Unmanned Aircraft Systems

FOR TRAFFIC INCIDENT MANAGEMENT

U.S. Department of Transportation

Federal Highway Administration

FOREWORD

The Federal Highway Administration's (FHWA) Office of Operations has actively engaged in the national deployment of Traffic Incident Management (TIM) programs since the office was deployed. Unmanned Aircraft Systems (UAS) are increasingly being used by public agencies for a variety of purposes. Public agencies are developing sections to coordinate UAS use. Several Law Enforcement agencies have been using UAS for crash investigation and re-construction that is showing significant potential. This Primer describes how unmanned aircraft systems can benefit traffic crash investigations and other traffic incident management-related activities.

Cover and Back Photo Sources:
Incident with Unmanned Aerial Vehicle: Enforcement Engineering, Inc., and Felix Mizioznikov/shutterstock.com
Unmanned Aerial Vehicle: Adobe Stock photo

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-HOP-20-063		

4. Title and Subtitle	5. Report Date
Unmanned Aircraft Systems for Traffic Incident Management	February 2022
	6. Performing Organization Code
7. Author(s) Grady Carrick (Enforcement Engineering Inc.), Lisa Burgess (Kimley Horn and Associates)	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Under contract to: Cambridge Systematics, Inc. 101 Station Landing, Suite 410 Medford, MA 02155	**10. Work Unit No. (TRAIS)**
	11. Contract or Grant No. DTFH61-16-D-00051/ 693JJ319F000293
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Operations 1200 New Jersey Avenue, SE Washington, DC 20590	**13. Type of Report and Period Covered** Final
	14. Sponsoring Agency Code HOP

15. Supplementary Notes

16. Abstract

The Federal Highway Administration's (FHWA) Office of Operations has actively engaged in the national deployment of Traffic Incident Management (TIM) programs since the office was deployed. Public agencies are increasingly using Unmanned Aircraft Systems (UAS) for a variety of purposes and are developing sections to coordinate UAS use. Several Law Enforcement agencies have been using UAS for crash investigation and re-construction that is showing significant potential. The Primer describes how unmanned aircraft systems (UAS) can benefit traffic crash investigations and other traffic incident management-related activities. Presentation of legal considerations, operation, crash investigation applications, and implementation guidance are included, as well as the benefits of UAS with examples from States.

17. Key Words	18. Distribution Statement
unmanned aircraft systems (UAS), traffic, crash investigation, traffic incident management, policy, procedure, funding, evaluation	No restrictions.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	38	N/A

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Table of Contents

List of Figures

List of Acronyms

2D	Two Dimensional
3D	Three Dimensional
ACLU	American Civil Liberties Union
APD	Austin, TX Police Department
CFR	Code of Federal Regulations
COA	Certificate of Authorization
ConOps	Concept of Operations
DUI	Driving Under the Influence
FAA	Federal Aviation Administration
FHP	Florida Highway Patrol
FHWA	Federal Highway Administration
IACP	International Association of Chiefs of Police
IP	Internet Protocol
Laser	Light Amplification by Stimulated Emission of Radiation
NCDOT	North Carolina Department of Transportation
NCSHP	North Carolina State Highway Patrol
NCSL	National Conference of State Legislatures
NIJ	National Institute of Justice
OVPD	Oro Valley Police Department
PAO	Public Aircraft Operator
TIM	Traffic Incident Management
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
WSP	Washington State Patrol

Chapter 1. Introduction

Traffic crashes are a common occurrence on the Nation's roadways and they adversely impact lives, time, and money. In 2018, there were over 6.5 million crashes reported by U.S. police agencies, resulting in 2,710,000 injuries and 36,560 fatalities.[1] Crashes are a problem for those involved and for those impacted by incident-related congestion. Crashes are responsible for travel time delays, contributing to the congestion that averages 97 hours and $1,348 per driver annually.[2] Serious and fatal traffic crashes present additional challenges, because investigations require detailed measurements that often close roadways for extended periods.

Traffic Incident Management (TIM) seeks to mitigate the impact of roadway incidents by promoting a shared sense of responsibility among incident responders, a unified approach to on-scene activities, and a sense of urgency to clear travel lanes. Crash investigation technology is proven to clear roadways more quickly and save lives, time, and money.

Unmanned aircraft systems (UAS) are a technology that has proven effective in reducing the amount of time needed to document fatal crash scenes. A study by the National Institute of Justice (NIJ) found that UAS were one hour faster than a robotic total station and two hours faster than a manual total station in a controlled comparison.[3] North Carolina Department of Transportation credited a field comparison UAS with more than 300 percent time savings over three-dimensional (3D) Light Amplification by Stimulated Emission of Radiation (Laser) mapping.[4] In more than 125 actual crash investigations, the Washington State Patrol estimates an 80 percent reduction in road closure at serious crashes because of the implementation of UAS for scene mapping.[5]

UAS holds great promise for TIM applications, improving safety, relieving congestion, and reducing the economic impacts of roadway incidents. This primer describes how UAS can

---

[1] NHTSA. Traffic Safety Facts: Police Reported Motor Vehicle Traffic Crashes in 2018. Department of Transportation HS 812 860. November 2019.

