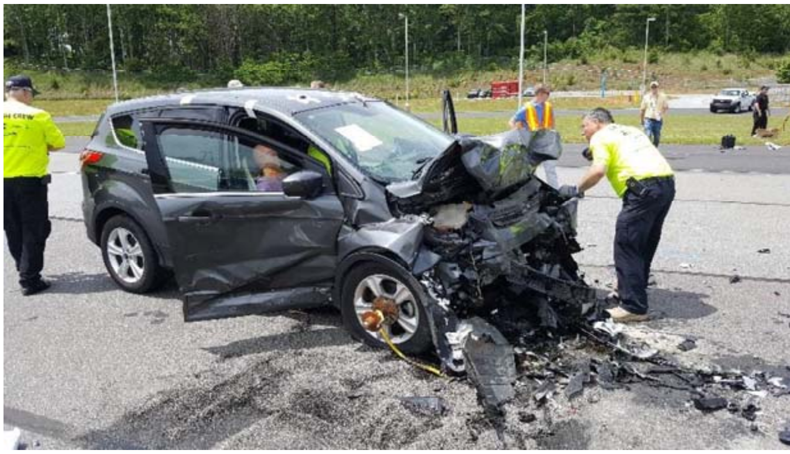



COLLISION SCENE RECONSTRUCTION & INVESTIGATION

USING UNMANNED AIRCRAFT SYSTEMS

August 2017

Division of Aviation | UAS Program Office
N.C. Department of Transportation

DIVISION OF AVIATION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Acknowledgements

The North Carolina Department of Transportation Division of Aviation is proud to work with the North Carolina State Highway Patrol (NCSHP) Collision Reconstruction Unit (CRU) on this study and we appreciate its contributions. Our findings affirm that unmanned aircraft systems (UAS) can provide state agencies better tools for serving the public interest and safety. The NCDOT looks forward to partnering with the NCSHP on future research projects.

The North Carolina State Highway Patrol (NCSHP) Collision Reconstruction Unit (CRU) extends its sincere gratitude to the N.C. Department of Transportation's Division of Aviation (DoA) for allowing its participation in this important UAS study. These results have been nothing short of amazing. Based on these findings, we believe that time spent at collision sites will be drastically reduced by using UAS technology, allowing for rapid restoration of traffic flow and the safety of investigative members.

N.C. Department of Transportation Division of Aviation

The North Carolina Department of Transportation Division of Aviation (DoA) is the state's aviation authority, responsible for promoting the economic well-being of North Carolina through air transportation system development and improved aviation safety and education. DoA's UAS Program Office ensures that UAS/drone operations in North Carolina are safe and responsible. As a leader in UAS/drone implementation, the NCDOT provides research and education that demonstrates how beneficial and safe this technology can be.

Governor's Highway Safety Program

The Governor's Highway Safety Program is dedicated to promoting highway safety awareness to reduce the number of traffic crashes and fatalities in the state of North Carolina through the planning and execution of safety programs.

North Carolina State Highway Patrol Collision Reconstruction Unit

The North Carolina State Highway Patrol (NCSHP) Collision Reconstruction Unit (CRU) conducts investigations that lead to the successful identification, apprehension and prosecution of offenders through implementation of advanced techniques and forensic equipment. CRU has established itself as the state's leading criminal investigative entity and is frequently called upon to provide evidential support in high-profile collision cases – approximately 200 statewide every year. Of these cases, 98% percent involve a state- or municipal-controlled roadway.

Overview

The N.C. Department of Transportation (NCDOT) maintains approximately 80,000 miles of roadways and works closely with multiple state and local agencies to respond to emergencies that impact road systems.

When collisions occur, the NCDOT Traffic Management Unit partners with the North Carolina State Highway Patrol (NCSHP) to clear roads quickly. Collision scene investigation and reconstruction, then, becomes a time-sensitive process focused on gathering and recording critical evidence in a safe, fast and efficient manner.

Two current methods of investigating collisions – total station and laser scanning – can be time consuming and extend highway closures. Our research demonstrates that using a combination of advanced imaging software and the latest UAS technology can greatly accelerate the investigation. Large scenes can be documented in less than 30 minutes, allowing roadways to be cleared and reopened more quickly. Further, UAS technology produces data more efficiently with accuracy equal to or better than legacy methods at a lower cost and with less risk to motorists and investigators.

