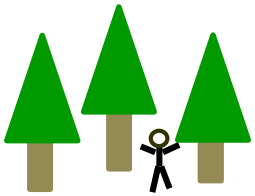


North Carolina Emergency Management's UAS program

Gary W. Thompson, Deputy Risk Management Chief

Implementing UAS tech into emergency management operations

- During any emergency or disaster the priorities for emergency responders and managers remain the same:

UAVs can help support these priorities:

  - Protect lives → **Save victims, rescuers, & property**
  - Protect property → **Increase response effectiveness**
  - Protect the environment → **Expedite relief & recovery**
  - Recover as quickly as possible

Brewer, S. (2013, March). *Applications In Emergency Response and Public Safety*. Presented at the Civilian Applications of UAVs – A California Perspective, a Policy Symposium. Westlake Village, California. Retrieved from https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

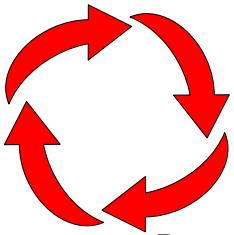
NCEM operates under the four phases of Emergency Management

Mitigation

Actions taken to prevent, reduce the chance of, or reduce the effects of a disaster

- **National Flood Insurance Program (NFIP)** section assists communities that participate in the NFIP.
- **Hazard Mitigation** section reduces the impacts of future natural hazards by identifying projects and funding to address local issues

UAVs can support each phase & act as a force multiplier



Preparedness

Actions taken to increase readiness & the ability to respond to a disaster

- **NC Floodplain Mapping Program (NCFMP)** determines flood hazard areas
- **Planning Operations** section assists communities to create an Emergency Operations Plan (EOP) (i.e. how to prepare for, respond to, and recover from a disaster)
- **Training & Exercise** branch conducts exercises and hosts training to prepare for various disasters
- **Public Information Officer (PIO)** informs the public on how to prepare for disasters (ReadyNC.org and ReadyNC app)

Recovery

Actions taken to restore an area and population to a pre-disaster condition

- **Individual Assistance** program helps families whose home has been damaged to secure housing and helps small business owners to restore damaged business property.
- **Public Assistance** program works with local governments to clear debris along roads and restore public infrastructure

Response

Actions taken by emergency service personnel & agencies to saves lives and to protect property & the environment

- **NC Flood Inundation Mapping & Alert Network (FIRMAN)** produces real-time & forecasted flood maps
- **State Emergency Response Team (SERT)** coordinates relief efforts and provides support to local & county governments

How UAVs could assist with each EM phase at various levels of government

- **Mitigation UAV applications**

  Actions taken to prevent, reduce the chance of, and/or reduce the effects of a disaster

  - Monitor development in flood hazard areas
  - Map and document pre-disaster conditions
  - Monitor hillsides subject to landslides
  - Monitor fuel loads in forests and natural areas

https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

How UAVs could assist with each EM phase at various levels of government

- **Preparedness UAV applications**

  Actions taken to increase readiness and the ability to respond to a disaster

  - Support training and exercise activities
  - Preplanning and familiarization for tactical responses
  - Provide high resolution aerial photos of hazard areas, evacuation routes, and safe zones

https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

How UAVs could assist with each EM phase at various levels of government

- **Response UAV applications (1 of 2)**

  Actions taken by emergency service personnel & agencies to saves lives and to protect property & the environment

  - Provide **real-time situational awareness** of threats and hazards (public and responder safety)
  - **Assess conditions of inaccessible, hazardous, and/or contaminated areas via images and sensors**
  - Determine status of roads and critical infrastructure
  - Provide geospatial references and navigation
  - Monitor response operations and effectiveness
  - Monitor the movement of persons, vehicles, resources, and provide security

https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

How UAVs could assist with each EM phase at various levels of government

- **Response UAV applications (2 of 2)**

  Actions taken by emergency service personnel & agencies to saves lives and to protect property & the environment

  - **Assist search and rescue operations**
  - Support or restore communications
  - Survey utilities and utility infrastructure

https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

How UAVs could assist with each EM phase at various levels of government

- **Recovery UAV applications**

  Actions taken to restore an area and population to a pre-disaster condition

  - Survey damaged areas and structures
  - Provide geospatial references and navigation
  - Determine status of roads and critical infrastructure
  - Assess conditions of inaccessible, hazardous, and/or contaminated areas via images and sensors
  - Monitor recovery operations and effectiveness
  - Monitor the movement of people, vehicles, & resources
  - Provide support for security in evacuated areas
  - Support or restore communications
  - Survey utilities

https://www.aiaa.org/uploadedFiles/About-AIAA/Press-Room/Key_Speeches-Reports-and-Presentations/2013_Key_Speeches/CA_Aerospace_Week_2013/Brewer-CAUAV2013.pdf

NCEM's UAS program

- **If you are interested in receiving a digital copy of the following 83-page directions document:**

  How to legally incorporate Unmanned Aircraft System (UAS) technology into your public agency's operations:

  I. Part 107 regulations route vs. II. Certificate of Waiver or Authorization (COA) route

  Then send an email:

