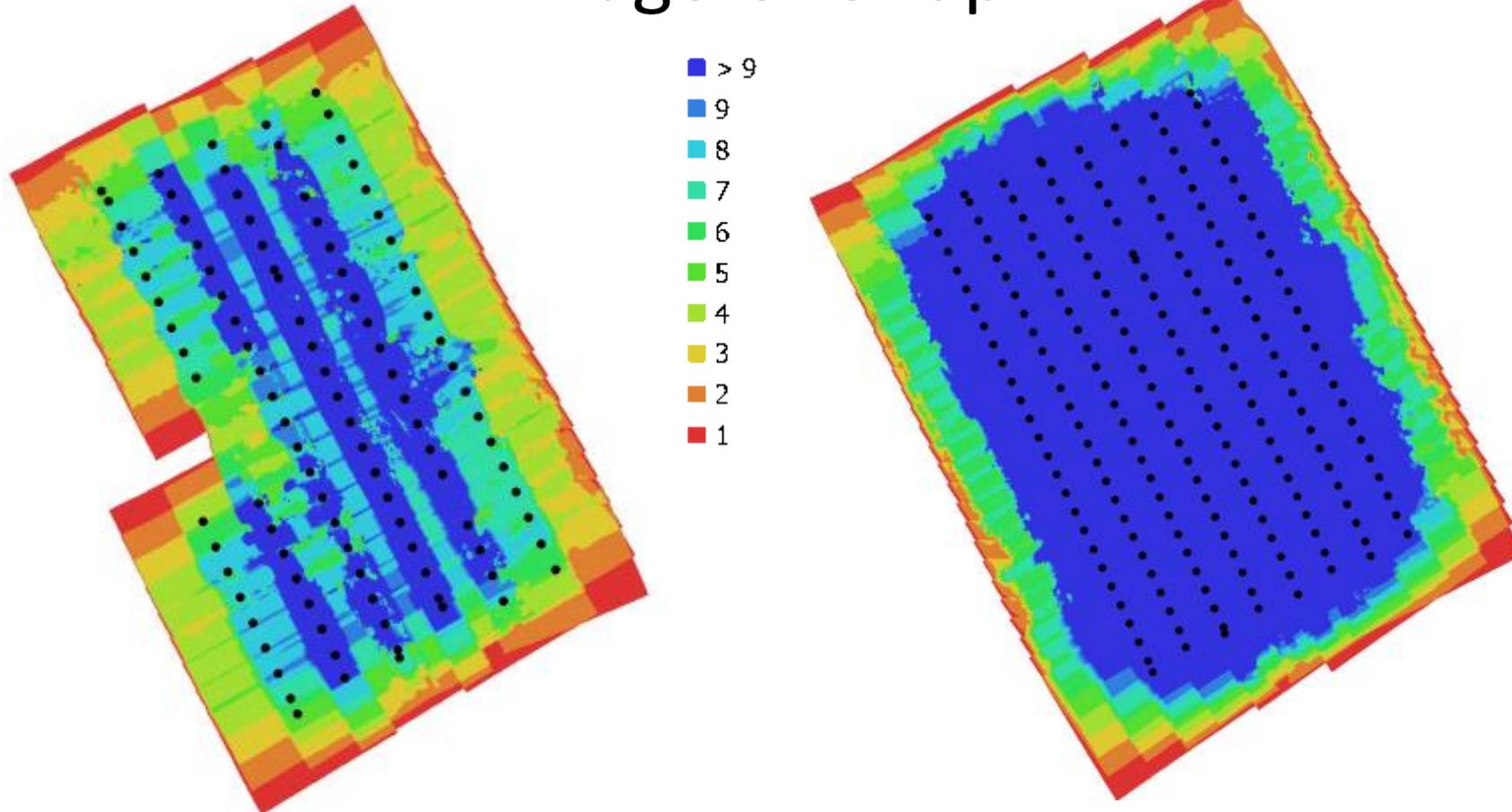
## Post Hurricane Florence at US 421 – UAS Nadir Imagery

