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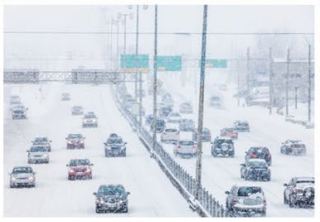


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EDC-5 UAS Peer-to-Peer Exchange

Work Zone Peer Exchange-Columbus, Ohio

October 18-19, 2022

U.S. Department of Transportation
Federal Highway Administration

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16. Abstract: This peer exchange brought together State Departments of Transportation (DOTs) to discuss and share UAS work zone management practices. States that have implemented UAS programs have found that the using UAS can save time and money, and increase safety and efficiency of construction zone management, traffic operations, and inspections in the field. This report is a summary of the information presented by the Ohio, Alabama, Delaware, and Minnesota DOTs during the work zone peer exchange. The information summarized was current and accurate at the time of the peer exchange, held on October 18-19, 2022.			
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CONTENTS

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ALDOT	Alabama Department of Transportation
CFR	Code of Federal Regulation
COA	Certificate of Authorization
DelDOT	Delaware Department of Transportation
DOT	Department of Transportation
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
LAANC	Low Altitude Authorization and Notification Capability
ODOT	Ohio Department of Transportation
SOPs	Standard Operating Procedures
TMC	Traffic Management Center
UAS	Unmanned Aircraft Systems
USC	United States Code

BACKGROUND

The Federal Highway Administration (FHWA) sponsored a peer review session to Unmanned Aircraft Systems (UAS) programs across the country and share innovative uses of UAS. The Ohio Department of Transportation (ODOT) hosted the UAS peer exchange, which was held on October 18-19, 2022, in Columbus, Ohio. The peer exchange focused on how using UAS in work zones can increase data collection, safety, and efficiency. Presentations also included an overview of UAS training, risk assessment, bridge inspections, data management, technology limitations, emergency management, UAS funding, and thermal imagery. This report summarizes information presented by the Ohio, Alabama, Delaware, and Minnesota DOTs. The information was current and accurate at the time of the peer exchange.

The following State Departments of Transportation (DOTs) were represented at the peer exchange:

- Alabama DOT
- Arizona DOT
- Delaware DOT
- Illinois DOT
- Kansas DOT
- Massachusetts DOT
- Michigan DOT
- Montana DOT
- Nebraska DOT
- Nevada DOT
- New Hampshire DOT
- North Carolina DOT
- Ohio DOT
- Pennsylvania DOT
- Tennessee DOT
- West Virginia DOT
- Wyoming DOT

PRESENTATIONS

UAS can provide State DOTs with immediate data to make informed decisions and improve situational awareness. UAS can also enhance safety for the traveling public and crews in work zones or in hard-to-reach areas.

State DOTs leaders engaged in discussions regarding:

- Starting UAS programs within their respective departments while contemplating project size, budget, and scope.
- Planning and monitoring work zones.
- Reducing work zone impacts and increasing safety.
- Considering technology needs, including those for data sharing and storage.

Two panel session discussions were held on UAS fleet management, practice sharing and standard operating procedures (SOPs), budget management, collaboration, public involvement, and data management.

GETTING STARTED WITH UAS

State DOTs which are initially integrating UAS into their operations may consider Federal Aviation Regulations (FAA), training, agency goals, pre-mission planning, and the operating environment.

FAA Regulations

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 as well as the requirements for the remote identification of unmanned aircraft. 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/

Training

The Alabama State DOT shared the importance of providing staff with practical UAS training that can help them develop core level competency, establish use case-specific training, and increase flying proficiency, which can help avoid crashes and material losses of equipment.

Existing training resources for UAS are available through various organizations, a list of these resources is included in Appendix A. Another training resource discussed at the peer exchange was a UAS simulator developed by the South Carolina DOT, in partnership with Clemson University, using funding from a State Transportation Innovation Council grant. This training simulation eventually became a practical class to provide UAS pilots with basic training and training for bridge inspections. As part of the funding agreement, State DOTs can obtain up to 10 free licenses for training through the hosting organization, Clemson University. The only associated cost is the purchase of a controller capable of interacting with the simulation program.

Pre-Mission Planning

The following list of best practices for pre-mission planning was identified from discussions between presenters from the Ohio, Alabama, Delaware, and Minnesota DOTs:

- Consider what documentation is needed before data collection.
- Determine UAS needs (fixed-wing or rotorcraft) based on project goals and environmental assessments.
- Keep software and data management needs in mind.
- Bring additional battery sources and supplies, especially if operations are occurring in remote areas.
- Have a backup plan if a UAS malfunctions and remote pilots are located far away from the duty station.
- Determine if the memory card at hand is the appropriate size as it can affect data collection operations, especially if pilots are conducting a mapping operation.