  To: curt.johnson@ncdps.gov

  Subject: UAS DIRECTIONS DOC

NCEM's UAS program

- **Operate under an FAA Blanket Area Public Safety Agency Certificate of Waiver or Authorization (COA) (issued 2016-06-13)**

  A. Self-certification of our remote pilots

  NCEM has a total of six FAA certificated Remote Pilots

  – Before the FAA Part 107 rules became effective on 2016-08-29, NCEM's remote pilots were required under our self-certification agreement with the FAA to pass the **Private Pilot - Airplane (PAR) exam**

  – After the FAA Part 107 rules became effective on 2016-08-29, NCEM's remote pilots are now required under our self-certification agreement with the FAA to:

    - Pass the FAA "**Unmanned Aircraft General - Small**" exam
    - Be vetted by the **Transportation Security Administration (TSA)**
    - Be issued an **FAA Remote Pilot certificate**

NCEM's UAS program

- **Operate under an FAA Blanket Area Public Safety Agency Certificate of Waiver or Authorization (COA) (issued 2016-06-13)**

  B. Coordination requirements

  Must file a **Notice to Airmen (NOTAM)**, which alerts pilots of the planned UAS activity, within a **72-24 hour** advanced notice time frame. **If it is an emergency**, the time can be reduced to **no less than 30 minutes prior to the operation**.

NCEM's UAS program

- **Operate under an FAA Blanket Area Public Safety Agency Certificate of Waiver or Authorization (COA) (issued 2016-06-13)**

  C. Communication requirements

  When operating in the vicinity of an airport without an operating control tower, the Pilot in Command (**PIC**) will **alert manned pilots of the UAS operations by announcing on an appropriate airport** Universal Communications (**UNICOM**)/ Common traffic advisory frequency (**CTAF**) **frequency**.

NCEM's UAS program

- **Operate under an FAA Blanket Area Public Safety Agency Certificate of Waiver or Authorization (COA) (issued 2016-06-13)**

D. Flight planning requirements

This COA will allow **small UAS (≤55 lbs)** operations **during daytime visual meteorological conditions (VMC)** conditions **only within Class G airspace** under the following limitations:

- At or below **400 ft above ground level (AGL)**, and
- **Beyond the following distances from the airport reference point (ARP)** of a public use airport, heliport, gliderport, or water landing port listed in the Airport/Facility Directory, Alaska Supplement, or Pacific Chart Supplement of the U.S. Government Flight Info Publications:
  - **5 nautical miles (NM)** from an **airport** having an **operational control tower**, or
  - **3 NM** from an **airport** having a **published instrument flight procedure, but not having an operational control tower**, or
  - **2 NM** from an **airport not having a published instrument flight procedure or an operational control tower**, or
  - **2 NM from a heliport**.
- The **Pilot in Command (PIC)** is **responsible for identifying the appropriate ATC jurisdiction nearest to the area of operations defined by the Notice to Airmen (NOTAM)**.

NCEM's UAS program

- **Operate under the FAA Addendum to approved COA for Public Safety Agencies (dated 2017-06-05)**

  In an effort to provide greater access into the National Airspace System (NAS) by public safety agencies across the nation, the FAA has amended approved COAs to now authorize public aircraft operators the ability to conduct **operations over people** and **nighttime operations when in compliance with the provisions listed below**:

  – ***Minimum Safe Altitude Operations***

  A waiver from the requirements of 14 CFR 91.119 Minimum safe altitudes (b) [1,000 ft over congested area] *and (c)* [500 ft over other than congested areas] *is approved as follows:*

  a. ***Except for those operations where it is necessary to safeguard human life**, no person may operate a small unmanned aircraft over a human being unless that human being is:*
     i. *Directly participating in the operation of the small unmanned aircraft; or*
     ii. *Located under a covered structure or inside a stationary vehicle that can provide reasonable protection from a falling small unmanned aircraft*

  b. *The groundspeed of the small UAS must not exceed 100 mph/87 knots*

  c. *The proponent must comply with 91.119(a).*

  d. *The proponent must report any accident/incident resulting in any human injury during COA operations over human beings.*

  Note: People "directly participating in the operation of the small unmanned aircraft" may include qualified non-crewmembers, as defined in 49 USC 40125.

  e. ***For those operations where it is necessary to operate over a human being in order to safeguard human life, the remote pilot in command must not operate any lower or in proximity to human beings [than] necessary to accomplish the operation.***

NCEM requires an NCDPS lawyer to determine whether or not a proposed UAS operation over people meets the "*safeguard human life*" criterion

Since the determination of whether or not a proposed UAS operation over people meets the "***safeguard human life***" criterion could be subjective, we have asked the NCDPS lawyer, Will Polk, to make that determination.

Met the criterion: The UAS operation to collect aerial imagery **over the drained Lake Surf**, which involved flying over some of the homes surrounding the lake with the UX5 fixed-wing, **met the "*safeguard human life*" criterion**, **because the operation collected topographic data that will be used to build a dam that would be strong enough to restore the lake and protect the people downstream.**

Did not meet the criterion: The UAS operation to collect aerial imagery **over the proposed Princeville housing development**, which would involve flying over the surrounding homes if conducted with the UX5 fixed-wing, did **not meet the "safeguard human life" criterion**, **because the flooding event was over.** Consequently, we did the operation with NCDOT flying their multirotors, which did not involve flying over the surrounding homes.

