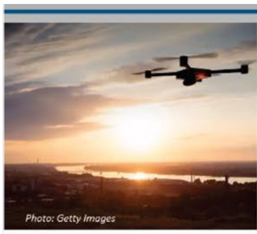

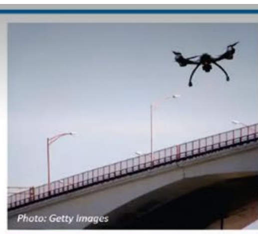

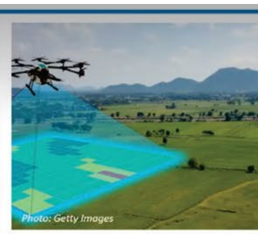


## Kentucky/Minnesota/Nebraska
## Unmanned Aerial Systems (UAS) Peer Exchange

# EDC-5 UAS Peer-to-Peer Exchange

UAS Peer Exchange-Minneapolis, Minnesota

**June 16-17, 2022**

U.S. Department of Transportation
**Federal Highway Administration**

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| CFR | Code of Federal Regulations |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| KYTC | Kentucky Transportation Cabinet |
| MnDOT | Minnesota Department of Transportation |
| NDOT | Nebraska Department of Transportation |
| SOP | standard operating procedure |
| UAS | Unmanned Aerial Systems |

# BACKGROUND

As part of the Federal Highway Administration (FHWA) Every Day Counts Unmanned Aircraft Systems (UAS) Initiative, the Minnesota Department of Transportation (MnDOT) hosted a peer exchange attended by representatives from the Kentucky Transportation Cabinet (KYTC) and the Nebraska Department of Transportation (NDOT). The purpose of the exchange was to discuss and share information about Unmanned Aerial Systems (UAS) programs.

The peer exchange allowed the State Departments of Transportation (State DOTs) to share overviews of their UAS programs focusing on risk assessment, UAS training, structure inspections, data management, limitations, emergency management, thermal imagery, and UAS funding. This report summarizes the information presented during the peer exchange and was current and accurate at the time of the exchange.

**Federal Aviation Administration (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 U.S.C. § 40102 and § 40125. Additionally, both public and civil UAS operators may operate under the regulations promulgated by the FAA. The provisions of 14 CFR part 107 apply to most operations of UAS weighing less than 55 pounds. Operators of UAS weighing greater than 55 pounds may request exemptions to the airworthiness requirements of 14 CFR part 91 pursuant to 49 USC §44807. UAS operators should also be aware of the requirements of the airspace in which they wish to fly 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/

# MINNESOTA DEPARTMENT OF TRANSPORTATION (MNDOT) OVERVIEW

MnDOT's UAS program initially focused on the use of UAS for inspections. Identifying key capabilities of UAS, MnDOT started slowly to ensure the public and media were aware of when and how UAS were being used by the agency. In 2015, UAS research began first in rural areas, as MnDOT worked through different research phases it was able to develop and set bridge inspection goals as follows:

- Plan inspections.
- Detect conditions and deficiencies.
- Document findings and communicate as needed to appropriate stakeholders.

As MnDOT implemented UAS as a supplemental tool in bridge inspections, it reported the following benefits:

- Safety improvements for inspectors and for the public.
- Quality gains from more accurate access and imagery.
- Cost savings.

However, MnDOT staff noted that UAS use was not without challenges. Some of the challenges shared included the difficult learning curve encountered by many of the personnel selected for UAS training.

Other challenges discussed were the public's concern over privacy and the management of the large amounts of data collected by UAS.

**Cost Saving Analysis**

MnDOT completed a cost savings analysis to understand bridge locations and identify the types that are best suited for UAS inspections. MnDOT found that the bridges that were the best candidates for UAS inspections were large and located in open areas. Additional efficiencies were realized in supplementing traditional reporting with UAS imagery to augment documentation to better communicate conditions and deficiencies. MnDOT found an average cost savings of 40 percent over conventional inspection methods by reducing or eliminating traffic control and access equipment. Figure 1 illustrates a breakdown of the cost savings achieved.

| Structure | Traditional Inspection Cost | UAS Assisted Inspection Cost | Savings +/- | Savings Percentage |
|---|---|---|---|---|
| 19538 | $1,080 | $1,860 | -780 | -72% |
| 4175 | $15,980 | $13,160 | 2,280 | 18% |
| 27004 | $6,080 | $4,340 | 1740 | 29% |
| 27201 | $2,160 | $1,620 | 540 | 25% |
| MDTA Bridges | $40,800 | $19,800 | 21000 | 51% |
| 2440 | $2,160 | $1,320 | 840 | 39% |
| 27831 | $2,580 | $540 | 2040 | 79% |
| 82045 | $2,660 | $1,920 | 740 | 28% |
| 92080 | $2,580 | $1,350 | 1230 | 48% |
| 92090 | $2,410 | $1,570 | 840 | 35% |
| 62504 | $3,660 | $1,020 | 2640 | 72% |
| 82502 | $3,240 | $2,400 | 840 | 26% |

