

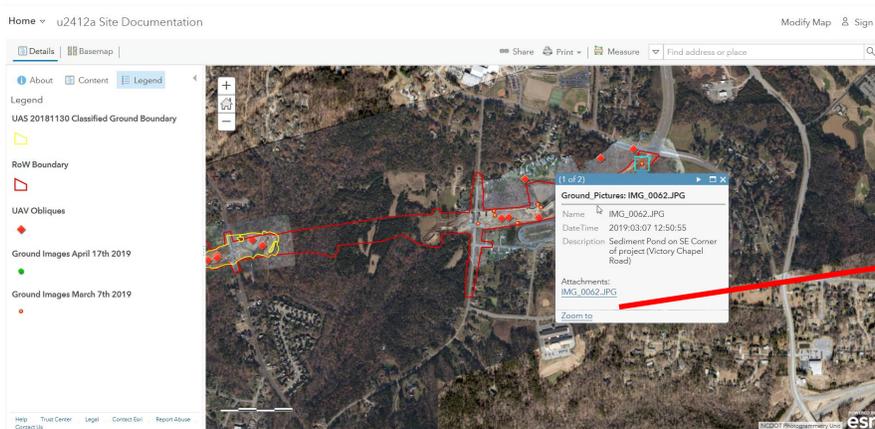


## Construction Monitoring with Small Imprecise Non-Metric Cameras (Photogrammetry Unit)

The NCDOT Photogrammetry Unit has piloted a unique approach to Construction Monitoring and Emergency Response Activities. Fusing UAS (drone) technology, Structure from Motion (SfM) processing with non-metric camera aerial imagery from UAS platforms, mapping from traditional photogrammetry processes, and Geographic Information System (GIS) software the unit has developed a geospatial image-based interface for documenting and monitoring NCDOT activities. The approach uses ArcGIS Online (AGOL), a web-based tool with multiple options of distributing information simultaneously to various users, to convey information to NCDOT Resident Engineer Offices, Division Engineers, and Executive Leadership for construction project monitoring and emergency response activities. Documenting NCDOT construction and emergency response activities for hurricane and slide events using a geospatial image-based tool offers many advantages for generating and retaining valuable information over the lifespan of a project and can also be used to support claims for federal reimbursement.

Examples for NCDOT STIP Project U-2412A Construction Monitoring and Hurricane Florence US 421 Emergency Response efforts follow:

### U-2412a Site Documentation



### Hurricane Florence US 421 Emergency Response

The image shown was taken of US 421 on October 2, 2018 from a manned aircraft. This photo shows damage to US 421 at Fishing Creek prior to any work efforts by NCDOT.

UAS imagery was used to monitor the work performed at this site. UAS flights were flown on October 7<sup>th</sup>, 10<sup>th</sup>, 12<sup>th</sup>, 16<sup>th</sup>, 19<sup>th</sup>, 23<sup>rd</sup>, and 28<sup>th</sup> to show the process of the work performed by NCDOT.



## NCDOT BUSINESS UNITS

- Photogrammetry Unit

- Division Resident Office

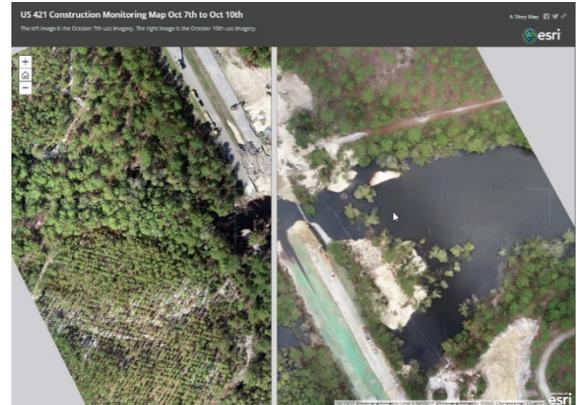
## PRODUCTS PRODUCED

**Orthophoto** – An orthophoto is an accurate image map with horizontal coordinates produced with mosaicked UAS images that have been corrected for tilt and relief displacement using camera position and attitude and elevation data

**AGOL Swipe Map** -This tool uses different dates of orthophotos that allows the user to interact with two different date orthophotos simultaneously by using a slider.

