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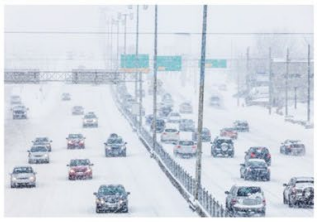


Mobility · Safety · Quality · Environment · Shortening Project Delivery

EDC-5 UAS Peer-to-Peer Exchange

Arizona Department of Transportation, Arizona State Land Department & Arizona Commerce Authority

June 2-3, 2021

U.S. Department of Transportation
Federal Highway Administration

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16. Abstract: This virtual peer exchange brought together representatives from the Arizona, Ohio, Alaska, California, and Utah Departments of Transportation. The peer exchange facilitated discussion and collaboration around Unmanned Aircraft Systems (UAS) practices and UAS use cases across infrastructure inspections, emergency response, roadway analysis, earth movement, traffic management, construction, and risk management. While the participating transportation agencies are at various stages of implementing UAS across operations, each agency reported benefits from utilizing UAS. The information contained within this report was up-to-date at the time of the peer exchange on June 2-3, 2021.			
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Introduction

As part of the Federal Highway Administration (FHWA) Every Day Counts Unmanned Aircraft Systems (UAS) Initiative, the Arizona Department of Transportation (ADOT) hosted a peer exchange on June 2-3, 2021. The goal was to share how the State DOTs in attendance use UAS across its operations, discuss practices, and foster collaboration. This report provides an overview of ADOT's UAS program and UAS use cases as presented by various attending State DOTs. The information was up-to-date at the time of the peer exchange. Participants from the following organizations were at the event.

- ADOT
- Arizona FHWA Division
- Arizona State Land Department
- Arizona Commerce Authority
- Utah FHWA Division
- Federal Aviation Administration (FAA)
- Arizona Department of Public Safety
- City of Tucson
- Utah Department of Transportation (UDOT)
- Ohio Department of Transportation (ODOT)
- California Department of Transportation (CalTrans)
- Alaska Department of Transportation

ADOT UAS Program

ADOT began using UAS in 2017 and built its program by procuring several UAS platforms through a grant from the Arizona Council for Transportation Innovation. ADOT has found UAS beneficial for bridge inspections where it provides access to hard to reach areas and allows personnel to work more safely and efficiently than in the past using conventional methods. ADOT reports that UAS are tools that have realized time and money savings within the agency. ADOT is using UAS in the following use cases:

- Assistance with the creation of Digital Terrain Models (DTMs).
- Construction, progress monitoring, and inventory management.
- Public outreach efforts.
- Traffic incident management.

In May 2017, ADOT first used UAS in the Engineering Survey Group to supplement conventional surveying methods. The Engineering Survey Group continues to expand UAS utilization across surveying, communications, bridge operations, and construction reporting and inspections.

ADOT began flying UAS on projects in July 2017, and by January 2021 had completed over 640 total missions and operated four different UAS platforms. ADOT's communications division purchased an initial UAS platform in early 2018 with assistance from an FHWA State Transportation Innovation Council (STIC) grant. By July 2018, ADOT had three FAA-certified remote pilots. The bridge inspection and geotechnical teams purchased eight UAS platforms in March 2018. In addition to the specific use cases discussed below, ADOT is also using UAS for mapping, documenting findings and project status,

recording construction progress, inspecting bridges, and identifying geological hazards where access is limited or deemed unsafe for employees.

ADOT has found that UAS have been cost effective, easy to mobilize, require fewer staff, and often do not require traffic control.

As part of its process, ADOT requires crews to do thorough pre-data collection mission planning to identify risks and ensure a safe operation. The field documentation required for a flight includes a flight plan, sectional chart, pre-flight checklist, flight log and aircraft inspection, certificate of insurance, airspace authorization, and UAS registration forms.

ADOT Use Case Examples

Traffic Monitoring

ADOT has used UAS to collect video data of roundabouts to help traffic engineers understand how large trucks navigate through the roundabout and how to mitigate any issues (Figure 1).