**Figure 1. MnDOT Traditional and UAS Inspection Cost Comparison. (Source: MnDOT)**

**MnDOT Summary**

According to MnDOT staff, keys to success include having clear intentions regarding how the UAS will be used, communicating the results, and documenting the findings. UAS can supplement inspections but does not replace the inspection itself, for example, Figure 2 depicts a UAS being used by MnDOT as a supplemental tool for a bridge inspection. According to MnDOT, collaboration with other stakeholders to share knowledge and promote future advancement is also important. Lastly, knowing where to store data and how to use it effectively is critical when using UAS, MnDOT indicated.

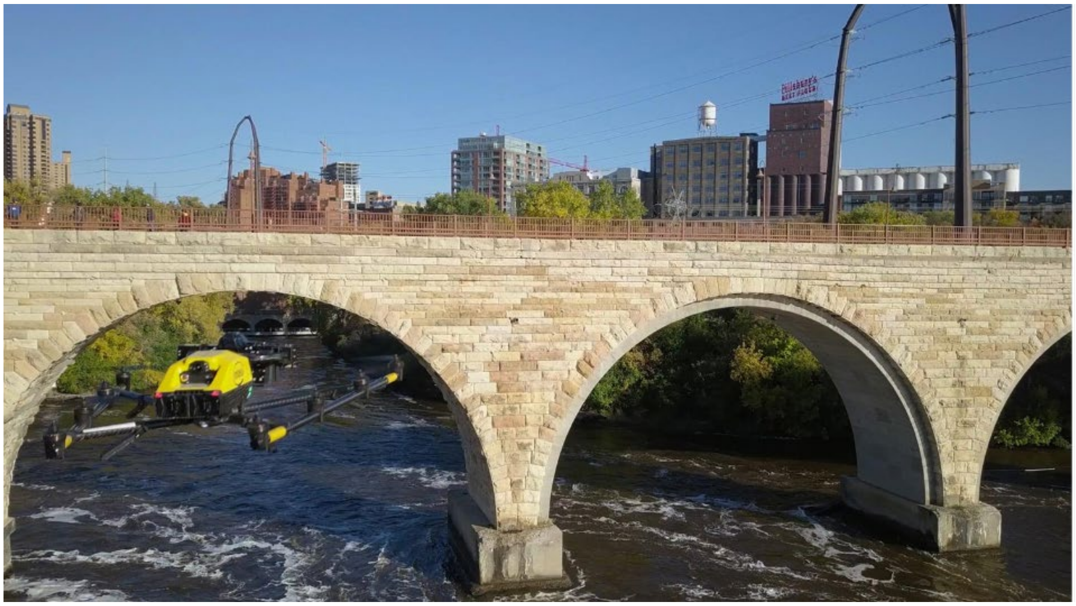

**Figure 2. MnDOT UAS Footage. (Source: MnDOT)**

# KENTUCKY TRANSPORTATION CABINET (KYTC) OVERVIEW

KYTC staff provided an overview on how they use UAS across their departments, including Construction, Design, Traffic Operations, Maintenance, and Incident Management Coordination. The departments use UAS for a variety of work, including public involvement, preconstruction environmental studies, project milestones, traffic pattern studies, bridge inspections, rockslides and landslides analysis, and event site observations (Figure 3).

Focusing on the bridge maintenance program, KYTC currently has eleven pilots operating from four districts and the central office, with an additional six in training. The goal is to have at least one pilot per district in each of the 12 districts.

**Figure 3. KYTC UAS Footage of an Event Site. (Source: KYTC)**

In 2017, KYTC adopted an internal procedures manual that covers the following topics:

- Regulations and requirements.
- UAS program point of contact.
- Roles and responsibilities of the remote pilot in command and visual observers.
- Equipment.
- Training procedures and pilot proficiency requirements.
- Work site risk assessment.
- Operational procedures.
- Post flight procedures.
- UAS incident procedures
- Data management.

# NEBRASKA DEPARTMENT OF TRANSPORTION (NDOT) OVERVIEW

NDOT staff described their program's accomplishments, including establishing the program foundation, developing the NDOT UAS policy, approving and signing the standard operating procedures (SOPs) in early 2022, and creating the NDOT standard UAS workflow. Work in progress includes technology evaluation, non-NDOT flights, and the procurement of additional UAS and remote sensors to scale operations.

