Use of Unmanned Aerial Systems (UAS) by State DOTs

February 27, 2018 Peer Exchange

Federal Agencies: Federal Highway Administration (FHWA)

Peer States and Associations:
North Carolina DOT
New Jersey DOT
Ohio DOT
Utah DOT
Wyoming DOT
American Road and Transportation Builders Association (ARTBA)
American Association of State Highway and Transportation Officials (AASHTO)

U.S. Department of Transportation
Federal Highway Administration

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16. Abstract This peer exchange brought together public and private organizations to discuss the state of the practice and possible future uses of UAS in the field of highway operations, construction, and maintenance. States that have implemented UAS programs have found that the use of drones can save time and money, and increase safety and efficiency. Each of the State DOTs is approaching the introduction and use of drone technology differently depending upon the structure of the State DOT.		
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Introduction

This report highlights key outcomes identified at the State DOTs' Use of UAS in Operations and Construction Peer Exchange held on February 27, 2018 in Arlington, Virginia. This event was sponsored by the Center for Accelerating Innovation (CAI) under the Federal Highway Administration (FHWA) Office of Innovative Program Delivery (OIPD) and the FHWA Office of Infrastructure. Representative of Federal offices, State Departments of Transportation, and private sector companies were in attendance. These individuals are referred to as "peers" throughout this report.

Overview

Why a Peer Exchange?

The Federal Highway Administration's (FHWA) Office of Innovative Program Delivery (OIPD) and Office of Infrastructure organized this peer exchange to learn how certain State Departments of Transportation (State DOT) are utilizing Unmanned Aerial Systems (UAS)[1]. This peer exchange also brought together public and private organizations to discuss the state of the practice and possible future uses of UAS in the field of highway operations.

Key Outcomes

Through facilitated discussion, the agency representatives participating in the peer exchange presented and identified a great deal of content that will be useful to their peers at other agencies. This information can be useful in beginning a UAS department from scratch; growing a UAS department and furthering the agency's maturity in the field; helping to communicate what is and is not possible (legally and practically) with UAS technology; and identifying areas of need, next steps, and how to move forward.

Key Findings from the Exchange

- States that have implemented UAS programs have found that the use of drones can save time and money, and increase safety and efficiency.
- Each of the State DOTs is approaching the introduction and use of drone technology differently depending upon the structure of the State DOT.
- State DOTs expressed an interest for additional guidance on their use and operation of a UAS program.
- Those States that have an advanced UAS program have had a champion who pushed for the adoption of a program by leveraging available resources and knowledge and experience.
- Private sector construction companies are beginning to utilize UAS technology to improve the efficiency of their work on highway projects.

[1] Sometimes referred to as Unmanned Aircraft Systems.

Getting Started with UAS

A number of key issue areas came up through discussion, each representing information learned by staff from the experience of beginning a UAS program, lessons learned, and/or things to be mindful of when starting a UAS program.

Buy-in

All peers believed that getting buy-in as early as possible and as widely as possible (from other departments and upper-level management) is a key success factor. Some DOTs felt that it is crucial to get support at the highest levels: the State Secretary of Transportation. This helps to ensure disparate groups are on the same page with respect to equipment, policies, procedures, and insurance coverage. Gaining buy-in also helps facilitate using UAS technology to its fullest extent in as many departments or divisions as possible, thereby maximizing return on investment. Through the process of engaging various business units, participants agreed that developing an objective, achievable road map on developing the department's UAS capabilities is a crucial step in avoiding inconsistencies in implementation.

When to Begin

Some agency representatives expressed a sentiment of feeling "behind the curve" when it comes to employing UAS for highway operations with respect to their counterparts. While some State DOTs have indeed developed effective UAS departments and employ UAS in a variety of use-cases, others are more hesitant to begin operations so enthusiastically. One benefit of beginning sooner rather than later is achieving cost efficiencies sooner and thereby more cost savings in the long run. Conversely, those agencies also have to resolve novel issues with few examples to lead the way. Allowing time for UAS programs at other DOTs to find novel ways to resolve issues before making an investment allows agencies to learn from those who have gone before them. However, with the number of agencies across the country using UAS for myriad purposes, best practices for using UAS for highway operations will become increasingly more available.

Capabilities

Many participants found that when other departments and companies in the private sector learn that a State DOT has UAS capability and is using it to implement projects, they want to leverage this new resource for a wide range and high volume of instances. This presents multiple challenges. For one, the UAS division may not have the capacity in terms of personnel or funding to fulfill all of the requests. Another reason is that UAS may not be the right tool for the job in question, and it may not even be possible to meet the objectives at all. Furthermore, the regulatory environment may prohibit the use of UAS for a specific use-case. When initializing or developing an organization or agency's UAS capabilities, it is important to manage expectations about what is possible with the new technology.