High resolution UAS imagery lets the engineers clearly see and better understand the assets (e.g., approach slaps, rumble strips, right-of-way fencing) on the roadways better than other tools.

Figure 1. SR-60 Cherry Creek Roundabout UAS Data Collection (Image ADOT)

Hazmat Cleanup and Mitigation

Other UAS uses for ADOT include using UAS to assist with hazmat cleanup by providing aerial data to understand the scale of the project which can inform the best resources needed to mitigate the incident. Information gathered via UAS confirmed that areas are cleaned up properly and provide high quality documentation of the operation.

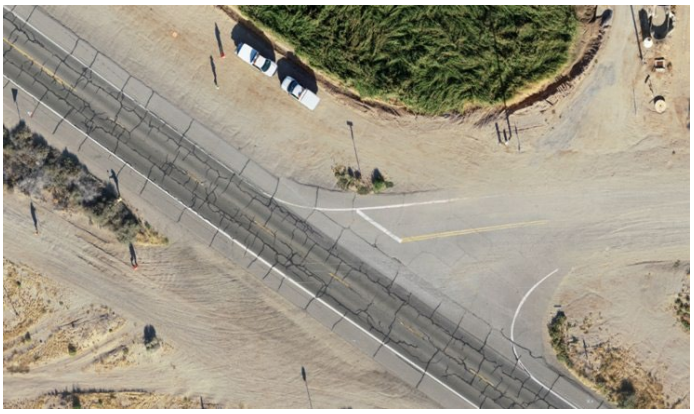

Figure 2. ADOT Pavement Inspection with UAS Data (Image ADOT)

Roadway Condition and Analysis

ADOT has also found success using UAS for pavement condition analysis. Teams were able to identify distresses in the pavement from longitudinal and thermal cracks captured via aerial imagery with UAS. (Figure 2) Furthermore, ADOT could analyze cut slopes and determine the proximity to the clear zone to ensure that adequate recovery zones were provided to mitigate accidents.

Earth Movement

ADOT has found that UAS can provide a new and valuable perspective that cannot be captured from the ground. UAS images allowed ADOT to determine where drainage problems occurred and provided insight into how to alleviate and mitigate future problems related to earth movements. UAS also identified

large boulders in other areas, allowing ADOT to plan for mitigation in this area where the rocks could affect the roadway below. UAS can assist with hazard identification without the need for workers to climb steep slopes and traverse dangerous terrain (Figure 3). The imagery can also be used to generate point clouds and digital terrain modules that can assist with quantities and help identify the resources needed to clean up sites.

Figure 3. Rockfall assessment (Image ADOT)

Right-of-Way Parcels

ADOT has used the aerial imagery provided by UAS to view right-of-way parcels overlayed with text to provide overall views of the property, including dwellings, improvements, and amenities.

Construction Progress

UAS has been instrumental in capturing data for ADOT construction progress. The images provide a visual reference for planning meetings with internal stakeholders such as crews and subconsultants. The images are also shared with external stakeholders such as the greater public to inform them of the status on various projects. The data also provide dated evidence of work completed.

Bridge Inspection

The bridge inspection team used UAS imagery to inspect for defects that could affect the structural integrity of the bridge. ADOT reports the inspections using UAS can help to identify items that could lead to a catastrophic failure. The ability to quickly mobilize a UAS and start the inspection process increases productivity and allows staff to perform operations in a safe environment away from traffic. UAS are a supplemental tool for bridge inspection and not a replacement for National Bridge Inspection Standards requirements.

ADOT has used UAS to realize the following key benefits:

- Improve operations, save time and money, and increase safety and efficiency. ADOT noted that the more UAS use it sees, the more convinced the agency is that that UAS will have a positive impact on the transportation industry.
- Leverage stakeholders expertise and perspective.
- Increase accountability of the agency through transparent and open coordination.
- Improve access to decision-making processes, resulting in the delivery of more efficient and responsive services.
- Identify synergies between stakeholders to drive innovation that encourages integrated and comprehensive solutions to complex issues.

