NCDOT STIC Grant Final Report: Safety Service Patrol Technology Pilot Project

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Executive Summary

The North Carolina Department of Transportation's (NCDOT) Traffic Systems Operations (TSO) group conducted a pilot to test two technology innovations for deployment on Safety Service Patrol (SSP) vehicles. NCDOT refers to their SSP program as the Incident Management Assistance Patrol (IMAP). Through a $50,000 Statewide Transportation Innovative Council (STIC) grant, NCDOT piloted tethered unmanned aerial vehicles (UAVs) and emergency vehicle alerting (EVA) devices.

The pilot project included small-scale implementations using different methodologies to evaluate each technology based on three primary goals. NCDOT tested the technology to determine the return on investment to the Department.

1. Improve *situational awareness*, to provide camera views of traffic conditions to operators in areas that do not have camera coverage
2. Improve *mobility*, to provide traveler information to motorists of real time traffic conditions
3. Improve the *safety of motorists and responders*, to make motorists aware of responders in the area and encourage them to move over away from the incident

Two tethered UAV device types were tested by IMAP in multiple regions across the state. During deployment, the tethered UAV streamed video to the traffic management centers (TMCs). The tethered UAVs demonstrated a greater value in the rural areas, which have limited camera coverage. Additionally, the Department may realize a higher return on investment if the UAV devices were available for additional purposes beyond incident response.

Four EVA product types were tested on IMAP vehicles across the state –seven of each device type provided the opportunity for a total of 28 deployments. Activation was a passive action where the emergency lights and/or their arrow board on the vehicle would send GPS locations and a standard message to navigation companies via the vendors programming interface. In theory, the system integration would alert the motorists of an emergency responder ahead and move over to the second lane. The EVA pilot did not demonstrate a clear benefit due to the current state of the connected technology and challenges with implementation. The Department recognizes some potential benefits and intends to continue monitoring advancements in the technology.

Introduction

The North Carolina Department of Transportation's (NCDOT) Traffic Systems Operations (TSO) group conducted a pilot to test two technology innovations for deployment on Safety Service Patrol (SSP) vehicles. NCDOT refers to their SSP program as the Incident Management Assistance Patrol (IMAP). Through a $50,000 Statewide Transportation Innovative Council (STIC) grant, NCDOT piloted tethered unmanned aerial vehicles (UAVs) and emergency vehicle alerting (EVA) devices.

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This report provides an overview of the assessment completed for the STIC pilot project. The report includes the following sections:

- Introduction / Project Description – brief overview of the project and the two technologies piloted.
- Unmanned Aerial Vehicles (UAV) – defines the UAV technologies assessed, the methodology applied, and the findings.
- Emergency Vehicle Alerts (EVA) Devices – defines the EVA technologies assessed, the methodology applied, and the findings.
- Summary – presents the results of the technology assessments.
- Recommendations – provides the recommendations for NCDOT regarding the two technologies.

Project Description

NCDOT's SSP Technology Pilot project used STIC funding to procure, install, and assess innovative technology options for UAV and EVA applications. NCDOT integrated multiple groups with the Department to participate in the assessment and provide feedback regarding the value the technologies could provide toward added safety to department and other responder personnel. The SSP Technology Pilot project asses the technologies' ability to support the following goals.

1. Improve *situational awareness*, to provide camera views of traffic conditions to operators in areas that do not have camera coverage
2. Improve *mobility*, to provide traveler information to motorists of real time traffic conditions
3. Improve the *safety of motorists and responders*, to make motorists aware of responders in the area and encourage them to move over away from an incident

IMAP responders regularly respond to incidents where the infrastructure lacks sufficient closed-circuit television (CCTV) camera coverage. IMAP drivers can use tethered UAVs (also known as drones) as a mitigation strategy to supplement capabilities for monitoring traffic impacts and providing live video feeds to traffic management centers (TMCs) and partner agencies. Tethered UAVs can improve situational awareness regarding impacts to traffic, back-of-queue conditions, and the effectiveness of traffic management solutions in place during an incident.

Integration of the emergency vehicle alert (EVA) have the potential to increase compliance to the State's "Move Over" law G.S. 20-157 (f) and provide additional safety for first responders. This technology supports increased awareness of IMAP responders present on North Carolina roadways. EVAs are passive devices that issue real time location information of IMAP vehicles using GPS location and connected technology to disseminate via traveler information tools and navigation providers (e.g., Waze, Google Maps).

Unmanned Aerial Vehicles (UAV)

The anticipated **benefits** of UAVs include:

- Better situational awareness in locations with limited coverage from traffic cameras
- Increased accuracy in traveler information
- Real-time monitoring of queues, traffic control implementations, and IMAP vehicle locations
- Reduced incident clearance time through improved scene management

UAV Evaluation Method

UAV Types (What)

TSO along with the Division of Aviation (DOA) procured two tethered UAVs technologies, Fotokite and Mavic2 with Volarius (V-line) Tether, as part of the pilot project. A tethered UAV connects to a ground station and consists of a base station, drone, and tether.

Fotokite

The Fotokite is an integrated mobile unit **(Figure 1)** that includes a ground station and a kite (flight unit) with a tethered connection to the ground station. The Fotokite includes a gimbal-mounted dual camera that supports both low-light view and thermal vision. The camera simultaneously streams both views within the visual application dashboard within the video management system. When activated, the system generates a unique QR code that provides live access to other agencies.

Figure 1. Photo of the Fotokite

The unit includes a tablet with a weather protected covering. The unit includes a power cord and must have a direct power source for the duration of flight. It does not operate on battery power or have a battery pack to support the unit's operation. Additionally, the tablet supports approximately four hours of battery life, but users should recharge after each use.

NCDOT Division of Aviation's (DOA) procured the Fotokite through the NCDOT DOA's partnership with North Carolina State University's (NCSU) Institute for Transportation Research and Education (ITRE).

Mavic2 with Volarius (V-Line) Tether (referenced as Mavic2 System)

The Mavic2 System is a mobile unit consisting of two different components, a DJI Mavic2 drone and a Volarius V-Line tether **(Figure 2**). The Mavic2 System also includes a gimbal camera for low-light views. Operation of the Mavic2 System as a tethered UAV on an IMAP vehicle requires the user to connect the V-Line to the drone. The Mavic2 System includes an operational joy pad that connects to a tablet.

Figure 2. Photo of the Mavic2 System (Source: Florida Drone Supply)

The Mavic2 System procurement did not include a tablet. TSO and DOA provided iPad tablets for IMAP Supervisors to use during the pilot project. The DJI application streams the video from the drone to the iPad. The IMAP Supervisor uses Microsoft Teams to share the video stream from the iPad.

NCDOT procured the Mavic2 System through NCDOT's Low Bid process. TSO developed requirements to include within a formal request for proposal (RFP) process. NCDOT received two bid responses and awarded the selection to the vendor with the lowest cost.

The Mavic2 System had a cost of over $15,000 whereas the Fotokite cost was nearly $25,000.

UAV Test Locations (Where)

IMAP tested the UAVs in multiple regions to provide variety in geography, weather conditions, population density (urban/rural), and cellular network coverage. The use cases for the tethered UAVs included *locations with limited CCTV camera coverage* and *incidents generating congestion*.

NCDOT did not mount the tethered UAVs to the vehicle to support efficient movement between vehicles and regions. NCDOT includes 14 Divisions as shown in **Figure 3**. NCDOT manages the IMAP program at a regional level and some of those regions span multiple Divisions.

