Research Spotlight

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Unmanned aerial vehicles assess highways and bridges faster with reduced cost and risk

MDOT estimates that 12 percent of Michigan's 11,000 bridges are structurally deficient. Current bridge inspection practices can be time-consuming, labor-intensive and subjective. On-site inspections also create safety risks for drivers and MDOT bridge inspectors. Unmanned aerial vehicles (UAVs) can assess the structural integrity of bridges and other critical transportation infrastructure more objectively and frequently without disrupting traffic. This technology will enhance MDOT's ability to address operations and maintenance needs.

Problem

Technological advances have resulted in a range of new designs and capabilities in UAVs, also known as unmanned aerial systems (UASs) and drones. Many units now have longer battery lives, are easier to use, and can carry sensors useful for collecting transportation operations and maintenance data. In Phase I of this project, researchers found that UAVs equipped with sensors could monitor and assess transportation facilities at a reasonable cost. In Phase II, researchers continued to evaluate and demonstrate the ability of several UAV platforms fitted with remote sensing equipment to collect, store and transmit the critical data.

MDOT sought to learn the capabilities of UAV platforms to gather and convey data for use in traffic operations, maintenance (such as bridge deck assessment), construc-
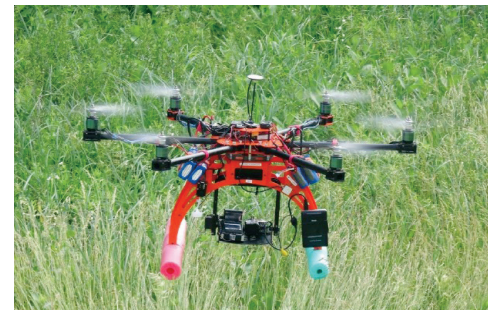
Researchers used a Bergen hexacopter with dual FLIR cameras to collect thermal imagery along the US-31 corridor.

tion, and design. Primary concerns were data acquisition and application, near-time imagery, critical quality, and use with software/algorithms to render information that MDOT could access and use quickly. In addition, MDOT needed benefit-cost analyses and performance measures to compare the costs and data results of UAVs with traditional methods.

"Unmanned aerial systems have the potential to reinvent and transform how transportation owners collect asset management and operations information. UASs increase safety, save time, and efficiently and effectively collect information that supports many transportation-related applications."

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Research

Researchers from the Michigan Tech Research Institute (MTRI) evaluated five UAV platforms: a Bergen hexacopter (a helicopter with six rotors), a Bergen Quad 8 octocopter (a helicopter with eight rotors, two (above/below) on one of four arms), a DJI Phantom 3 Advanced quadcopter, a DJI Mavic Pro quadcopter, and a waterproof Mariner 2 Splash quadcopter. They used three kinds of remote sensing equipment, either singly or paired with the UAVs: optical digital cameras, thermal imaging sensors, and LiDAR (light detection and ranging) sensors. Team members obtained the Federal Aviation Administration's new Part 107 Certification of Waiver or Authorization to fly UAVs. In addition the team also applied and secured a Section 333 exemption approving flights of more than 1,100 UAV platforms.

Using various platforms with UAV-enabled imaging equipment, investigators evaluated five bridges, three road corridors, one construction site, and one site near MTRI. They also used UAVs to inspect four bridges with traffic rerouted to allow uninterrupted bridge data collection. To demonstrate the UAV's ability to collect data without road closure on a busy highway, researchers also imaged a fifth bridge at an oblique angle (from the roadside/shoulder area) with live traffic.

For bridges, researchers used UAVs, including the waterproof Mariner 2 Splash, to image the undersides and substructure elements of bridges. They also created high-resolution optical images and software-generated 3-D profiles of some pavements. Spalls – deteriorations of bridge deck concrete – were located and visualized using an updated spall detection algorithm known as a "spallgorithm." Two thermal cameras detected potential delaminations.

The Bergen hexacopter with an optical sensor also collected imagery of construction site aggregate mounds to compare its accuracy to a high-end ($400,000) commercial drone tested by Surveying Solutions, Inc. (SSI), the project partner. SSI stored the UAV output data for the project and enabled data sharing with MDOT. Throughout the study, researchers monitored and evaluated the speed, accuracy and manageability of all sensing data.

Results

The UAV platforms with onboard sensing equipment effectively assessed and monitored transportation facilities such as bridge decks and highway corridors throughout the extensive testing and field demonstrations of this study. Compared to other nondestructive techniques requiring lane closures and maintenance workers on the roadways, UAVs were faster and less costly. Further, the more precise UAV/remote sensing assessment strategies may prevent overestimation of bridge deck deterioration and avoid extensive maintenance or replacement before it is necessary.

The research team collected, stored, analyzed, assessed, and processed data streams, which were substantial at times, throughout the study in ways that were applicable to MDOT's needs.

The project included a detailed benefit-cost analysis, showing savings from more precise pavement evaluations. Researchers also provided an implementation action plan as a separate report. The plan focuses on potential next steps for implementing UAV technologies as a part of MDOT operations.

Value

MDOT would benefit from UAV-based sensing in many practical ways. This project showed the capacity of UAVs to collect many kinds of bridge and road inspection data quickly and easily, without risk to inspection staff. UAVs also could provide low-cost traffic monitoring, quick determination of volumes of construction aggregate mounds, and high-resolution identification of roadways assets. In Phase III of this study, researchers will focus on steps MDOT needs to take to fully implement UAVs as a new tool for its workforce.