Every Day Counts 6, Next Generation Traffic Incident Management Overview

EDC-6 NextGen Traffic Incident Management (TIM) focuses on working with State, local, and tribal stakeholders to improve TIM on all roadways by integrating proven, yet underutilized, innovative technology, data, and training strategies. More information can be found at: https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/nextgen_tim.cfm

NextGen TIM focus areas include:

- Expanding TIM programs to all roadways, including local roads.
- Training responders.
- Using TIM data for better safety and operational decisions.
- Innovating technologies that are proven yet underutilized at State DOTs.

Arizona has made a lot of progress with TIM data and has become a leader on providing examples of how TIM collected data can be used. The State plans to integrate additional technology opportunities into TIM, including computer-aided dispatch integration, UAS use for incident management, and video sharing between Transportation Management Centers (TMC) and responder vehicles. Arizona hopes to complete computer-aided design (CAD) integration between ADOT and the Department of Public Safety to explore expanded use of UAS.

Areas that have shown promise for UAS use for TIM are:

- Traffic crash investigation.
- Situational awareness.
- Detour route monitoring.
- Queue detection and monitoring.
- Secondary crash detection.
- Response vehicle routing.

Utah, Puerto Rico, and Washington State are also using UAS for TIM. The Utah DOT has all of its incident management vehicles equipped with UAS and all members of the incident team are also FAA-certified remote pilots. Puerto Rico is using UAS for TIM training with its police academy. It is also testing use of UAS for real-time monitoring to share with TMCs for alerts. The Washington State Patrol found that UAS provided an economic savings of $4,210,500 and can provide an 80 percent reduction in road closure time compared to other methods used in measuring scenes (Figure 4). Furthermore, Washington found its State investigators are safer by not being in the roadway taking measurements, and UAS allows investigators to clear the scene quickly, minimizing exposure to risks.

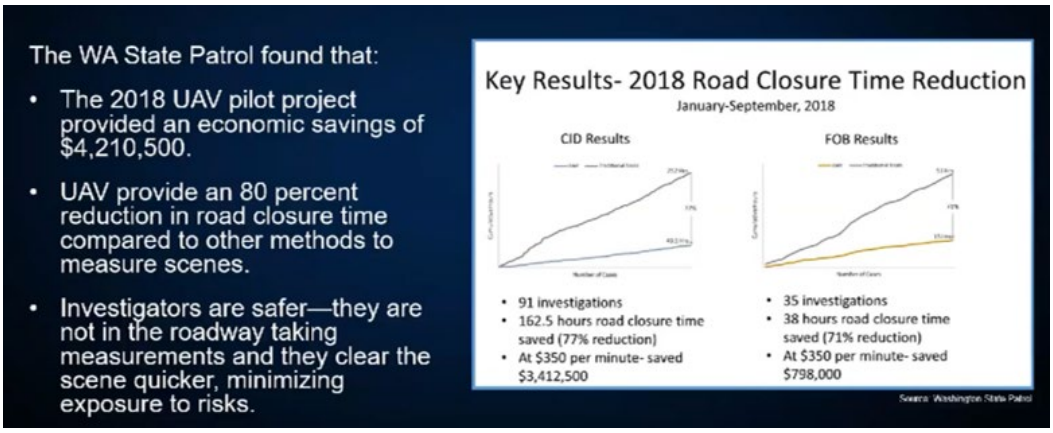

Figure 4. Savings of UAS for TIM (Source Washington State Patrol)

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/

How to Start up and Grow a UAS Program

Information was presented about how to start and grow a UAS program, and lessons learned from development and implementation of other programs from infancy to more advanced operations. The importance of having an end goal in mind and determining areas where UAS can assist to improve safety, increase efficiency, and supplement existing tools was discussed. State Aeronautics divisions can be an integral partner to help with these endeavors.