- Division 3
- I-95 Corridor (Division 4, Division 6)
- Triangle Region (Division 5)
- Division 6
- Triad Region (Divisions 7 & 9)
- Metrolina Region (Divisions 10 & 12)
- Mountain Region (Divisions 13 & 14)

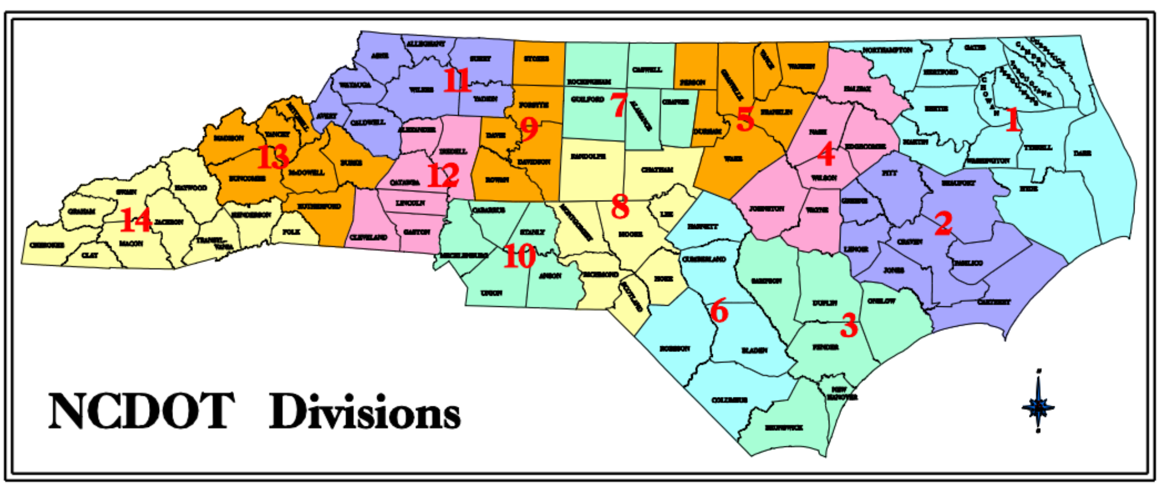

Figure 3. NCDOT Division Map

UAV Testers (Who)

IMAP supervisors were identified as the primary users to test the tethered UAVs. To ensure the safety of the IMAP supervisors and other responders on scene, the IMAP supervisors needed to be IMAP

Responder certified prior to using the tethered UAVs. This certification ensures a level of consistent expectations of the roles and responsibilities of the IMAP Supervisor while on scene during an incident.

The team trained eleven IMAP supervisors on both tethered UAV technologies.

DOA received the tethered UAV systems and assessed the capabilities and operational nuances of each. DOA documented their observations and provided input on the use of each system prior to training the IMAP supervisors.

The IMAP Master Trainer and TSO conducted training for each IMAP Supervisor prior to them using the tethered UAV. The tethered UAV training session included capabilities and challenges of the technology, process for launch and landing, and an overview of power and communication needs. The training provided the attendees with a flight checklist and flight instructions specific to each technology. This included important procedural steps and verifications for before, during, and after the launch processes. These documents are in **Appendix A**.

Challenge: *Division 3 hired a new IMAP supervisor after training occurred with all other IMAP supervisors on the use of the tethered UAVs. Division 3 requested for this new supervisor to utilize the tethered UAV. However, this new supervisor was not IMAP Responder certified.*

UAV Distribution (When)

The team provided the tethered UAVs for a minimum of 4 weeks in each region. **Table 1** (Fotokite) and **Table 2** (Mavic2 System) present the training and distribution schedule for each tethered UAV.

Challenge: *Mavic2 System encountered issues with the camera calibration when testing/ training with DOA. After discussions with the vendor, TSO returned the system to the manufacturer to fix and resend.*

Challenge: *The Fotokite was asked to attend special events throughout the pilot. This meant the device was not in the Divisions for IMAP use. As such, there were missed opportunities to use this device and support additional awareness on scene.*

Table 1. Distribution Schedule for Assessing the Fotokite

	Fotokite
Division/Region	**Distribution and Assessment Dates**
Training with DOA	*1/13/2022, 1/24/2022, 1/26/2022*
Division 3	*IMAP Supervisor had not completed their IMAP Responder Certification and thus was unable to utilize either tethered UAV.*
Division 6	1/28/22-5/2/22
DOA/Other (FHWA Demo)	*5/4/2022*
Triangle	5/11/22-9/14/22
Triad	*Since the Triad region was testing the Mavic2 System, the Fotokite was moved to Metrolina.*
Metrolina	9/14/22-12/2/22
Peer Exchange Meeting (HOGs)	*12/2/22-12/7/22*
Mountains	12/7/22-1/10/23
DOA (NC Transportation Summit)	*1/18/23-1/19/23*
Division 6	1/19/23-1/27/23 *A demo to the Governor's Highway Safety Program (GHSP) occurred 1/26/23*
DOA (Media Event)	*1/30/22 DOA rescheduled for a later date (no set date at the time of this report)*

Table 2. Distribution Schedule for Assessing the Mavic2 System

	Mavic 2
Division/Region	**Distribution and Assessment Dates**
Training with DOA	*1/13/2022, 1/24/2022, 1/26/2022*
Division 3	*IMAP Supervisor had not completed their IMAP Responder Certification and thus was unable to utilize either tethered UAV.*
Additional Training with DOA	*3/30/2022-3/31/2022*
Triad	4/12/22-5/18/22
Division 6	6/17/22-8/19/22
Triad	8/25/22-1/27/23 *Triad Planning group planned 4-day weekend event (8/27/22-8/30/22). Eventually reduced to one day. More information in the Key UAV Insights section.*

Impacts:

1. IMAP did not use the Mavic2 System between January 2022 and March 2022. DOA completed Initial training for the Mavic2 System in January 2022; however, due to issues identified with the unit, DOA sent the system back to the manufacturer. IMAP / TSO provided additional training once the Mavic2 System returned in March 2022.
2. The Fotokite's original power cord to connect the unit to the IMAP vehicle did not work. TSO requested a new cord from the vendor. IMAP used a substitute cord in the meantime. The

substitute cord was only available for Division 6. TSO representative picked up the new cord from NCSU on 5/3/2022.

3. Transitioning the tethered UAVs between IMAP Regions required a certain amount of coordination, which impacted the time each Region could use the device.

UAV Procedures (How)

IMAP responds to incidents either from identifying the incident during patrol or TMC dispatch (refer to **Figure 4** for TMC locations). Once on scene, IMAP Responders assess the incident severity (minor, intermediate, or major) and proceed to set up appropriate emergency traffic control (ETC). According to the MUTCD, Chapter 6I, a minor incident has an expected duration under 30 minutes while a major incident has an expected duration of more than two hours. IMAP Supervisors respond to support IMAP Responders during *major incidents*.

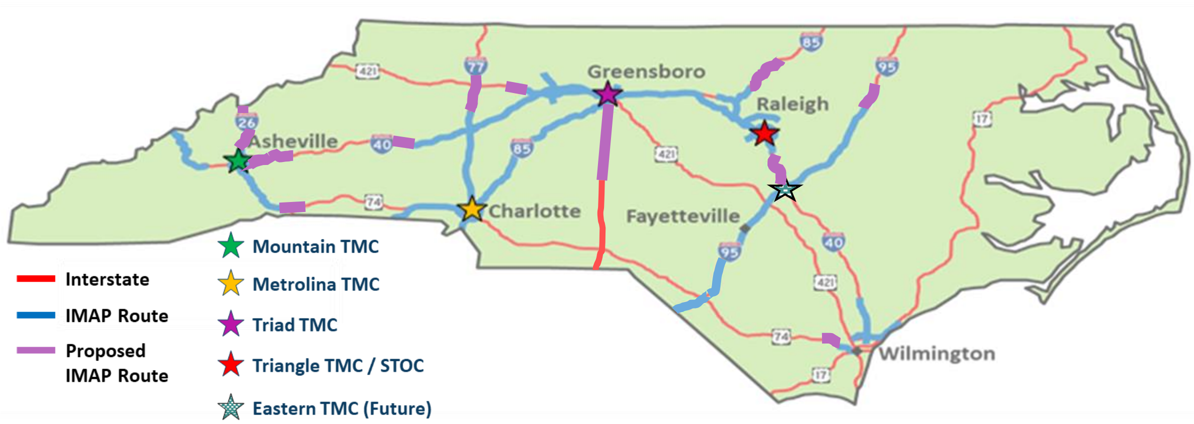

Figure 4. IMAP and TMC Footprint

IMAP Supervisor coordinates with the IMAP responder and partner agencies, confirm if traffic management requires other activities, and then activate the tethered UAV. Flight regulations restrict IMAP Supervisors to an altitude of 150 for the tethered UAVs. Once launched, the IMAP Supervisor shares the live video stream in one of two ways.