Environmental Considerations

Additional environmental considerations shared in the group discussion regarding planning operations included:

- Obstructions (powerlines may cause anomalies with the signal, birds could impact aircraft, and landing and takeoff zones might affect line of sight).
- Airspace (is the airspace restricted, controlled, proximity to airports, hospitals, or other air traffic).
- Population (urban, rural, are there vehicles nearby or radio interference).

UAS FOR WORK ZONE PLANNING AND MONITORING DURING CONSTRUCTION

The Ohio Unmanned Aircraft Systems Center is under ODOT's Drive Ohio and Fly Ohio umbrella and was formed in 2013. The Center helps develop policies and procedures on proper use of UAS statewide and serves as a shared resource for other State agencies (e.g., the Ohio Department of Public Safety, Ohio Department of Agriculture, and the Ohio Department of Natural Resources).

ODOT reported that the main reasons that it incorporated UAS use into its operations is because UAS enables the agency to increase efficiency by saving time and money while also increasing safety in agency operations. Some uses of the ODOT UAS fleet include:

- Aerial photography/GIS.
- Exterior/interior inspections.
- Construction progress monitoring.
- Traffic monitoring.
- Natural disasters/emergency management.
- Communications and public engagement/promotional videos.
- Work zone management.

The ODOT UAS Center has a UAS Deployment Program; staff involved with this program noted that training non-traditional pilots, including bridge inspectors, engineers, surveyors, and other traffic staff to specialize in UAS flying was helpful. This has also allowed bridge inspectors and surveyors to become self-sufficient in their roles. The staff obtain a remote pilot certificate under 14 Code of Federal Regulation (CFR) Part 107, and then ODOT provides an additional 10 hours of solo flying time along with training on risk assessment and flight planning before staff can operate UAS in the field.

ODOT outlined multiple examples from various projects on how UAS can be a helpful tool in construction work zones. Figure 1 depicts a highly complex project in Toledo, Ohio, where a bridge is being constructed over water. ODOT used UAS to provide overall project situational awareness of the construction equipment, traffic patterns, and the level and flow of the water. At times, UAS were used to live-stream video of this project to engineers in their office to collect and show specific data in real time.

Figure 1. UAS-captured image of complex project in Toledo, Ohio.(Source: ODOT)

Figure 2 depicts one of ODOT's most common uses of UAS, which is for ongoing construction progress monitoring. ODOT reported using UAS weekly across an average of 12 work zones to capture aerial images and videos to document the overall progression of these construction projects.

Figure 2. UAS-collected construction progress monitoring images.(Source: ODOT)

Figure 3 is a UAS image of a work zone where the four roads approaching the intersection are being widened. UAS are used on this project to assist with traffic monitoring, construction equipment and personnel placement, and overall project progression. ODOT staff reported that UAS helped staff understand traffic patterns, which resulted in changing the placement of barricades and traffic control equipment to increase safety of workers.

Figure 3. ODOT used UAS to assist with placement of traffic control equipment to increase safety.(Source: ODOT)

In addition to the above examples of how UAS can be used in active work zones, ODOT also discussed efforts to eliminate work zones. ODOT reported that utilizing UAS technologies allows the agency to keep more agency personnel off the road, which increases safety. One of the best examples where this has been successful is in bridge inspections. ODOT reported that UAS has enabled more frequent data collection, allowing the agency to change its policy to inspect bridges with snooper trucks every other year rather than annually. This results in fewer work zones and increases safety, efficiency, and high-quality data.

UAS FOR UNPLANNED WORK ZONES/TRAFFIC MONITORING

At times, State DOTs may seek to use UAS in unplanned work zones or for traffic monitoring during an emergency situation. Representatives from the Delaware Department of Transportation (DelDot) discussed their familiarity with unplanned flight operations and the requirements to fly in controlled and uncontrolled airspace. DelDot staff recommended that State DOTs know what airspace requirements exist in their respective areas and establish systems in place ahead of time.

Data Sharing

DelDOT mainly uses the methods described below to share information regarding emergency traffic monitoring and other situations:

- Using third-party software with a live-streaming service that works over the internet and is designed for cellphone and mobile hot-spot speeds. No special hardware is required, and setup is quick and easy. The live-streaming has extremely low latency (1 second), and users can securely send an invitation protected with a PIN code to others outside the organization so they can join the live session.
- Users can send video directly to the Traffic Management Center (TMC) and only people with prior access to the software can view the feed. This tool operates over a private cellular network.

