NORTH CAROLINA
Department of Transportation









UAS Technology for Small Site Surveying & Transportation Applications

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Presentation Outline

- **NCDOT Photogrammetry Unit**
  - Regulatory Considerations
  - NCDOT Aerial Surveying Program Business Plan
  - What Type of Deliverable Products Can Be Requested
  - Project Highlight

- **NCDOT Locations and Surveys Unit**
  - Current Capabilities (Pilots & UAV's)
  - Current UAS Usage
  - Project Examples and Testing
  - Future Uses
  - Conclusion/Questions

Regulatory Considerations

Federal Requirements to Operate a UAS

- 14 CFR Part 107 Rules for Operating Small UAS (sUAS)
- https://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf

Requirements to Operate a UAS in North Carolina

The NCDOT Division of Aviation (DoA) has the responsibility to ensure safe and legal UAS operation in North Carolina.

Please see:

- https://www.ncdot.gov/aviation/uas/
- NC GS 63-95. Training required for operation of unmanned aircraft systems
- NC GS 63-96. Permit required for commercial operation of unmanned aircraft systems

Professional Regulatory Considerations

- Acquisition and development of survey products require PLS certification.

Survey Products

A derived survey product has coordinates and can be used to perform accurate, reliable measurements. Examples of derived survey products from manned or UAS sensors are orthophotos, orthomosaics, point clouds, LAS files, and elevation models.

This is considered the practice of Land Surveying in North Carolina, and as such, is regulated by the North Carolina Board of Examiners for Engineers and Surveyors which requires the provider of these materials to be a properly licensed NC PLS. Please see:

- http://www.ncbels.org/ (NCBEES Newsletters Fall 2017 and Spring 2016)
- NCBELS Rule 21 NCAC 56 .1606. Specifications for Topographic and Planimetric Mapping, including Ground, Airborne, and Space borne Surveys
- NCBELS Policy BP-0510-2. Oblique Aerial Imaging Policy
- NCBELS Policy BP-1007-2. Volume Computation Surveys Policy

NCDOT UAS Aerial Surveying Program Business Plan

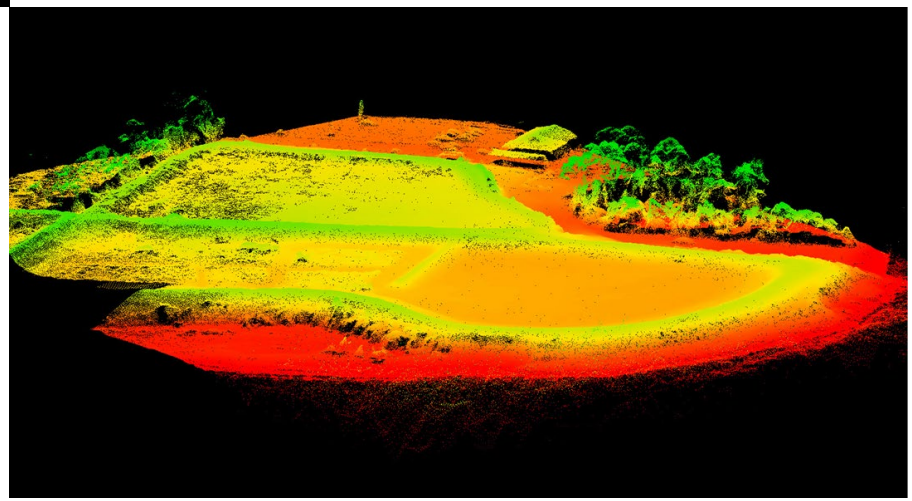
EXECUTIVE SUMMARY

This section of the business plan summarizes the direction in which the UAS Aerial Surveying program plans to move forward.

The business plan includes:

- **ROLES AND RESPONSIBILITIES**
- **BUSINESS APPLICATIONS**
- **UAS AERIAL SURVEYING PRODUCTS**
- **REQUIRED RESOURCES**
- **VARIOUS TECHNOLOGY OPTIONS COST**
- **IMPLEMENTATION STRATEGY**

Deliverable Products



Deliverable Products

R-2582A Fitzhugh Pit Cut Quantities for 19.18 Acre Terrain Data Boundary

Comparison DTM	Mission Date	Point Spacing (ft)	Voided Areas Excluded	Cut (cubic yards)
UAS Mission UCS-744FP	03/18/2020	2.5	No Void Areas	
UAS Mission UFI-744FP	06/09/2020	2.5	No Void Areas	142007.506