[2] Reed, T., & Kidd, T. (2019). INRIX Global Traffic Scorecard. Kirkland, WA: INRIX Research.

[3] National Institute of Justice (NIJ). Operational Evaluation of Unmanned Aircraft Systems for Crash Scene Reconstruction: Operational Evaluation Report. AOS-17-0078. January 2017. https://www.ncjrs.gov/pdffiles1/nij/grants/251628.pdf.

[4] NCDOT. Collisions Scene Reconstruction & Investigation Using Unmanned Aircraft Systems. August 2017. https://www.ncdot.gov/divisions/aviation/Documents/ncshp-uas-mapping-study.pdf.

[5] Durbin, R. Washington State Patrol Unmanned Aerial Vehicle (UAV) Program Overview. Agency PowerPoint Presentation. 2020.

benefit traffic crash investigations and other TIM-related activities by providing a general overview, benefits, and implementation guidance.

Unmanned Aircraft Systems Described

While there are over 18,000 police agencies in the U.S., less than 200 have manned aviation capabilities.[6] According to the Center for the Study of the Drone at Bard College, the number of drones used for public safety has increased steadily over the past several years. Their Public Safety Drones report counts 1,578 public safety agencies using drones, with law enforcement comprising 70 percent of those agencies (1,103).[7] Figure 1 shows the number of police agencies throughout the country that are actively using UAS.

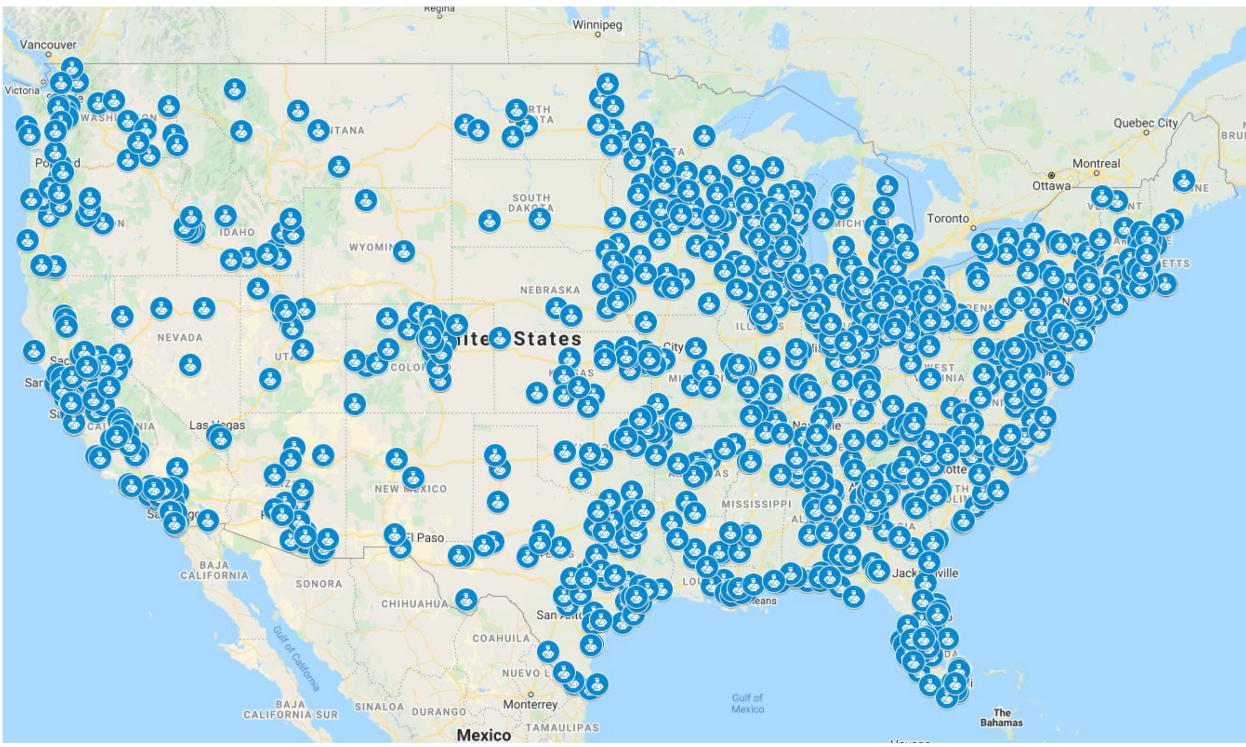

Figure 1. Map. U.S. police agencies using unmanned aircraft systems (does not include Alaska (3 agencies) and Hawaii (2 agencies)).

(Source: Bard College.)

---

[6] Police Foundation. Why law enforcement is using UAS for public safety. https://www.policefoundation.org.

[7] Gettinger, Dan. Public Safety Drones, 3rd Edition. https://dronecenter.bard.edu/files/2020/03/CSD-Public-Safety-Drones-3rd-Edition-Web.pdf March 2020.

A new era of unmanned flight operations is rapidly becoming a part of the law enforcement toolkit. Sometimes referred to as “unmanned aerial systems,” UAS encompasses the hardware and software components required for flight of an unmanned aerial vehicle (UAV), commonly referred to as a “drone.” Unmanned systems are well-suited for many tasks, and the cost to operate is a fraction of manned air operations. Small UAVs are those weighing less than 55 pounds and typically used for law enforcement applications.

