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*Tech Brief*

# UNMANNED AERIAL SYSTEMS PEER EXCHANGE, GRAND FORKS, NORTH DAKOTA

## INTRODUCTION

Proven uses for small unmanned aerial systems (UAS) include structural inspections (bridge, high mast lighting, confined space, retaining walls, and tunnels), construction inspections (Figure 1) (surveying, routing, quantities, project scoping, and work zone traffic monitoring), and emergency response (flooding events [Figure 2], wind events, landslides, mudslides, volcanoes, fire, and earthquakes).

The North Dakota Department of Transportation (NDDOT) hosted a UAS peer exchange in Grand Forks, North Dakota, October 8–9, 2019. Forty-one individuals attended to share knowledge about successful practices in the adoption and use of UAS.

Of the 41 participants, 28 were from the following six state departments of transportation (DOTs):

- Iowa DOT
- Minnesota DOT (MnDOT)
- Montana DOT (MDT)
- NDDOT
- South Dakota DOT (SDDOT)
- Wyoming DOT (WYDOT)

Six Federal Highway Administration (FHWA) personnel represented division offices in Minnesota, Montana, North Dakota, and South Dakota. Four university personnel were from the following: Iowa State University, University of North Dakota, and University of Wyoming. The other three participants were consultants and industry personnel.

The Iowa DOT, MDT, MnDOT, and NDDOT have UAS programs underway; SDDOT and WYDOT are fact finding to substantiate implementing a program.

The peer exchange was sponsored by the FHWA through its Every Day Counts (EDC-5 Innovations) technical assistance program for UAS. UAS can benefit nearly all aspects of highway transportation, from inspection to construction and operations, by collecting high-quality data automatically or remotely.

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*Figure 1. Construction inspection*

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*Figure 2. Flooding event repair*

U.S. Department of Transportation

**Federal Highway Administration**

Northern Plains Unmanned Aircraft Systems Test Site, used with permission

*Figure 3. UAS in flight*

Northern Plains Unmanned Aircraft Systems Test Site, used with permission

*Figure 4. Test flight by a Northern Plains partner member*

UAS are relatively low-cost devices that enable agencies to speed-up the data collection needed for better-informed decisions while reducing the adverse impacts of temporary work zones on work crews and the traveling public (Figure 3).

The first day of the peer exchange used several case studies to focus on the use of UAS for bridge maintenance inspection, surveying, landslides, construction quantity measurements, emergency response, and traffic management. The second day consisted of round table discussions centered on the following:

- UAS equipment, consultant and contractor use of technology
- How to start a UAS program, laws, regulations, policies, insurance, risk management, spectrum management, unmanned traffic management (UTM), and public outreach
- UAS staffing, licensing, training/experience, and data standards/storage
- Research and the future of UAS with highway transportation

## UNMANNED AIRCRAFT SYSTEMS INTEGRATION PILOT PROGRAM

The Federal Aviation Administration's (FAA's) Unmanned Aircraft Systems Integration Pilot Program (IPP) creates a mechanism for the private sector and state, local, and tribal governments to make experience-based and data-driven contributions to the national framework to safely integrate UAS into the economy. The program objectives include the following:

- Identify and resolve technical challenges to UAS integration
- Address airspace use to safely and efficiently integrate all aircraft
- Inform regarding operational standards and procedures to improve safety
- Inform on FAA standards that reduce the need for waivers
- Address competing interests regarding UAS operational expansion, safety, security, roles and responsibilities of non-government entities, and privacy issues

The first nine lead entities included three state DOTs, two cities, one university, one tribe, two county airport authorities, and an investment authority. There are a multitude of federal, state, tribal, and private partnerships within each lead organization.

Currently, there are 152 partners in the IPP program with some partners being shared across multiple lead entities. The FAA is also involved with five program managers assigned specifically to selected entities and a team of 140 experts ready to assist the IPP efforts.

## NORTHERN PLAINS UNMANNED AIRCRAFT SYSTEMS TEST SITE

With its operations supported by North Dakota's legislature, the Northern Plains Unmanned Aircraft Systems Test Site is located at Grand Sky, a UAS-specific business and aviation park on the Grand Forks Air Force Base in North Dakota. Grand Sky has a platform for UAS take-offs and landing as well as sufficient space for the 29 partners that are conducting test flights (Figure 4).

Two issues being looked at by this group are ground risk and air risk. The risk factor is different for the private sector than the public sector given the inherent advantage to government agencies being self-insured.

Since the UAS movement is relatively new, safety data are limited, which results in more constraints being applied to aircraft and flight space. The bulk of the responsibility for regulating airspace falls to the FAA with the exception of the military within its area of jurisdiction.