Deliverable Products

Left: February 2016| Right: October 2018

US 421 | Hurricane Florence

Project Highlight

NC-12 | Ocracoke Island Sand Dune Survey

Additional Information on UAS Survey Products

Photogrammetry and Location & Surveys Units Products to Support Construction Products with Unmanned Aircraft – Should be requested by Division Resident Engineers						
Product	**WHAT It Provides**	**WHAT it is used for**	**Typical Scale**	**WHEN is it typically ordered?**	**Units involved**	**How long to deliver product?**
UAS Original Construction Earthwork Mapping (UOX) (raster digital image mapping, + DEM with TIN, and optional point cloud)	Project specific georeferenced raster digital image product with photogrammetric elevation data that updates the project area after clearing & grubbing that aligns with existing project geospatial datasets. 2-D raster digital image (.sid) file, 3-D (digital elevation model) DEM (.dgn) file with 1' and 2.5' spaced elevation points generated from a classified point cloud, and corresponding triangulated irregular network (.tin) file. Debris piles, rock piles, and any other areas designated by the Resident Engineer will be shown as voids and excluded from elevation data.	Used for developing original ground elevation data. Best utilized in areas of bare earth with minimal vegetation. Best suited for borrow pits.	Standard Raster GSD 0.11 ft Standard Mapping Scale (1" = 50')	After clearing and grubbing have been finalized. Best Practice Before any major earthwork has commenced. When Necessary Upon Resident Engineer's request.	Photogrammetry plans flight and control configurations, acquires imagery, and produces mapping. Location & Surveys sets and ground surveys "panels".	2-3 weeks after aerial photography completed and receipt of ground control. Requires receipt of verified mapping limits in advance of photo mission.
UAS Intermediate Construction Earthwork Mapping (UFI) (raster digital image mapping, + DEM with TIN, and optional point cloud)	Project specific georeferenced raster digital image product with photogrammetric elevation data that updates the project area where earthwork is in progress that aligns with existing project geospatial datasets. 2-D raster digital image (.sid) file, 3-D (digital elevation model) DEM (.dgn) file with 1' and 2.5' spaced elevation points generated from a classified point cloud, and corresponding triangulated irregular network (.tin) file. Debris piles, rock piles, and any other areas designated by the Resident Engineer will be shown as voids and excluded from elevation data.	Used for monitoring and calculation of earthwork quantities on active construction sites. Best utilized in areas of bare earth with minimal vegetation. Best suited for borrow pits.	Standard Raster GSD 0.11 ft Standard Mapping Scale (1" = 50')	In between monthly estimates. Best Practice After any major earthwork has commenced. When Necessary Upon Resident Engineer's request.	Photogrammetry plans flight and control configuration, acquires photos, and produces mapping. Location & Surveys sets and ground surveys "panels".	2-3 weeks after aerial photography completed and receipt of ground control. Requires receipt of verified mapping limits in advance of photo mission.
UAS Final Construction Earthwork Mapping (UFX) (raster digital image mapping, + DEM with TIN, and optional point cloud)	Project specific georeferenced raster digital image product with photogrammetric elevation data that updates the project area where earthwork has been completed that aligns with existing project geospatial datasets. 2-D raster digital image (.sid) file, 3-D (digital elevation model) DEM (.dgn) file with 1' and 2.5' spaced elevation points generated from a classified point cloud, and corresponding triangulated irregular network (.tin) file. Debris piles, rock piles, and any other areas designated by the Resident Engineer will be shown as voids and excluded from elevation data.	Used for monitoring and calculation and finalization of earthwork quantities on active construction sites. Best utilized in areas of bare earth with minimal vegetation. Best suited for borrow pits.	Standard Raster GSD 0.11 ft Standard Mapping Scale (1" = 50')	Before final earthwork estimate has been payed. Best Practice After earthwork has been finalized. When Necessary Upon Resident Engineer's request	Photogrammetry plans flight and control configuration, acquires photos, and produces mapping. Location & Surveys sets and ground surveys "panels".	2-3 weeks after aerial photography completed and receipt of ground control. Requires receipt of verified mapping limits in advance of photo mission.
UAS Emergency Terrain Mapping (UDTM) (raster digital image mapping, + DEM with TIN, and optional point cloud)	Situations specific georeferenced elevation data that aligns with existing statewide geospatial datasets. 2-D raster digital image (.sid) file, 3-D (digital elevation model) DEM (.dgn) file with 1' and 2.5' spaced elevation points generated from a classified point cloud, and corresponding triangulated irregular network (.tin) file. An ArcMap GIS On-Line (AGOL) swipe map is available upon request	Used for rapid response mapping, monitoring, and quantities for emergency sites such as rock or landslides and infrastructure damage caused by acts of nature.	Standard Raster GSD 0.11 ft Standard Mapping Scale (1" = 50')	As soon as a target area has been identified Best Practice First clear weather day When Necessary Upon Division Engineer's request	Photogrammetry plans flight and control configuration, acquires photos, and produces mapping. Location & Surveys sets and ground surveys "panels".	2-3 days after aerial photography completed and receipt of ground control. Requires receipt of verified mapping limits in advance of photo mission.
UAS Emergency Orthophotography (UOP) (raster digital image mapping + AGOL swipe map)	Project specific georeferenced raster digital image product that aligns with existing statewide geospatial datasets. 2-D raster digital image (.sid) file and ArcMap GIS On-Line (AGOL) swipe map	Used for rapid response monitoring for emergency sites such as rock or landslides and infrastructure damage caused by acts of nature.	Standard Raster GSD 0.11 ft	As soon as a target area has been identified Best Practice First clear weather day When Necessary Upon Division Engineer's request	Photogrammetry plans flight and control configuration, acquires photos, and produces mapping. Location & Surveys sets and ground surveys "panels".	2-3 days after aerial photography completed and receipt of ground control. Requires receipt of verified mapping limits in advance of photo mission.