Small UAVs are remotely controlled by a pilot. The battery-operated aircraft can be easily flown over a traffic crash scene to capture images using high-definition digital cameras. During pre-flight setup, software enables the pilot to establish the perimeter of the area to be flown and the pattern that will be used. Once airborne, the UAV automatically flies a pattern over the defined area taking scores of pictures that are later “stitched” together using computer software.

The Federal Aviation Administration (FAA) regulates operation of UAS in the United States, including recreational, commercial, and governmental use. For information, please see https://www.faa.gov/uas/.

Operating Environment for Unmanned Aircraft Systems

UAS operators in both the public and private sectors must adhere to statutory and regulatory requirements. Public aircraft operations (including UAS operations) are governed under the statutory requirements for public aircraft established in 49 USC § 40102 and § 40125. Additionally, both public and civil UAS operators may operate under the regulations promulgated by the FAA. The provisions of 14 Code of Federal Regulations (CFR) part 107 apply to most operations of UAS weighing less than 55 pounds. Operators of UAS weighing greater than 55 pounds may request exemptions to the airworthiness requirements of 14 CFR part 91 pursuant to 49 USC §44807. UAS operators should also be aware of the requirements of the airspace in which they wish to fly. The FAA provides extensive resources and information to help guide UAS operators in determining which laws, rules, and regulations apply to a particular UAS operation. For more information, please see https://www.faa.gov/uas/. Figure 2 is an example of the FAA Part 107 license.

Figure 2. Photo. A sample Federal Aviation Administration Part 107 remote pilot certificate.

(Source: Federal Aviation Administration.)

Certificate of Authorization and 107 Waiver

If the FAA determines that the UAS can be operated safely under specific conditions, a waiver can be obtained, known as a certificate of authorization (COA), that allows the law enforcement agency to fly UAS under conditions that would otherwise be exempted by law.[8] Most commonly, law enforcement agencies look to use the COA to fly in additional airspaces that may be limited by law, as well as at night.

The COA can also designate the agency as a “public aircraft operator” (PAO), which authorizes them to certify their own equipment and pilots.[9] Many law enforcement agencies opt to do both Remote Pilot certification and COA to authorize exemption to specific restrictions.

---

[8] FAA. COA. Federal Aviation Administration, April 25, 2019. https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/aaim/organizations/uas/coa/.

[9] FAA. Drones in Public Safety: A Guide to Starting Operations. Federal Aviation Administration, February 2019. https://www.faa.gov/uas/public_safety_gov/media/Law_Enforcement_Drone_Programs_Brochure.pdf.

State Laws for Law Enforcement Agencies

According to the National Conference of State Legislatures (NCSL), since 2013 44 States have adopted some type of UAV law and three more have resolutions.[10] Some States have both legal restrictions and legal exemptions for governmental use of UAS.

While there are many States that restrict the use of UAS by law enforcement, there are others that specifically allow the use of the technology for traffic crash investigation.

[10] NCSL. Current Unmanned Aircraft State Law Landscape. https://www.ncsl.org/research/transportation/current-unmanned-aircraft-state-law-landscape.aspx. Accessed April 4, 2020.

Chapter 2. Unmanned Aircraft Systems for Traffic Incident Management

Quick Clearance Strategy

The typical traffic incident management begins with arrival on-scene and management of critical first actions, like assessing injuries, implementing Traffic Incident Management (TIM) procedures, and seeking assistance from and coordinating with other response agencies. Documenting the characteristics of roadway incidents is an important part of clearing events from the roadway and subsequently clearing the scene.

While reliable and inexpensive, manual data collection techniques are increasingly giving way to technology that can accomplish the task with greater speed. Close range photogrammetry, Total Station, and three-dimensional (3D) Light Amplification by Stimulated Emission of Radiation (Laser) Mapping are key technologies that are moving the needle in crash scene mapping.