Personnel

Some States have found that staffing a newly created UAS department to be difficult because it does not fit well into the historical structure of a State DOT. New Jersey DOT (NJDOT) decided to create a new position of "UAS Coordinator" in the Division of Multimodal Grants & Programs & Office of Aeronautics. Other State DOTs decided to employ qualified UAS pilots to help with the start of the program. In an effort to broaden awareness of the capabilities that UAS technology offers, North Carolina DOT offers a course that staff and residents can take to become qualified UAS pilots for commercial and government purposes. While the State DOT found many external contractors willing to help them develop the course, it also discovered a deep base of knowledge on the subject found among current employees who already have commercial pilot's licenses. One lesson learned here is to assess the full extent of the personnel resources that are already available within the immediate workforce before investing in additional resources.

The table below summarizes where within each DOT's organizational structure the respective UAS departments sit for those State agencies who participated in the peer exchange which have a dedicated UAS division.

State DOT	UAS Department Name
Alabama DOT	Aeronautics Bureau
Caltrans	Division of Aeronautics
New Jersey DOT	Division of Multimodal Grants & Programs & Office of Aeronautics
North Carolina DOT	Division of Aviation
Ohio DOT	Ohio/Indiana UAS Center
Utah DOT	Technology Advancement
Washington State DOT	Aviation Division

Funding

Funding can be difficult to secure within an agency for a soon-to-be created business unit whose primary focus is on a non-traditional technology. NJDOT found funding from Federal grant programs helpful in getting its UAS program up and running. While there are many similar funding mechanisms available for such purposes, the three grant programs that NJDOT applied to and received funding from were:

- FHWA's Technology and Innovation Deployment Program
- FHWA's State Transportation Innovation Councils (STIC) Incentive Program
- FHWA's State Planning and Research (SP&R) Program

New Jersey used these funds to invest in equipment and train employees.

Research

State DOT representatives found that doing due diligence and research in advance of beginning to establish a UAS program was beneficial overall, and in particular when it came to getting widespread buy-in. Participants found that approaching upper-management with hard data on how UAS affects drivers' distraction, resultant effects on traffic congestion, and data on the possibility of an incident (severity, cost risks, etc.), upper management was far more amenable to providing support and resources to a fledgling UAS program.

Policies & Procedures

When founding a UAS department or beginning with UAS operations, State DOTs found it beneficial to have a common set of pre-determined, universally agreed-on policies and procedures. Here, too, is an example of achieving buy-in from as many stakeholders as possible. In particular, State DOTs reported that one big issue with respect to policies and procedures is risk management. One suggested way to address risk management issues, among other issues, is to develop a manual encompassing as many policies and procedures as possible with respect to the new program.

Logistics

Unforeseen logistical concerns can be numerous when beginning UAS operations. While this was not a top concern among State DOTs when discussing hurdles to beginning operations, it was mentioned as something that would be beneficial to plan for. One example of a logistics problem relates to hardware storage, particularly batteries. A number of different aircraft models using non-interchangeable batteries raises a number of challenges. Developing a system or procedure and the infrastructure to simply charge and track the status of a number of batteries can prove to be a challenge. Furthermore, agencies found that they are unaware of what precautions to take when storing a large number of batteries.

Cost-Savings

The consensus among the group of participating State DOTs was that the cost savings associated with UAS operations is more than substantial. Agencies were hesitant to discuss precise amounts with respect to savings; however, all agreed that replacing traditional methods of the operations they have employed to date, were completed with a fraction of the cost that they otherwise would have. Depending on the type of hardware purchased and the highway operation completed using UAS, States said they saw a return on the investment with the first use of aerial systems to replace traditional methods of inspection.

> "A cost savings of 10-15% is 'significant.' When it's double that amount in cost savings- that's *colossal*. That is what UAS can help deliver."
>
> -Glenn Stott, NJ DOT

In an as-yet-unpublished report at the time of this report's publication, the Ohio State University (OSU) conducted a case study on cost savings that Utah DOT (UDOT) has achieved through employing UAS. UDOT used a roadway construction project on SR20 as an opportunity to pilot multiple technology innovations that rely on geospatial technology, including UAS. OSU found that the use of UAS resulted in a completion of the project 25 days ahead of schedule and a cost savings of over $82,000. Looking at historical cost data for traditional highway operations methods and comparing it to costs associated with conducting similar operations using UAS, the OSU study cites three primary areas in which ODOT has achieved savings:

- Equipment rental and usage (e.g., snooper cranes are not necessary when employing UAS);
- Traffic control (e.g., UAS eliminate the need to shut down a travel lane); and
- Travel expenses (e.g., fewer necessary personnel achieve savings through reduced lodging and meals & incidental expenses)

Challenges and Successes

This section summarizes at a high level the types of challenges that agencies encountered and if they overcame the challenge, how they did so, or how they were attempting to do so at the time of the peer exchange.