1. **Fotokite**: Each device has a specific URL associated to that device. The Fotokite generates a QR code and specific event code once video is streaming on the visual application dashboard. The IMAP Supervisor shares the QR code with appropriate first responders and the TMC. The TMC distributes the code and URL using an internal NCDOT email distribution list (*NCDOT-Traffic Operations – UAS*). This distribution list includes each of the IMAP Supervisors, incident management engineers (IMAP Supervisor's supervisor), regional ITS engineers and their equivalent positions, DOA, and TSO.
2. **Mavic2 System**: The IMAP Supervisor shares the video stream through a Microsoft Teams channel (*NCDOT-Traffic Operations – UAS*). The IMAP

Challenges: *TSO had to work with DIT (state's IT group) on access through the firewall to enable the STOC/TMC to view the video via the QR code.*

Supervisor logs into Teams, initiates a meeting in the Teams channel, and 'shares' their screen. Microsoft Team notifies the members of that group who can then access the live stream once they join the meeting. The TMC sends an email to the defined distribution list (*NCDOT-Traffic Operations – UAS*).

The Mavic2 System uses a DJI drone, programmed to restrict flight in designated zones. Therefore, the DOA had to acquire a waiver from FAA to permit the Mavic2 System to operate within some designated zones. Regardless of location, procedures require the drone operator to use a flight verification application on the tablet or a smartphone to confirm if the current location was in a no-fly or height restricted zone. DOA recommended a few possible applications to meet this need (i.e., B4UFly, Aloft). TSO chose to select Aloft as the preferred application.

Lastly, after each launch, the IMAP Supervisor completes the Flight Checklist form and submits to TSO to support the data collection of the pilot project. The checklist includes questions regarding the launch date, location, purpose for the launch, and a confirmation that the IMAP Supervisor followed the launch/during/landing processes.

Challenges: *a) The original video streaming application for the Mavic2 System (Vimeo) had licensing challenges. b) TSO worked with the IT department to set up a Microsoft Team's page, not a quick process.*

The flight instructions and the checklists, including examples, are in **Appendix A**.

UAV Findings

The assessment team collected feedback from each IMAP Region that used the tethered UAVs using an evaluation form. The form focused on the users' experience with the device, reliability of the technology, and the perceived value the technology provided during the incident response. The evaluation form asked questions related to six qualities shown in **Figure 5**. Examples of completed evaluation forms are in **Appendix B**.

The most significant difference between the two technologies was the Mavic2 System was a disparate system while the Fotokite was an integrated system. **Table 3** below includes a listing of additional pros and cons identified during the project lifespan.

Table 3. Pros and Cons for Fotokite and Mavic2 System Tethered UAV

	Fotokite		Mavic2 System	
	Pro	**Con**	**Pro**	**Con**
Unit	One integrated unit.			Individual components that require assembly prior to each use.
Set Up	Quick set-up time.	Requires hot spot to share live video feed with STOC/TMC.	Used built-in data connection from the iPad	Packed in multiple cases.
	Self-contained within a single case and only requires plugging into the power source on the vehicle.	Need to ensure power source is available the entire length of launch (*i.e., not run out of gas*).		Multi-step set-up process that requires some assembly and disassembly.
	'Push' button to launch the device	Required IMAP to install inverters on the vehicles to power the unit.		Internal compass sometimes requires calibration, which involves untethering the UAV and conducting calibration process.
Battery		A power source is necessary to operate. No battery.	Can fly using external batteries. Has AC power backup option.	Battery would not maintain a full charge.
Camera	Camera can rotate and has great streaming visual.		Camera can rotate and has great streaming visual	
	Additional video features including thermal.			
Weather	Unit is waterproof and can fly in the rain.			System is not waterproof and cannot fly in rain, specifically due to the added battery pack and tether.
Operations	Auto-corrects position when impacted by wind.		NCDOT exemption from FAA allows DJI drone (system) to fly in no-fly zones (up to specific heights).	Operator must pilot the system as an actual drone, even though tethered.
	Can auto-land back to the base without operator assistance.			Landing is not automated and requires advanced skills from the operator.
	Operator can select a specific altitude for flight.			iPad used to operate the System will overheat if left in direct sunlight.

	Fotokite		Mavic2 System	
	Pro	Con	Pro	Con
	While launched, the unit alerts operator of nearby aircraft in case landing is necessary.		While launched, the unit alerts operator of nearby aircraft in case landing is necessary.	
	The unit will alert the operator if the base is moved, unplugged, or no longer has power source.			
Video Stream	Integrated application for streaming videos on scene.	Required extensive firewall troubleshooting for TMC users to be able to see the video stream.		Requires additional software to stream video (via Microsoft Teams)
	Single login to the tablet operating the unit.			No single login into Teams; each user had to log in to share video.

Example of Using the Fotokite

IMAP used the Fotokite on I-95 near Dunn, NC during an incident involving a vehicle striking a bridge. This incident required an NCDOT bridge inspection to validate the safety of the bridge prior to allowing traffic to proceed across. NCDOT routed traffic to the exit prior to the bridge, through the traffic signal, and then back onto I-95. Increased situational awareness for both NCDOT and the public were essential to clearing the incident. Live video streams from the Fotokite to the STOC allowed for real-time traffic management, which included real-time adjustments to signal timing, guidance for modifications in emergency traffic control, and more accurate traveler information.

Example of Using the Mavic2 System

The Triad Planning Group used the Mavic2 System to monitor anticipated traffic from a four-day sporting event. The Division 7 drone pilots had anticipated use of the tethered UAV for at least three of the four days. Due to specific challenges during the use on day one, the team decided to not use the Mavic2 system on days two and three. Some of the challenges the team encountered include:

- Poor communications via the cellular service in the area of the event.
- The battery pack lasted approximately 2 hours per charge.
- The Mavic drone would try to land when the users had not instructed it to do so.
  (After the event, it was determined that the user could mitigate this by changing to the Attitude (Atti) Mode then back. *Atti Mode is where the drone will maintain a specific altitude but not position.*
- Transport and deployment of the Mavic2 System is cumbersome due to it including multiple components that require assembly and disassembly around each launch.

Additional evaluations from the Triangle and Triad regions are in **Appendix B**.

UAV Assessment

The tethered UAV assessment includes seven categories presented in **Figure 5**.

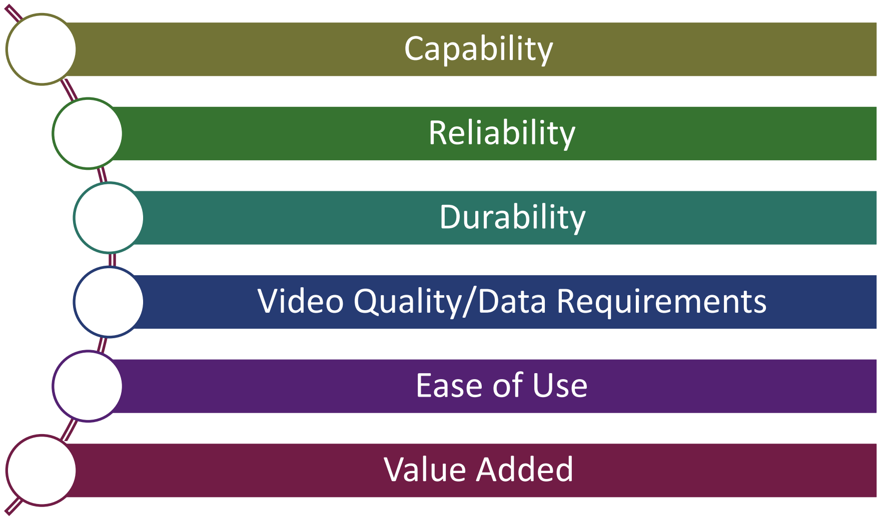

Figure 5. Tethered UAV Evaluation Areas

Table 4 provides the Evaluation Area and a corresponding description of what the team asked the users in each Region.