This research report documents the results of a collision scene investigation and reconstruction test conducted in partnership with the NCSHP's Collision Reconstruction Unit (CRU). DoA's UAS flight team mapped the scene using three different UAS. The CRU team used a FARO Focus3D X330 Laser Scanner.

Our findings affirm the significant benefits and advantages UAS technology offers the North Carolina State Highway Patrol, as well as government agencies of all types, that seek to serve the public interest safely and responsibly.

"Based on these findings, we believe that time spent at collision sites can be dramatically reduced by using UAS technology, allowing for rapid restoration of traffic flow and the safety of investigative members.

N.C. State Highway Patrol
Collision Reconstruction Unit

Abstract

Collision reconstruction is a scientific approach to solving the questions of how and why a roadway collision occurred. It aims to provide detailed and accurate information for collision analysis that can improve traffic safety. When reconstructing a collision scene, the goal is to complete the recordings in a quick and efficient manner so that roadways can be cleared and reopened quickly.

Current legacy methods of investigating collisions – total station and laser scanning -- can be time consuming. Our research shows that documenting a collision scene using photogrammetry and UAS can be advantageous, especially in terms of speed and cost.

Study partners tested UAS and legacy technologies at the Buncombe County Public Safety Training Facility.

With a combination of advanced imaging software and the latest unmanned aircraft systems (UAS) technology, we find that the North Carolina State Highway Patrol (NCSHP) can rapidly map collision scenes and simultaneously gather more information than legacy technologies. Indeed, large scenes can be documented in less than 30 minutes.

This report discusses the logistics, procedures and results of using UAS, compared to laser scanning, in a simulated collision scene.

The simulation occurred on May 22, 2017, as state and local law enforcement agencies came together at the Buncombe County Public Safety Training Facility to kick off the annual Click It or Ticket campaign, part of the Governor's Highway Safety Program. The demonstration simulated a head-on collision, showing the impact of two cars traveling about 40 miles per hour. Two sets of crash test dummies were placed in the cars, with one set buckled and the other unrestrained.

The UAS flight team (two people) from the N.C. Department of Transportation's Division of Aviation mapped the scene using three different UAS. Specifications for the UAS are attached with this report. The NCSHP's Collision Reconstruction Unit (CRU) used a FARO Focus3D X330 Laser Scanner.

On-sight flight operations with UAS are simplified by using app-based software, in which basic details are set and the software automatically develops the flight plan. When ready, the UAS automatically flies the mission, capturing all necessary photos or videos, returns home and lands. After the scene is captured, photogrammetry processing software, such as Agisoft or Pix4D, renders the high-resolution photos into a complete three-dimensional map. With the map, the scene can be viewed and measured from any position and/or angle.

The goal of this report is to explore the capability and potential of UAS for collision scene investigation and reconstruction.

Aerial Mapping

DJI Mavic Pro

The Division of Aviation UAS flight team mapped the crash scene using three platforms – DJI Mavic Pro, DJI Phantom 4 Pro and DJI Inspire 2 – selected for their cost, capability, accuracy and image quality.

The platform of interest is the DJI Phantom 4 Pro, a compact and lightweight drone with a gimbal stabilized 12MP/4K camera.

The UAS flights were flown in autonomous and semiautonomous flight modes at 90-100 feet above ground level (AGL). Each flight captured between 60 and 81 pictures.

DJI Phantom 4 Pro

The flight team also captured video using the DJI Inspire aircraft and took pictures of the scene using a DSLR camera.

In total, three flights were completed in under 25 minutes using three UAS. Pictures taken from each UAS were processed using Agisoft PhotoScan software.

Data Processing

DJI Inspire 2

While many photogrammetry processing software platforms exist on the market, NCDOT selected Agisoft PhotoScan software, a stand-alone software that utilizes a semiautomatic workflow that can be customized by the user producing orthophotos, DEMs and image-quality assessments.

Once images have been downloaded from the UAS to Agisoft, images can be included for the reconstruction process area and added to the project. Images can then be run through a high-accuracy pair selection process (Align Photos).

Ground Control Points (GCP) data can be imported into the process and markers (GCPs) read. A dense point cloud can be generated with a moderate depth filtering setting. Once a point cloud is generated, it can be cleaned of any “noise”. Mesh & Texture can be run to give the data a clean, high-visual appearance. A Georeferenced Orthophoto can then be exported for use with various Microstation, CADD or rendering programs.