- North State Environmental collecting UAS oblique & nadir imagery using DJI Phantom 4 Pro

Date	North End GCP deltaX	South End GCP deltaY	Images Matched	% Image Matching	Comment		
<b>UnControlled Missions</b>	LP04 (ft)	LP01 (ft)					
US421_20180928_AM	3.825	12.793	105 of 121	87%	insufficient overlap		
US421_20180928_PM	12.333	15.170	217 of 217	100%	83-85% FOL & 70-80% SOL for all missions thereafter		
US421_20180929_PM	1.692	4.483	203 of 203	100%			
US421_20180930_PM	2.799	4.503	202 of 202	100%	<b>in situ camera calibration</b>		
Controlled Missions					<b>f (pix)</b>	<b>cx (pix)</b>	<b>cy (pix)</b>
US421_20181001_PM	0.111	0.016	196 of 196	100%	3665.16	6.40	20.03
US421_20181007_PM	0.048	0.026	203 of 203	100%	3641.90	3.21	20.71
US421_20181010_PM	0.048	0.018	201 of 201	100%	3653.81	6.18	21.25
US421_20181012_PM	0.477	0.032	197 of 197	100%	4694.13	13.86	7.56
US421_20181016_PM	0.070	0.027	197 of 197	100%	3661.93	6.87	20.29
US421_20181019_PM	0.077	0.028	200 of 200	100%	3683.35	7.26	21.45
US421_20181023_PM	0.055	0.034	194 of 194	100%	3654.82	6.43	20.97

## Post Hurricane Florence at US 421 – UAS Nadir Imagery

## Image Overlap



US421\_20180928\_AM  
Flying Altitude: 334 ft

US421\_20180929\_PM  
Flying Altitude: 443 ft

# Post Hurricane Florence at US 421 – UAS Nadir Imagery

## Orthophoto Coverage



US421\_20180928\_AM  
Flying Altitude: 334 ft

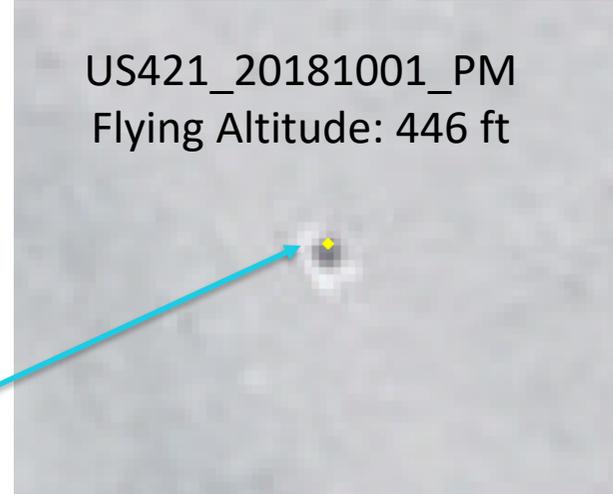


US421\_20180929\_PM  
Flying Altitude: 443 ft

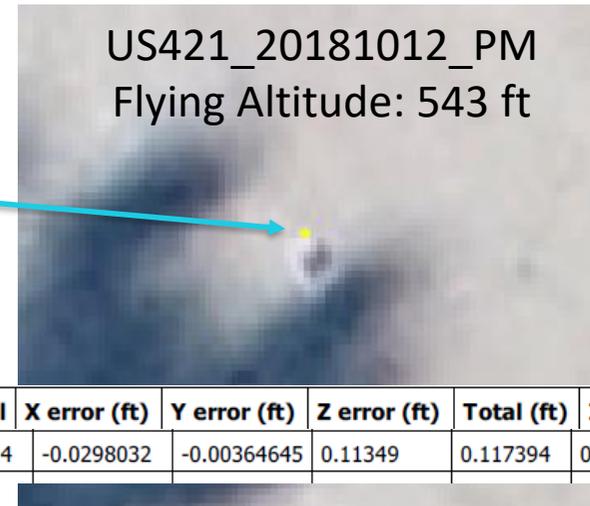
# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Horizontal Fit



US421\_20181001\_PM  
Flying Altitude: 446 ft



US421\_20181012\_PM  
Flying Altitude: 543 ft



Label	X error (ft)	Y error (ft)	Z error (ft)	Total (ft)	Image (pix)
LP04	-0.0298032	-0.00364645	0.11349	0.117394	0.304 (11)

# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Horizontal Fit

## US 421 Construction Monitoring Map Oct 10th to Oct 12th

The left side is the October 10th uas imagery. The right side is the October 12th uas imagery.

