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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:
$33,506

UAVs can remotely provide visual, infrared and mapping detail to inspectors safely and without requiring traffic control.

# Unmanned Aerial Vehicles Enable Safe and Cost-Effective Bridge Inspection

*Researchers found that UAVs can be an effective tool for bridge inspectors, an option that reduces safety risks to inspectors and inconvenience to the public while providing high-quality detail to inspectors. New, inspection-specific UAVs will soon be available that should improve the range of uses of drones as bridge inspection tools.*

## What Was the Need?

Timely bridge inspection is the critical first step in keeping bridges safe and in good driving condition. MnDOT inspects every bridge in its system at least once every 24 months, with fracture-critical bridges (where failure of a single component could cause collapse) receiving reviews every 12 months. Small bridges can be inspected in a day, but large bridges can take weeks to fully inspect. With more than 20,000 bridges and 600 bridge inspectors statewide, the task proves more than just a logistical challenge.

Because the core of bridge inspection is visual review, inspectors are often put in physically challenging situations in order to access all the bridge components. They may need to utilize rope climbing gear or climb into the buckets of under-bridge inspection vehicles: articulated cranes that reach from the bridge deck surface over the edge of the bridge to the underside. These "snooper" trucks cost about $750,000 and present expenses for fuel, training, maintenance and on-bridge traffic control.

Fortunately the new technology of unmanned aerial vehicles may reduce some of this expense as well as the safety risk to inspectors. Camera-equipped drones can be flown beneath bridge decks to capture images or video footage of bridge elements quickly and efficiently, with limited impact on traffic and at a significantly lower cost. UAVs offer promise for bridge inspection, but MnDOT had not conducted formal research to evaluate such applications until now.

## What Was Our Goal?

This project aimed to develop a field demonstration of UAVs for bridge inspection and to evaluate the technology's effectiveness and safety implications for routine bridge inspections and interim or special inspections.

## What Did We Do?

Researchers identified four bridges in Minnesota that represented key configurations that inspectors encounter: an 80-foot local bridge in Chisago County; a medium-size concrete arch bridge in Oronoco; a large steel truss bridge in Morrison County; and a 2,682-foot-long railroad bridge near Stillwater that rises 185 feet above the St. Croix River.

Researchers then reviewed current and proposed Federal Aviation Administration rules and regulations pertaining to UAV use for bridge inspection, and worked with the MnDOT Office of Aeronautics Services to acquire necessary authorization for inspections. After reviewing UAV options, researchers selected the Aeryon SkyRanger UAV and contracted a drone pilot to help conduct inspections of each selected bridge. Researchers compared UAV results to recent bridge inspection records.

*continued*

*"This is one of the first state DOT studies of its kind. We were really able to see a lot of detail with the UAV—more than we anticipated. UAVs have the potential to be an effective tool for bridge inspection to improve both quality and safety."*

**—Barritt Lovelace,**
Regional Manager, Collins Engineers, Inc.

*"Minnesota's State Bridge Engineer has been very forward-thinking about using new technology. Drones would be a good option to aid in bridge inspection data gathering."*

**—Jennifer Zink,**
Bridge Inspection Engineer, MnDOT Bridge Office

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Under-bridge inspection vehicles pose safety risks to workers and are expensive to purchase and operate.

## What Did We Learn?

The UAV provided high-quality detail on the two large bridges, and its zoom lens was effective with the medium-size concrete arch bridge, allowing viewing and assessment of many bridge element conditions according to national standards. Smaller bridges with limited clearance underneath prove challenging for UAVs, particularly those which, like the SkyRanger, can lose GPS signals under concrete decks. At $140,000, the SkyRanger would be a cost-effective alternative to snooper trucks in many situations.

Based upon analysis of fieldwork, inspection results, regulations for UAV use and emerging inspection-specific UAV technology, researchers concluded the following:

- UAVs can be used for bridge inspection with little risk to inspectors and the public, and can reduce safety risks inspectors currently face. They should be considered as a tool in routine inspection use and for situations not requiring hands-on inspection, testing, sounding or cleaning. They also suit pre-inspection surveys and can identify rope anchor points and other safety needs before hands-on inspection begins.
- UAVs provide inspection detail that effectively replicates some of the detail learned through use of snooper trucks without the traffic control requirements and at significantly lower cost in equipment and traffic control needs.
- UAVs provide both infrared and 3-D modeling detail of bridges, effectively identify concrete delamination, gather topographic mapping detail, and efficiently map riverbank conditions upstream and downstream from the bridge site.
- Inspectors should select UAVs capable of pointing cameras upward and operating without GPS.
- Current FAA rules are a time-consuming obstacle to using UAVs in bridge inspection. Recently proposed rules may remove such obstacles for bridge inspection as early as June 2016, according to the FAA.

## What's Next?

Further study would review additional technologies for infrared images, 3-D mapping, still and video photography, ultrasonic investigation and more. Newer UAVs designed specifically for inspections and mapping are emerging, including one $40,000 drone that researchers would like to use for a Phase II study. Further research could include developing best practices and safety guidelines to be added to the MnDOT Bridge and Structure Inspection Program Manual. UAVs could also be used with more bridges and bridge types, and for an even broader range of inspection roles.

*This Technical Summary pertains to Report 2015-40, "Unmanned Aerial Vehicle Bridge Inspection Demonstration Project," published July 2015. The full report can be accessed at* mndot.gov/research/TS/2015/201540.pdf.