NDOT staff also discussed their current use cases for UAS work which include:

- Infrastructure inspections.
- Environmental (wetland and earth movement monitoring).
- Emergency management.
- Construction project monitoring (Figure 4).
- Airport inspections.

**Figure 4. NDOT UAS Footage. (Source: NDOT)**

# RISK MANAGEMENT

Following the overview presentations from the agencies, MnDOT, KYTC, and NDOT held a roundtable discussion about risk management. Each agency has specific training processes for UAS pilots, including documents, forms, and additional training beyond the requirements of 14 CFR § 107. However, the main focus of the roundtable discussion was about how each agency evaluated and mitigated risks for UAS operations. Collectively the group of these three State DOTs made several suggestions regarding routine risk assessments.

- Identifying risks in need of mitigation.
- Evaluating the severity of the identified risks (losing a UAS versus more severe risk).
- Evaluating the potential presence of hazardous attitudes of the UAS remote pilot (FAA, n.d.).
- Incorporating and understanding the overall risk of the project beyond UAS; e.g., the risk associated with a denial to fly over traffic that results in a lane closure, which could present more safety risks for drivers.

Suggestions to mitigate risks included:

- Communicating to remote pilots that UAS are replaceable, and pilot safety should aways be a top consideration.
- Being clear on the risks and prioritizing risks and the associated risk mitigation efforts to ensure the best and safest results.
- Conducting a full risk assessment of the entire project and not limiting it to the UAS to better understand how to serve the project from the UAS perspective.

**UAS Standard Operating Procedures and Training**

Each agency has UAS-specific SOPs and training in place for its use of UAS and has revised and added to its operational manuals as the respective UAS programs have grown. NDOT partnered with a university to assist with the development of its SOPs and to provide internal UAS training. The training program consisted of a 4-day course which provided training related to 14 CFR § 107 to prepare NDOT participants for the remote pilot certification exam. The training program also included ground training and hands-on flight training for UAS operations.

# PRESENTATIONS

Each agency gave a presentation describing its UAS program and associated operations in more detail. The main topics discussed included: UAS for bridge inspections, UAS workflows, processing data and data management, UAS limitations, and best practices.

Each agency was able to cover several of the above topics and describe case studies on work it is doing or has done as it relates to UAS in the various functional department areas. The agencies provided additional details about specific tools and technology, including the various types of UAS it uses, and were able to highlight successes with specific technologies. MnDOT, NDOT, and KYTC each reported benefits, such as improved data quality and access, time savings, and growing cost savings gained from implementing UAS. Case studies were presented and discussed, allowing the presenters to speak in detail about processes, lessons learned, and project successes. The agencies shared detailed imaging from UAS projects. These images offered key visuals for specific types of projects, such as cracks in infrastructure and debris accumulation (see Figure 5).

Technologies discussed included:

- Deck coring and chloride analysis.
- Three-dimensional radar and ground penetrating radar.
- High-resolution and infrared imaging.
- Augmented reality goggles.
- Mixed reality/Artificial Intelligence (AI).

Challenges varied by state, due in large part to the maturity of the State DOT's UAS program. Representatives from the KYTC described not having UAS pilots in every district as a key challenge and noted that the lack of remote pilots limits the data available throughout the State. The KYTC representatives noted that while it does not require its districts to have UAS pilots, it is encouraged.

**Figure 5. Image Showing Aerial View of Debris Removal Project. (Source: KYTC)**

**Roundtable Discussions**

The roundtable discussions focused on a few topics, including UAS funding, Artificial Intelligence, thermal imagery, setting-up bridge inspections, and data management.

The three agencies used different mechanisms to secure funding for UAS and other UAS-associated costs. KYTC used State bridge maintenance funds to pay for UAS, while NDOT used State funds and procured tools through requests for proposals. MnDOT has used year-end funds to purchase UAS.

NDOT and MNDOT had the most experience with thermal imagery, and presenters discussed different tools, including a product that develops and applies innovative, infrared-based nondestructive evaluation technologies. NDOT reported that there is a narrow time of day and season for the highest quality data when using thermal sensors. Presenters talked about using thermal imagery in the following use cases:

- Searching through trees.
- Search and rescue at night.
- Delimitations of bridge decks (see Figure 6).
- Landslides.
- Water infiltration at tunnels.
- Inspections of tunnels tiles.

AI, while still in development for all three agencies, is showing promises of even more success as it continues to be tested, researched, and funded by the agencies. MnDOT has experimented with AI in data analysis, for example, detection of roadside signs (Figure 7). But MnDOT noted that, to date, the easiest way to use AI has been for detection of deficiencies and to generate measurements and quantities.