The presentation covered the following topics:

- Overview of UAS platforms and remote sensors.
- How to obtain executive support when starting and growing a program.
- UAS organizational structures across the nation.
- Policies and procedures for success.
- Importance of public engagement when using UAS and best practices.
- Differences in UAS platforms, the strengths and weaknesses of each type, and best use cases for each.
- Establishing a successful UAS training program.
- The importance of establishing safety and risk management as a keystone for success.
- Importance of a good UAS fleet and remote pilot management solution.
- Having a plan and solution for UAS data management.
- Lessons learned on ways to innovate existing processes at State DOTs through the use of UAS and how best to integrate UAS into multiple divisions of a DOT.

Key Takeaways:

- Find easy wins or low-hanging fruit when starting out. There are many resources available to help through the FHWA, other States, and the FAA.
- Provide a viable plan in the beginning for data management and include the Information Technology department in the conversations.
- Properly manage all resources to prevent issues as the program grows and to increase productivity.
- Help other divisions understand what UAS can do to assist its operations.
- Ensure a safety culture for all UAS operations.

UAS Innovations in Arizona Panel Session

State Perspective – Arizona Department of Public Safety

The Arizona Department of Public Safety started its UAS program in 2017 within a vehicular crimes unit. The department is using UAS for:

- Crime/collision scene documentation.
- Hazardous materials incidents.
- Surveillance/scouting.
- Public relations.

- Training.
- Aerial photography.
- Radio tower inspections.

The Arizona Department of Public Safety has approximately 45 FAA certified remote pilots and 45 UAS, and it hopes to procure additional UAS in the coming months. The department has its own training program with an enrollment cap of 8 to 10 remote pilots per class. In an evaluation of UAS the department has found significant time savings over traditional methods. Presenters reported UAS has been a tool which contributes to the overall safety to the traveling public on Arizona's roadways. It found that larger scenes realized greater savings with UAS over a traditional Leica TS-12 for documentation. It also found UAS collected more useful data of the entire scene (rather than individual gathered by traditional equipment) that helped the department to better understand the scene in its entirety. In addition, staff did not have to be as selective about what information was collected due to time constraints. By collecting data from the entire scene, the entity receiving the data can select what it feels is important as opposed to having the data collection crew only collecting what they understood to be valuable for the collection effort.

UAS data collection has improved the department's process of scene diagramming by providing a better image of the actual scene rather than linework in a diagram. Creating three-dimensional (3D) models of the scenes allows staff to better visualize the data, which also allows the creation of fly throughs at different speeds to simulate what a driver or occupant may have experienced. Using UAS also provides staff with the capability to better analyze a scene without any impacts to the roadway. For night flights, the department has found it beneficial to use lighting directly on the UAS to illuminate the scene rather than lights on the ground. This technique provided the best illumination and prevented unwanted shadows on the areas of interest.

Local Agency Perspective – City of Tucson

The Department of Transportation and Mobility of Tucson was the first city transportation agency to start a UAS program. In 2015, the department started its own program to provide UAS capabilities in-house as an effort to reduce the need to hire contractors. The department was able to get support from executive leadership to start a UAS program and it currently has three FAA-certified remote pilots for operations. The department primarily uses UAS to update orthophotos, which fills in gaps for new construction to ensure it has the latest imagery on its GIS servers for use. The department has also found success using UAS to create 3D models for zoning infractions to determine building heights. The department reported the conventional method was time consuming and expensive, while the ability to use UAS has greatly increased productivity in this area. To have accurate data it necessitated the use of ground control points (GCPs). UAS has also been beneficial to calculate volumes for water basins before and after rain events. Traffic congestion studies are an additional area where the department has used UAS to hover above the intersections to better understand light cycle changes and its impacts on traffic.