Table 4. UAV Evaluation and Description Used

Evaluation Area	Description
Capability	*Was the set-up simple and efficient?*
Reliability	*Was network access to the UAVs dependable?*
Durability	*Did weather, wear and tear, or other external factors impact the device's performance?*
Video Quality/ Data Requirements	*Was the video stream viewable in the application used?*
Ease of Use	*Was UAV easy to use or did it require more skills to operate it?*
Device Support	*Was technical support available when needed throughout the project?*
Value Added	*Did the tethered UAV enhance the capabilities of the Department during incident response?*

Figure 6 presents the average scoring for six of the seven evaluation areas listed in **Table 4**. The scores are based on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree). Users noted the video quality for both tethered UAVs with a 'Good' quality based on an assessment of either 'Good' or 'Bad.'

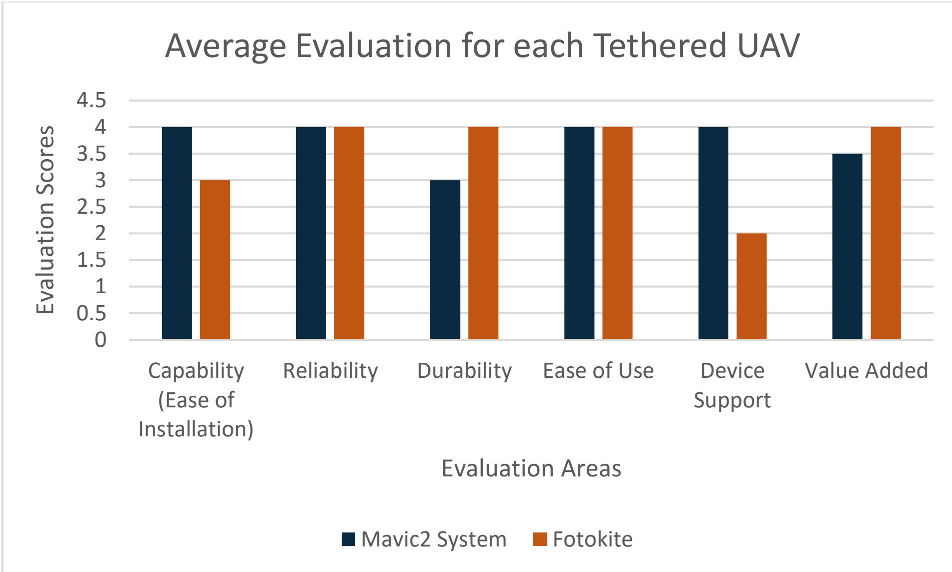

Figure 6. Average Tethered UAV Evaluations Graph

UAV Conclusion

Both tethered UAV technologies received similar scores in most of the evaluation areas. The users gave the Fotokite slightly higher scores based on the solution being a single integrated system. The multiple cases for the Mavic2 required additional storage space in the IMAP vehicle. The assessment captures the following observation based on the feedback from the multiple users that interacted with the technologies.

- **Laws, FAA guidelines, and restricted airspace** – *The Mavic2 System required a DJI waiver. IMAP Supervisors had to use an app to confirm possible airspace restrictions prior to launch. FAA recommends a one-hour class but allowed the DOA to incorporate the FAA information within the IMAP training.*
- **Line of sight vs. beyond line of sight** – *Current federal law (49 USC 44801 – Actively Tethered Unmanned Aircraft Systems) notes any user operating a tethered UAV must be within line of sight of the device. This requires the IMAP Supervisor to maintain eye contact with the tethered UAV while it is in operation.*
- **Use around traffic** – *The primary purpose for the use of the tethered UAV was to support traffic management and back of queue monitoring. Not every incident location provided a safe location to support adequate visuals of the queue.*
- **Weather** – *The Mavic2 design prohibited users from launching it in the rain, which limited the ability to assess in certain scenarios.*
- **Live streaming and connection** – *Some locations experienced challenges with cellular access to adequately support live streaming the video. NCDOT was able to issue a hot spot with access via FirstNet to gain dedicated access to more reliable network.*
- **Additional use cases** – *The regions noted additional non-incident scenarios where the tethered UAVs could add benefit.*
- **Resistance to Technology Adoption** – *Use of the tethered UAV required some additional investment in education and training during the pilot to overcome resistance to adopting a newer technology.*

- **Use or Not Use –** *Not every region had as many opportunities to launch the tethered UAV.*
    - *The Region has sufficient CCTV camera coverage.*
    - *The Region did not experience any incidents with durations long enough to warrant use of the tethered UAV.*
    - *Regions spanning multiple Divisions required an extra layer of coordination to share the equipment between IMAP Supervisors.*

The use of a tethered UAV did provide benefit based on the assessments from the pilot project. Users of the tethered UAVs should be aware of any constraints with the systems, understand them, and accept them prior to using them as a solution. The following are suggestions to consider for deploying or having the tethered UAVs as a long-term tool.

1. Identify the initial problem to solve prior to assessing a solution to that problem
2. Identify an assessment with well-established and communicated use cases. This clarity helps determine the parameters and circumstances in which the device may be useful.
3. Identify who will use the device and *why* they will be using the device.
4. Ensure that the tools can withstand the conditions in which the user will need them and that the users possesses the required technologies to work with each tool. For example, if you need communication, verify there is a way to provide adequate communication in the areas where the user will apply the tool.

Emergency Vehicle Alert (EVA) Devices

The anticipated **benefits** of EVAs include:

- Increased motorist compliance with the Move Over law
- Improved safety for IMAP Responders
- Reduced secondary crashes through more accurate and timely traveler information

EVA Evaluation Method

EVA Types (What)

Emergency vehicle alert (EVA) devices are beacons integrated into a vehicle and allow for passive activations triggered by the vehicle status. Agencies install EVA devices on emergency vehicles, work zone equipment, and SSP vehicles and broadcast the vehicle location and preprogrammed messages when the vehicle in a "response" mode. This system broadcasts the message via multiple platforms including third party navigation and traveler information tools.

NCDOT identified three vendors based on industry research of the EVA market. The pilot project included the deployment of devices from iCone, Makeway, and HAAS.

TSO procured different device types from the three available vendors. TSO was able to procure seven devices directly from each vendor due to the individual cost of the equipment. This provided the pilot project with a total of 28 devices. The procurement included the device, a direct wire power and cable, and a 1-year data integration service subscription. This subscription service supports communication with the device and the vendor's dashboard. It also supports the ability to communicate the collected data to navigation applications, fleet manufacturers, fleet solutions, infrastructure, and road safety equipment. Three of the procured devices are truck mounted devices and the fourth is arrow board mounted.

Challenge: *Although the data / communication subscription package was free for the length of the pilot, NCDOT would need to purchase a subscription if it were to decide to continue to utilize the devices. Without the data subscription, the devices are unable provide the advance warning.*

Most of the iCone Panel devices were installed by iCone themselves while the truck mounted kits were installed through NCDOT Fleet Management, either at the statewide level or at the Division level. TSO shared vendor provided instruction guides to the Fleet Management groups to support the installation process.