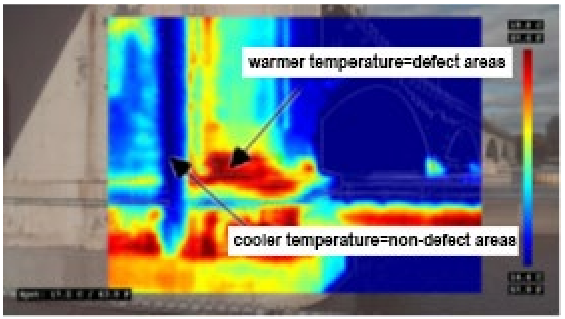


**Figure 6. Image of Infrared Collection for MNDOT. (Source: MnDOT)**

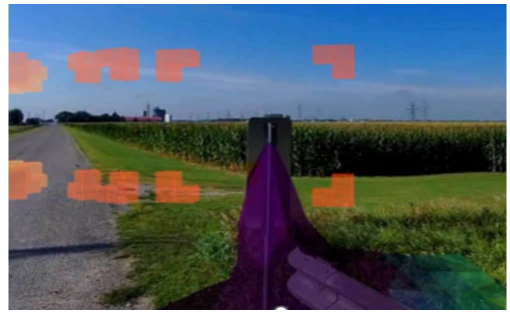

**Figure 7. Image of AI System. (Source: MnDOT)**

Agency representatives mentioned data many times throughout the exchange as an important and key part of the project work. Each agency has different systems in place for data storage, management, and governance. Many of the systems discussed were cloud based, which these State DOTs reported provides convenient and secure sharing capabilities.

Other discussions regarding data were about how long data is being stored and the different types of data (e.g., raw versus processed data). A potential advantage to long-term storage of UAS-collected data is the ability to reprocess data as other advancements are made, which can increase quality or produce different products. MnDOT stores data for various lengths of time depending on the specific project, while KYTC and NDOT do not have a policy in place around storage length.

**Key Takeaways**

Several key takeaways and lessons were shared among the agencies throughout the sessions. There were similarities regarding the use of UAS and the technologies being used across the three attending State DOTs. Benefits gained from UAS use included improved quality of data, time saved collecting data, improved asset management, cost savings, and safer accessibility to hard-to-reach areas. Another shared takeaway was that UAS have been used thus far to supplement inspections instead of replacing them.

There were also similarities in how training occurred for the UAS pilots as well as challenges and lessons learned. Key challenges were placement and access to UAS and qualified remote pilots throughout the various State DOT districts.

Key lessons for tools and the UAS included keeping batteries charged and having at least two UAS when going to conduct an operation; this was specifically mentioned for emergency response situations. For safety, all three agencies discussed the importance of pilots understanding that their personal safety comes first. Another lesson is the importance of understanding the risks, how to mitigate those risks and the overall goals prior to each UAS flight. Preparing for flights includes being clear on what information is to be captured, the goals of the data collection mission, and the protection of pilots, public, and resources as best as possible.

Another takeaway was regarding public involvement. Ensuring members of the public and local media outlets were aware of when and where UAS operations were taking place helped ease concerns of privacy and safety. Education around what UAS were being used for and communicating this information clearly and early seemed to help with image control. Beyond this, KYTC reported using UAS to help show progress on projects and visually communicate project updates. UAS footage was seen as a successful tool for engagement and keeping members of the public and other project stakeholders actively engaged when needed.

**Flight Demonstration – Day Two**

On the second day of the peer exchange MnDOT hosted a flight demonstration, which began at the historic stone arch bridge over the Mississippi River in downtown Minneapolis. This demonstration allowed participants to see how the MnDOT UAS team conducts a bridge inspection using UAS. Team members described their SOPs and UAS workflow throughout the demonstration and showed the various ways they use UAS throughout an infrastructure inspection. The team demonstrated the capabilities of varying UAS platforms as seen in Figures 8 through 11 below.

**Figure 8. MnDOT UAS Remote Pilots Prepare for Bridge Inspection. (Source: FHWA)**

**Figure 9. MnDOT UAS Bridge Inspection Demonstration. (Source: FHWA)**

**Figure 10. MnDOT Demonstrating Various UAS Platforms for Bridge Inspections. (Source: FHWA)**

**Figure 11. MnDOT UAS Operator Explains Bridge Inspection Workflow. (Source: FHWA)**

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Federal Aviation Administration, (n.d.). *Decision-Making Concepts for UAS Pilots*. https://www.faasafety.gov/gslac/ALC/course_content.aspx?cID=723&sID=1448&preview=true