NCEM's UAS program

- **Operate under the Addendum to approved COA for Public Safety Agencies (dated 2017-06-05)**

  In an effort to provide greater access into the National Airspace System (NAS) by public safety agencies across the nation, the FAA has amended approved COAs to now authorize public aircraft operators the ability to conduct **nighttime ops** and **ops over people** when in compliance with the provisions listed below:

  – ***Night Small UAS Operations.***

  Small UAS operations may be conducted at night, as defined in 14 CFR § 1.1, provided:

  a. *All operations under the approved COA **must use one or more visual observers (VO)**;*

  b. *Prior to conducting operations that are the subject of the COA, the **remote pilot in command (PIC) and VO must be trained to recognize and overcome visual illusions caused by darkness, and understand physiological conditions which may degrade night vision**. This training must be documented and must be presented for inspection upon request from the Administrator or an authorized representative;*

  c. *The **sUA must be equipped with lighted anti-collision lighting visible from a distance of no less than 3 statute miles**. The intensity of the anti-collision lighting may be reduced if, because of operating conditions, it would be in the interest of safety to do so.*

NCEM's UAS program

- **Special Governmental Interest (SGI) [Emergency COA (eCOA)]**

  You will need a Special Governmental Interest (SGI), which was formerly referred to as an Emergency COA (eCOA), if any part of your proposed UAS operations site is within either of the following:

  - Temporary Flight Restriction (TFR)
  - National Security UAS Flight Restrictions area
  - Non-Class G airspace
  - Do not fly area around an airport as defined in your agency's COA

  – **What qualifies?:** Significant and urgent governmental interests [e.g. national defense, homeland security, law enforcement, & emergency operation (critical infrastructure)]

  – **Who can apply?:** Requested operations must be flown by a government entity or sponsored by a government entity

  – **UAS ops route?:** An agency can be operating under an active COA or Part 107 regs

  – **How to apply?:** https://www.faa.gov/uas/resources/event_archive/2017_uas_symposium/media/Breakout_1A_Options_as_an_Operator.pdf
  https://connect.ncdot.gov/resources/Aviation%20Resources%20Documents/Special%20Government%20Interest%20COA%20Addendum.pdf
  https://www.faa.gov/documentLibrary/media/Order/FAA_JO_7200_23_2.pdf

NCEM's UAS program

Parameter	Trimble UX5	Trimble UX5 HP
Type	Fixed-wing 	Fixed-wing 
Ground control station (GCS)	Yuma Tablet for pre-programmed flights	
Satellite guidance	**GPS**	
Takeoff	**Catapult launcher**. Requires 280 m for takeoff. The first 50 m must be clear of obstacles. The remaining section (50 m - 280 m) must be clear of obstacles above 15°.	
Landing	• **Linear**: 50 x 30 m landing zone. No obstacles above 12° along the landing path from 300 m to 25 m out. • **Curved**: 75 x 30 m landing zone. No obstacles above 19° along the landing path from 300 m to 165 m out and no obstacles above 6° from 165 m to 50 m out.	
Sensor (digital camera) GSD: Ground sample distance	24 MP with a fixed focal length 15 mm lens: • 2.0 cm (0.8") GSD @ 75 m (246 ft) • 2.6 cm (1.0") GSD @ 100 m (328 ft) • 3.13 cm (1.23") GSD @ 120 m (400 ft)	36 MP w/ a fixed focal length set of lenses (**15**, 25, & 35 mm): • 2.4 cm (0.9") GSD @ 75 m (246 ft) • 3.2 cm (1.3") GSD @ 100 m (328 ft) • 3.8 cm (1.5") GSD @ 120 m (400 ft)
Collects	Photos plus telemetry [**GPS** positioning (latitude, longitude, & elevation) and attitude (yaw, pitch, & roll)]	Photos plus telemetry [**GNSS** positioning (latitude, longitude, elevation) and attitude (yaw, pitch, & roll)]
Processing software output	• Georeferenced orthomosaic • Digital elevation model (DSM or DTM) • Measurements (distance, surface area, & volume)	

NCEM's UAS program

Parameter	DJI Matrice 600 Pro	DJI Mavic Pro
Type	Multirotor	Multirotor
Ground control station (GCS)	Radio control + tablet	Radio control + smartphone or tablet
Satellite guidance	GPS	GPS
Takeoff Landing	Vertical takeoff & landing (VTOL)	Vertical takeoff & landing (VTOL)
Special feature	Remotely activated hook for deploying a life vest, rope, rations, or a cell phone	Compact, moderately priced aircraft, and moderately priced batteries
Sensor (digital camera)	• **Zenmuse Z30 (zoom)** • **Zenmuse XT (infrared)** • ZX3	• Built-in 12.34 MP camera with 28 mm lens
Collects	• Photos plus telemetry (latitude, longitude, elevation, yaw, pitch, & roll) • Movies	Can be streamed for real-time viewing
Processing software output	• Georeferenced orthomosaic • Digital elevation model (DSM or DTM) • Measurements (distance, surface area, & volume)	

Using a Trimble UX5 fixed-wing unmanned aircraft to collect aerial imagery of Princeville, NC after Hurricane Matthew

West levee: 3:58 - 4:25 pm on Mon, Oct 17, 2016

The Town of Princeville was flown in three flight blocks on two different days and at different times on each day.