Truck Mounted Kit Devices

The truck mounted devices include kits that hard wire the EVA directly to the IMAP's emergency lights. The device activates when the emergency lights are on. The three device types included:

- iCone 8700 (iCone beacon)
- Makeway – **Figure 7**
- HAAS 5000 (HAAS) – **Figure 8**

Figure 7. Makeway Device (per Installation Guide)

Figure 8. HAAS Device

Arrow Board Kit Device

The fourth device type included the iCone Arrow board 1000 (iCone panel). The iCone Panel is hard wired to the IMAP vehicle's arrow board. When IMAP activates the vehicle's arrow board, the system activates the iCone Panel.

EVA Test Locations (Where)

TSO distributed the EVAs across the state within each of the IMAP Regions. NCDOT includes 14 Divisions as shown in **Figure 3**. NCDOT manages the IMAP program at a regional level and some of those regions span multiple Divisions. **Figure 4** provides the IMAP Footprint.

- Division 3
- I-95 Corridor (Division 4, Division 6)
- Triangle Region (Division 5)
- Division 6
- Triad Region (Divisions 7 & 9)
- Metrolina Region (Divisions 10 & 12)
- Mountain Region (Divisions 13 & 14)

The objectives for assessing the EVA devices in multiple regions include:

1. Validation of performance consistency in multiple geographic locations.
2. Impacts to driver behavior.
3. Perceived safety benefits from the IMAP Responders on scene.

Challenge: *If the IMAP Responder was out of the office or didn't use their truck (maintenance) for a period, the device would deactivate. The IMAP Responder would need to reactivate the device once they were using the vehicle again. This period of time could be as little as 2 days.*

EVA Testers (Who)

NCDOT installed EVA devices on IMAP vehicles in six regions for the pilot project. **Table 5** includes the detailed distribution of each EVA device listed by Region. The number in '()' in the first column shows the number of available Responders at the time of distribution. NCDOT assigns each IMAP vehicle to a specific Responder, who became the user of the corresponding EVA device during the pilot project.

Table 5: EVA Type Per Division

	EVA Type

Division/ Region (# of drivers available)	iCone Arrow	HAAS	iCone Truck	Makeway
Division 3 (2)	1	1		
Triangle Region (5)	1	1	1	1
Division 6 (4)	1	1	1	1
Triad Region (16)	2	2	3	2
Metrolina Region (12)	1	1	1	1
Mountain Region (10)	2	1	1	1
Total (28 devices)	*(7)*	*(7)*	*(7)*	*(7)*

EVA Distribution (When)

TSO procured 28 devices to allocate between six Regions. This allowed for just over 50% of the IMAP Responders to receive a device and participate in the pilot project. The EVA devices required a two-week period for installation on the vehicles. The devices remained installed on the vehicles throughout the duration of the pilot project.

EVA Procedures (How)

IMAP responds to incidents either from identifying the incident during patrol or being dispatched by a TMC (refer to **Figure 4** for TMC locations). As the IMAP Responder approaches an incident, they activate the emergency lights on the IMAP vehicle. Once they arrive on scene, the IMAP Responder activates the arrow board. The emergency lights remain activated until the IMAP vehicle has left the scene and is back to free flow speed.

Based on the type of device installed on the IMAP vehicle, either the emergency lights or the arrow board activation trigged the EVA device. The system communicates the EVA status and location to the vendor dashboard. The system then pushes the real time data from the vendor dashboard to TIMS and the navigation providers (i.e., Waze, Google). The real time data includes the vehicle location and an automatic standard message shown below (based on the type of device installation).

> **Challenge**: *The latency between message transmission and Waze or Google broadcast of the message was up to three minutes.*

Truck Mounted Device Type Message: **Emergency Vehicle Ahead, Slow Down and Move Over**

Or

Arrow Board Device Type Message: **Emergency Vehicle Ahead, Slow Down and Move [DIRECTION]**

The system allows the user to customize the arrow messages based on the direction of the arrow displayed on the board. If the arrow board displays four dots in the corners (when the IMAP vehicle is on the shoulder), the message defaults to the Truck Mounted Device type message.

Figure 9 provides examples of the messages seen in Waze regardless of the EVA devices.

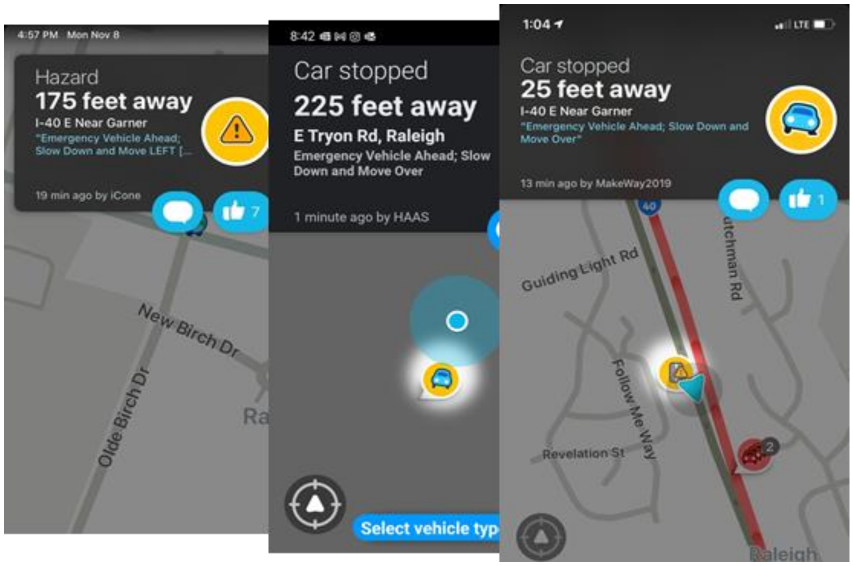

Figure 9. EVA Messages

The IMAP Responder turns off their emergency lights when they are leaving a scene, which deactivates the EVA device. The system updates the data collected by the vendor dashboard and subsequently, all messages to TIMS and clears the messages to the navigation companies. This is the same for EVA devices connected to the arrow board. The latency of the information updates is important as it reflect the real-world conditions. Motorists can easily lose trust in the overall information if this data is unreliable to frequently.

Challenge: *Inaccuracy of the IMAP vehicle location as displayed by the navigation companies – ranging from the correct spot location or direction.*

NCDOT worked with each of the vendors to obtain their application programming interface (API) to integrate it into the NCDOT Traveler Information Management System (TIMS). The TIMS data feeds the DriveNC traveler information website and thereby can reflect the EVA data once ingested by TIMS. NCDOT also created an internal dashboard to display IMAP vehicle locations to better support dispatching. The map only includes those IMAP Responder vehicles with the EVA devices installed.

Challenge: *EVA dashboard confidence based on inaccuracies and timeliness in the API information.*

EVA Findings

The team performed periodic checks on the EVA devices throughout the course of the project including inquiries with the IMAP Regions, downloads of the EVA device data, and spot checks when an IMAP Responder was on scene. The pilot project assessed the EVA devices based on four use cases as shown in **Figure 10**.

Notification given to approaching traffic with limited sight distance

Compliance with the Move Over Law

Accurate notifications within Work Zone Boundaries

Additional safety to Responders

Figure 10. EVA Use Cases

EVA Assessments

The research team conducted multiple interviews during the pilot project. These interviews captured input from the Regions regarding their experience with each of the EVA devices. The questions were based on eight metrics shown in **Table 6**. The interview asked the TIMS users and operators for feedback regarding the *Integration with Other Systems*, and TSO staff for feedback regarding the *Pricing* metric.

Table 6. EVA Evaluation Area

Evaluation Area	Description
Ease of Installation	*How easy was the device to install on the IMAP vehicles*
Latency Information (Dashboard/Waze)	*How quickly was the information resonating between the vehicle, the dashboard, and onto Waze for the public motorist to view*
Quality of the Data	*How accurate was the information*
Durability	*How well is the device holding up in its location*
Device Support	*How well did the vendor respond to questions or issues*
Applicability	*How applicable are the capabilities with respect to traffic incident management (TIM)*
Integration with Other Systems	*How well is the data able to integrate with TIMS and Waze*
Pricing	*Is the price reasonable for the solution*

The team assigned each metric a specific weighted value based on importance to the overall qualitative assessment of the EVA devices. **Table 7** presents the weights, which range from 1 (lowest importance) to 4 (most important).