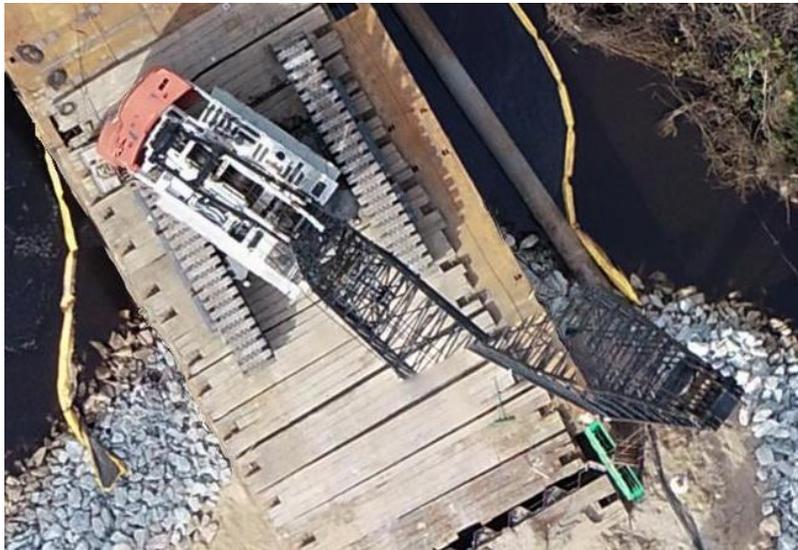
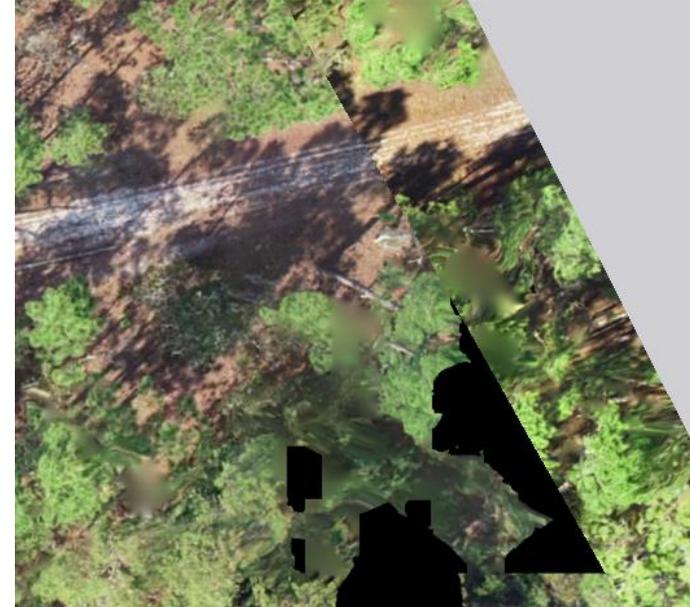