Public Perception and Education

UAS operators in both the public and private sectors must also 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 Federal Aviation Administration. The provisions of 14 CFR part 107 apply to most operations of UAS weighing less than 55 lbs. Operators of UAS weighing greater than 55 lbs 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/.

North Carolina DOT (NCDOT) provides a good example of a State agency that is actively educating the public on the proper use of UAS. In 2017, NCDOT produced a series of six very short videos (approximately 20 seconds each), each of which illustrates a general safety guideline or a regulation from 14 CFR part 107. This video series is posted to YouTube and available for public viewing. As of this report, the videos have hundreds of views each. NCDOT also offers a course that residents can take to become qualified UAS pilots for commercial and government purposes. NCDOT reports that both the public as well as NDCOT staff have shown a great deal of interest in the course. Further, NCDOT has made available on its website a *North Carolina Unmanned Aircraft Systems (UAS) Operator Permit*

Knowledge Test Study Guide[2], a 47-page pdf with the information necessary to pass a NCDOT-approved UAS Operator Permit.

Pushback

By definition, disruptive technologies invite pushback from those heavily invested in the status quo. In this case, there are those with vested interest in the way some of these operations, which can now be done more efficiently with UAS, are carried out. Some States have reported no pushback from incumbents. However, others have run into this challenge. Those that have reported encountering this issue found it helpful to demonstrate the efficacy of UAS in supplementing certain operations done by traditional methods, rather than replacing them. Further, when UAS are demonstrably less effective at completing a given highway operation, State DOTs felt it helpful to concede the point and continue to operate using traditional methods. Depending on the task at hand, such methods may include necessary equipment such as snooper cranes as well as necessitate the closure of travel lanes.

Hardware

One challenge that agencies have come across is the selection of the appropriate hardware. Not only is this an issue when beginning UAS operations within an agency, it continues to be an issue as operations mature and as technology and the variety of models increase over time.

While there is not a one-size-fits-all solution to which hardware to choose, there are models of UAS that can perform a wide variety of tasks with the appropriate hardware additions. Each agency at the peer exchange had experienced both successes and failures with different models of aircraft. The only real solution to this challenge is to become educated on what functionality is available on the market and what functionality will be needed by an agency's proposed use of UAS. Things to consider when selecting an aircraft include deciding between fixed-wing aircraft and quadcopter aircraft. Further, different aircraft are capable of accommodating different imaging apparatuses, specifically limited by the weight each can lift and the directions in which the onboard gimbal can rotate the imager. Some models sacrifice one functionality for another. For example, some models allow two cameras to be mounted facing different directions, however, to properly mount both requires the removal of a GPS antenna, thereby limiting the aircraft's special awareness. Flight time is another consideration; this too can vary dramatically even on the same model aircraft as different camera and imaging devices can vary in weight.

Software

Once data collection is complete, a suite of other challenges arise. Data maintenance, data storage, and data processing are all necessary considerations when using UAS. Similarly to hardware considerations, the best solution will vary depending on usage. Some operations require 3D mapping and point cloud datasets while other operations require simple video output. And depending on the frequency of the use-case, the datasets being stored can vary dramatically in size. Some agencies found that simply

[2] https://connect.ncdot.gov/resources/Aviation%20Resources%20Documents/UAS_Study_Guide.pdf

storing data locally was sufficient for their purposes while others found they needed to set up complex data transfer and storage architecture, employing sending data over 4G cellular service and storing data through a cloud data storage service provider.

Solutions to data processing fall along a similar spectrum. While some agencies preferred to process the data on a laptop in the field, others found that the necessary software doesn't run well on under-powered machines. Some agencies were able to invest in a more powerful computer while others resolved this issue by running data processing software in the cloud on remote servers more capable of handling the load.

While many UAS models come with stock software to handle data management, often this is not sufficient for the required operations. To fill this gap, many agencies found it necessary to purchase specialized software for the use-case at hand. There are myriad commercial off-the-shelf (COTS) software suites that are designed to handle most things a transportation agency would need. No organization found it necessary to employ software so specialized that a COTS solution was insufficient.

Operation

During operation, some agencies encountered unforeseen challenges. These challenges were largely due to environmental issues in the field. For example, one agency ran into issues with interference due to electromagnetic field created by nearby, underground power lines and trees encroaching too close to the infrastructure to be inspected. These issues were both resolved the same way, by electing not to use UAS for these inspections in particular and falling back on traditional inspection methods.

Peer Presentations

State DOTs with more mature UAS operations as well as some private firms gave brief presentations. The intent of the presentations was to inform the group on the current state of the practice while raising salient discussion points and offering an opportunity to allow others present to engage on the topic. While the key points raised and issues identified in those discussions as well as the action items that resulted are summarized elsewhere in this report, this section summarizes the content of each presentation.

Figure 1: Ohio DOT image illustrating the zoom capabilities of its UAS equipment.

