Department of Environmental Quality Unmanned Aerial Systems Programs

Business Process Innovations

North Carolina

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Mavic 2 Pro Drone Imagery - 0.43 In Resolution

2016 NAIP Imagery - 6 In Resolution

EXECUTIVE SUMMARY

The North Carolina Department of Environmental Quality (DEQ), in conjunction with the Department of Information Technology, devised and is actively using an Unmanned Aerial Systems (UAS) drone program to modernize and improve efficiencies in data collection and mapping processes. This program has allowed divisions within DEQ to considerably improve their business processes, increase productivity, save staff time, and decrease costs.

The UAS program's goal is to implement, where feasible, the use of drones for field data collection. DEQ had made marked improvements in data collection with tablets and Geographic Information Systems (GIS) apps over the last five years. The Environmental Systems Research Institute (ESRI) has recognized the state for these efforts. While tablets with built-in GPS were a great improvement over pad and paper, they did not significantly change the work processes or the amount of time it took to collect the data. To make significant process improvements, the teams needed disruptive change. Thus, the introduction of drones.

Initial case studies carried out in collaboration with the University of North Carolina Wilmington started in the spring and summer of 2018. These initial efforts produced compelling results and garnered buy-in from the state.

Initial flights and analysis efforts were predominately focused on the Division of Marine Fisheries (DMF) Estuarine Benthic Habitat Mapping (EBHM) program. **The cost savings and accuracy gains afforded by the implementation of a DJI Phantom 4 Pro drone were astonishing. Acreage mapped in a day increased 5,900% for a two-person team.** Traditional methods averaged 10 acres per day, while the UAS produced data for 600 acres per day. Estimated savings for the small portion (7,500 acres) of the EBHM study were approximately $400,000. As this area was only a fraction of the EBHM area, the potential savings for this program alone are in the millions.

In addition to the EBHM data collection, the department has utilized drone methods to map and analyze landslides, create three dimensional (3D) models for construction projects, create 3D models to estimate volumes of material for the artificial reef program, and verify pole locations of shellfish leases within the state.

Drones are being used to map landslide events which can block major corridors and endanger lives. The use of drones to map these events and estimate volumes of debris flows has drastically increased efficiency. A drone can map in minutes what took days with traditional land survey methods.

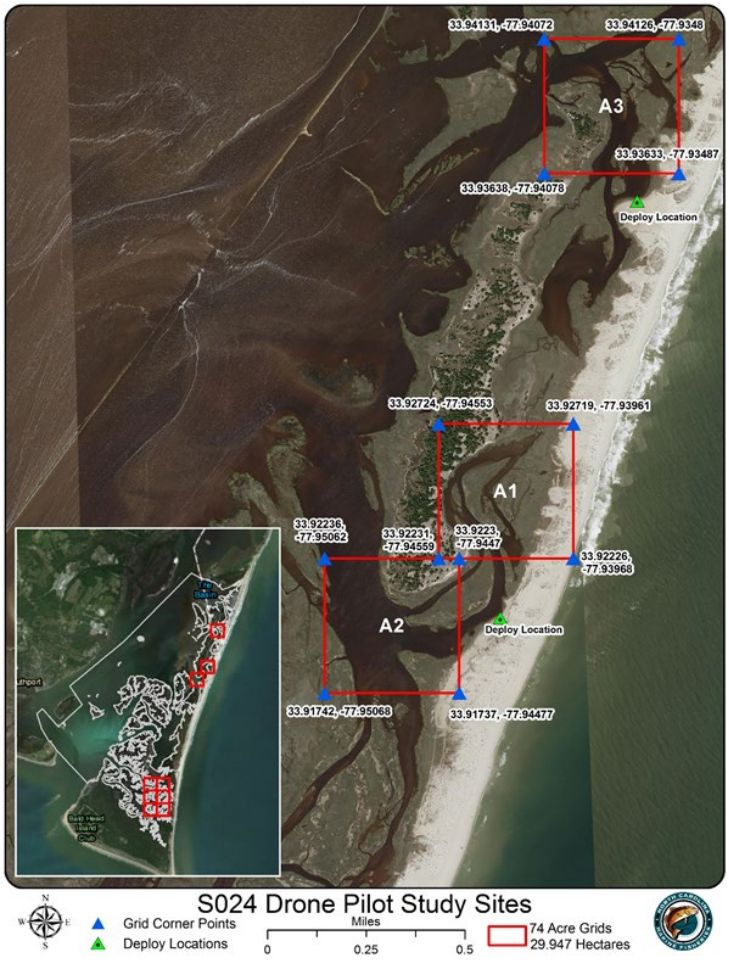
3D modeling with drones has also allowed divisions to track construction projects with periodic 15 – 30 minute flights rather than expensive and time-consuming methods such as terrestrial laser scanning.

The shellfish leasing program of DMF is now using drones to verify pole locations of leases in under 10 minutes for a 10-acre lease. Traditional methods with two-staff member teams took hours with boat and GPS methods.

The possibilities for the UAS program are endless. Divisions across DEQ are implementing UAS plans and modernizing their business processes, improving data collection accuracy, efficiency, and cost. The cost and time savings realized with this technology are allowing staff to focus on other or new projects, enhancing DEQ's overall mission.