The city of Tucson reported UAS provides a tool to view data from a new perspective, and allows the city to be more transparent with the public. UAS can provide the public with a bird's eye view to help average citizens better understand the magnitude and scale of a particular project. UAS has also allowed the department to be more creative in its messaging by actually showing what is happening rather than trying to describe it with words. The department can provide the data to the media and the community to better tell a story and expand the knowledge of what is happing in the city. For projects with a long duration UAS helps to illustrate progress and provides the department an effective mechanism to interact with the community.

Breakout Sessions – Day 2

While the first day of the peer exchange provided the foundation for the workshop, the goals of the second day were to highlight some best practices and innovations seen nationally and to share lessons learned. Day Two included breakout sessions regarding the following specific use cases for UAS operations:

- Traffic Conditions/Incident Management
- Emergency Management
- Construction

Traffic Condition/Incident Management

Representatives from ODOT's Ohio UAS Center and UDOT both presented in this breakout session.

The Ohio UAS Center was stood up in 2013 to:

- Support and conduct UAS operations within ODOT.
- Develop UAS policy and procedures.
- Review proposed UAS operations for ODOT contracts.
- Provide services to external users (shared resource).
- Support State and Federal agencies and State universities.
- Promote the safe and proper use of UAS throughout the State.
- Reduce redundant UAS functions within the State.
- Allow for more efficient use of resources.

The Ohio UAS Center has increased operations and use cases to innovate operations. In the last three years, the center has logged more than 4,400 flights and participated in 1,168 projects. UAS have been used to assist with traffic monitoring, analyze traffic hot spots, and monitor special events. Some highlighted projects include monitoring UAS for signal timing. The data helped inform decisions to mitigate traffic congestion areas at peak traffic times.

UDOT discussed how it has integrated UAS into all of its incident management team (IMT) operations and added an FAA remote pilot certificate as a requirement for IMT staff. UAS are standard equipment on UDOT incident management vehicles, and UDOT has found UAS to be a valuable tool for situational awareness at the scene, including providing the queue locations and to determine potential ways for other response vehicles to enter the scenes. A secondary area where UAS has helped is with the towing and recovery industry. UAS can provide data that allow the towing and recovery teams to respond with the appropriate equipment and reduce the time required to clear the incident scene. For incident mapping, the IMT works alongside the Utah Highway Patrol to map incidents. Once the incident is mapped, the data is validated in the field to ensure that the images are clear and meet the defined goals for the collection. If an IMT member flies the UAS, once the data is verified, the raw data (micro-SD card) can be provided to the Utah Highway Patrol for further processing and analysis. The process helps with the data chain of custody to ensure an efficient process for scene mapping and analysis. UDOT has found that using this approach allows for an efficient scene management and staff can be allocated to assist with scene clearance to improve safety for the traveling public.

Emergency Management

The emergency management session discussed responding to earth movement events and natural disasters. Representatives from CalTrans provided a presentation for this breakout session.

The presentation discussed the distinctions between different types of disasters and how to best use UAS for hurricanes, landslides, earthquakes, and flooding. The seven missions for UAS disasters and four

guiding principles to help agencies decide when and how to use UAS, as well as six misconceptions to avoid were also discussed.

It classified the phases of a disaster into four categories: (1) prevention, (2) preparedness, (3) response, and (4) recovery.

Considerations when determining how to use UAS for disasters can be based on:

- Size of the area or work envelope.
- Topology of the area.
- Access to the area.
- Airspace density and regulations.
- The specific goals for the missions.

The following four principles for success were also shared:

- Consider all phases of the disaster, not just response and recovery.
- Put a single person in charge of all UAS teams during a response.
- Determine the missions first, then match the assets to the mission using the "COPIED" workflow (Constraints [day, altitude], Operator factors [training, fatigue], Penetration or distance, Information to whom and when, Envelope the aircraft works in, and Duration of the flight).
- Make (and execute) explicit plans for collection, post-processing, and curation because UAS is all about the data.

An outline was presented about the potential benefits of using UAS during disaster response. The correct platform supporting data collection and the objective of coordination with other emergency management team members was discussed.