## NORTH DAKOTA UAS PROGRAM

NDDOT is one of the FAA IPP lead participants and owns 17 small (less than 50-lb) UAS that fly in three of its eight districts. A lot of NDDOT's attention has been on flooding of the Red River and on using social media to inform the public of current situations.

NDDOT has found, for the most part, using the FAA UAS website for waivers has been successful, as most waivers are processed at the regional level. However, members of the North Dakota legislature were contacted for help in getting waivers on a few occasions.

## FHWA UAS DEPLOYMENT, USE, AND RESOURCES

These are the current EDC-5 funding opportunities for UAS:

- State Transportation Innovation Council (STIC) Incentive program
  - Up to $100,000 per STIC incentive per year to standardize an innovation
  - https://www.fhwa.dot.gov/innovation/stic/
- Accelerated Innovation Deployment (AID) Demonstration program
  - Grants up to $1 million available, with approximately $10 million per year to deploy an innovation not routinely used
  - https://www.fhwa.dot.gov/innovation/grants/

Ongoing efforts to advance UAS include the FHWA national UAS peer exchange, the Permanent International Association of Road Congresses (PIARC)/World Road Association report and webinar, a domestic scan, tech briefs, and a bridge inspection data management project. Planned efforts will address state peer-to-peer exchanges, webinars, regional workshops, YouTube videos, and college curriculum perspectives.

The FHWA UAS website at https://www.fhwa.dot.gov/uas/library.cfm has posted three tech briefs to date (Construction Inspection, Bridge Inspection, and Emergency Management of Flooding). Another resource is the National Cooperative Highway Research Program (NCHRP) Project 20-68A, Scan 17-01: Successful Approaches for the Use of Unmanned Aerial Systems by Surface Transportation Agencies at http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_17-01.pdf.

## FAA REQUIREMENTS

UAS operators in both the public and private sectors must adhere to statutory and regulatory requirements. Public aircraft operations (including UAS operations) are governed under the statutory requirements for public aircraft established in 49 USC § 40102 and § 40125. Additionally, both public and civil UAS operators may operate under the regulations promulgated by the FAA.

The provisions of 14 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/.

FHWA

*Figure 5. UAS with goggles*

## LOCAL, COUNTY, AND CONSULTANT USE OF UAS

Five topics were discussed at the peer exchange to highlight efforts and resources available for UAS implementation outside of a typical state highway agency.

- EDC-5 UAS, structural and construction inspection
- First person view (FPV) goggles to maximize field inspections: “A Game Changer!”
- UAS and goggles (Figure 5) as a tool for bridge inspectors
- Demonstration of UAS and FPV goggle capability
- Inspector safety and other UAS/goggle opportunities

Additionally, a short recap from the NCHRP Project 20-68A, Scan 17-01 executive summary provides several recommendations for successful UAS implementation, as listed in Table 1. Note that these are not FHWA recommendations.

*Table 1. UAS implementation items for consideration*

| Timing | Items |
|---|---|
| Initial start up | • Start small and grow with success<br>• Does not require a large investment to get started<br>• Justify UAS use with increased safety, reduced liability, greater cost savings, greater productivity, better end products, enhanced environmental protections, and reduced impact on the public<br>• Follow standard operation procedures |
| As program develops | • Leverage the UAS across disciplines and share UAS assets throughout the state<br>• Leverage expertise in UAS operations<br>• Use post-processing software and hardware<br>• Have workflow processes for data collection, storage, usage, application development, and repurposed use of collected data |

Source: NCHRP Project 20-68A, Scan 17-01


MnDOT, used with permission

*Figure 6. Traffic signing for bridge inspection*

Collins Engineers, used with permission

*Figure 7. UAS on bridge inspection*

## MNDOT BRIDGE INSPECTIONS UTILIZING UAS

MnDOT started using UAS for bridge inspections (Figures 6 and 7) in 2015.

When assessing which UAS technology to use for bridge inspections, MnDOT listed the following areas to address: inspection-specific UAS, object sensing, looking-up capability, ability to fly without global positioning system (GPS) under bridge decks, have photo, video, and thermal imaging, and ability to work in a confined space.