The water in the eastern portion of the aerial photo is darker than the rest of the photo, because that flight block was flown near sunset.

The eastern section and southern section of the town were not flown due to the following reasons:

- Not being able to find a suitable takeoff and landing location for either of those sections
- Not being able see the aircraft if we had attempted to fly those sections from our observation location, the Highway 64 overpass

West: 2:14 - 2:46 pm on Sat, Oct 15, 2016

East: 5:43 - 6:02 pm on Sat, Oct 15, 2016

Parameter	UX5
Cruise speed	80 kph (50 mph)
Wingspan	100 cm (39.4 in)
Weight	2.5 kg (5.5 lbs)
Weather limit	60 kph (40 mph) & light rain
Communication & control range	5 km (3.1 mi)
Resolution [Ground Sample Distance (GSD)]	2.0 - 19.5 cm (0.79 - 7.6 in)
Height above takeoff location (AGL)	75 - 750 m (246 - 2,460 ft)
Maximum ceiling	5,000 m (16,404 ft)
Legal ceiling in the U.S.	122 m (400 ft)

Flight crew	Person
Pilot in command (PIC)	Curt Johnson
Visual observer (VO1)	Ronald Harding
Visual observer (VO2)	D.J. Ferraro

Edgecombe County requested North Carolina Emergency Management (NCEM) to collect aerial imagery of the Town of Princeville.

Before the flights were conducted, the PIC submitted the flight plans to the Federal Aviation Administration (FAA) and the NC National Guard for permission to fly within the area devastated by Hurricane Matthew.

Upon receiving permission, the PIC submitted a Notice to Airmen (NOTAM) to warn other pilots of the scheduled unmanned aircraft activity.

The flights were flown at 100 m (328 ft) AGL elevation with a GSD of 2.6 cm (1.0 in).

The PIC and VOs would like to thank Trooper Charles Purvis for escorting them to the takeoff/landing site on the Hwy 64 bridge, the S. Main St bridge over the Tar River, and a potential takeoff/landing site on the eastern edge of town. In addition, they would also like to thank Watson Ross for processing the 1,962 aerial photos into the single mosaic image.