State Departments of Transportation:

Glenn Stott, New Jersey DOT, Division of Multimodal Grants & Programs & Office of Aeronautics

New Jersey DOT (NJDOT) provides a good example of how a State DOT has created a fully operational UAS program. Stott described the major pillars as:

- Personnel – NJDOT created a new position, "UAS Coordinator." within the Bureau of Aeronautics with the express purpose of managing UAS operations for NJDOT.
- Funding – NJDOT applied for and received a number of grants to help bootstrap its UAS operations.
- Coordination – NJDOT learned a lot about what other agencies are doing in the UAS space from a peer exchange it organized and hosted on the topic.

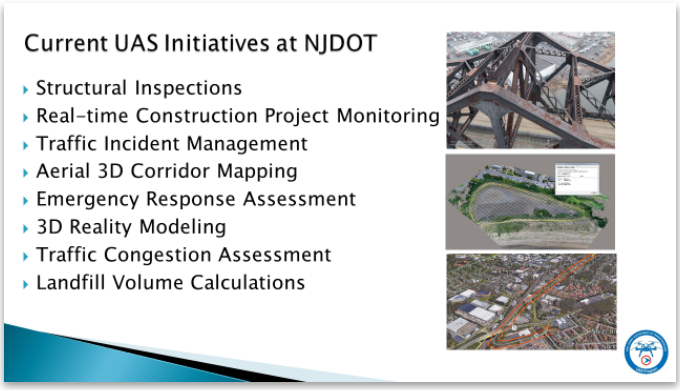

Figure 2: Current UAS Initiatives at New Jersey DOT at time of peer exchange.

For NJDOT to select a project on which to employ UAS, the project must meet at least one of the following criteria: i) increase safety ii) increase efficiency iii) save time and iv) save money. NJDOT executed a successful project inspecting High Mast Light Poles (HMLP) albeit not without encountering some unforeseen challenges. Details of this project can be found in the Use-Cases section of this report. NJDOT has also accomplished a great deal with respect to coordination with sister agencies (e.g., Port Authority, New Jersey Office of Homeland Security 7 Preparedness, New Jersey State Police) as well as cost- and efficiency-comparisons with traditional (non-UAS) methods, both of which have been found to be colossal.

Fred Judson, Ohio DOT, Ohio/Indiana UAS Center

Ohio recently established DriveOhio, a division of Ohio DOT (ODOT), which facilitates the development of autonomous and connected technologies. The UAS Center is a part of DriveOhio focusing on the future of mobility and preparing the State for new and disruptive technologies. ODOT uses an extremely detailed map with an overlay for each type of regulation that needs to be followed in a particular area. ODOT employs UAS for a variety of data collection methods using various types of aircraft, each of which has advantages and disadvantages.

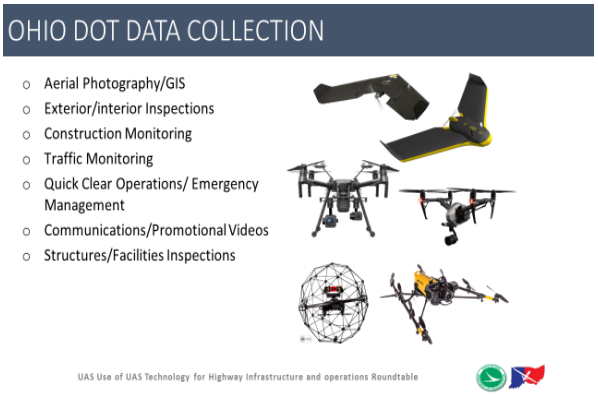

Figure 3: Types of UAS equipment employed at Ohio DOT for data collection operations.

Basil Yap, North Carolina DOT, Division of Aviation

At a high level, NCDOT permits commercial UAS operators, provides educational support to those interested, provides flight services to other State agencies and local governments, and has recently begun exploring vehicle collision reconstructions. NCDOT has also produced myriad videos to illustrate the work it has done in each of these categories, primarily for external education and outreach. See the Use-Cases section of this report for more information.

Paul Wheeler, Utah DOT, Technology Advancement

Utah DOT (UDOT) is currently using UAS for quite a number of activities, such as structure inspections (delamination, deck mapping, etc), landslide monitoring, and traffic monitoring, and is planning to expand UAS usage to a few more project-types such as emergency response and asset and property management. UDOT has practices in place to regulate UAS use. The State uses UAS to support structure inspections such as delamination and deck mapping, and has mapped landslides at Bryce Canyon in coordination with the National Park Service. Future uses of UAS that UDOT intends to explore include avalanche mitigation, counter-UAS operations to enforce illicit use of UAS by bad actors, equipping emergency vehicles with UAS to expedite response time, and using Light Detection and Ranging (LiDAR) for asset management purposes.