CalTrans presented on rapid steep terrain UAS mapping for landslides and storm damage. CalTrans has an 11-member working group to help determine best practices for using UAS for mapping. The CalTrans UAS program is managed through the Aeronautics division, which establishes rules for flying UAS for State purposes and tracks UAS use across the State for safety and compliance. CalTrans discussed the specific workflow for each flight, which is broken into three phases. The three phases consist of a Pre-flight, Flight, and Post-Flight with multiple steps in each phase to provide the desired output to create topographic maps and cross-sections to better understand the impact of the event and provide data for informed decision making. The complete workflow is illustrated in Figure 5.

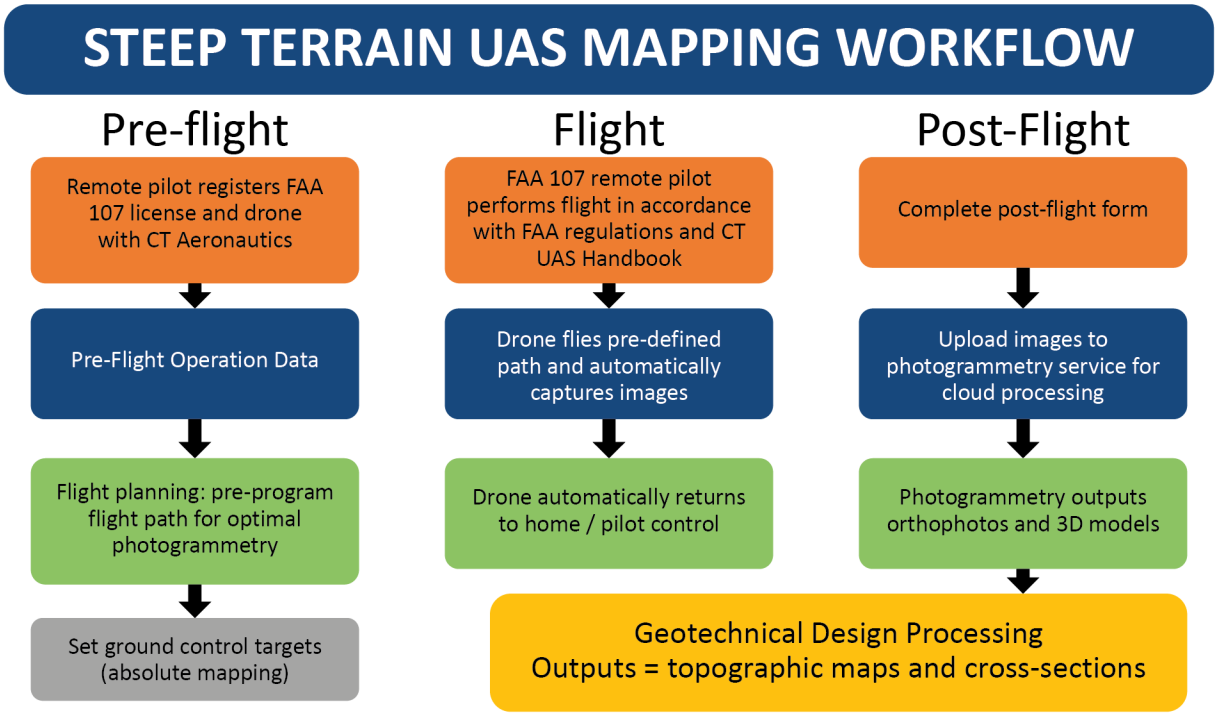

Figure 5. CalTrans Steep Terrain UAS Mapping Workflow (Image CalTrans)

CalTrans has used UAS for multiple earth movement events and has found it to be an integral tool to capture information that was difficult or dangerous for employees to collect in the past. CalTrans reported UAS is useful in capturing real time data and contributes to decisionmaking about roadway and other infrastructure in the vicinity of earth movements. UAS can quickly deploy and capture data, which increases productivity and produces high quality data that can be used to aid in the design-level decision-making process as well. CalTrans has used UAS to:

- Assess embankment failures.
- Assist in fire response.
- Monitor and mitigate rockfalls.
- Monitor small slips.