The most common UAS used by MnDOT has a cage that can be tethered when winds exceed 10 mph. The UAS weighs 1.5 lbs, has high-definition (HD) video and a thermal camera, and is capable of a 10-minute flight time. These are MnDOT's three bridge inspection goals:

- Detect conditions and deficiencies – Use as an access tool in conjunction with traditional tools (aerial work platforms, rope access, and structure climbing, ladders, and binoculars)
- Document – Use a high-end computer to process reality modeling software input images and ground control for output orthomosaics, GeoTIFF, digital surface model (DSM), digital terrain model (DTM), point clouds, three-dimensional (3D) mesh, and computer-aided design (CAD)
- Communicate – Cloud sharing with visuals is quick and efficient

Three Minnesota case studies were presented: the Stone Arch Bridge, the St. Croix Crossing Extradosed Bridge, and the Blatnik Bridge. When comparing traditional inspection costs to UAS-assisted inspection costs, MnDOT estimates a cost savings up to 40% where traffic control and access equipment can be reduced or eliminated.

MnDOT has found that using UAS works well for large bridges, bridges in open areas, and bridges that depend on traffic control and under bridge inspection vehicles or trucks (UBIVs or UBITs), commonly known as snooper trucks, for inspection. MnDOT has found that UAS do not work as well for bridges over high average daily traffic (ADT) roadways or in heavily wooded areas.

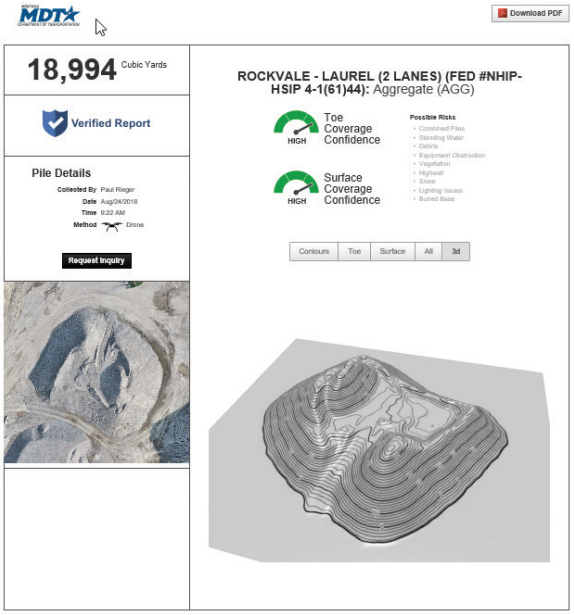
If looking to contract UAS work, MnDOT considers the following:

- Equipment costs to reduce hours
- Lump sum contract, as hourly contracts are difficult to administer
- Allowing for weather in the schedule
- Setting up demos separately from work
- State registrations adding another layer of costs

MnDOT does not have dedicated UAS staff and considers UAS functions to be a part of certain job descriptions within the department. As part of its social media outreach to encourage more UAS use and knowledge, the agency has developed a program to visit high schools to talk about job opportunities within the UAS field.

## MONTANA DOT USE OF UAS

MDT purchased its first UAS in 2016 for stockpile measurements (Figure 8), snow plowing activity (Figure 9), rockfall sites (Figure 10), and construction monitoring (Figure 11).




MDT, used with permission

*Figure 8. Stockpile measurement report*

MDT, used with permission

*Figure 9. Snow drifts on roadway*

MDT, used with permission

*Figure 10. Rockfall site*

MDT, used with permission

*Figure 11. Construction monitoring*

MDT contracts out stockpile image processing and inventory management on a year-to-year basis. Agency representatives listed several steps to consider when setting up a UAS program:

- Obtain institutional buy-in
- Select motivated participants
- Employ competent pilots who also exhibit subject matter knowledge when feasible

To begin your first trial mapping project, MDT representatives suggested the following steps:

- Get the OK from management
- Pass the FAA Part 107 exam
- Obtain the software
- Buy the UAS
- Practice a bit
- Select a trial project away from everywhere
- Collect data
- Process data
- Manipulate point cloud
- Incorporate into design

MDT's future endeavors include thermal imaging, in-service bridge inspection, and light detection and ranging (LiDAR).

## IOWA DOT USE OF UAS

The Iowa DOT is not centralizing UAS operations. It is instead treating UAS as a tool and providing training so offices and districts have the technology readily available to them. Implementation has been significantly aided by strong management support and the development of an operational framework.

The Iowa DOT has 14 approved pilots to-date with more on the way to operate the agency's 14 UAS. A 16-member user's group representing districts and offices meets quarterly to address current and future issues. The Iowa DOT published a two-page Small Unmanned Aircraft Systems (sUAS) Guidelines document effective January 1, 2019 and distributed it at the peer exchange. The document covers the following:

- UAS use
- Operational and training requirements
- UAS procurement
- Contracting UAS services
- Protection of individual privacy and personal information
- Accident reporting

The peer exchange group was briefed on three other Iowa DOT publications that are available for other agencies to review and modify for their own use. They include an sUAS Preflight Checklist, sUAS Flight Review checklist used to confirm pilot knowledge and operational skills, and a set of Mitigations for sUAS flights in the vicinity of airports needing air traffic control authorizations that are above listed FAA facility map altitudes part of the Low-Altitude Authorization and Notification Capability (LAANC) AirMap program.