CONCEPT

North Carolina has the largest and most productive estuarine system of any state on the east coast. Just behind the state's fragile strand of barrier islands lie shallow sounds where the land and sea gradually merge to form estuaries and brackish wetlands that support large populations of fish, shrimp, crabs and shellfish. In order to promote shellfish production and protect vital habitats, the Division of Marine Fisheries (DMF) maps and samples the benthic habitats of the coastal waters to determine habitat type, acreage and populations of oysters, clams, scallops and submerged aquatic vegetation (SAV).



Mapping the distribution of different bottom habitats is critical to effectively protect and manage estuarine resources. To facilitate shellfish harvest and aquaculture, DMF maps and samples the benthic habitats within areas known for shellfish growth. Estuarine benthic habitat types are delineated systematically using sounding poles and GPS coordinates along a map grid. The benthic habitat types are classified as soft, firm, or hard; vegetated or non-vegetated; and with or without shell. DMF workers sample benthic habitat types for the presence of shellfish and SAV using tongs, rakes, and meter squares. Sampling data include shellfish species counts, SAV species and density, and other environmental data. By collecting and utilizing the mapping and sampling data, DMF creates estuarine benthic habitat resource maps illustrating benthic habitat boundary types, SAV species habitat and productive shellfish habitat. To date, the division has mapped over 602,000 acres of the coastal estuarine waters from Little River in Brunswick County at the state's southern border to the Roanoke and Croatan sounds in Dare County in the north.

Initiated in the 1980s, the Estuarine Benthic Habitat Mapping (EHBM) program is vital in identifying habitat as well as mapping shellfish and submerged aquatic vegetation (SAV). Habitat data collected are used in Coastal Habitat Protection Plans, Fishery Management Plans, shellfish lease authorizations, and rulemaking. Historically, EBHM data collection was done with hand-drawn paper maps in the field, which were then scanned and digitized in the office. More recently, the program transitioned to an iPad Pro system in the field to create more accurate maps with Bluetooth GPS devices. This improved

efficiency, but still required immense field time. On average, a team of three following this process could map between 10 and 20 acres in a day.

Mapping North Carolina's Estuarine Benthic Habitats

In February 2018, DMF partnered with faculty at UNC-Wilmington to test the use of Unmanned Aerial Systems (UAS) to map estuarine benthic habitats. DMF had one 7,500-acre zone of habitat left to map to complete documentation of North Carolina's estuarine benthic habitats.

Implementation of the UAS program began in March 2018 with the drafting of a policy for appropriate use of UAS. Initial case studies were carried out in collaboration with UNC-Wilmington through summer 2018. These initial efforts produced compelling results and aided in the buy-in from the state.

The UAS program utilizes numerous technologies. First and foremost are the airframes used for collection. DIT and DEQ choose to utilize DJI copter solutions as the exclusive airframe option. The DJI Phantom 4 Pro was used for the initial case study. Subsequent flights within the program incorporated the DJI Mavic 2 Pro with Hasselblad Sensor. Additionally, GPS receivers, ground control targets, and the Environmental Systems Research Institute's (ESRI) mapping platform, which includes Drone2Map, have been incorporated.

The initial goal of the program was to create high-resolution orthomosaics in an efficient cost-effective manner. The EBHM program within DMF was chosen as the initial case study to explore the feasibility/usefulness of drones for environmental data collection.

The pilot study for the UAS program selected three 74-acre study areas in the Cape Fear River estuary. DJI's Phantom 4 Pro, with a one-inch CMOS 20-megapixel gimbaled sensor, was utilized in the study. Study area grids were programmed to fly using Pix4D Capture mobile application. This software allows the user to easily program the flight, selecting altitude, image overlap, camera angle, and speed. The flight was conducted at the FAA limit of 400 feet. At this altitude and chosen speed, each grid took approximately 17 minutes to fly. All images were stored locally to the drone's SD card. Ground control points were established in the field using Bad Elf GPS receivers and incorporated in the post-processing orthomosaic creation. ERDAS IMAGINE photogrammetry software performed the post-processing analysis to create one seamless orthomosaic of the survey. After completion of the orthomosaic, unsupervised classification of the image was performed to automatically identify varying benthic habitats. Imagery was then moved to ESRI's ArcMap 10.6 for supervised polygon creation of the numerous benthic habitat strata. These polygon files are the final product of the benthic habitat mapping.

Results from the UAS EBHM analysis provided 2.3-inch resolution, allowing users to zoom in tight on features without distortion. North Carolina has exceptional imagery services for the state; however, the resolution is limited to six inches. Further, the service is only flown every four years, and not typically at low tide. UAS solutions allow for more detailed analysis at varying times of day and tide conditions.

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Through the pilot, a finished product for 74 acres of habitat was achieved in under three hours. Traditional methods only averaged 10 acres a day (with three staff members in the field), not including office processing time. **It took more than 30 years to map the first 90 percent of NC's estuaries. The improvement initiatives that DIT and DMF have implemented in the last year created a framework for completing the final 10 percent in 12.5 days.**

Landslide Mapping

DEQ responds to and analyzes public safety hazards, such as landslides on a regular basis. Large precipitation events, seasonal changes, and human interaction can all trigger landslide events. Impacts can include road closures, property destruction, and potential injury to people and wildlife.