Private Sector & Association Participants:

Mark Berry, Pecker & Abramson, representing ARTBA

Private-sector contractors have tremendous interest in UAS use. However, Berry said there have historically been quite a number of compliance issues in this regard. The greatest risk factor for a contractor using UAS is liability, as there has been minimal enforcement action taken by the FAA to date. The public outreach component of Part 107 has been very effective in encouraging contractors to remain in compliance of the regulation. Now that UAS practitioners are aware of Part 107, they are approaching legal counsel to ask appropriate questions so that they may fly legally. Further, there are

waivers of Part 107 for which one can apply; the waivers that have already been granted are made available to the public as a reference for others seeking a waiver: https://www.faa.gov/uas/request_waiver/waivers_granted/. One continuing issue that Berry finds difficult to addresses is that there are no good contract documents that flow down to DOT documents and reports. Ideally, he would like to have standard specifications and procedures in the contract language that is agreeable to a State DOT.

Tim Duit, Duit Construction, Representing ARTBA

Duit Construction is adept at using UAS to record aerial imagery and video of construction sites. Doing this before work begins has two benefits: the company can compare before and after photos, and verify conditions for insurance claims, if need be. For example, in one case a property abutter claimed Duit Construction's equipment damaged its property during the course of construction. Mr. Duit's firm also uses UAS to assess quantities of dirt, gravel, and other construction materials quickly and accurately. For example, scanning a yard with UAS can provide specific data such as how many cubic yards of each type of land-fill is in their inventory.

Figure 4: Image pulled from a Duit Construction video demonstrating assessing the progress of a construction site.

Jim Sterling, Beaver Excavating, Representing AGC

Beaver Excavating has been using UAS for construction operations since 2015. Beaver Excavating currently employs three fixed-wing UAS and two quad-copters in addition to an autonomous boat. The firm uses UAS in 60-70 percent of its projects. Some of the benefits to using UAS in this context include mapping hundreds of acres of complex terrain in a matter of hours, keeping personnel out of harm's way, and benefits associated with the level of detail that a 3D point-cloud provides.

Jonathan Shapiro, Identified Technologies, Representing ARTBA

Identified Technologies is working to support those using UAS technologies in multiple sectors. For example, many State DOTs may run into limitations with respect to computational power when processing large amounts of data. Identified Technologies addresses this problem by providing cloud-based solutions that crunch data remotely. The firm also finds that clients are apprehensive about investing in new technologies for fear of a limited use-case due to an unclear regulatory environment.

Use-Cases

This section highlights the wide variety of uses for which the presenters at the peer exchange are employing UAS technology.

NJDOT: High Mast Light Pole Inspections

For NJDOT to select a project in which to employ UAS technology, a project must either increase safety and/or efficiency or provide a reduction in time and/or cost compared with completing the operation by traditional means. One operation with which NJDOT has had a lot of success is high mast light pole (HMLP) inspections, one of the first successes when the agency began its UAS program in 2016. NJDOT chose HMLP inspections not only due to the cost and efficiency gains, but also because the inspections did not present the challenges associated with something more complex, such as bridge inspections. Bridge inspections using UAS present challenges such as poor lighting and visibility conditions as well as interruptions in the GPS signal that is necessary for some models to fly properly. NJDOT wanted to achieve one success early on in the program before moving on to more complex procedures.

Figure 5: Image of a New Jersey DOT UAS inspecting a high mast light pole.

NJDOT sought to inspect a total of 250 HMLPs, and ultimately successfully inspected 241 of them. Five HMLPs were unable to be inspected due to "airspace issues," two due to dense surrounding vegetation, one HMLP was too close to a roadway to be safely inspected, and one was located in an area with a high degree of electromagnetic fields due to surrounding electrical equipment, interfering with UAS communications.

NJDOT found that it was able to inspect far more HMLPs more quickly and less expensively than by traditional means. Cost savings include lost productivity due to the traveling public experiencing congestion issues. One advantage of inspecting with UAS is that it does not necessitate shutting down a travel lane for a bucket truck to occupy. Furthermore, it only takes a crew of three to complete an inspection: two controllers: one pilot and one engineer, each with a camera and screen, and a third visual observer to monitor the site. Using this method NJDOT, was able to complete six or seven inspections per day compared with one or two using traditional methods. Glenn Stott of NJDOT mentioned that "significant" cost savings can be construed as a 15% reduction in cost; this methodology provides "double, triple, or quadruple" the cost savings.

Ohio DOT: Inspections and Traffic Monitoring

Ohio DOT (ODOT) uses a map of the State that illustrates the road network overlaid with the various airspace types across its six regions. Depending on the type of airspace and proximity to an airport, different regulations apply. They use this map to plan their approach to a given UAS operation.