Juniper Unmanned, used with permission

*Figure 12. Ortho image*

## CONSULTANT PERSPECTIVE ON USE OF UAS TECHNOLOGY

Juniper Unmanned contracts the majority of its work in the area of LiDAR and photogrammetry and utilizes an assortment of equipment. An example project was for the Colorado DOT on CO 79 where the state set survey level accuracies at a 95% confidence level to be as follows:

- 0.1 feet vertical on hard surfaces
- 0.2 feet horizontal on roadway, bridge structures, drainage structures, etc.
- 0.66 feet for terrain outside of roadway
- Orthoimagery resolution (Figure 12) and accuracy: 5.0 cm resolution and 0.2 feet horizontal

Juniper Unmanned has flown a number of geohazard projects in Colorado primarily for pre-event mitigation or planning purposes. One example is DeBeque Canyon. When looking at the terrain (Figure 13) one can see the difficulty in using a standard survey crew to document the land area in question. Using the LiDAR equipment, an image (Figure 14) was developed to reflect the areas of possible rockfall locations.

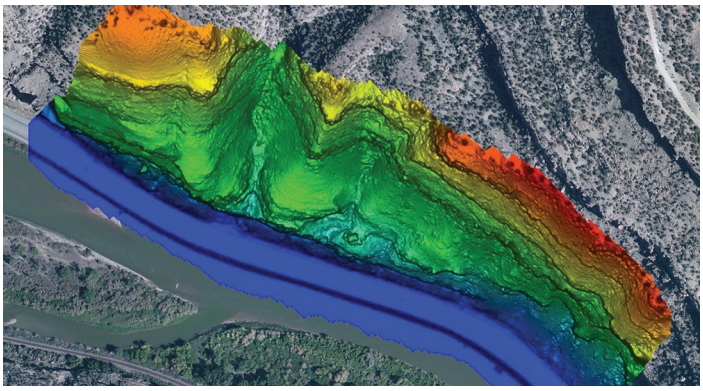
When looking to start a UAS program in-house or for a consultant to perform the work, Juniper Unmanned recommends considering the following:

- Data security and management
- Operations workflow and approvals
- Technology supply chain
- Business process integration
- Fleet management
- Risk mitigation and safety
- Training and compliance

It was also noted that the delivery of components in today's environment can potentially be lengthy due to most of the manufacturing of UAS equipment being done overseas.

Juniper Unmanned, used with permission

*Figure 13. Potential rockfall site*



Juniper Unmanned, used with permission

*Figure 14. Rockfall risks using LiDAR*

## ROUND TABLE DISCUSSIONS

### UAS Equipment, Consultant and Contractor Use of Technology

Participants shared what they use for batteries and where they are made. NDDOT uses a 25-minute battery that costs about $135 and can fly at 25 knots, but said wind will impact the battery life. MnDOT has a hexicopter with a large battery that costs about $600 and runs 15–20 minutes on a charge. A Minnesota consultant uses a UAS that has a 15-minute flight time.

A participant noted that most of the UAS software has a fail safe option to return to the UAS to its place of origin when battery life gets close to 30%, although that option can be overridden. Software is available that allows for controls to be switched from a primary pilot to a secondary pilot. Most of the agencies reported using 4K resolution when available to achieve higher video quality. The Iowa DOT is generally using 1080 video settings to minimize file sizes and storage issues.

Participants noted insurance should be a line item. MnDOT does not do maintenance in-house but has used maintenance agreements. Small UAS may not warrant a maintenance agreement due to cost and year-to-year upgrades in hardware and software. MnDOT replaces equipment approximately every 2.5 years while engineering firms average 2.2 years.

### How to Start a UAS Program

SDDOT and WYDOT are looking to start a UAS program and welcomed insight from the attending agencies. The participants discussed considerations when starting a UAS program including regulations, policies and protocols, staying abreast of airspace and privacy legislation, insurance, risk management, unmanned traffic management, and public outreach. It was also noted that some stadiums are looking at UTM for crowd control.

Public outreach by states includes the following:

- The NDDOT reports activities once a month on its social media webpage.
- MnDOT has also done outreach with footage ending up on multiple social media websites. If there are complaints, they usually have been submitted to the FAA.
- The Iowa DOT outreach has focused on the education of airports and public safety officials. They have a dedicated UAS web page and participate in activities like the FAA's National Drone Safety Awareness Week.