UAS HARDWARE AND SOFTWARE FOR WORK ZONE MONITORING

The Alabama Department of Transportation's (ALDOT) UAS Program was created in 2016. Since then, the program has grown significantly, and ALDOT currently has six full-time pilots on board. ALDOT's UAS program is centrally located and responsible for the whole State. In 2021, ALDOT UAS pilots flew more than 4,000 flights.

ALDOT staff offered the following recommendations for starting a UAS program:

- It is important to consider what type of program a State DOT has the capacity to create—centrally located, separated into regions or districts, or having consultants on board.
- Having a set of SOPs may be beneficial to establishing a streamlined set of training and operating practices throughout the UAS program.
- There are many different types of hardware, software, and applications for UAS, and it may be helpful to determine which types (or combination of types) best fit the needs of the UAS program.
- Storage and processing of UAS data could be a challenge due to the size of the files and type of data being shared. Therefore, Information Technology department support may be beneficial to determine best practices in storing, processing, and sharing the data, and ultimately integrating the data into current workflows.

With its existing hardware and software, ALDOT is able to produce progress overviews with UAS flights over construction projects by conducting daily flights and producing auto-generated weekly progress reports. The software also allows ALDOT to create shareable links for stakeholders and to live-stream video to assess natural disasters quickly.

Figure 4 depicts one of ALDOT's progress reports from a smaller active work zone. Each icon in the progress report is a live link that stakeholder can click to view photos, panoramas, videos, or models of the project.

Figure 4. ALDOT construction progress report using UAS data.(Source: ALDOT)

Figure 5 outlines one of the larger projects ALDOT has flown with UAS. In 3.5 days, ALDOT UAS pilots conducted 42 flights using a fixed-wing UAS to survey 75 miles of the West Alabama Highway. Each night staffers processed the UAS-collected data; this allowed them to deliver a complete data package in one week. ALDOT reported the use of UAS on this project allowed it to save significant time and personnel-hours over traditional methods.

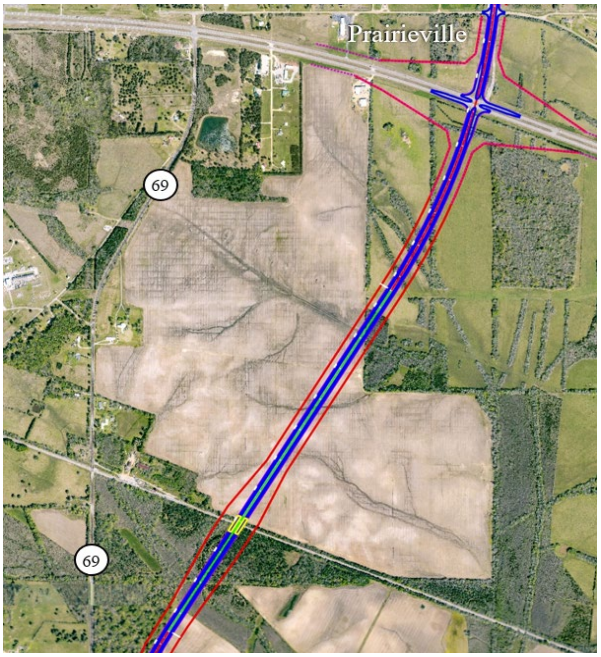

Figure 5. ALDOT used fixed-wing UAS to capture data on 75-miles stretch of highway. (Source: ALDOT)

ALDOT UAS pilots also assist bridge inspectors throughout the State to conduct routine and emergency bridge inspection. ALDOT requires the full-time UAS pilots to complete training specific to bridge inspections, so they are familiar with bridge inspection terminology and methodology. Representatives from ALDOT report that the implementation of UAS on bridge inspections has resulted in high-quality data, useful 3D models, and increased safety by minimizing or eliminating the impact of active work zones and traffic control. Figure 6 depicts pre-mission planning with UAS software prior to beginning a bridge inspection.

Figure 6. UAS software allows for pre-mission planning prior to the bridge inspection.(Source: ALDOT)

To improve context capture models, ALDOT staff recommended adding QR codes or adding something to the structures to change the texture temporarily so that the software better captures the different edges and corners and can tie in all images together. This can prove useful when dealing with water reflections and different materials such as concrete and steel.

ALDOT staff offered the following lessons learned from standing up the UAS program:

- Take time and research the different available hardware and software.
- Proficiency leads to efficiency. To train highly effective pilots, it is helpful to train in different scenarios.
- Lean on established UAS programs and industry experts.

- Safety is enhanced with the use of UAS, it is important to share key findings with leadership for continued support.
- Track and document return on investment.