Table 7. EVA Metric Weight

Evaluation Metric	Weight (1-4) (4 is most important)
EASE OF INSTALLATION	Somewhat Important (2)
DEVICE SUPPORT	Lowest Importance (1)
LATENCY TO DASHBOARD	Very Important (3)

Evaluation Metric	Weight (1-4) (4 is most important)
QUALITY OF DATA	Most Important (4)
DURABILITY	Somewhat Important (2)
APPLICABILITY TO THE USE CASES	Most Important (4)

Each metric presented different challenges for different regions. During the interviews, the Regions scored the six metrics on a scale of 1 (Strongly Disagree) to 4 (Strongly Agree). The team multiplied those scores by its corresponding weight. The *Integration with Other Systems* and *Pricing* metrics were determined during separate discussions. The integration and pricing metric did not include a weight, but users provided a response as 'Good,' 'Okay,' or 'Bad.'

- *Integration with Other Systems* metric was 'Okay.' NCDOT received the APIs from the three vendors and integrated the locations of the IMAP vehicles from the API into the EVA dashboard. The users experienced some inconsistencies with the information. The STOC operators had difficulty confirming the vehicle location from the EVA dashboard. It was hard to determine whether any of the issues experienced were due to the API, the device setup and configuration, or the polling rate by NCDOT.
    - Examples included: poor differentiation between on- and off-duty; lagging in the system, etc.
- *Pricing* metric was 'Good.' TSO subjectively thought the price was a *good* price. And all vendors waived the data subscription fee for the pilot. If NCDOT does consider moving forward with any of the vendors, the costs would include a data subscription-based fee added to the overall costs. **Table 8** include costs breakdowns.

Table 8. EVA Cost Breakdown

EVA Type	Number of Devices Purchased	Total Purchase Price Per EVA Type (*for the pilot project*)
Makeway	7	$ 4,697.00
iCone Work Truck	7	$ 3,850.00
iCone Arrowboard	7	$ 4,270.00
HAAS	7	$ 4,915.35
		$ 17,732.35 *(total costs)*

Each vendor had their own EVA vendor dashboard, which the team did not formally evaluate. However, the limited assigned users (e.g.., TSO, Divisions, operators) did provide informal feedback of the features. A couple of the dashboards emphasized the technology versus the accessibility of the data. It was difficult for users to always know how to identify the data needed due to inconsistencies of the presented data. Also, the vendor dashboards were challenging to navigate.

Table 9 details the average scores for each device based on feedback from the IMAP Regions. The higher score(s) indicated a more favorable opinion on that metric.

Table 9: EVA Matrix Summary

Summary Table	Devices			
Metrics	iCone Arrow (Panel)	Haas	iCone Truck (Beacon)	Makeway
EASE OF INSTALLATION	8.0	8.0	8.0	8.0
DEVICE SUPPORT	4.0	2.5	4.0	2.0
LATENCY TO DASHBOARD	7.5	8.0	8.0	8.0
QUALITY OF DATA	7.2	9.0	8.0	8.0
DURABILITY	6.8	7.6	7.5	6.0
APPLICABILITY TO THE USE CASES	10.4	6.0	9.0	7.0
Weighted Average	**43.9**	**41.1**	**44.5**	**39**

EVA Conclusion

Overall, the EVAs testing was inconclusive on identifying the full benefit of using these device types for the IMAP Program. Based on opinion feedback, the IMAP Responders did not feel the EVA devices accomplished what the pilot project was hoping to see – ***an increase in compliance with the Move Over law***. They did not perceive a noticeable impact on motorists' compliance.

One of the lessons learned from the pilot project was the need to better align the functionality of the devices with how IMAP operates. The technology for the EVA devices was dependent on consistent field procedures from the IMAP Responders. For example, IMAP Responders could leave arrow boards activated, but lowered, even though they have left the scene. This unchanged status in the arrow board created misinformation for the IMAP vehicle status.

Observations

The pilot project's anticipated performance was to influence driver behavior by providing reliable traveler information and encourage motorists to move away from responders in a lane or on the shoulder. However, there is an uncertainty whether the EVA devices positively impacted driver behavior. Additional high-level performance observations encountered during the pilot project included the following.

- **Delay to Waze** – *The transmission time for messages from the AVEA devices to Waze experienced latency that was higher than expected. NCDOT, along with the Eastern Transportation Coalition, worked with Waze to try and decrease this delay; however, the assessment did not observe any measurable improvements during the pilot project.*
- **Standardizing Messages for Motorists** – *NCDOT wanted a standard message independent of the device type. The vendors were eventually able to standardize the messages with some coordination effort and multiple iterations.*
- **Inaccurate Location & Direction** – *Waze would not always show the IMAP Responder in the correct location or in the correct direction of travel. This inconsistency included showing the IMAP Responder in the eastbound direction when they were in the westbound lane, or their location shown on service roads versus the correct location on the freeway. It was hard to determine if the inaccuracies were due to the device or the integration between the vendor's API*

and the navigation companies. It is important to note that majority of these data inaccuracies occurred within active work zones.

- **Installation Instructions** – *Although the installation of these devices was not overly complicated, the instructions provided to the Fleet Management garages were inconsistent or difficult to follow. Fleet Management had several installation questions for these new device types, which delayed the initial installation. Latter installations were more efficient.*
- **Driver Concern** – *The IMAP Responders had concerns about the EVAs tracking their vehicle location and performance. As a result, the team had concerns about users disabling the EVA devices. The EVA devices captured vehicle speed while patrolling or responding to an incident. IMAP Responders must abide by the posted traffic speeds, and Responders may have considered this information intrusive to their basic daily routing by some drivers.*
- **Inconsistent Operations** – *The EVA devices would trigger when the arrow board posted a directional arrow or four corners (on the shoulder designation). However, some IMAP Responders only lower their arrow board keeping them active versus turning them off when they leave a scene. This is counter to how NCDOT trains the IMAP Responders.*
- **No Change in the Move Over Law Compliance** – *The IMAP Responders did not perceive a change in motorists' behavior based on active and accurate Waze notifications.*

Suggestions in consideration for use EVA of devices as a long-term tool.

1. Identify the initial problem (or goals) to solve prior to assessing a solution to that problem.
2. Ensure the team communicates the use cases effectively to the users, including the relative importance and timeframe. This clarity will help bridge the *why* and *when* the NCDOT wishes to use the devices.
3. Perform a risk assessment and either mitigate or accept the identified risks prior to deploying the devices. Major risks are data inaccuracy or data latency, and the users need to accept these risks as part of the use or implement additional tools to mitigate those risks.

Summary

NCDOT's goals for testing innovative technology through the SSP Technology Pilot project was to determine how well these technologies can:

1. Improve *situational awareness*, especially in areas that do not have camera coverage
2. Improve *mobility*, to provide traveler information to motorists of real time traffic conditions
3. Improve the *safety of motorists and responders*, to make motorists aware of responders in the area and encourage them to move over

Goal 1: Improve Situational Awareness

The **tethered UAVs** were able to provide some additional scene awareness when the IMAP Supervisor arrived on scene to support. This was especially evident in areas with limited camera coverage. Goal Met

The **EVA devices** were able to inform motorists through navigation applications that someone (*or something*) was upstream of their location. Although there were some accuracy and timeliness challenges, it was hard to determine whether this was based on the device or the navigation company. Goal Partially Met

Goal 2: Improve Mobility (traveler information to motorists)

The **tethered UAVs** provided direct video feed back to the STOC so they in turn were able to provide the appropriate traveler information to motorists – either on DriveNC or on dynamic message boards (DMS). The tethered UAVs also supported the partnership between internal NCDOT groups and on scene partners (per the ability to share the video stream). The prime example was IMAP, TMC, and signal timing group working together to move motorists around a scene, improving mobility. Goal Met.