A few hurdles that need to be overcome were mentioned by the SDDOT and WYDOT. SDDOT management wants data to justify a UAS program. SDDOT is looking at bridge inspection or photogrammetry as an example and for the right champion for the program. Participants noted a peer-to-peer exchange in South Dakota might help.

WYDOT is working on establishing protocols to get its program started and will likely bring in a subject matter expert to help. They may look at bridge inspection as a beginning point. The Wyoming Highway Patrol is getting a small UAS, as is the University of Wyoming Information Technology Center. It was suggested that WYDOT could apply for a STIC grant.

### UAS Staffing, Licensing, Training/Experience, and Data Standards/Storage

- Iowa DOT – To be successful, Iowa DOT participants noted that agencies need management buy-in at the highest level. Iowa currently has no full-time employees (FTEs) in its UAS program but has assigned the lead to its Aviation Bureau to push the technology out widely throughout the Iowa DOT. The Iowa DOT suggests it is helpful if the UAS champion is a manned aircraft pilot and recommends borrowing information and sharing insights from other states. Iowa started its program in 2016 in the Aviation Bureau monitoring floods, etc. Every district, as well as the main central offices, now have a small UAS.
- MDT – Started its UAS program with stockpile reports. Construction and geotech were the first MDT offices to use UAS. MDT started small and modified protocol procedures to satisfy privacy requirements. MDT representatives shared it was easy to start with photogrammetry and that MDT is looking to expand its application. MDT representatives also said they will be submitting a proposal to hire three FTEs for UAS.
- MnDOT – Started flying UAS in 2015 for bridge inspection and expanded the program to include photogrammetry and surveys. MnDOT's central office and two district offices have UAS, and it currently has 1.75 UAS FTEs in the Office of Aeronautics. MnDOT is utilizing 2019 STIC funds to purchase UAS for district bridge inspection staff.
- NDDOT – Started with consultant work because the legislature said UAS were aircraft and the department could not purchase aircraft. State laws changed and NDDOT leveraged a STIC grant to purchase equipment. NDDOT has a photogrammetry employee dedicated part time to the UAS program and three pilots, with additional ones to come. The NDDOT risk management group maintains a list of all UAS owned by the department. NDDOT also has a fixed wing aircraft with a lot of hours on it and is looking at UAS as a replacement.
- SDDOT – Noted SDDOT staff would be meeting to determine their agency's direction.
- WYDOT – Is in the beginning stages and wants a subject matter expert within each unit. WYDOT does have buy-in from staff with limited funding to start.

Training was brought up with the following discussion:

- Iowa DOT – Uses a third-party, commercial training course for self-paced online 14 CFR Part 107 training, a minimum of two hours of practice flights in open areas, and then successful completion of a flight review prior to flying on Iowa DOT projects.
- MDT – Training is the responsibility of the MDT pilot. The state reimburses the cost of the test.
- MnDOT – Offers a four-day class. The cost of the exam can be reimbursed, but that is up to each unit's discretion. Each MnDOT unit may require additional training beyond the minimum requirement.
- NDDOT – Has a one-day boot camp and encourages on-line training courses. NDDOT pays for training and exams.

Storage requirement protocols:

- Iowa DOT – IT office has no concerns yet, but a subcommittee is exploring standard work for processing and storage needs
- MDT – Has its own servers so not an issue
- MnDOT – Use shared drives but bridges has its own server
- NDDOT – Went with the cloud 5 years ago
- SDDOT – Shared drives but looking at the cloud
- WYDOT – Use own servers but Highway Patrol uses hard disks for evidence storage

### Research and the Future of UAS with Highway Transportation

MnDOT is not looking to expand UAS capability but technology capability and LiDAR. MnDOT is still trying to figure out the right mix between using contractors versus in-house staff for certain applications considering the cost of equipment and ever-changing software. MDT mentioned it has flown in cold temperatures and is looking at future options. The Iowa DOT is looking forward to gaining more expertise as its pilots begin flying more missions and using UAS for additional applications. Participants expressed it will be important to standardize the mapping process in the coming years. The Iowa DOT Office of Bridges and Structures prefers the smaller UAS. NDDOT is looking at larger aircraft to handle LiDAR and thermal imaging, working with other state agencies, and sharing sensors.

## SUGGESTIONS FOR THE NEXT PEER-TO-PEER EXCHANGE

The FHWA is interested in supporting a limited number of regional peer-to-peer exchanges under the EDC-5 program. Participants of this peer-to-peer exchange suggested inviting vendors, both hardware and software companies, to participate, and including consultants who use more than one software program.

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