UAS FOR REDUCING WORK ZONE IMPACTS AND INCREASING SAFETY

The Aeronautics UAS Team at MassDOT works closely with the Highway and Massachusetts Bay Transit Authority divisions. The team also partnered with the FHWA in its "Everyday Counts" initiative to identify where UAS can provide the best use cases and value to supplement data collection initiatives. MassDOT's current use cases are emergency management, monitoring construction sites, tracking traffic flows and patterns, and mapping transportation assets. MassDOT UAS pilots have conducted more than 3,000 successful flights. Additionally, MassDOT partners with a State integration program that works in conjunction with private industry, academia, and other State and Federal agencies to support UAS innovation and commercial use of UASs in the State.

MassDOT's Aeronautics UAS Team was formed in 2017 and regulates UAS use by vendors and contractors that fly on behalf of MassDOT. The Aeronautics UAS Team ensures safe flying along MassDOT's infrastructure such as highways, light rail, and airports. The Aeronautics UAS Team also provides UAS data to support transportation infrastructure projects and fuel innovation in industry and academia.

MassDOT is focused on working collaboratively across transportation divisions because there is sometimes an intersection between rail and highway systems, and such collaboration has proven helpful in providing better bridge inspections, mapping, and surveying along with overall asset inspections of rail, tunnel, electrical, and other airport systems. The team has also been able to provide enhanced support with UAS to emergency management operations across the State by partnering with State and Federal agencies.

As MassDOT has grown its UAS program, it values the use of a steering committee that assists with the alignment of stakeholders and the development of SOPs for UAS operations. The program is currently expanding and is training additional remote pilots across other departments within the agency. MassDOT has recognized the need for a well-developed data management plan to process and store the large amount of UAS data being collected. Figure 7 outlines the high-level workflow for UAS data

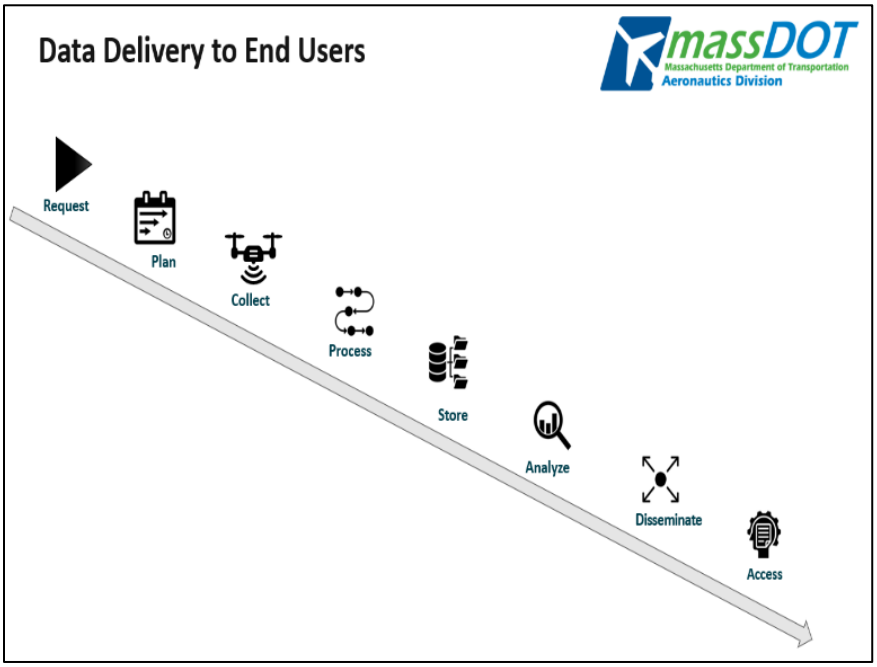

Figure 7. MassDOT's Data Management Overview. (Source: MassDOT)

management within MassDOT.

MassDOT reported that it has found UAS to be a tool that contributes to increasing work zone safety. Presenters from MassDOT expressed concerns about working on a busy bridge or roadway with only cones as a separation barrier. UAS has enabled MassDOT to reduce the need for work zones. As an example, presenters shared Figure 8 from the inspection of a busy bridge in the Boston area.

Figure 8. MassDOT use UAS on bridge inspections to reduce work zones.(Source: MassDOT)

MassDOT representatives indicated that using UAS in construction monitoring has increased safety by minimizing the need for lane closures. The agency uses various software programs to create and deliver progress reports and provides UAS livestreams of construction sites to key stakeholder groups when requested. Figure 9 is an image captured from a UAS live-streaming mission of a bridge replacement. The UAS was able to provide real-time situational awareness and data to guide decisions throughout the project.