The information shared from the **EVA devices** informed motorists an emergency responder was ahead and to slow down but only one of the device types provided a direction to move aiding the motorist. Goal Partially Met

Goal 3: Improve the Safety of Motorists and Responders

Like Goal 2, when the **tethered UAVs** provided direct video feed back to the STOC, the operators at the STOC or regional TMC can post the most appropriate message on the DMS for motorists. They are aware of the situation on scene and in the back of queue to message to motorists to move over. This improves the safety of the first responders on scene while slowing traffic down to try and prevent secondary crashes. Goal Met

Similarly, the **EVA devices** warned motorists an emergency responder was ahead and to slow down. However, based on this study it was hard to measure whether motorists complied with the warning provided since the study could not verify how many people received the warning. The perspective from the IMAP Responders was no change in motorist's behavior; so, they did not feel any safer having the EVA devices on their vehicles. Goal Unconfirmed

Recommendations

The SSP Technology Pilot Project provided TSO an opportunity to assess the viability of two technology innovations. This pilot project included a small-scale implementation within the IMAP program to pilot each of the innovations and their approach prior to spending substantial resources and/or funding.

The overall goal of the project was to assess whether these technologies can improve NCDOT's service, which would then provide insight for a potentially larger investment. While both technology applications showed some benefit to the TIM program, tethered UAVs proved to be more beneficial than the EVA devices. Although the warning to motorists is beneficial, there were challenges in the interface between the devices and the communication platform for motorists that hindered what benefit the EVA devices could provide. Below includes recommendations for next steps.

1. **Purchase additional tethered UAVs** – *expand the use of tethered UAVs beyond IMAP for use by the Division. Preference towards the Fotokite due to the Mavic2 System limitations in weather operations; tethered UAVs could provide additional benefit outside the traffic control awareness, specifically in rural areas.*
2. **Monitor technological advances** – *this could include improvements in next generation tethered UAV and improved EVA devices. Newer models have the capability of mounting directly to the vehicle. This could minimize the time needed for launching at a site.*
3. **Reevaluate the EVA devices as technology improves** – *the pilot did not find advantages of using the devices for the IMAP program currently. But as technology changes, these devices should improve and be reevaluated within the IMAP program.*

Appendix A – Checklists and Instruction Reference

Fotokite Flight Checklist

Controller in Command: **Date:**

Observer (optional): **Location:**

Fotokite Number:

Purpose of Flight (check 1): □ **Incident Management** □ **Queue Management** □ **Other (Describe)**

Time Launched:
Time Landed:

Checklist

Important: Complete all check list items in the order they are presented. If you cannot check off an item **STOP!** And correct the problem before continuing.

No.	Item	Acceptable Conditions	Good
Pre-Flight			
1	Weather	Visibility >3 miles; Winds <35 MPH	
		No Thunderstorms	
2	Airspace	Maximum height (150’) for area (Aloft) Note height restriction if there is one: ______________	
3	Airspace	Potential obstructions near intended flight path identified (15’ from trees or powerlines). Note obstructions: _______________	
4	Communication	No Life Flights in the area	
5	Fotokite Airframe/Props	No structural defects visible	
6	Fotokite Power	Yellow extension cord is properly plugged into Fotokite box	
7	Tablet Battery	Tablet battery sufficient for intended flight, not less than 75%	
8	Lights	All green lights are showing on Fotokite	
9	Power and Connection	Wi-Fi Connection is good	
		Follow Flight Instructions (on back)	
During-Flight			
10	Display	Display shows the camera image	
11	Display Height	Height of flight is properly set	
12	Fotokite Flight	Check area for hazards again/stay within 20’ of the base	
Post-Flight			
13	Fotokite Power	Fotokite unplugged and stored (with yellow cord) in truck	
14	Tablet Power	Tablet plugged in to charge (when finished)	

Additional Items

No.	Item	Reminders	
1	Video Feed	DO NOT RECORD VIDEO	
2	Drone/Tablet	Do not leave drone or tablet unattended	
3	Position	Avoid placing on hill or moving base while in flight	
4	PTZ View	Adjust camera view by tapping or zooming on controller screen	
5	Conditions	Drone needs to be grounded during Life Flights	
6	Weather	Properly clean and dry if flown in adverse weather	
7	Tablet	Wipe off tablet is wet or dirty	

8	Tablet	Perform any system updates when available	
9	Test Flight	Conduct monthly tests of the Fotokite if no flights	
When the flight is complete, finish the form and submit to Supervisor			
Notes:			

Fotokite Flight Instructions

No.	Steps
1	Arrive on scene and position truck in safe area to launch Fotokite
2	Communicate with on-scene incident command to confirm drone launch
3	Check Aloft application on mobile device to confirm maximum flight height in area
4	Remove Fotokite from truck and place on level ground at least 15’ from trees or powerlines
5	Place safety cones around Fotokite
6	Plug Fotokite yellow power cord into the Fotokite box and truck power source
7	Take off Fotokite lid and place to the side
8	Confirm all green lights appear on Fotokite
9	Turn on tablet and open Fotokite Live Application
10	Turn on MiFi Hotspot
11	Connect tablet Wi-Fi to the drone by selecting the Wi-Fi button in the top left corner of the screen
12	Connect tablet Wi-Fi to Mi-Fi Hotspot by selecting Menu – Ground Station – Scroll to NCDOT_ITS_1 Upstream – Press Connect – Press Connect
13	Alert nearby people that launch is occurring
14	Press START (Initial height will be 3’)
15	Set drone height to desired launch height using the slider on the main screen under SET MAX HEIGHT
16	Lock height by pressing the Lock button above SET MAX HEIGHT
17	Pan and tilt camera to desired view by double tapping on the screen to center the image on the selected point
18	Press START LIVESTREAM
19	Send email/Radio Livestream Code # or screenshot QR Code to the **STOC**
20	Press Livestream if you need to access the Livestream Code again
21	Visually observe the drone during flight and do not leave drone or tablet unattended
22	Press LAND to ground the drone after incident resolves
23	Turn wings inward
24	Place lid back on Fotokite and buckle the latches
25	Unplug yellow power cord from Fotokite box and truck power source
26	Place kit back inside the truck
27	Turn off the tablet and plug in to charge
28	Return Fotokite back to the office and submit Flight Checklist
No.	**Disengaging Video Feed**
1	Press LAND to ground the drone
2	Wait 30 seconds and press START (relaunching drone)
3	Provide new code to TMC via radio
Count	**Fotokite Inventory**
1	Blue box with Fotokite drone
2	Yellow power cords
1	MiFi Hotspot
1	MiFi Hotspot charging cord
1	Tablet
1	Tablet charging cord

Fotokite Flight Instructions

No.	Steps
1	Fotokite User Manual (binder)