[UAS Mapping Surveys Products Overview]

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Current UAS Status L&S Unit

- L&S started ramping up drone program in early 2020.
- Goal of having 1+ pilot per L&S Division Office.
- Currently have 35 Part 107 pilots in 16 offices across the state.

- Currently have the following equipment:

- 14 - DJI Phantom 4 RTK aircraft
- 1 - DJI Matrice 210 with Zoom camera

UAS Usage in L&S Unit

- Post Tornado and Land Slide emergency response.
- Project/Bridge Scoping and Maintenance Yard Stockpile volumes.
- Testing on small projects utilizing Drone Deploy Software.
- Working to acquire a Lidar capable Drone for future missions to enhance Preliminary Engineering missions of the unit.
- A Lidar payload would allow for vegetation penetration and faster processing of data of DTMs in Emergency response situations .

Brunswick County Tornado Damage – 2021

Post Tropical Storm Fred – Cruso, NC -2021

Pre-Event

Post-Event

Post Tropical Storm Fred - Cruso , NC – 2021(ORD)

Post Tropical Storm Fred - Cruso , NC – 2021 (ORD)

Disaster Response - Concerns

- L&S is developing a SOP/checklist for use in emergency response situations.
- Several employees attended a UAS Emergency Response course though the University of Hawaii.
- It is most important that we coordinate with local authorities and make sure we are not impeding operations and are operating in a safe/legal manner.
- We are documenting lessons learned as we perform missions in emergency situations.

UAS use on NCDOT Projects

- Recon and Project scoping
- Recordation of Construction project milestones

R-2303 E in Sampson County

Top photo taken July 24, 2020

Bottom photo taken Nov 21, 2020

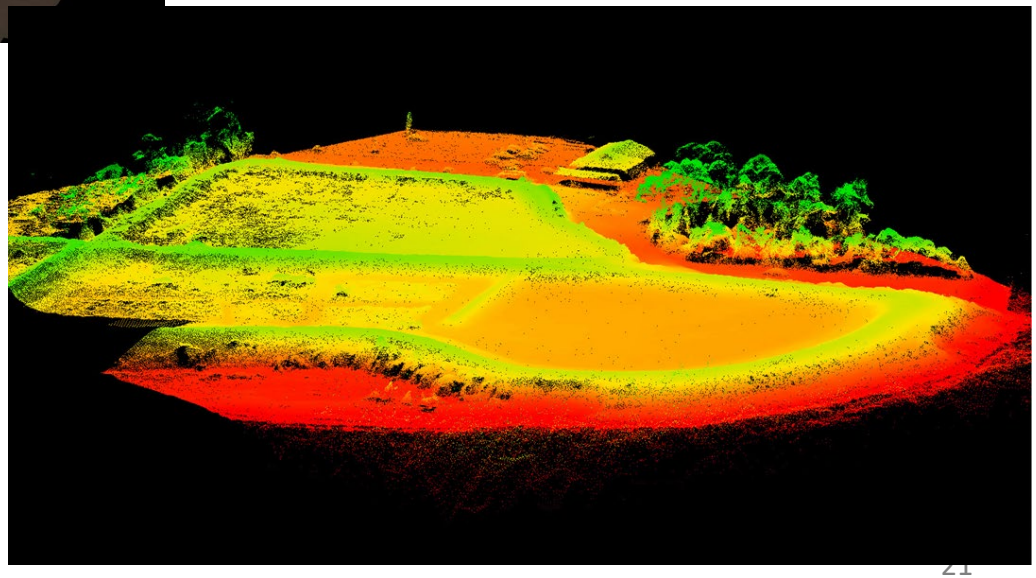
Bridge Scoping

NCDOT
Project #BP6.R002.1

Southport Ferry Spoil Site (Before)