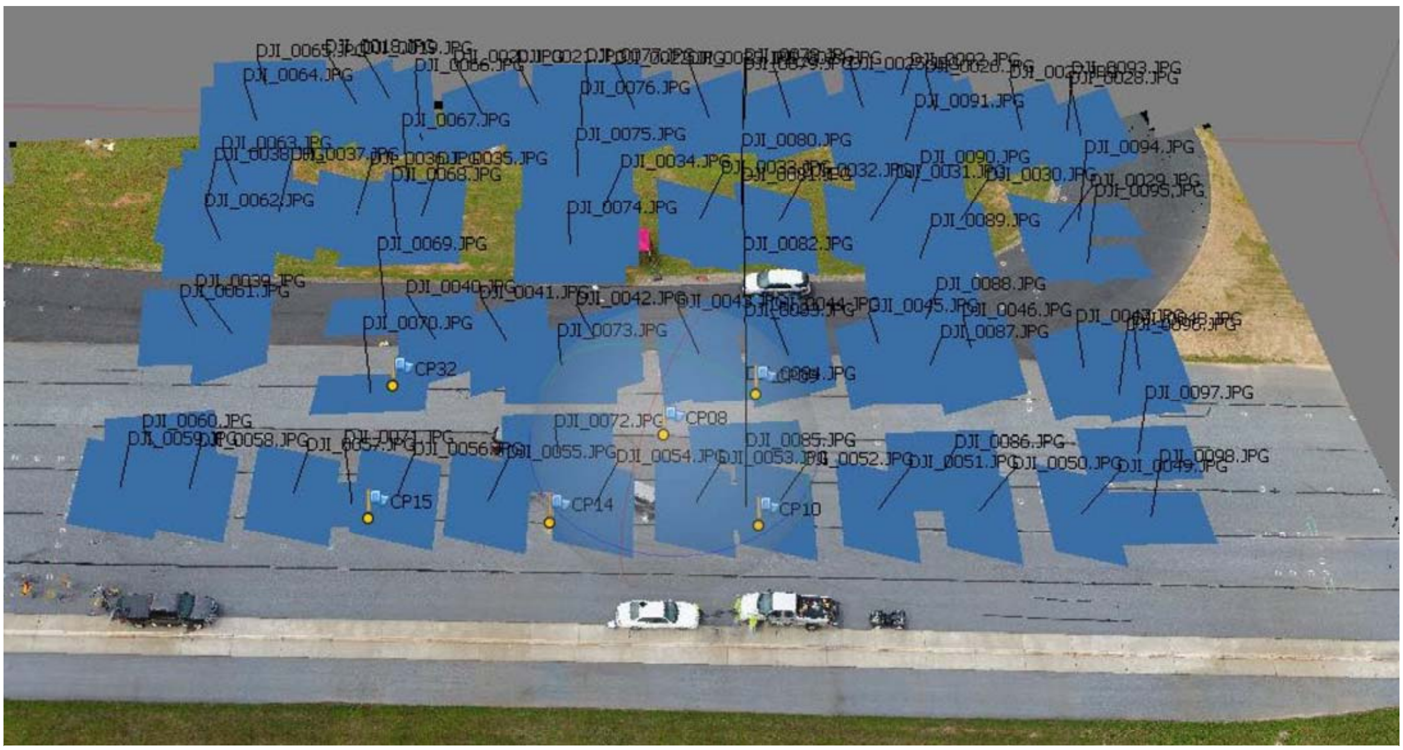
Workflow for reconstruction using Agisoft PhotoScan is as follows:

1. **Add Photos**: Images to be used in reconstruction (five minutes)
2. **Align image**s: High accuracy and pair selection (10 minutes)

3. **Build dense (point) cloud**: Medium quality and moderate depth filtering should be used to start (one hour 15 minutes)
4. **Build mesh**: Base the mesh on the dense point cloud. (one minute)
5. **Build textures**: Textures give a higher visual appearance (26 minutes)
6. **Export model**: For use with 3D modelling packages (two minutes)

Quick Report

- Med Alignment settings
- 81/81 aligned photos
- Tie Points – 46,174 pts
- Dense Cloud – 8,547,150 pts
- DEM and Orthomosaic generated
- Two -hour total processing time



Flight Line Layout

Ground Mapping

After aerial mapping the crash scene, the NCSHP CRU utilized the FARO Focus3D X330 Laser Scanner to map evidence of the same scene. A total of 106,703,633 points were captured through 11 scans of the scene. The total time to map this scene was one hour, 51 minutes.