While ODOT is currently employing UAS technology for a number of applications such as construction monitoring and promotional videos, one unique application for the agency is using the technology is to monitor traffic for car and truck counting. The equipment ODOT is using for this operation- a DJI Matrice 210 RTK- is equipped with a camera capable of 30x zoom, letting the operator fly quite a distance away from the intersection being studied. To monitor traffic, the video feed is analyzed by a machine learning algorithm trained to identify vehicles and record the direction of travel. The software can provide a total count of vehicles per direction of travel. When using a tethered aircraft, ODOT is able to fly and capture imagery continuously for up to 9 hours. By comparison, when using a battery-powered aircraft, ODOT reports achieving 20-30 minutes of flight time followed by 5-10 minutes to change the dead battery for a new one.

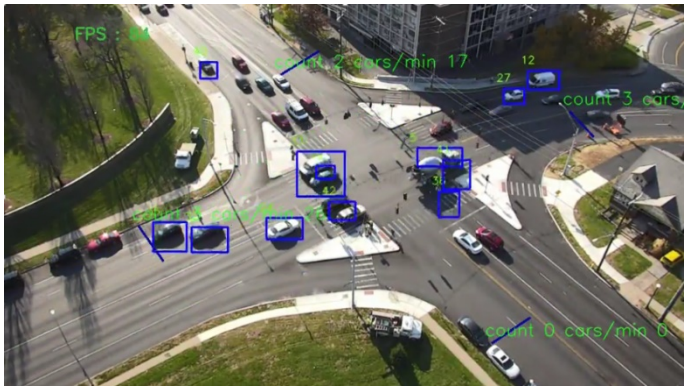

Figure 6: Image from Ohio DOT's UAS Demonstrating Traffic Counting Software.

Duit Construction: Uses in Highway Construction

Duit Construction uses UAS technology to assist in a number of construction operations including pre-bid and pre-work photos and videos, progress photos during construction for job analysis, mapping project topography to document existing conditions, and surveying waste sites and recycle yard topography to assess quantities. One unique use is the assessment of quantities of dirt and other construction materials being stored in yards. By using UAS, Duit can quickly scan a storage yard full of piles of construction materials to get its topology. Using this information the company can assess, pile by pile, how much quantity of any given material type remains. For example, Duit can identify a specific pile of material and assess its volume. Duit does not contract out this service, but uses it for internal inventory keeping purposes only.


Figure 7: Image pulled from a Duit Construction video demonstrating using topographical imagery to assess material volumes in a recycle yard.

While this methodology is much quicker than traditional methods, it does have some drawbacks that need to be considered. The camera technology cannot see through trees or thick brush, limiting what a UAS can see from where. Duit also has encountered aberrant aircraft such as crop dusters flying very low to the ground. This application also demands a good deal of computing power and therefore cannot be used on low- or mid-range computing hardware.

North Carolina: Collision Reconstruction

> UAS allow responders to collect data to digitally reconstruct the scene of a collision from a safe distance in as little as 25 minutes.

North Carolina has one of the more robust UAS programs among State DOTs. The agency has a streamlined permitting process for commercial UAS operators, has been involved in educating the public about UAS safety, and even contracts out some of its services to other State agencies and local governments.

One unique operation for which NCDOT employs UAS technology is motor vehicle collision reconstruction. After a collision, it is necessary to document evidence of the scene. To do so requires lane closures, and it is important to open the roadway as quickly as possible. The two traditional methods of collision reconstruction – total station and laser scanning – are relatively time consuming and can put responders in harm's way. NCDOT has shown that it can use advanced imaging software in conjunction with UAS hardware to document the scene of a collision more quickly and accurately. While traditional methods can close travel lanes for up to two hours, NCDOT can begin clearing the scene after 25 minutes using UAS to document the event. Furthermore, responders can collect sufficient data on the scene to digitally reconstruct it while maintaining a safe distance from the collision itself and any nearby moving traffic.

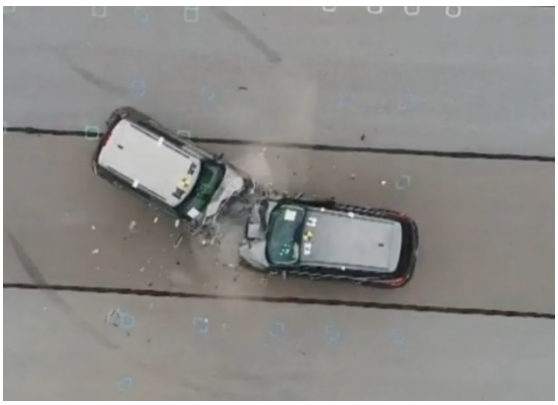

Figure 8: Image of a staged vehicle collision pulled from slow-motion video recorded by a North Carolina DOT UAS.

Lessons Learned

Toward the end of the peer exchange, all participants were asked about their biggest take-aways and lessons learned.