DEQ implemented the Mavic 2 Pro system to map these events with high-esolution 3D models allowing the state to study the events

and plan mitigation efforts to limit future damage or incidents. Cleanup and construction efforts can be carried out quickly and cost effectively using measurements from drone analyses.

Fisheries 3D Efforts

DMF has utilized a combination of Mavic 2 Pros and the ESRI Drone2Map software to create 3D models for construction projects and volumetric estimates. Fisheries headquarters started a major construction project in 2019, and staff tracked the progression of the project using the drone program. Initial baseline 3D models of the building were created and are being flown periodically to track progress and create a documented record in case issues arise.

In addition, DMF's artificial reef program creates reefs in NC coastal waters for fish habitat. Massive amounts of material, including, concrete, marle, shell, reef balls, old ships, and piping are used in the creation of these reefs. Material is often donated to DMF for this effort. Logistically, this presents a challenge, as staff need to know the volume of the material in order to coordinate pickup and deployment resources. The Mavic 2 Pro system is being used to easily produce volumetric estimates. The drone collects high-resolution images at an angle, which is then processed in Drone2Map. Once the 3D model is created, the software easily calculates the volume of any given area within the model. This solution has proved tremendously valuable in the planning of the reef program.

Lease Verifications

North Carolina issues bottom and water column shellfish leases to applicants yearly. DMF staff are responsible for investigating potential new leases and verifying pole locations of existing leases. Drones have significantly increased the efficiency and accuracy of these efforts. The drone is able to fly a lease in under five minutes and the embedded GNSS GPS receiver enables staff to accurately identify pole locations for verifications.

SIGNIFICANCE & IMPACT

The staff time and cost savings realized from the UAS program are allowing North Carolina to collect critical information rapidly, and free up resources to initiate new projects critical to DEQ's core mission that otherwise may have taken years to begin.

The EBHM program is designed to map the estuarine benthic habitats for the entirety of the state – approximately 610,000 acres.

Using the drone, DMF was able to map 80 acres in just 25 minutes - the equivalent of over 1,500 acres in a day. Three 80-acre blocks were mapped to test the methodology, and all 240 acres were mapped in just 90 minutes.

Initial EBHM case studies highlighted the savings that will be realized with future adaptations of UAS technology. For instance, the S024 (lower Cape Fear Estuary) area measures 7,500 acres. With traditional methods, that equates to 750 field days (assuming a team of three mapping 10 acres per day). Further tests of the UAS program proved it to be capable of 600 acres in a two-hour window around low tide. Low tide is required for either method to capture the estuarine benthos. At this rate, the UAS can complete the field work for the 7,500-acre area in 12.5 days. The estimated savings

potential realized from S024 alone is about $400,000. Extrapolated coast-wide, the EBHM program savings are in the millions.

	Traditional Mapping	Drone Mapping
Field personnel requirements	3	1
Acres mapped per field day	10	600
Total field days required to map 7,500 acres	**2,250**	**12.5**

This program allowed DMF to eliminate the need for three individuals to spend 750 days in the field manually collecting data. Instead, those employees were able to spend time analyzing the data collected.

Using methods developed in these initial studies, DMF competed similar EBHM mapping projects in two additional counties. Legacy methods have now been replaced with this new process. The division developed an interactive story map with background on the EBHM program and a specific drone project in Hoop Pole Creek, NC.

DEQ has identified several other areas where drones will be used to significantly increase efficiencies while providing safety and environmental improvements.

When the initial groundwork was laid for the UAS program, approximately 10 DEQ programs were identified that would benefit from this technology. That number is growing rapidly as every division within DEQ plans to implement the technology. Considering the savings possibilities realized by the initial DMF program, this initiative has the potential to save the state millions in data collection costs year over year.

Numerous plans are being discussed within DEQ, but the following are already in latter stages of development for UAS deployment:

- **Farmland inspections**. These inspections are currently performed manually by a three-person team. The use of drones would save over $400,000 per year in salary, gas, and supply costs.
- **Harmful Algal Bloom (HAB) monitoring.** Drones can accurately map the extend of HABs without exposing staff to the harmful algae. The use of drones would improve safety, speed, and accuracy of reporting.
- **Rhodamine Dye studies.** This would increase the accuracy of tracking the dispersion, timing, and extent of the dye. The drones would reduce internal costs of these studies by 50 percent.
- **Hurricane response.** Drones can provide a useful tool for post-storm analysis to identify pollution sources, shoreline changes, and habitat destruction. Additionally, UAS would be a valuable tool for Marine Patrol for search and rescue.
- **Mine and dam inspections.** DEQ is tasked with inspecting mines and dams throughout NC to ensure environmentally sound practices. The department is in the process of streamlining much of the inspection tasks with the Mavic 2 Pro fleet.

Short-term gains have been realized in efficiency and accuracy. Long term, this technology will revolutionize the way North Carolina collects environmental data.