## US 421 Construction Monitoring Map Oct 12th to Oct 16th

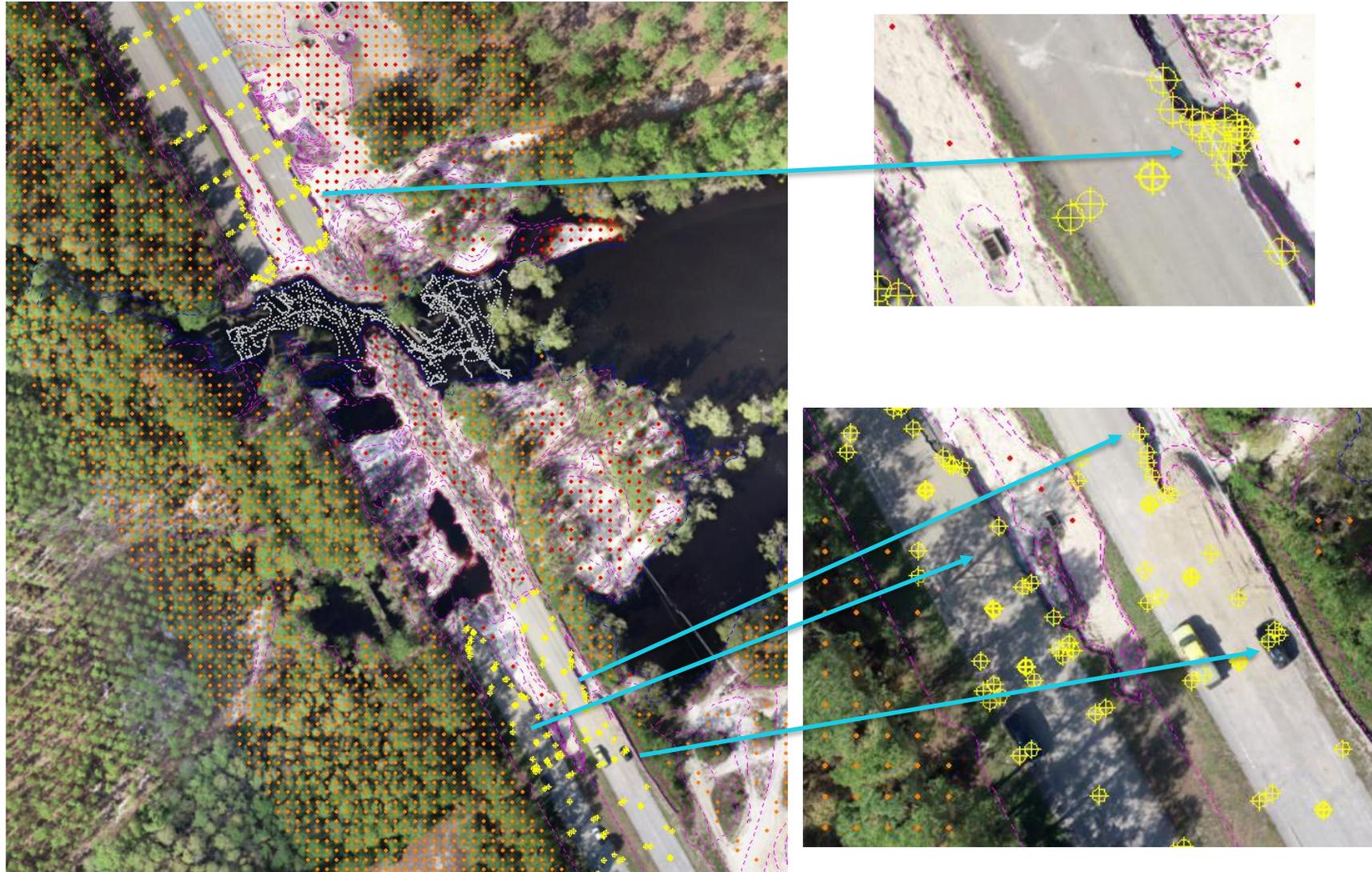
Left image is the October 12th UAS imagery. Right image is the October 16th UAS imagery