CalTrans identified the key takeaways for the UAS use cases highlighted as:

- Oblique aerial images to provide immediate visual observation of steep terrain sites, especially where staff safety was a concern.
- Video for reconnaissance and to better understand real-world rockfall and landslide behavior.
- Steep Terrain UAS Mapping-Photogrammetry to:
    - Create relative models of steep terrain sites to take accurate measurements.
    - Import slope geometries directly into geotechnical analysis software including slope stability analyses and rockfall simulation analysis.
    - Compare models over time to detect changes in site conditions.

Construction

The construction break out session featured presentations from Alaska DOT and Utah DOT.

Alaska DOT

Alaska DOT discussed the importance of having an operations manual that can standardize UAS operations across the State. It digitized its manual so it can be used with mobile devices in the field to make it easier for operators to access check lists and documentation, which can be essential when operating in remote areas that are miles away from any cities. Additionally, it also discussed the importance of data quality checks while in the field to help assist with accurate data, noting that it may be difficult to return to some of the remote areas where Alaska DOT operates.

During the Sterling Highway project in Alaska, UAS were used to gather data over various alignments. The project was spread over 14 miles with an estimated cost of $400 million. The Sterling Highway Bridge is one of the largest bridges in the State with a span of more than 800 feet. To assist with the data collection operation, Alaska DOT used multiple visual observers to ensure it maintained visual line of sight with the aircraft at all times. A portable battery pack instead of generators was used to change the batteries remotely to meet the charging needs faced in remote areas to continue the data collection efforts.

Lessons learned from Alaska DOT include improving the documentation of the data and ensuring that all aspects of the operation are documented. It learned that this can help to improve workflows and learn from each operation to make future projects more efficient through lessons learned. The same information can also be used to update the operations manual in an effort to capture the process improvements that each operation brings and to share that information across the organization.

UDOT

Utah DOT started researching UAS operations in 2010. It recognized the benefits early on but waited to fully create a program until 2016 when technology and the regulatory environment were advancing for UAS operations. The State DOT has 41 remote pilots and 40 UAS platforms across multiple divisions. Utah DOT uses rotorcraft and fixed wing aircraft with red, green, and blue (RGB) therma light detection and ranging (LiDAR) sensors.

It discussed the benefits of sharing the UAS data to help innovate processes and assist with data-driven decision-making. Utah DOT has found that UAS has been instrumental in helping across all phases of a project from concept and planning to post construction to help in collecting data needed to assist with the digital delivery process.

Utah DOT also found UAS helpful with data visualization particularly in collaborations with stakeholders. One example discussed was the use of UAS in working on a high profile project with the National Park Service. Utah DOT collected data utilizing a UAS in the national park, which was instrumental in stakeholder meetings to determine the best design alternatives for the site as well as resulting in cost savings and a more efficient project outcome.

Conclusion

Key takeaways from the peer exchange include:

UAS use is rapidly advancing across organizations

The use of UAS has been growing at many State DOTs and local organizations. There are a variety of use cases where State DOTs are using UAS technology, and have reported favorable results with increased productivity, enhanced safety, and the ability to improve the quality of data collection. State DOTs also reported the benefits of having a structured program to help with adherence to regulations and resources to assist with using UAS for multiple uses across an agency.

Grow a UAS program organically

Starting small and scaling a program as funds or resources are available was a common theme among the State DOTs which presented. This allowed the State DOTs to better understand the strengths and weaknesses of UAS platforms and sensors and ensure the transporation agencies were able to procure the correct tool for its needs.

UAS as a supplemental tool

Multiple State DOTs reported that using UAS as a supplemental tool for each functional area has helped to provide another "tool in the toolbox" that can provide benefits for safety and costs savings across the organizations.

Training

Training both from a knowledge and practical aspect was a common theme to help prevent incidents and improve the quality of the data collected.