Scene v6.2.4.30 software was used to register the 11 scans onto a single coordinate system. Total time to process and register the 11 scans was one hour, 58 minutes. Additional time was required to create a Webshare2Go file so that the scene could be shared with others who do not have Scene software.

The FARO system is a great tool for capturing a lot of data. However, capturing the data using FARO requires significantly more time than using UAS photogrammetry, especially when scanning in color.

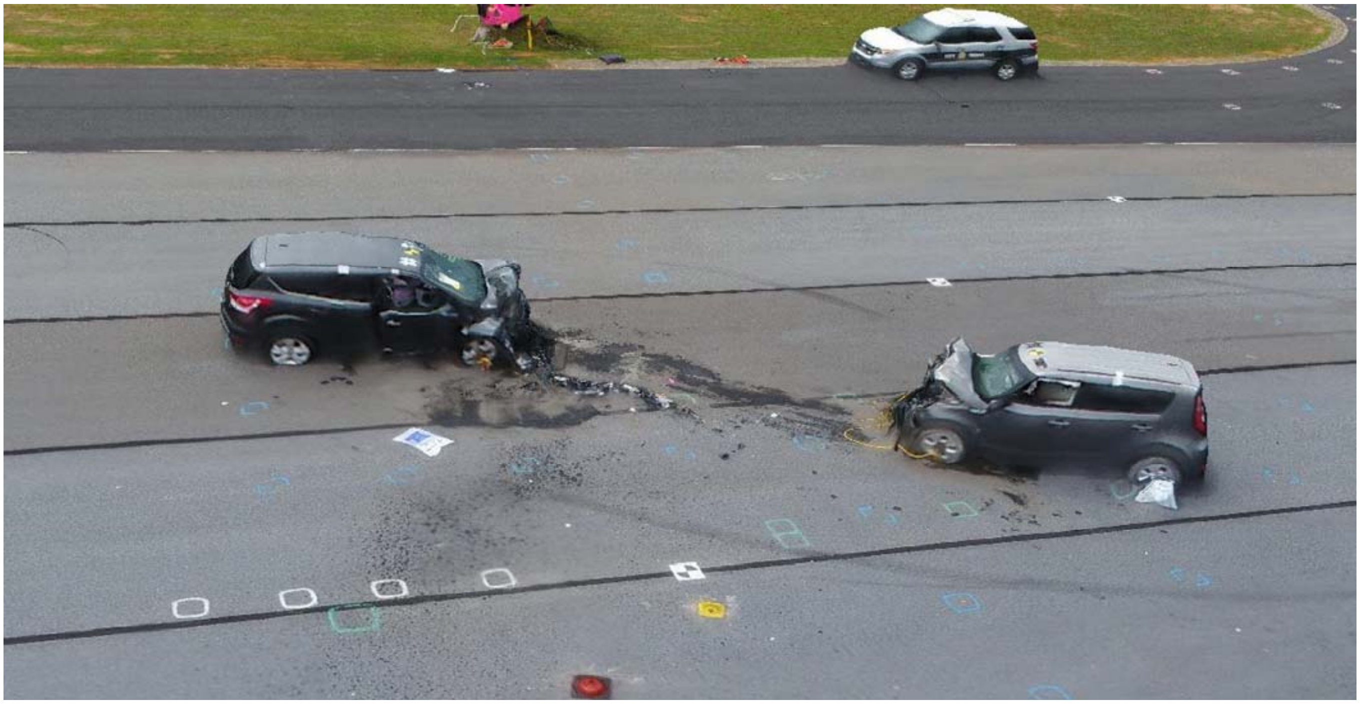
FARO Focus3D X330Laser Scanner

Data Comparison

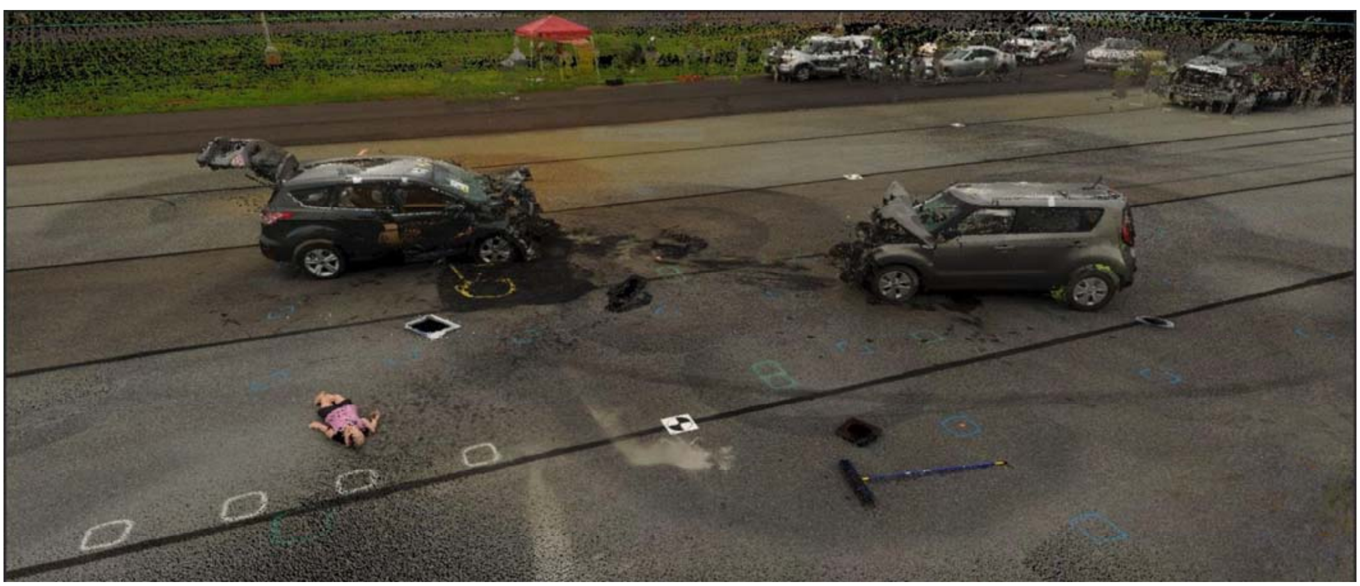
Two point clouds from the FARO system and Agisoft were taken and were rendered into a 3D model of the crash scene. The two files were relatively similar in size, roughly 12 million points each. The point cloud renderings from each system produced great detail, making it easier to recognize skid marks.

The targets were also easy to read accurately from medium flying height. Merging the two data sets should allow investigators to create an extremely accurate and time-saving product.

Point Cloud Comparison



Agisoft PhotoScan 3D Model Rendering



FARO System Laser Scan 3D Model Rendering

Skid/Target Comparison

Agisoft Skid/Target Comparison

FARO Skid/Target Comparison

Data Accuracy

Six (6) ground control point (GCP) targets were established before the acquisition of the imagery to evaluate the accuracy of the crash scene data acquired by the DJI MavicPro. A survey crew from the local NCDOT Field Survey Office determined the X, Y, Z coordinates for each of the GCP targets.

The data was processed using the Agisoft software to create an Orthomosaic. The image quality was evaluated using the software's image quality tool and found to be a value of 0.87, which is well above the minimum value of 0.6 recommended by the software.

The Orthomosaic was georeferenced into Microstation and compared to NC OneMap to verify that it was in the correct location. The locations of the GCPs in the Orthomosaic were measured in Microstation and their values were compared with the actual ground locations. The overall accuracy of the measured locations was found to be within 0.03 feet. We were also able to make accurate measurements of the skid marks and the relative distance between the vehicles after impact.