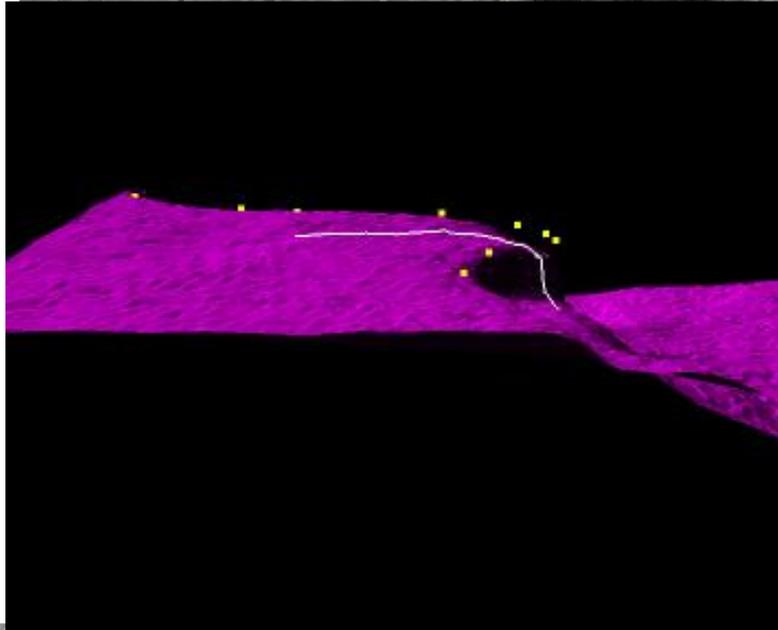
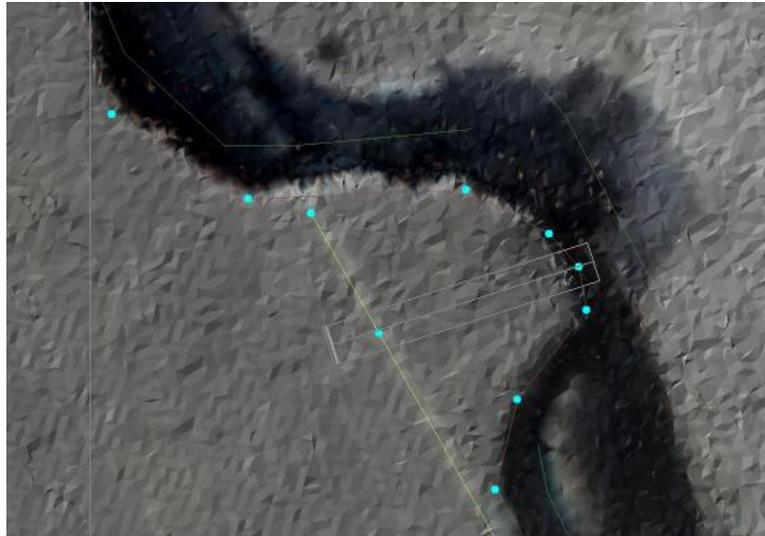
# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Horizontal Fit - Orthophoto



# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit

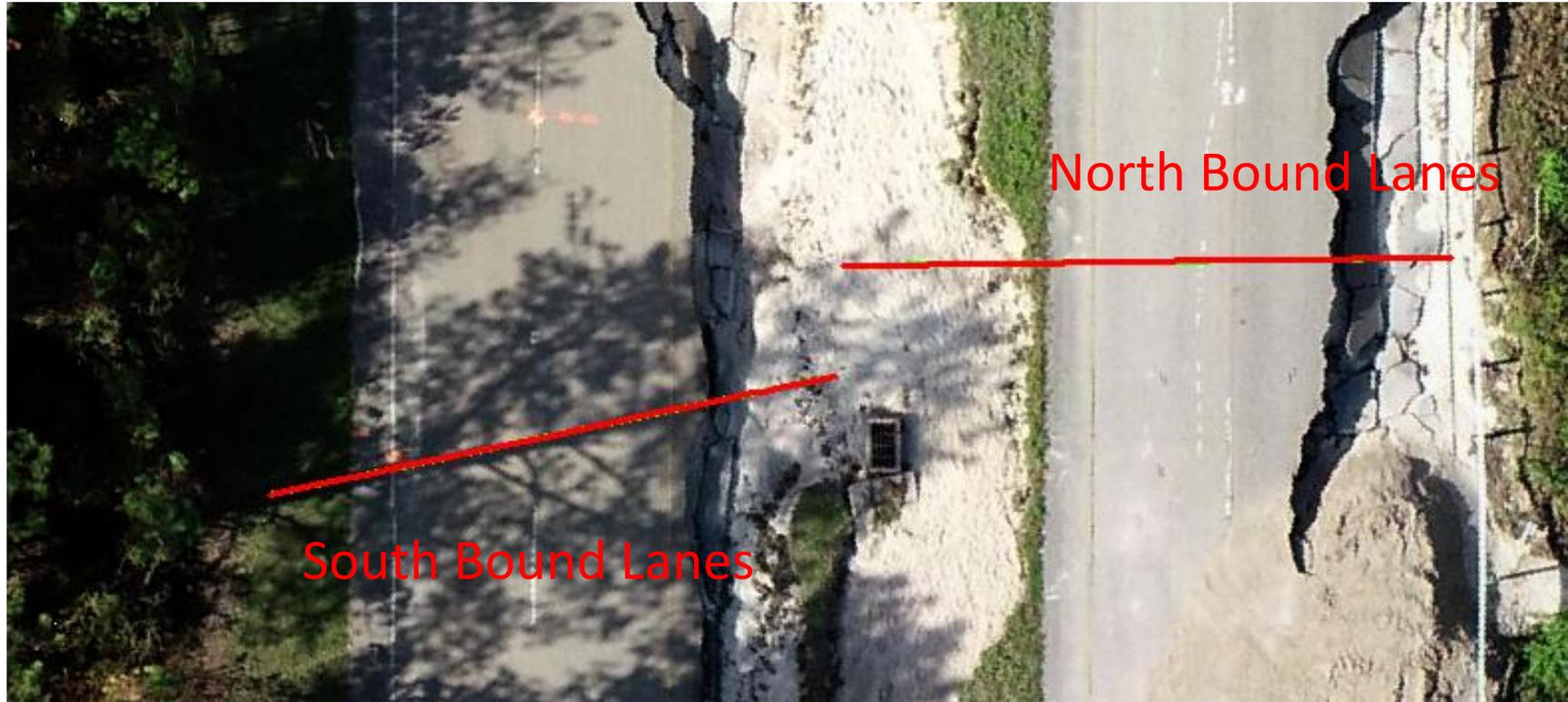


# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit – North End Pavement



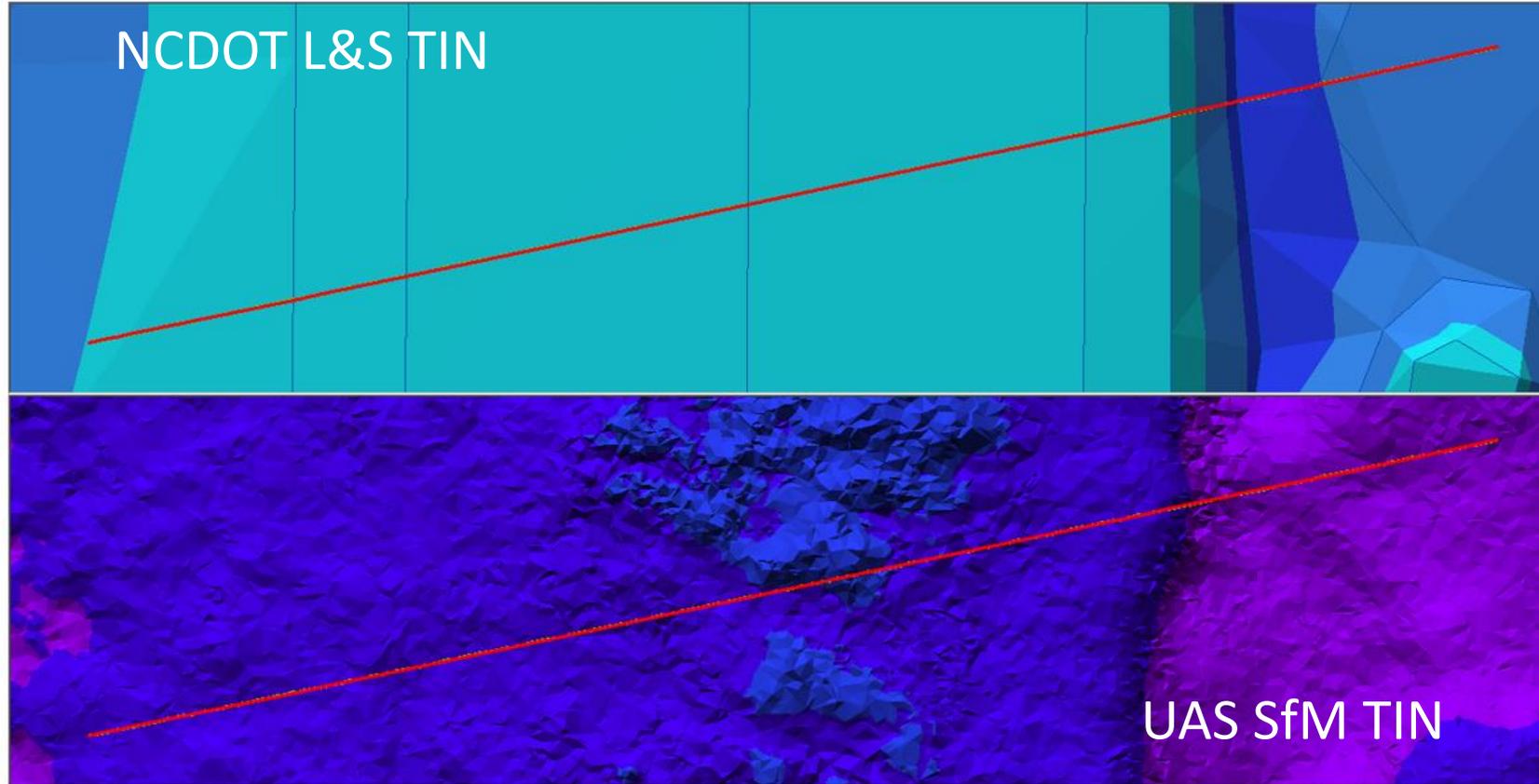
US421\_20181001\_PM

# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit – South End Pavement



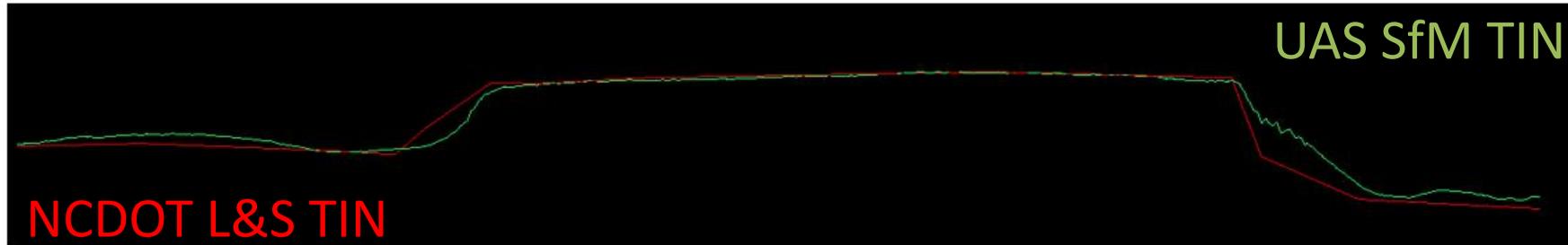
US421\_20181001\_PM

# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit – South End Pavement



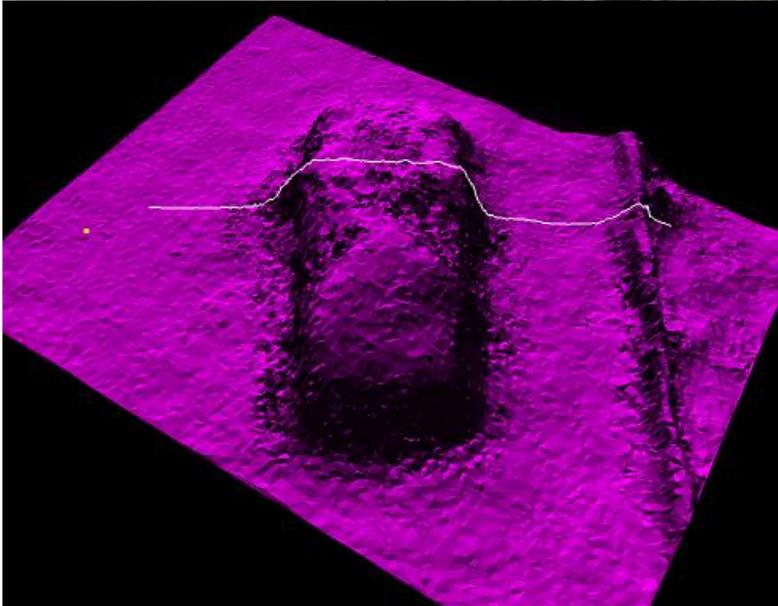
US421\_20181001\_PM  
South Bound Lanes

# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit – South End Pavement



US421\_20181001\_PM  
North Bound Lanes

# Post Hurricane Florence at US 421 – UAS Nadir Imagery Observations on Vertical Fit – South End Pavement



US421\_20181001\_PM  
Vehicle

# Manned Flight Preparations for Future Events

## Pre Hurricane Flights over NCDOT Facilities

- I-95, from SC line to Fayetteville
- I-40, from exit 390 to exit 384 (near Wallace)
- Ocracoke and Hatteras Islands
  - Flights recently completed
  - Expect AGOL service to be up +/- August 1<sup>st</sup> unless events dictate otherwise