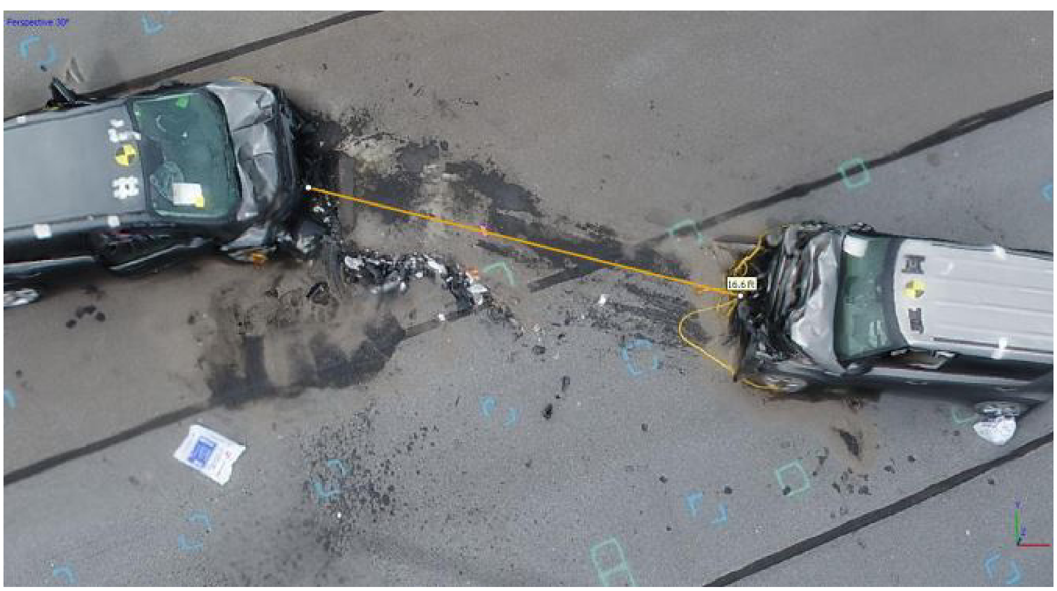

Figure 3. Photo. Example of measurements from photographs.
(Source. North Carolina Department of Transportation.)

While technology has advanced traffic crash investigation and reconstruction significantly, the emergence of unmanned aircraft systems (UAS) promises to provide another significant leap forward. Combining the well-established science of photogrammetry with aerial photography a new era of traffic crash measurement and scene documentation is taking place. Studies have demonstrated that the ability to obtain centimeter (cm) accuracy in measurements is possible with UAS.[11,12] More importantly, the use of UAS has shown significant time savings, enabling responders to clear the roadway and the scene much faster than before. Finally, the price point for entry into UAS may allow agencies to have multiple units in the field, eliminating the need to retrieve more expensive technology from a storage location or the need to respond to another officer in possession of a 3D scanner or Total Station.

Unmanned Aircraft Systems for Other Traffic Incident Management-Related Purposes

The time saving advantage of using UAS for traffic crash mapping and modeling is easily understood compared to other technologies. The potential of the technology for other TIM-related purposes is less understood. Like many new tools, experimentation will likely unleash the creativity of people to solve problems in new ways. One can envision a few places where UAS might help with TIM. The following activities might be augmented by UAS:

- Situational Awareness.
- Detour Route Monitoring.
- Incident Verification.
- Queue Detection and Monitoring.
- Secondary Crash Detection.

The Texas A&M Transportation Institute reviewed a number of UAS-TIM functions to demonstrate the potential for UAS to accomplish these functions.[13] The research team established that UAS was capable of incident verification and monitoring traffic incidents, alternate routes, and queuing.

The Florida Highway Patrol (FHP) can securely access a live video feed from an unmanned aerial vehicle (UAV) available to any authorized user via Internet Protocol (IP) address. The

---

[11] Jurkofsky, D., "Accuracy of SUAS Photogrammetry for Use in Accident Scene Diagramming," SAE Int. J. Trans. Safety, 3(2):2015, doi:10.4271/2015-01-1426.

[12] Bullock, John L, Robert Hainje, Ayman Habib, Deborah Horton, and Darcy M. Bullock. “Public Safety Implementation of Unmanned Aircraft Systems for Photogrammetric Mapping of Crash Scenes.” Transportation Research Record: Journal of the Transportation Research Board. 2673.7 (2019): 567-574. Print.

[13] Stevens, C., T. Blackstock. Demonstration of Unmanned Aircraft Systems Use for Traffic Incident Management (UAS-TIM). Texas A&M Transportation Institute. PRC 17-69F. December 2017.

agency recently provided the State Emergency Operations Center with images of traffic congestion at a South Florida health testing facility. These are shown in figure 4.

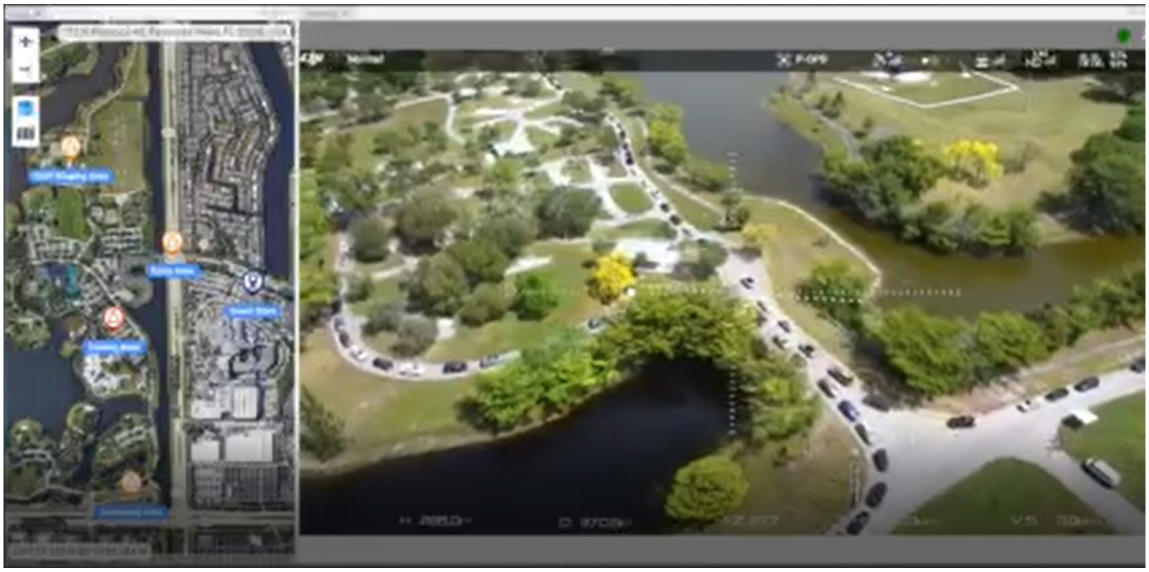

Figure 4. Screenshot. Florida Highway Patrol unmanned aerial vehicle live feed images.
(Source: Florida Highway Patrol.)