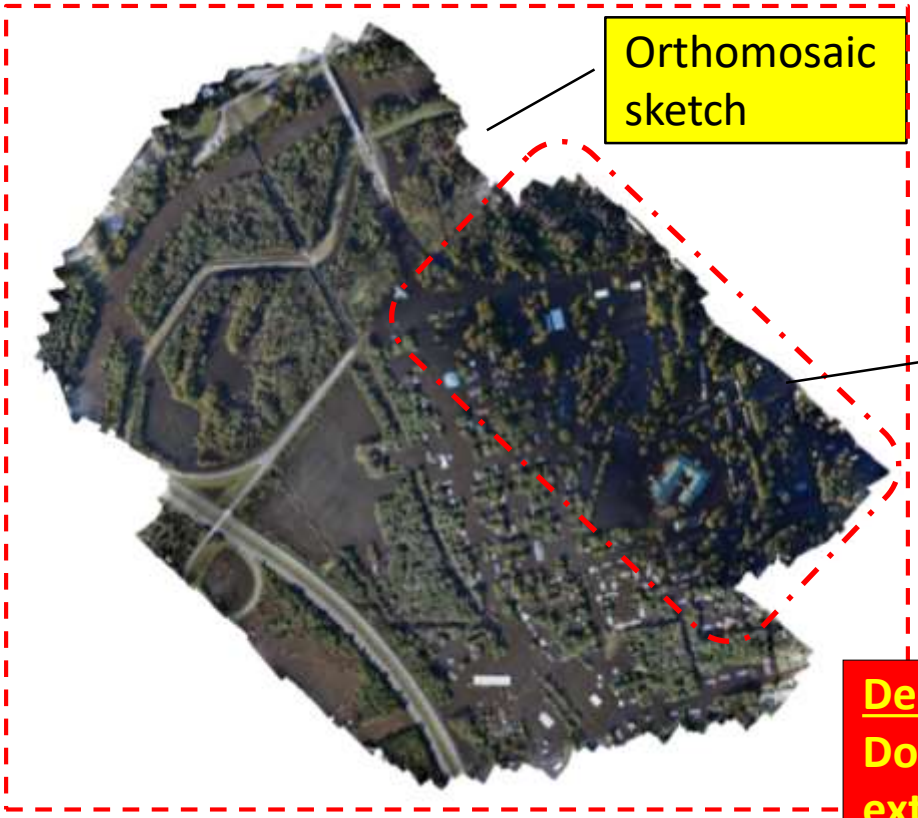
Princeville: Oct 17, 2016

Processing report

Agisoft PhotoScan

Processing Report
20 October 2016

Defaults to the processing date



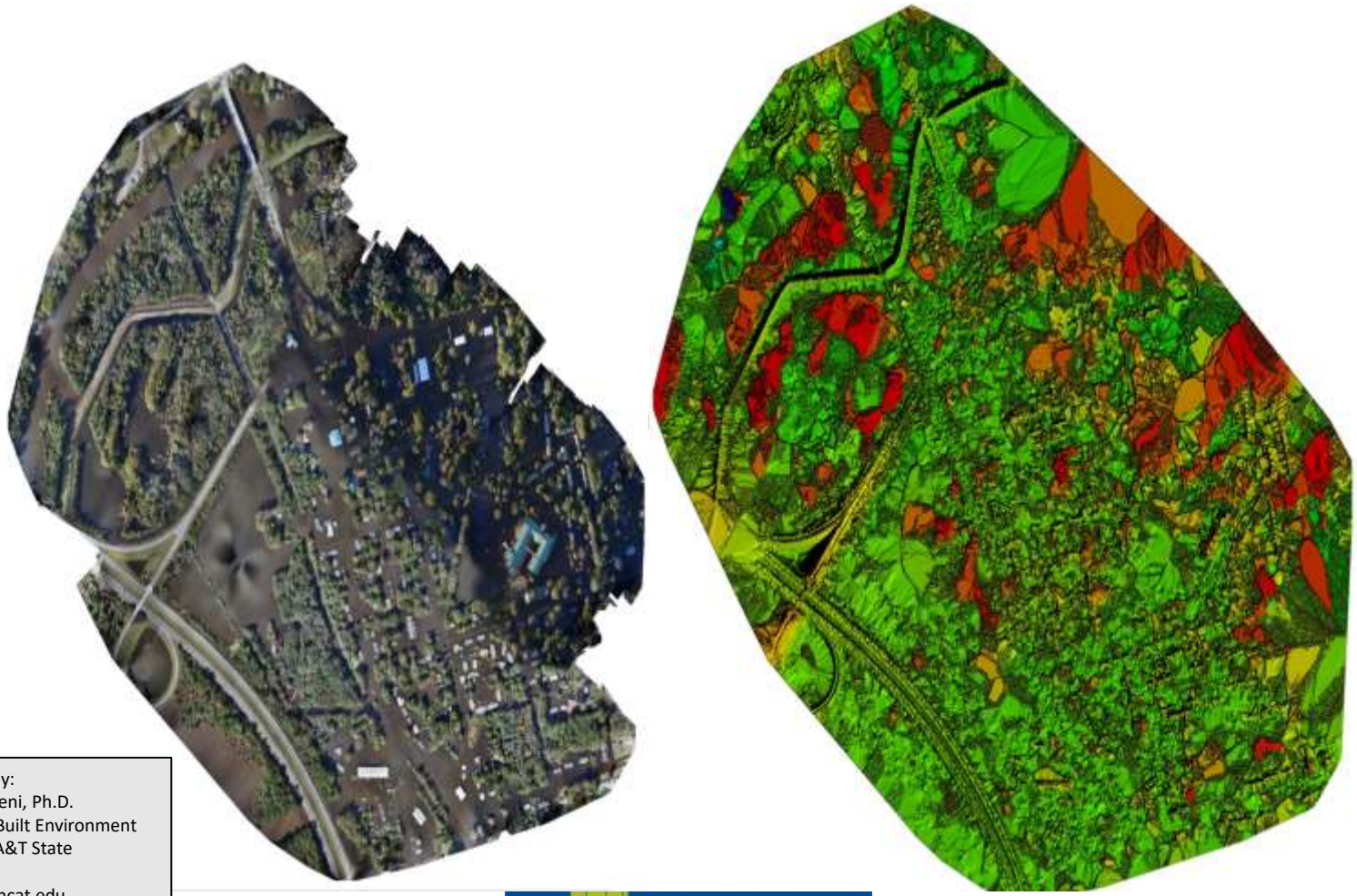
Orthomosaic sketch

This section is dark, because it was flown late in the afternoon.