Overall, participants were struck with the technical expertise of their colleagues and the variety of uses for which UAS can be employed. This observation supports the idea that at this point in the new technology's deployment, one of the best resources can be one's colleagues in similar positions at other State agencies. Further, participants made note that everyone involved in the peer exchange was enthusiastic about the deployment of UAS for highway operations and that no one indicated any hesitance or indication otherwise about investing in the technology.

State DOT Colleagues as a Resource

Regardless of how well-developed an agency's UAS program was at the time of the peer exchange, all agreed that they saw a lot of potential in openly communicating with each other to provide support in various areas. One aspect of the current industry landscape that became clear is that each of the State DOTs present have put a lot of work into doing their due diligence, research and development, and trial and error independently from each other. Many agencies have encountered similar problems and found similar solutions by "reinventing the wheel" using their own resources. While participants now know what other participant-agencies are working on and to whom they can go when assistance in a particular area is needed, a more sustainable solution can be achieved by generalizing the idea of agencies employing UAS for highway operations sharing knowledge and resources. One area in which all agencies are currently seeking best practices is how to structure a UAS department within an agency such that it is most efficiently and widely utilized.

Public Sector and Private Sector

Some participants saw the role of the private sector to push the technology forward by being nimbler and less bound by bureaucratic hurdles. Some saw the role of UAS operations within the public sector as following close behind the private sector, reducing the amount of money spent on unforeseeable setbacks. However, even participants representing private firms at the peer exchange expressed the opinion that, as taxpayers, they expect their representative agencies to conduct business as efficiently and cost-effectively as possible- if that means employing UAS technology sooner rather than later, then that should be the chosen path. Participants representing both private and public entities made clear that there is tremendous potential for the two sectors to work together, share resources, and seek common efficiencies. For example, regardless of sector, each participant expressed that an understanding of the number of potential use-cases for UAS technology had been broadened greatly by others' presentations at the peer exchange.

Proposed Areas for Federal Support

A discussion was held about the support FHWA should provide to State DOTs to aid in the adoption and use of this technology in the construction and operations phases of a State's efforts.

Guidance

The participants are very interested in upcoming Federal guidance on the use of UAS by State DOTs. While Part 107 has done a lot to further the use of UAS, there is still a lot of work to be done before the process of adopting UAS operations is streamlined. State DOTs remain interested in learning more about how to take full advantage of the benefits that come with employing UAS.

Forum of Communication

Peers requested that a formal forum of communication be developed for those working with UAS technology in State DOTs. Participants would use such a forum to keep apprised of UAS initiatives underway at their peer agencies, actively seek support for issues that arise, and generally support one another in a newly emerging field of expertise. Many participants found commonalities in the types of issues they had encountered in the past, and felt they were lacking resources in resolving those issues, relying only on in-house expertise and developing novel solutions when necessary.

Next Steps

UAS is one of ten programs identified as a focus area for FHWA's Every Day Counts initiative (EDC-5).

Under EDC, FHWA works with State DOTs and the private sector to identify a collection of proven, yet under-utilized innovations that merit accelerated deployment to promote and support in 2-year cycles. Citing a 2018 survey conducted by the American Association of State Highway and Transportation Officials (AASHTO), FHWA reports that 20 State DOTs are already using UAS in some capacity and anticipates 15 additional State DOTs to bring UAS operations online in the near future.
From the FHWA website outlining the program:

> After selecting EDC innovations, transportation leaders from across the country gather at regional summits to discuss and identify opportunities implementing the innovations that best fit the needs of their respective State transportation program. Following the summits, States finalize their selection of innovations, establish performance goals for the level of implementation and adoption over the upcoming two-year cycle, and begin to implement the innovations with the support and assistance of the technical teams established for each innovation.

Additional information on EDC can be found on the FHWA website at https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/uas.cfm.

In the effort to support State DOTs through the EDC program, FHWA has also published a short, two-page fact sheet that provides State DOTs who may be interested in starting a UAS program with a high-level overview of what can be accomplished through employing UAS as well as the benefits that come with it. The benefits gained in safety, accelerated construction through data collection, and terrain mapping, all of which peers have experience first-hand, are outlined. The Fact Sheet also lists a number of the ways in which State DOTs are using UAS, many of which were presented at the peer exchange. This provides State DOTs who have not yet begun a particular UAS operation with a starting point as to which peer DOTs already have.

The fifth round of Every Day Counts will run for two years, through 2019 and 2020. Over this two-year period, beginning in the Fall of 2018, FHWA will organize multiple regional summits across the country.

Further, over this time period, they will deploy a wide range of UAS activities with an initial focus on structural inspection, construction inspection, and emergency response operations.

The fact sheet (www.fhwa.dot.gov/innovation/everydaycounts/edc_5/docs/uas-factsheet.pdf) provides links to other resources and contact information for FHWA employees that support the program.