The North Carolina State Highway Patrol provided video images and photographs of roadway flooding during 2018 tropical storm and hurricane events. Following Hurricane Michael, the FHP flew similar missions to detect queues on Interstate 10. Examples of these images are shown in figure 5.

Figure 5. Photo. Emergency applications for unmanned aircraft systems.
(Source: Federal Highway Administration and Florida Highway Patrol.)

The towing and recovery industry is an important part of traffic incident management and they are beginning to use UAS for complex recovery operations at roadway incidents. There is also an opportunity for towing and recovery to use UAS to review incident scenes before they respond, ensuring that they understand the situation and bring the appropriate equipment.[14] Sample images from a tow operator in Florida are shown in figure 6.

Figure 6. Photo. Roadway images to support tow operator assessment.
(Source: Superior Towing, Davie, Florida.)

Planned special events are another application of UAS, particularly as it relates to the movement of people and vehicles. In Daytona Beach, the Police Department has acquired four UAS specifically for use in planned special events like the Daytona 500 race and “Bike Week.”[15]

The National TIM Responder Training Program advances the state of the practice nationally for TIM. Through mid-2020, almost 500,000 U.S. responders had been trained in one of the several delivery mechanisms for the program. The Puerto Rico Police Academy used UAS as part of their TIM training to bring a different perspective to their TIM training practicum that was held on a closed parking lot with actual response vehicles. With UAS, trainers were able to conduct live training and then bring an aerial view back into the classroom for discussion. Figure 7 is an image from the Puerto Rico TIM training.’

[14] Brown, Shelby. Drones could help during your next car breakdown. c/net. September 2019. https://www.cnet.com/news/drones-could-help-during-your-next-car-breakdown/.

[15] Griffin, N. Daytona Beach Police to use Drones During Daytona 500. Spectrum News 13. February 2019. https://www.mynews13.com/fl/orlando/news/2019/02/08/daytona-beach-police-to-use-drones-during-daytona-500.

Figure 7. Photo. Puerto Rico Traffic Incident Management training practicum with Unmanned Aircraft System.

(Source: Puerto Rico Police Academy.)

Chapter 3. Benefits of Unmanned Aircraft Systems for Traffic Incident Management

The following list represents some of the benefits of Unmanned Aircraft Systems (UAS):

- Easy to Use.
- Provides Aerial Views of The Scene.
- Shorter Road/Lane Closures.
- Less Time on Scene.
- Less Time in Roadway.
- Lower Cost Aerial Images vs. Manned Aircraft.
- Lower Cost of Investigative Man Hours.
- Fewer Errors Transposing Manual Measurements.
- Faster Crash Investigations.
- Safety of Incident Responders.
- Reduced Likelihood of Secondary Crashes.
- Saves Time Required for Data Collection.
- Provides Immediate Viewing of Images.
    - Ability to live stream images to another location.
    - Fewer Impacts on Commerce.
    - Cost Effective Measuring and Mapping Solution.
        - Scalable versus Three-Dimensional (3D) Light Amplification by Stimulated Emission of Radiation (Laser).
        - Distributed Storage versus Central Storage.
        - Less Expensive than Total Station and 3D Lasers.
        - Less Maintenance Cost Compared to 3D Lasers.
- Improved Investigative Outputs.
    - Aerial Views.
    - Modeling Possible.
    - Easy for Layperson to Understand.
- Better Situational Awareness.

While there are a number of mapping solutions available to law enforcement, UAS is the only one that typically does not require road/lane closure, and the only one that can be used without placing officers in travel lanes.

Law enforcement has noted that having access to overhead images at crash scenes helps them better understand vehicle movement and the dynamics of the crash.[16] Measurements from photographs is the major benefit for traffic crash investigation using UAS, as all users noted that UAS was much faster than any other scene measuring or mapping technique.

In general, mapping with Total Station could involve 100 to 200 points, requiring up to two hours, and the roadway is often fully or partially closed for safety reasons. While 3D scanners create point clouds with millions of points, closing the road is routine with their use. UAS may take 100 to 200 photographs, containing millions of points in a 10 to 15-minute flight where the roadway can generally stay open.

Collecting points with total station or scans with 3D scanners require more actions as scenes get larger or more complex. Additional points and scans require more time. Regardless of complexity, size of the scene, or number of vehicles, the UAS time is virtually the same for most traffic crash scenes.