Figure 9. UAS monitoring of active construction projects. (Source: MassDOT)

CONCLUSIONS FROM THE PANEL SESSIONS

Through individual presentations and facilitated panel discussions, the State DOT representatives presented and identified proven successful practices. They said this information could be especially beneficial to other State DOTs as they:

- Implement UAS programs within their departments.
- Grow UAS departments and develop capacity and scope of work.
- Communicate the benefits and possible limitations that might exist when implementing UAS technology within existing work.
- Identify additional areas of need.
- Determine next steps.

The panel discussion provided the opportunity for the audience to interact with various State DOTs representatives who made presentations throughout the peer exchange. Questions to panelists covered a large range of topics related to UAS programs overall. A list of the high-level conclusions as a result of this roundtable discussion is provided below.

- MassDOT expressed the importance of employing software to assist with fleet management to actively monitor all UAS and related equipment such as batteries and controllers. ODOT also shared how useful it is to track each flight, including flight time and which pilot conducted the operation.
- ALDOT has a full-time position within its UAS program responsible for fleet management and maintenance of the program's UAS. ODOT has a similar system in place for internal maintenance and has followed traditional aviation schedules regarding aircraft maintenance and conducts 50-hour and 100-hour inspections.
- DelDOT takes a different approach and performs little to no internal maintenance on the program's UAS; it sends all repairs and required maintenance to the UAS manufacturer.
- State DOTs may consider the use of an internal UAS pre-mission approval system that accounts for levels of risk.
- Different types of funding may be available to start and grow a UAS program. DelDOT shared that a lot of its funding comes from State or Federal grant programs, whereas ODOT is currently funded by discretionary funds but is pursing being able to qualify for State gas tax funding as UAS are used to help maintain and build the roads. ALDOT's UAS program is funded by the Alabama Department of Transportation general fund.
- MassDOT expressed the importance of tracking return on investment when using UAS to justify the funding ask.
- DelDOT shared how it demonstrated the utility of UAS and invited decision makers, including the State governor, to come participate in flight demonstrations. ODOT also seeks to demonstrate what a powerful tool UAS can be and used UAS assisted bridge inspections as a prime example of increased work zone safety, minimized impact on traveling public, and cost savings.

FLIGHT DEMONSTRATIONS

The second day of the workshop focused on the practical aspect of UAS through flight demonstrations. ODOT organized field trips to help attendees understand the technology and demonstrate how the department has integrated UAS technologies in its operations. The first segment of the day was spent at the Ohio TMC to see a live-streaming demonstration using UAS to broadcast videos and imagery to the TMC.

During the second portion of the day, ODOT provided a hands-on demonstration to let attendees see the technology in action for the various UAS platforms that ODOT uses across its operations. ODOT also demonstrated a Contingency Management Platform (CMP). The CMP utilizes three separate Unmanned Traffic Management radar systems placed around Columbus, Ohio. This system offers airspace services, such as aircraft detection and situational awareness, conflict detection, health monitoring, and various weather services to help ensure the safe operation of all unmanned aircraft. Additionally, this system will be placed in ODOT's UAS Center's air operation center in the fall of 2023.

Figure 10. Visit to the Ohio TMC. (Source: FHWA)

Figure 11. UAS demonstrations of Various Platforms. (Source: FHWA)

KEY CONCLUSIONS FROM THE PEER EXCHANGE

The peer exchange captured how State DOTs that have implemented the use of UAS have seen an increase in work zone safety, cost savings, and overall efficiency. The increase of safety is largely a result of minimizing or removing the need of active traffic management and work zones by using UAS to inspect infrastructure or monitor construction projects and traffic. Other key takeaways include:

- UAS can provide high-quality, real-time data that increases situational awareness and improves overall decision-making.
- Documenting return on investment on UAS programs and determining cost analysis can help increase buy-in and expansion of UAS programs within State DOTs.
- Sharing information with other State DOTs and industry partners on best practices can improve UAS programs.

- Tracking fleets, number of flights, types of projects, and pilot training can provide insights on efficiencies and can help scale UAS programs over the long term.
- Having a champion who pushed for the adoption of a program by leveraging available resources and knowledge and experience can be invaluable for those State DOTs with advanced UAS programs.
- Using UAS can save time and money, and increase safety and efficiency, according to those States that have implemented UAS programs.

APPENDIX A: UAS TRAINING RESOURCES

Below is a list of organizations which provide information that may be helpful for UAS training, each organization is linked to the respective website:

Federal Highway Administration

Federal Highway Administration EDC-5

Federal Aviation Administration

National Institute of Standards and Technology