Decision making: Documented the extent of the flooding

Data Processing

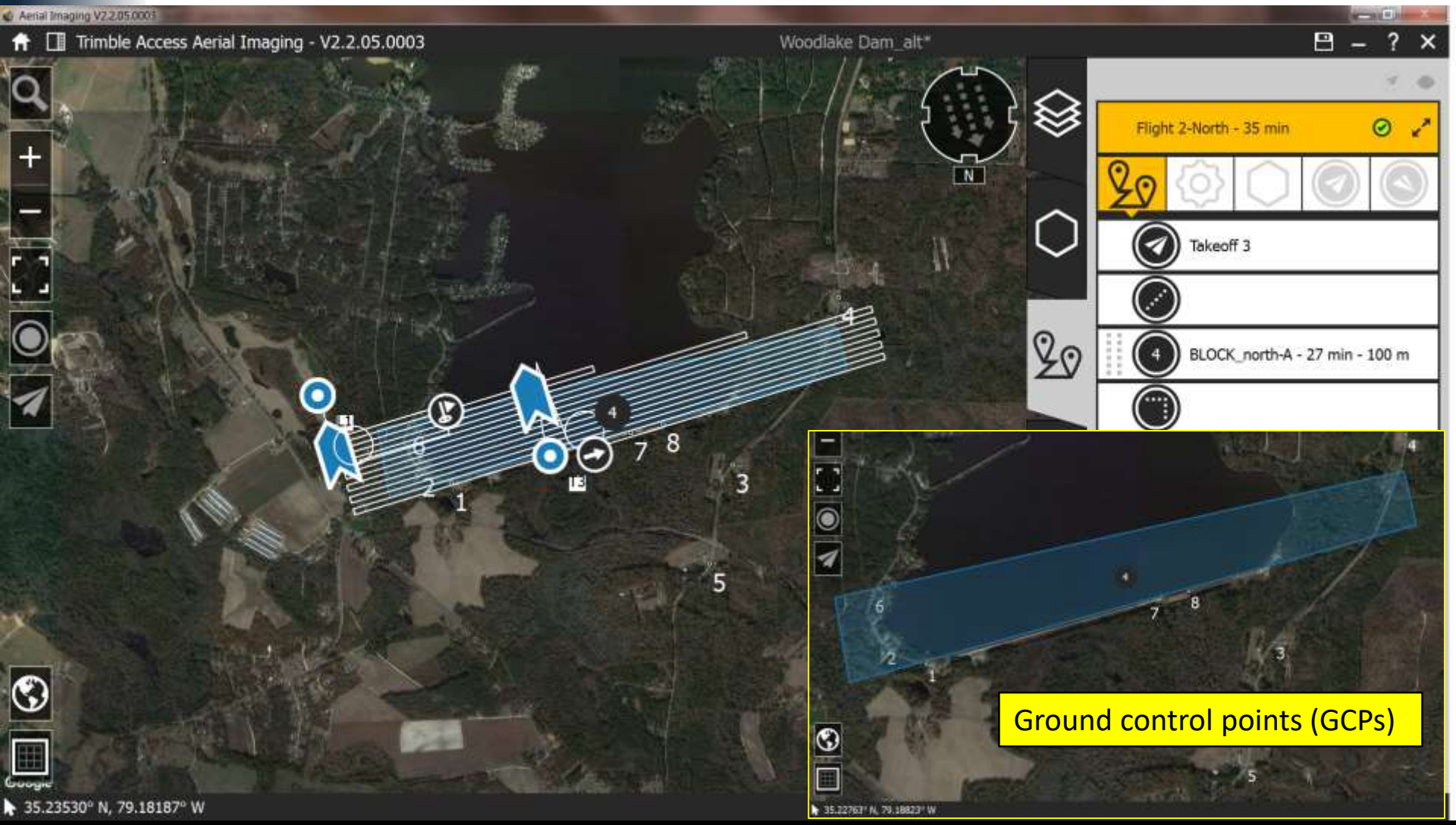
Processing of the imagery was performed by Pix4D software



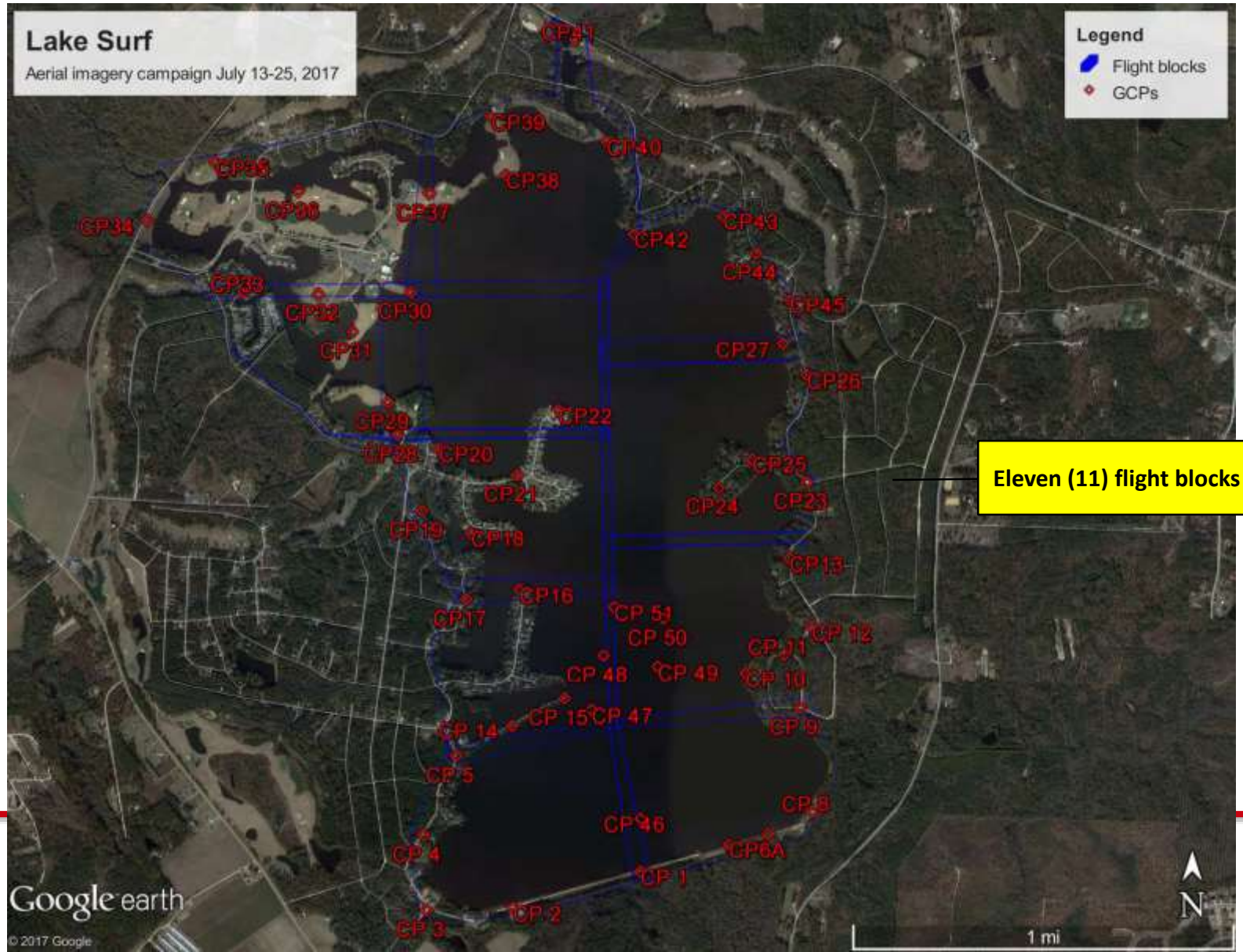
Slide provided by:
Leila Hashemi Beni, Ph.D.
Department of Built Environment
North Carolina A&T State University,
lhashemibeni@ncat.edu