A study by the National Institute of Justice (NIJ) used technology at a staged traffic collision to determine accuracy of the approaches and to a lesser degree time savings. The NIJ study compared UAS with the use of both manual and robotic total stations and found that UAS was one hour faster than the robotic total station and two hours faster than the manual total station.[17]

The North Carolina Department of Transportation (NCDOT) and North Carolina State Highway Patrol (NCSHP) completed a field comparison that provides the most cited evidence that UAS represents a time savings over 3D laser mapping. The two approaches were the same from an accuracy standpoint, but the UAS approach demonstrated significant time savings. UAS was

---

[16] National Institute of Justice (NIJ). Operational Evaluation of Unmanned Aircraft Systems for Crash Scene Reconstruction: Operational Evaluation Report. AOS-17-0078. January 2017. https://www.ncjrs.gov/pdffiles1/nij/grants/251628.pdf.

[17] National Institute of Justice (NIJ). Operational Evaluation of Unmanned Aircraft Systems for Crash Scene Reconstruction: Operational Evaluation Report. AOS-17-0078. January 2017. https://www.ncjrs.gov/pdffiles1/nij/grants/251628.pdf.

found to be 311 percent more efficient, requiring just 25 minutes to document a staged two-car collision, while the 3D scanner required one hour and 51 minutes.[18]

In a study with Purdue University, the Tippecanoe, Indiana Sheriff's Office found that overall scene time was reduced by 60 percent with the use of UAS.[19] In one example, the agency noted that an 800-foot crash scene was documented in a mere 22 minutes.

The Washington State Patrol (WSP) has data that shows the effectiveness and value of UAS as a tool for actual traffic crash investigations during their 2018 pilot program.[20] The WSP has documented more than 125 UAS deployments and found:

- Unmanned aerial vehicles (UAV) provide an 80 percent reduction in road closure time compared to other methods to measure scenes.
- The estimated fiscal impact of road closures is $350 per minute to the State in economic impact.
- The 2018 UAV pilot project provided an economic savings of $4,210,500.
- Investigators are safer—they are not in the roadway taking measurements and they clear the scene quicker, minimizing exposure to risks.

Figure 8 shows a graphic summary of the time savings for road closures with UAS compared to traditional tools.

---

[18] NCDOT. Collisions Scene Reconstruction & Investigation Using Unmanned Aircraft Systems. August 2017. https://www.ncdot.gov/divisions/aviation/Documents/ncshp-uas-mapping-study.pdf.

[19] Bullock, John L, Robert Hainje, Ayman Habib, Deborah Horton, and Darcy M. Bullock. "Public Safety Implementation of Unmanned Aircraft Systems for Photogrammetric Mapping of Crash Scenes." Transportation Research Record: Journal of the Transportation Research Board. 2673.7 (2019): 567-574. Print.

[20] Durbin, R. Washington State Patrol Unmanned Aerial Vehicle (UAV) Program Overview. Agency PowerPoint Presentation. 2020.

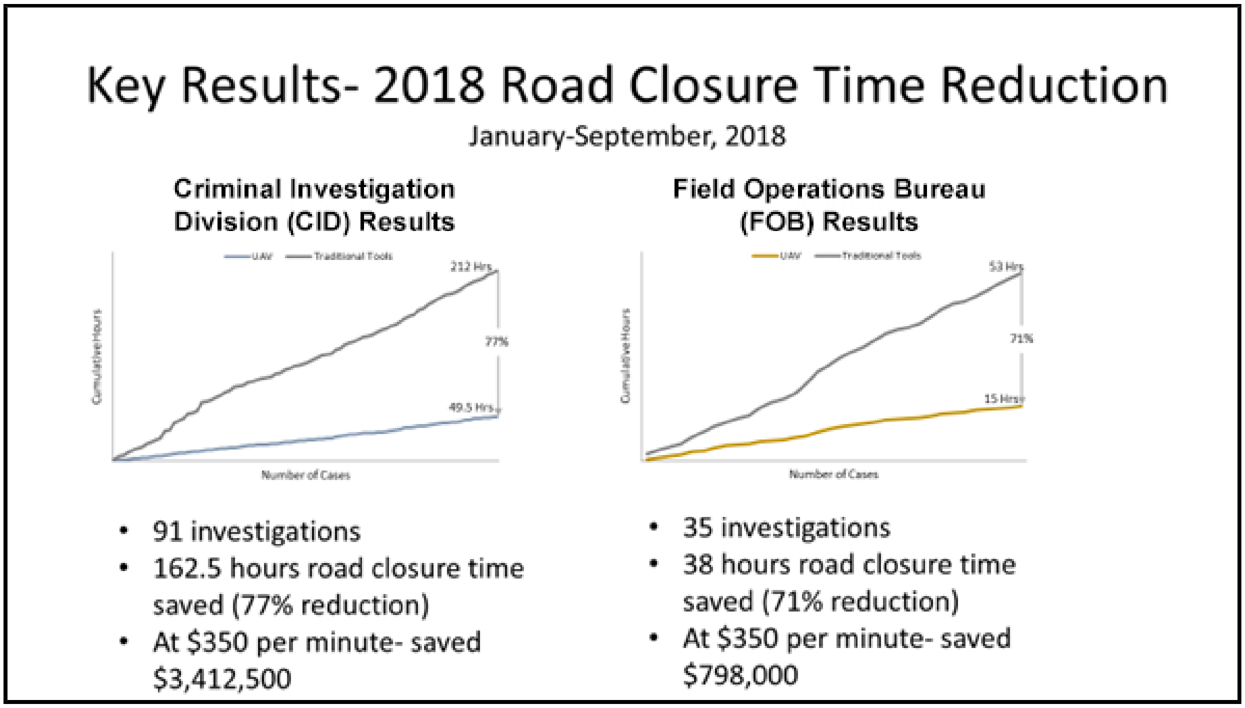

Figure 8. Slide. Key results slide from Washington State Patrol presentation.
(Source: Washington State Patrol.)