Berm repair project

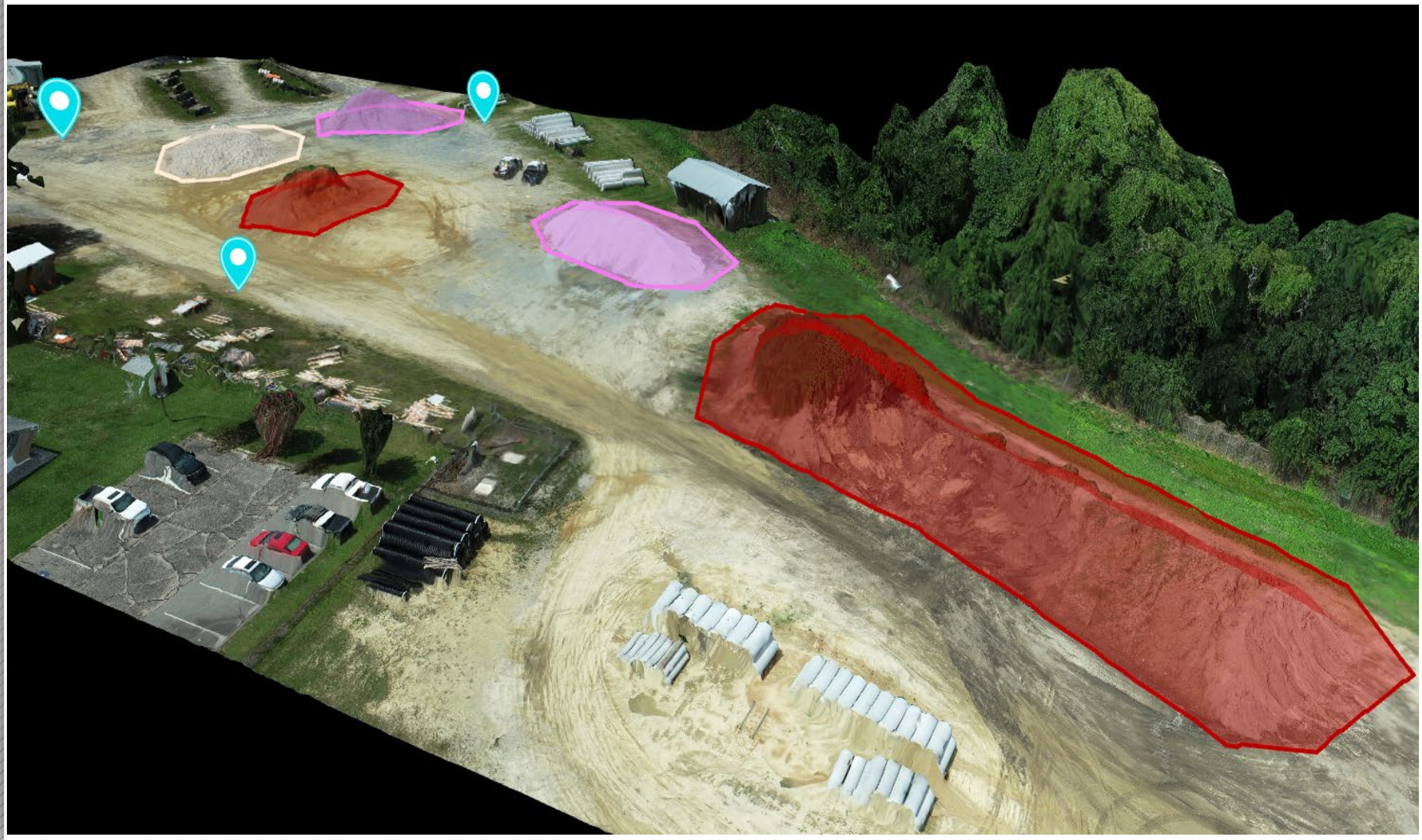
Onsite Spoil material was used for repair.



Southport Ferry Spoil Site (After)

Maintenance Yard Stockpile Volumes

Maintenance Yard Stockpile Volumes



Future possible uses in L&S

- Supplement Photogrammetry data with UAS data.
- Use for construction erosion control analysis and documentation after large rain events on Construction projects.
- Use for intermediate volumes on small Borrow pits and earth work projects.
- Small project updates / Secondary roads and intersection surveys.
- Location and Surveys is looking for new and innovative ways to use this new technology to help in our mission to collect data and produce mapping for NCDOT projects.

Conclusion

- Discuss UAS usage with Local L&S Division Locating Engineer.
- We can coordinate with Photogrammetry and Aviation to develop a solution for your particular project conditions and needs.