Hurricane Matthew Unmanned Aircraft Vehicle (UAV) Imagery

Woodlake Dam: Oct 13, 2016



Lake Surf: July 13, 14, 17, 19, 20, 24, & 25, 2017



Eleven (11) flight blocks

Statewide deployable Remote Pilot database

NCEM is creating a database of vetted **qualified** government agency sUAS remote pilots available for emergency & disaster support missions.

- **Purpose**
  To provide, upon the request of a local first responder/emergency manager who contacts the State EOC, a list of **vetted** government agency sUAS remote pilots who are **qualified** & willing to serve when a need arises.
- **Requirements**
  a. **Qualification**
     - FAA Part 107 Remote Pilot Certificate and an NCDOT UAS Government Operator Permit

  b. **Education and training**
     - 24 Hours of logged flight time as the Pilot in Command (PIC) of the UAS platform(s) that would be used

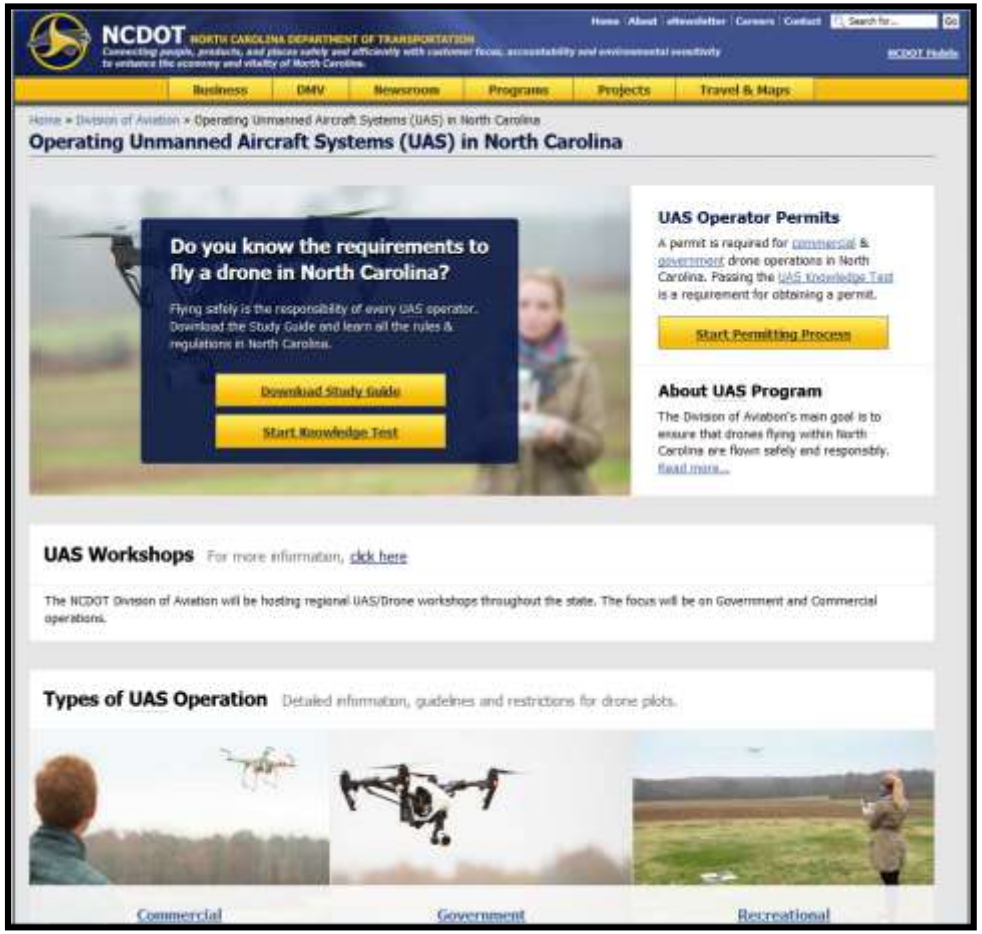
  c. **Flight standards documentation**
     - A letter of organizational affiliation signed by the agency head that explicitly states that the organization supports the applicant participating in the statewide deployable Remote Pilot database.
     - Proof of the organization's worker's compensation and liability insurance
     - Signed and executed NCEM release
     - FAA Certificate of Waiver or Authorization (COA) (if your agency has a COA)
     - FAA Part 107 Waiver (if your agency has any waivers)
     - Information on the UAS platform and its capabilities
     - PIC signs the flight standards attestation on the program application (abide by FAA and NC regulations, not fly under the influence, abide by the incident commander's deconfliction procedures, etc.)
- **Review process**
  NCEM would review each application packet (application plus required docs) and issue an approval or a denial. NCEM would then enter into the database: the name of each approved applicant, equipment info, and support documents.
- **For more info:** Please contact **Justin Graney** (justin.graney@ncdps.gov). The anticipated roll out is spring 2018.