Time and safety create very compelling cases for clearing traffic incidents more quickly. The juxtaposition is the need for a complete and thorough crash investigation, particularly when there is a fatality and potential criminal charges. The concept of “safe, quick clearance” is a national traffic incident management (TIM) objective and represents the belief that safety and expedience are complementary objectives. With UAS time and quality are both potentially improved.

While only a few examples provide empirical evidence, more than 45 “anecdotal” benefits attributed to the use of UAS for traffic crash mapping were identified in media accounts. Some examples of anecdotal benefits:

- Crashes that took three to four hours were down to 20-30 minutes using UAS.
- Three hours versus 45 minutes with UAS.
- Contract helicopters cost $400 per hour and UAS only costs $20 per hour.
- Cuts scene time by 80 percent and measuring time by 66 percent.
- Average flight takes 15 minutes, reducing traffic backup by hours.
- Three hours down to 15-30 minutes.
- Cleared a DUI crash in one hour versus three hours.

- Three hours to 15 minutes.
- More accurate than manual methods.
- Seven-minute flight to cover a three-acre scene.
- A 75-80 percent reduction in mapping time.
- Four to five hour crashes are cleared in half the time.
- Shorter road closures, quicker measurements.
- Mapping went from 1.5 hours to 15 minutes.

Chapter 4. Implementing Unmanned Aircraft Systems for Traffic Incident Management

Unmanned Aircraft Systems (UAS) can be an effective tool for law enforcement agencies in traffic incident management (TIM). Deploying a law enforcement UAS program for TIM applications requires a comprehensive approach, considering agency objectives, community engagement, policy, training, and data stewardship. A well-developed plan for using UAS sets the stage for success.

Having Clear Objectives and Mission Focus

The use of UAS in a law enforcement agency must be mission-driven and align with the agency's mission. The decision to use UAS as a law enforcement tool should be approved by the Chief Executive of the agency and the purpose should be effectively communicated from the top down. Every member of the organization should have a basic understanding of the need for UAS and the boundaries for use. The intended uses and specific prohibitions for use should be identified and stipulated at the onset by the agency head.

A concept of operations (ConOps) or staff study can help clearly define the vision for how, when, where, and why the agency should use UAS. The foundational work of a staff study or ConOps helps establish specific and measurable objectives. It is never too early to involve internal and external stakeholders.

While UAS holds great promise as a technological leap forward, alternative methods for mapping and photographing traffic crash scenes are necessary for the integrated crash reconstruction business approach. A minimum weather visibility of three miles from the control station can make flight prohibitive in fog, smoke, and smog. Precipitation and extreme temperatures can also be problematic for some UAS aircraft. Depending on the UAS and its motor/rotor strength, excessive wind conditions can also inhibit UAS operation. These are all factors that might be considered in an agency analysis.

Privacy, Community Engagement, and Support

Before any unmanned aircraft are purchased, the agency should have a clear idea for the mission and objectives, but also a communications plan for public information and education.

Groups that are concerned with privacy rights have weighed in on the use of UAS by law enforcement in recent years and there is concern among those organizations that drones may jeopardize individual rights. With that said, those same groups have shown flexibility with law enforcement missions related to traffic crash investigations.[21] Both the American Civil Liberties Union (ACLU) and the Electronic Privacy Information Center have stated that crash investigation uses would not necessarily be objectionable.[22]

The Austin, Texas Police Department (APD) realized that using UAS for traffic crash investigations required listening sessions with the public to provide information and also hear public concerns about privacy.[23] Similarly, in Oro Valley, Arizona, the Police Department (OVPD) felt compelled to host demonstrations and public talks to be as transparent as possible.[24] A public advisory board is another way that agencies can garner support for their UAS program and the concept of operations for the use of UAS.[25] Regardless of how community engagement is undertaken, it should be initiated at the beginning of the process, preferably before any equipment is purchased.

Law enforcement use of UAS should also be rooted in ethics, transparency, accountability, and record keeping. Documentation of flight activities cuts across many program areas and supports transparency, officer proficiency, policy compliance, maintenance, and legal operation. Program and workflow management should dictate how agencies track operators, authorizations, missions, and logs. Every UAS flight, even training, should be documented. Some States, like

---

21 Bergal, J. Drones Help Officials Investigate Auto Crashes but Raise Privacy Concerns. State Legislatures Magazine. September 2018. https://www.ncsl.org/research/transportation/drones-help-investigators-find-crash-causes.aspx. Accessed April 8, 2020.

22 Ibid.

23 Margaritoff, Marco. Austin Police Department to Hold Public Hearings to use Drones for Traffic Accident Investigations. August 27, 2018. https://www.thedrive.com/tech/23177/austin-police-department-to-hold-public-hearings-to-use-drones-for-traffic-accident-investigations. Accessed April 12, 2020.