**TO_UAS email group will receive video once the code is shared (from the STOC)

Mavic2 Flight Checklist

Controller in Command:			**Date:**
Observer:		**Location**	
Mavic2 Number:			
Purpose of Flight (check 1): □ **Incident Management** □ **Queue Management** □ **Other (**Describe**)**			
Time Launched: **Time Landed:**			
Checklist **Important:** Complete all check list items in the order they are presented. If you cannot check off an item **STOP!** And correct the problem before continuing.			
No.	**Item**	**Acceptable Conditions**	**Good**
Pre-Flight			
1	Weather	Visibility >3 miles; Winds <35 MPH Do not fly in rain	
2	Airspace	Maximum height (150’) for area (Aloft) Note height restriction if there is one: ______________	
3	Airspace	Potential obstructions near intended flight path identified (15’ from trees or powerlines). Note obstructions: _______________	
4	Communication	No Life Flights in the area	
5	Mavic2 Airframe/Props	No structural defects visible	
6	Mavic2 Power	Black extension cord is properly plugged into Mavic2 base	
7	Battery (iPad & Controller)	iPad and controller battery sufficient for intended flight, not less than 75%	
8	Lights	Green lights are showing on front of Mavic 2	
9	Power and Connection	iPad cellular data connection is good	
Follow Flight Instructions (on back)			
During-Flight			
10	Display	Display shows the camera image	
11	Mavic2 Height	Height of flight is manually set	
12	Mavic2 Flight	Check area for hazards again/stay within 20’ of the base	
Post-Flight			
13	Mavic2 Power	Mavic2 unplugged and stored in truck	
14	Power (iPad, Controller, & Drone Batteries)	iPad, controller, and drone batteries plugged in to charge (when finished)	
Additional Items			
No.	**Item**	**Reminders**	
1	Drone	DO NOT FLY DRONE WITHOUT TETHER	
2	Drone/Tablet	Do not leave drone or iPad/controller unattended	
3	Position	Avoid placing on hill or moving base while in flight	
4	Conditions	Drone needs to be grounded during Life Flights	
5	Weather	Properly clean and dry if flown in adverse weather	

6	Test Flight	Conduct monthly tests of the Mavic2 if no flights	
When the flight is complete, finish the form and submit to Supervisor			
Notes:			

Mavic2 Flight Instructions

No.	Steps
1	Arrive on scene and position truck in safe area to launch Mavic2
2	Communicate with on-scene incident command to confirm drone launch
3	Check Aloft application on mobile device to confirm maximum flight height in area or no-fly zone
4	Remove Mavic2 from truck and place on level ground at least 15’ from trees or powerlines
5	Place safety cones around Mavic2
6	Take off Mavic2 lid and place to the side
7	Plug Mavic2 black power cord into the Mavic2 box and truck power source
8	Insert the 6 TB47s/TB48s (drone batteries) into battery compartments
9	Turn on all TB47s/TB48s (ensure all switches are at OFF position) by pushing once and then pressing down until lights start flashing
10	Remove Mavic2 drone and controller from case
11	Attach front two wings (Match white to white and black to black).
12	Attach carabiner onto V-Hook on drone
13	Turn on drone battery (green light will appear)
14	Insert Tethered Power connector securely into the Power Module
15	Turn on Reel System Switch
16	Turn on Drone remote controller and iPad
17	Turn on Power Module (check for video feed)
18	Turn on Tethered Power Switch
19	Confirm all green lights appear on Mavic2
20	Open DGI Pilot Application and login to Teams Application
21	Alert nearby people that launch is occurring
22	Hold down the right and left sticks at the same time to start wings
23	Adjust left stick-on controller up to desired height
24	Use the left scroll to tilt and right scroll to zoom
25	Open the Teams Channel, share screen, and broadcast the camera feed
26	Visually observe the drone during flight and do not leave drone or tablet unattended
27	Press green light on Mavic2 to turn off drone
28	Manually land the drone back on the drone base after incident resolves
29	Turn off Tethered Power Switch
30	Turn off Power Module
31	Turn off Drone remote controller and plug into truck power source to charge
32	Turn off Reel System
33	Turn off all TB47s/TB48s (batteries)
34	Remove Tethered Power connector from Power Module
35	Remove carabiner from V-Hook on Mavic2
36	Remove front two wings and turn arms inward
37	Place V-Line AC Power Adapter, cord, and controller in larger black case with Velcro secured
38	Place Mavic2 drone in smaller black case
39	Place lid back on Mavic2 and buckle the latches

Mavic2 Flight Instructions

No.	Steps
33	Place all cases back inside the truck
34	Turn off the iPad and plug into truck power source to charge
35	Return Mavic2 back to the office and submit Flight Checklist

Appendix B – Evaluation Forms

Mavic2 System Evaluation – Triad Region

Tethered UAV Rating: 4 Strongly Agree; 3 Agree; 2 Disagree; 1 Strongly Disagree			
Mavic2 Drone Evaluation		*Evaluator:*	Jeffery Mosley
		Region:	Triad Div. 7 & 9 — *Date* 1/17/2023
Metrics	Description	Rating	Notes
Ease of Installation	Was the IMAP truck set-up simple and fast?	4	Installation is very clear and efficient. However, lifting / carrying the Drone is a bit demanding due to the weight and depending on the distance from the vehicle to set up.
Reliability	Was there network access to the dashboard?	4	One item to note with the Tablet is the ability to communicate while in the field. Headphones and a microphone may help eliminate back-ground noise and improve the audio.
Device Support	Was technical support available when needed?	4	
Ease of Use	Was the flight checklist and instructions helpful before, during, and after flight?		
Set-Up		4	
In-Use		4	
Pack-Up		4	
Battery Life	Was there drone and controller battery availability during flight?	3	
Durability	Did weather or any external factors impact device performance?	3	The key is "acceptable" weather. There were several times the drone was not deployed due to unacceptable weather i.e., wind and rain.
Value Added	Did the drone provide value during incident response?		
Scenarios *Compare against form to inquire what "other" entails*	What types of scenarios should be considered to deploy the drone?	N/A	The drone has proven to be very beneficial and is a great asset to our operations. Not only has IMAP benefited from it but other departments and partners have expressed an interest. The ability to transmit live situations and events has provided the greatest value. Scenarios; Overturned Tanker, Fatality, identifying locations for future cameras, Communicating with dispatchers, etc.

Fotokite Evaluation – Triangle Region

Tethered UAV Rating: 4 Strongly Agree; 3 Agree; 2 Disagree; 1 Strongly Disagree			
Fotokite Tethered UAV Evaluation		*Evaluator:*	James, Dom, Steve, Amanda, Jeff, Sarah
		Region:	D6 — *Date* 5/2/2022
Metrics	Description	Rating	Notes
Ease of Installation	Installation process for the IMAP truck was clear and efficient.	3	
Reliability	The Tablet was able to connect consistently and support Tethered UAV operations.	4	Division 6 was using AT&T; should have access to First Access (first responder) MiFi; may want to confirm the MiFi
Device Support	Technical support was available when needed.	2	Need to identify internal TIM Team support and provide contacts to the Division users (need access to individuals who are more tech savvy and more familiar with equipment).
Ease of Use	The flight checklist and instructions were helpful in supporting Tethered UAV operations.		Able to easily provide (via radio communications) either QR code or access code to the TMC/STOC.
Set-Up		4	
During Flight		4	
Pack-Up		4	
Battery Life	The battery life for the Tethered UAV, tablet, or other accessories was reliable during operations.	4	
Durability	Tethered UAV performed consistently during acceptable weather conditions.	4	The Tethered UAV would drop altitude to accommodate any wind or rain in the vicinity.
Value Added	The expected impact was recognized during the use of the Tethered UAV.	4	Value added in more than one instance
Scenarios *Compare against form to inquire what "other" entails*	Identify scenarios that provided the greatest value when using the Tethered UAV.	N/A	Signal Timing – used during incident management Bridge Inspection – conducting remote assessments Traffic Counts (for signals) – record and count later, video analytics Maintenance – Inspection for property damage (from a crash)

Appendix C – Project Budget

EVA Type	#s Purchased	Total $ Per EVA Type
Makeway	7	$4,697.00
iCone Work Truck	7	$3,850.00
iCone Arrowboard	7	$4,270.00
HAAS	7	$4,915.35
	Sub Total EVAs	**$17,732.35**

UAV Type	#s Purchased	Total $ Per UAV Type
Mavic2 w/ V-Line Tether (Low Bid)	1	$18,853.80
Fotokite	1	$23,500.00
	Sub-Total UAVs	**$42,353.80**

Total EVAs/UAVs	**$60,086.15**
Total Labor + Other	**$37,615.35**
Total Project Costs	**$97,701.50**

Total STIC Grant	**$50,000.00**
Total Statewide Funding	**$47,701.50**