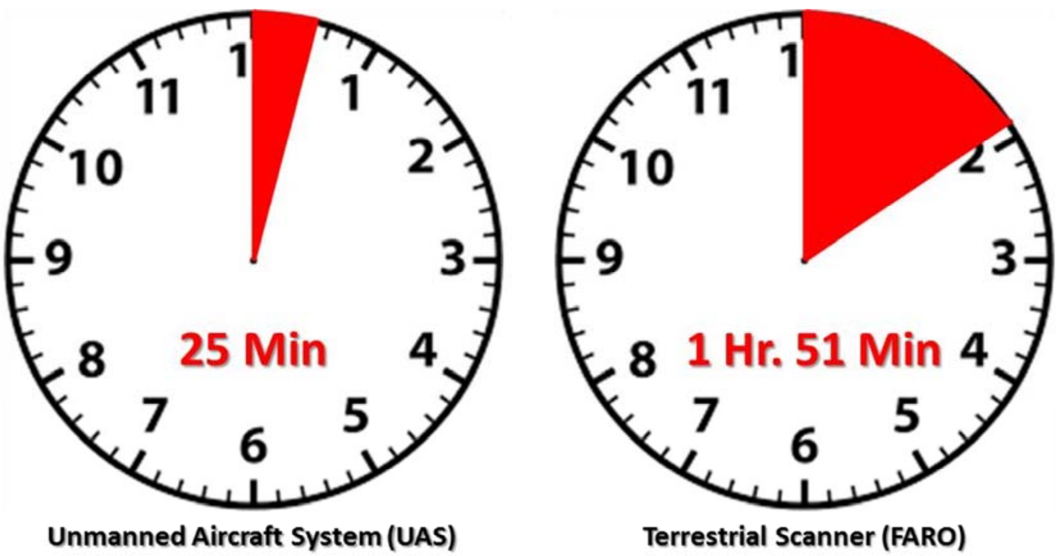
Distance calculation using Agisoft

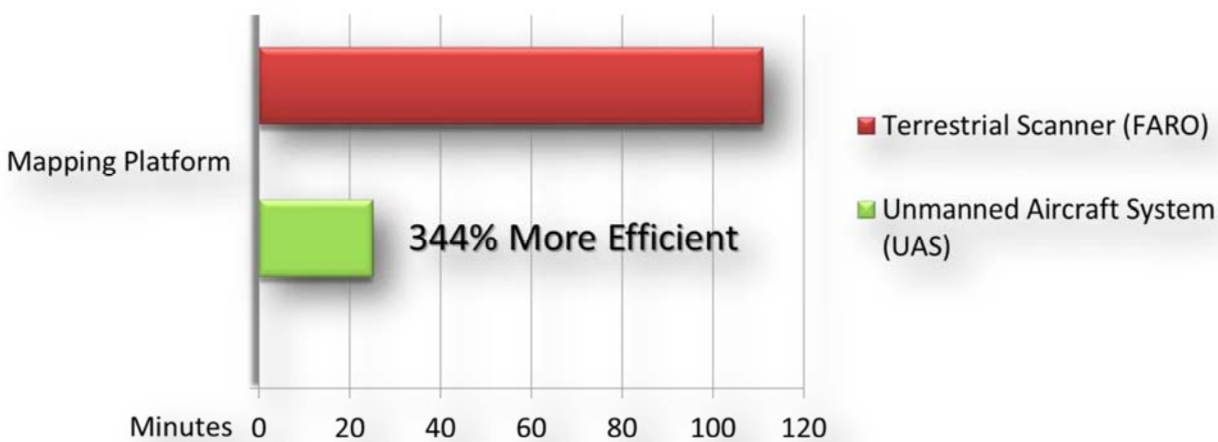

Orthophoto overlaid on NC OneMap

Time to Map Comparison

The time to map comparison favors a UAS over traditional methods (25 minutes versus 1 hour, 51 minutes).

The ability to start the clearance of the collision and restore traffic is of significant interest to the NCDOT. It reduces exposure time of first responders to traffic and helps preserve the safety of personnel at the scene. The faster a highway can be reopened to traffic, the better NCDOT can maintain the mobility of roads and the commerce that passes through them.





Conclusion

Our research shows that using UAS for collision scene reconstruction offers benefits for both NCDOT and NCSHP's CRU. The research detailed in this report indicates that utilizing a UAS and proper photogrammetry processing techniques yields accurate data comparable to current legacy methods for collision scene reconstruction. Used with photogrammetry software, such as Agisoft, this technology has huge potential for quick and accurate documentation of vehicle collision scenes, which is especially important when there is a large loss of property or life. Furthermore, its video capability offers the opportunity to revisit a collision scene multiple times from an aerial perspective.

Among its benefits, UAS technology:

- Saves time required for data collection.
- Significantly reduces risk for investigators and motorists.
- Reduces the time required to reopen roadways following a collision.
- Provides immediate documentation of acquired data.
- Requires less maintenance and investment.
- Is easy to use.
- Provides aerial views of the scene.

It should be noted that there are certain limitations to UAS, and further research to overcome some of these limitations is warranted. The UAS flights used for the research in this paper were flown during daylight hours and clear conditions. Further research on UAS operations should be conducted at night utilizing the lights from emergency response vehicles to illuminate a crash scene. UAS operations in rain, snow and other inclement weather should also be researched.

Based on these findings, NCDOT recommends that NCSHP integrate UAS into its collision scene reconstruction units to help improve the safety and efficiency of our state's roadway system and conduct additional research to examine how UAS compares to legacy methods during inclement weather and nighttime conditions.

As more and more states look to UAS technology for collision investigation and reconstruction, North Carolina has the opportunity to lead in this area. NCDOT Division of Aviation's UAS Program Office stands ready to support NCSHP in these efforts.