Appendix A: Participants and Organizations Represented

	Full Name	Organization
FHWA/Federal Staff	Teresa Denchfield	FAA
	Jim Herrera	FAA
	John Meehan	FAA
	Zeke Rios	FHWA Federal Lands Highway
	Hoda Azari	FHWA office of infrastructure R&D
	Jean Nehme	FHWA Long Term Infrastructure Performance
	Katherine Petros	FHWA FHWA office of infrastructure R&D
	Jeff Zaharewicz	FHWA CAI
	Connie Yew	FHWA- Construction Management
	James Gray	FHWA -HICP
	Dennis O'Shea	FHWA Structures Safety
State DOT representative	J.D. D'Arville	Alabama DOT
	Don Haug	Caltrans - Division of Aeronautics UAS
	Fred Judson	Ohio DOT
	Jeffrey Milton	Virginia DOT
	Kurt Stiles	WSDOT Aviation Div
	Glenn Stott	New Jersey DOT
	Sheri Taylor	Wyoming DOT
	Paul Wheeler	Utah DOT
	Basil Yap	North Carolina DOT
Private Sector and Association	Mark Berry	Peckar & Abramson
	Eric Diederich	Industrial Builders Inc
	Tim Duit	ARTBA - Duit Construction
	Paula Hammond	ARTBA - WSP
	Rich Juliano	ARTBA
	Jag (Jagannath) Mallela	AASHTO Innovation Initiative
	Jonathan Shapiro	Identified Technologies

Appendix B: Peer Exchange Agenda

FHWA Office of Infrastructure
Use of UAS for Highway Infrastructure and Operations
Roundtable Agenda
Location: National Highway Institute, 1310 North Courthouse Road, Suite 300
Arlington, VA 22201
Tuesday, February 27, 2018 8:15 am – 4:15 pm

Session	Description	Questions to consider

	Registration (8:15 – 8:45)
	
	• Welcome from the hosts
	  ○ James Gray, FHWA Office of Infrastructure
	  ○ Jeff Zaharewicz, FHWA Center for Accelerating Innovation
	• Overview of the day	

	Welcome and Introductions (8:45 – 9:15) • Participants introduce themselves • Each State DOT participant provides a short overview (2-4 minutes) of their current or potential use of UAS technology • Each industry representatives gives a brief overview of how their field utilizes UAS technology	

1	**Current Use of UAS by State DOTs** (9:15 – 10:30)
	
	• Overview on the use of UAS by State DOTs
	  ○ John Meehan, Federal Aviation Administration
	• Launching a UAS Program
	  ○ Glenn Stott, New Jersey DOT;
	  ○ Fred Judson, Ohio DOT
	• Legal Framework and Restrictions on UAS Operations
	  ○ Mark Berry, Pecker & Abramson law firm
	• Facilitated discussion
		• What are lessons learned in starting up a program that utilizes UAS technology?
		• What resources are needed to start up a program?
		• What are the present legal restrictions of UAS usage, potential regulatory changes which may reduce barriers and
		• What are the available exemptions to the regulations that may be available to State DOTs?

Session	Description	Questions to consider
		• What are some "low hanging fruit" that can be quickly adopted and implemented by SDOTs? • What are the most significant transportation infrastructure challenges that using UAS may help overcome?
	Break (10:30 – 10:45)	

2	**Use of UAS by other modes/fields** (10:45 – 12:00)
	
	• Introduction of the session by Rich Juliano, ARTBA
	• Presentation by construction industry representatives
	  ○ Eric Diederich, Industrial Builders;
	  ○ Tim Duit, Duit Construction
	• Facilitated discussion
		• How is the use of UAS in your field transferable to highway use?
		• How are construction companies currently utilizing drone technology? What are some lessons learned to date?
		• How has the use of this technology made your work more efficient and cost effective?

	Lunch (12:00 – 1:00) • Lunch on your own- see list of nearby restaurants	

3	**Future use of UAS technology** (1:00 – 2:00)
	
	• UAS Operations 5-years in the Future
	  ○ Basil Yap, North Carolina DOT;
	  ○ Paul Wheeler, Utah DOT
	• Discussion on key challenges (payload, technology, operations, staffing, cost/benefit) to future implementation
	• Facilitated discussion
		• What are public sector potential uses of UAS?
		• What are potential future uses by construction firms of UAS?
		• What are the key factors to determine the cost-benefit ratio of UAS?
		• What are the needed research or outreach directions to further explore UAS effectiveness and application in highway infrastructure condition assessment?

	Break (2:00 – 2:15)	
4	Open Discussion (2:15 – 3:30)	

Session	Description	Questions to consider
	• Round Robin Discussion about key topics discussed during the day • Discussion of possible next steps	
5	**Roundtable Wrap-Up** (3:30 – 4:15) • Summary of Key Lessons Learned discussed at the roundtable • Summary of Recommendations for Future Efforts and Next Steps ○ James Gray, FHWA • Completion of roundtable evaluations	