### US 421 Construction Monitoring Maps

([Oct 7<sup>th</sup> / Oct 10<sup>th</sup>](#) & [Oct 23<sup>rd</sup> / Oct 28<sup>th</sup>](#))



**AGOL Site Documentation**- This Online mapping tool that can display orthophotos created from UAS Imagery, overlay planimetric features and ground based photos taken from mobile devices. [U-2412a Site Documentation](#) (site shown on first page)



## UAS PLATFORM

- **Aircraft** - Inspire2 (U-2412a) / Phantom 4 Pro (US 421)
- **Camera** - DJI Zemuse X4s
- **Airborne GPS System** – Loki / On-board System

## Requirements

- **Operator Training/Certification:** FAA Part 107 Remote Pilot Certification, Certificate of Authorization (COA), FAA Part 137 Authorization
- **North Carolina (NC) Registered Professional Land Surveyor (PLS):** These procedures and products must be done under the responsible charge of a licensed North Carolina Professional Land Surveyor. See North Carolina Engineering and Land Surveying Act (NCGS 89C-3(7).a.5) and Board Rules (21 NCAC 56 .1606).

## CONSTRUCTION MONITORING & EMERGENCY RESPONSE WITH UAS COMPARED TO TRADITIONAL METHODS

The conventional methods for construction monitoring are construction diaries. These diaries in recent years have transitioned from handwritten entries to digital entries. These documentations record any work that the contractor completes during that day, including emergencies, meetings, and edits to the original plans. Construction diaries serve as living documents that detail the life of the project. Using UAS in conjunction with the methods for construction monitoring already in place, NCDOT staff can add and share important information with other NCDOT Units and any other individuals that have an interest in the project.

Fusing multiple technologies and utilizing AGOL allows the Photogrammetry Unit to use various tools to display information. One example of this innovative approach was used on NCDOT Project U-2412A in Jamestown. The Photogrammetry Unit used SfM processing to produce an orthophoto from UAS aerial imagery acquired during the unit's initial pilot UAS mission for the project. The orthophoto was uploaded to AGOL for the small project area of interest, after which preconstruction plan sheet mapping from traditional photogrammetry techniques, ground based iPad images, and UAS oblique images were then incorporated into the project's AGOL map service to create documentation for the construction site at that specific time. This AGOL map service has had several UAS orthophotos added as the construction progressed. It is important to note the AGOL map service can be accessed through NCDOT iPads and other mobile devices, making it a great tool for NCDOT staff that are often at the construction areas without access to a desktop or laptop.

Another example of these tools are AGOL swipe maps which can be accessed by NCDOT executive and senior engineering staff as well Division based construction staff. Swipe maps created from UAS imagery were used during US 421 reconstruction after Hurricane Florence to share the project's progression which in turn supported NCDOT's claims for federal reimbursement. To publish the AGOL swipe maps, Photogrammetry Unit staff produced orthophotos using SfM processing from twice weekly UAS flights.

## **EFFECTIVENESS**

For small area construction projects where NCDOT controls the site, UAS technology provides the ability to capture imagery more frequently at a lower cost than manned aircraft flights. Oblique UAS images also provide a different perspective than manned aircraft nadir flights. Fusing UAS image derived orthophotos with UAS oblique images, preconstruction plan sheet mapping from traditional photogrammetry techniques, and ground based iPad images in a web based AGOL map service provides information to construction offices as an additional option for construction monitoring. Sharing information and having a tool that not only displays information, but allows you to share it gives you the ability to look at construction sites as a whole and not just the individual diaries created by inspectors. Using the UAS imagery allows for more accurate analysis of the project life as well, by visually recording the location of rock piles, silt fences, pipes, soil movement, erosion control, and any other important information you could derive from the UAS imagery.



## **EFFICIENCY**

Using UAS for construction monitoring will increase efficiency by providing information previously unavailable to the Division Resident Engineer Offices and other interested parties. This is accomplished through facilitating the fusion of ground based and UAS imagery to create a tool that can display the project as a whole through a geospatial image-based interface, along with preconstruction planimetric features, and ground base photos documenting areas of interest. Additionally, this AGOL map service tool can be accessed on mobile devices virtually anywhere.

## **SAFETY**

When utilizing a UAS, for the safety of NCDOT personnel and for other people on site, a request is made for all work in the area to be discontinued for the duration of the flight. This will also allow landing of the UAS with minimal interference and avoid any damage in case of an emergency. In addition, using UAS for this application allows NCDOT personnel to access the site from different perspectives allowing evaluation of the site for any possible safety concerns