  - 0.5 foot color orthoimagery

# Manned Flight Preparations for Future Events

## Pre Planned Missions in Event of Hurricane Landfall

- I-95, from SC line to I-40
- I-40, from Wilmington to US 70 Bypass
- US 17, from SC line to Wilmington
- US 74, from Rockingham to Wilmington
- US 70, from I-40 to Beaufort
- US 64, from Whalebone to I-40
- Entire Coastline
  - **Flights will be 0.5 foot color orthoimagery**
  - **Flights only conducted if activated by NCDOT management**

# Manned Flight Preparations for Future Events

## Coordination with NCDOT GIS Unit

- NCDOT GIS Unit is preparing to publish an AGOL service with key transportation related layers
- The AGOL service will include both NCDOT UAS images/video and NCDOT orthoimagery (if activated)
- The AGOL service would also include access to other image service providers such as NOAA

# Preparations to Process nadir or block UAS Imagery for Future Events

- The NCDOT Photogrammetry Unit is continuing to evaluate non-metric camera photogrammetry software to include
  - UASMaster (Trimble product)
  - Context Capture (Bentley product)
- The NCDOT Photogrammetry Unit is continuing to evaluate tools to work with dense terrain data.
- The NCDOT Photogrammetry Unit is actively training additional NCDOT staff to process UAS Imagery
- The NCDOT Photogrammetry Unit has upgrade specific computers with more memory and greater processing speeds to work with both UAS and Manned imagery.



# Air Operation Center

- Web EOC
  - Available Air Resources

## Available Air Resources Daily Operations 2019

Resource Tracker > Available Air Resources All  Search Clear

Name	A/C ID	Agency Name	Pilot Name Co-Pilot	Aircraft Capability	Location ID	Location Name	
B407	N407NC	State Highway Patrol	Jim Laningham Chris Agner	Aerial Imagery Command & Control (C2) Communications Relay General Support HART - Short Haul NVG Search / Scout Thermal Imaging (FLIR)	RUQ	MID-CAROLINA RGNL	View Deploy History (0)
EC135	N136KY	Duke University		Medevac	JNX	JOHNSTON RGNL	View Deploy History (0)
UH-60	24402	NC National Guard		Medevac	RUQ	MID-CAROLINA RGNL	View Deploy History (0)





# NCEM SERT AIR OPERATIONS

# QUESTIONS?