24 Gardner, Jeff. OVPD begins work with unmanned aerial vehicles. Tucson local media. March 7, 2018. https://www.tucsonlocalmedia.com/news/article_7c4917dc-2172-11e8-a40c-7314e7eab9a9.html. Accessed April 12, 2020.

25 US DOJ. Considerations and Recommendations for Implementing an Unmanned Aircraft Systems (UAS) Program. NCJ 250283. https://www.ncjrs.gov/pdffiles1/nij/250283.pdf.

Texas, enacted legislation that requires bi-annual reporting by law enforcement agencies that engage in UAS, including specific information about every use of the aircraft, type of activity and information collected, and estimated cost.[26]

Training, Safety, And Data Security

Organizationally, an agency's UAS coordinator can create a point of contact for questions, both internal and external to the agency. Beyond the coordinator role, the agency should plan for pilots and observers to support the use of UAS. Like all equipment, some degree of technical expertise is required of all personnel who are part of the agency UAS program, enabling them to handle technical issues and routine maintenance.

Training is at the forefront of law enforcement operations and UAS is no different. UAS operators in both the public and private sectors must also adhere to statutory and regulatory requirements.

As a unique type of camera equipment, it is important to recognize that the images created by UAS are not unlike other photographic evidence. The agency's UAS implementation plan should include data processes and a data policy. The plan might address how to collect, process, store, analyze, disseminate, and access UAS images and flight record data. Data storage is an important part of that plan, given each UAS photograph is about six megabytes in size and a single orthomosaic can be one gigabyte.

Most aircraft can store flight statistics, which can be downloaded and saved for reporting, and flight software captures data on flight operations, using apps that are especially suited for logging flights by date, time, location, and operator.

Written Policies and Procedures

As with any law enforcement endeavor, good written policies are an essential part of the framework that guides organizational and employee activities. The International Association of Chiefs of Police (IACP) has created a recommended policy for UAS. In addition, there are now enough agencies using UAS that finding sample policies is easy.

---

[26] Texas Government Code Chapter 423 Use of Unmanned Aircraft. https://statutes.capitol.texas.gov/Docs/GV/htm/GV.423.htm. Accessed 3/28/20.

The IACP's model policy gives information about the purpose, policy, definitions, and procedures for UAS in an agency. Procedures include program administration, personnel qualifications and training, operational procedures, safety, and maintenance.

Flight checklists, procedures, mission planning, and technical aspects of crash scene mapping might be added to a UAS policy, covered in procedural guidelines, or added to training.

Funding

Part of the planning for UAS is evaluating operational costs, which include hardware, software, and accessories. There are companies that provide "turn key" solutions for UAS, but most agencies acquire UAS components individually during the initial establishment of their programs. Again, the experience of other agencies through a planning document will minimize missteps in acquiring the right aircraft, computer hardware, and software.

The budget for UAS should be defined by the needs of the agency with the goal of obtaining the right equipment for the mission. Starting small and building a UAS program may avoid making significant investments and over-purchasing equipment or accessories. Acquiring moderately priced consumer grade systems may be useful for crash mapping without modification.

Program Evaluation

The impetus for UAS for crash mapping and TIM is that it solves multiple problems that all stem from the same source, roadway incidents. The UAS solution provides faster scene mapping, reducing the exposure of incident responders and clearing roadways faster, which will ultimately reduce secondary crashes. Law enforcement can make the business case for UAS using quantitative and qualitative results from successful agencies. To reinforce the decision to use UAS and expand programs, more tangible results might benefit agency management. Where the agency can show that UAS provided direct savings, a return on investment, or benefit cost, a strong foundation for the technology is possible.

Direct cost savings reflect that UAS is cheaper than current or alternative systems, like total station or three-dimensional (3D) scanners. Return on investment might equate to tangible agency benefits like less investigator scene time or fewer overall hours per crash investigation.

The Washington State Patrol (WSP) developed a very simple model to estimate the benefits of UAS. As part of its pilot program, the actual time to map each scene was recorded and compared to what the investigator estimated would be the time required using another technology. The difference in minutes was aggregated across all investigations. Using the

Washington Department of Transportation estimate that each minute of Interstate road closure cost $350 per hour, WSP calculated a net savings to Washington State.[27]

[27] Durbin, R. Washington State Patrol Unmanned Aerial Vehicle (UAV) Program Overview. Agency PowerPoint Presentation. 2020.

Acknowledgements

The authors wish to thank the following organizations for their assistance in providing information for this document:

Austin, Texas Police Department

Center for the Study of the Drone at Bard College

Delaware Department of Transportation

Delaware State Police

Florida Highway Patrol

Iowa State Patrol

Lee County, Florida Sheriff's Office

Maine State Police

Michigan State Police

North Carolina State Highway Patrol

Oro Valley, Arizona Police Department

Stafford County, Virginia Sheriff's Office

Superior Towing, Davie, Florida

Tippecanoe, Indiana Sheriff's Office

Washington State Patrol

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

https://ops.fhwa.dot.gov

February 2022
FHWA-HOP-20-063