NCEM's UAS program

- **UAS test sites**
  - Lake Wheeler (NCSU Agroecology Farm located just north of the Historic Yates Mill County Park)
  - N.C. A&T University Farm (east of Greensboro)
  - Butner (Umstead Correctional Center)
  - Dupont State Forest

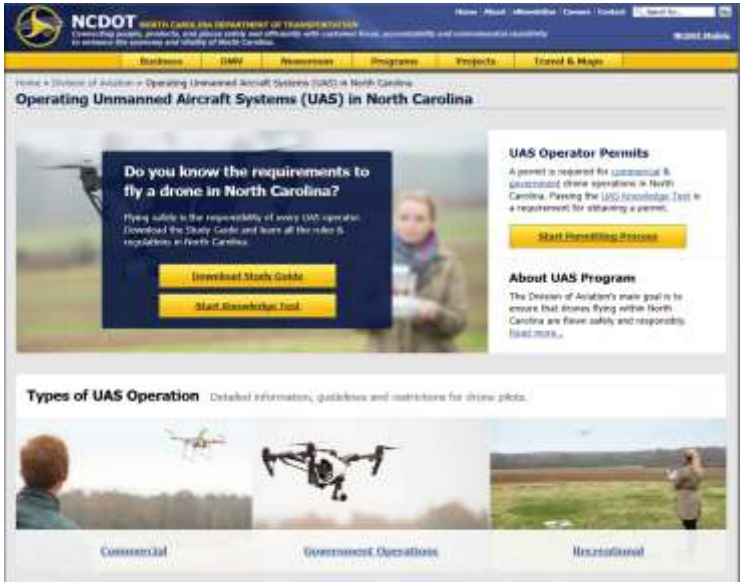
N.C. A&T University Farm: Sept 8, 2016

NCDOT Aviation



North Carolina UAS regs

- **A permit is required for commercial & government UAS operations in NC**
  - Requires a UAS operator to pass a test covering the following NC General Statutes:
    - Chapter 63 – Aeronautics
      - §63-95 Training required for operations of UAS
      - §63-96 License required for commercial operation of UAS
    - Chapter 15A – Criminal Procedure
      - **§15A-300.1 Restrictions on use of UAS**
      - §15A-300.2 Regulation of launch and recovery sites
    - Chapter 14 – Criminal Law
      - §14-7.45 Crimes committed by use of UAS
      - §14.280.3 Interference with manned aircraft by UAS
      - §14.401.24 Unlawful possession and use of UAS (Weapon attached)
      - §14.401.25 Unlawful distribution of images
    - Chapter 113 – Conservation and Development
      - §113-295 Unlawful harassment of persons taking wildlife resources



https://www.ncdot.gov/aviation/uas/
https://www.ncdot.gov/aviation/download/UAS_Memo.pdf

Future use of UAS technolgy

Zipline operates the world's only drone delivery system at national scale to send urgent medicines, such as blood and animal vaccines, to those in need – no matter where they live. **Zipline**

BUSINESS

Drones could soon deliver medical supplies in NC

FAA Integration Pilot Program

NCEM's UAS program

- **Contact info**
  - Gary Thompson, Deputy NCEM/Risk Management Chief

    gary.thompson@ncdps.gov

    919-948-7844

  - Curt Johnson, Technical Writer

    curt.johnson@ncdps.gov

    919-948-7837