UTC Project Information	
Project Title	MPC-535 – Development of Unmanned Aerial Vehicle (UAV) Bridge Inspection Procedures
University	Colorado State University
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Brief Description of Research Project	Maintenance of deteriorating bridges is a pressing need throughout the U.S., and for the Mountain-Plains area in particular, as these infrastructure are critical to economic performance. In the maintenance process, condition evaluation of this sector of the infrastructure is critical, as it informs repair decisions, load-rating and management of limited state resources. Throughout the Mountain-Plains region, the condition of nearly 25,000 bridges must be evaluated by state DOTs regularly. In Colorado, the condition of a total of 8,612 state owned and local bridges are inspected routinely (typically every two years) by CDOT and consultants. About 540 of

	these bridges are rated as structurally-deficient bridges and thus typically need more frequent inspection and monitoring. The cost of bridge inspection forms the basis of much of the bridge management budget for CDOT, which varies from about $4.5 to $10 million annually. Considering the need for frequent inspection of a large number of bridges in the state and the significant expense, an efficient and cost-effective bridge inspection system is highly desirable. In current practice, the condition assessment of bridges mainly relies on human-based visual inspection, which often requires inspectors to climb ladders or use specialized equipment such as a "cherry-picker" to be lifted into place. This type of inspection is not only expensive and interrupts traffic, but also poses a danger to inspectors, especially in the Mountain-Plains region where mountain bridges can be difficult to access. In addition, the condition ratings reported by the inspectors might not be consistent due to the subjectivity of individual experience and difficult inspection conditions. The significant cost, safety issues, traffic interruption, as well as the subjective nature in current bridge inspection practice highlight the need to explore a fast, low-cost, quantitative and safe solution for bridge condition assessment. Recently, remote sensing technology based on unmanned aerial vehicles (UAVs) has emerged as a promising technique to provide such a solution. It has already attracted significant attention from both federal and some state DOTs. The Federal Aviation Administration (FAA) has been working diligently to safely promote drone use to spur job growth, advance critical scientific research and save lives. The first regulations for routine commercial use of small UAVs (weighing less than 55 pounds) released by the FAA in June, 2016 are the result of this effort and are expected to create new opportunities for research communities and government use of drones. Recent research has focused on investigations to use drones for inspecting bridges, large retaining walls, dams, buildings, poles, etc. (Eschmann et al. 2013; Ellenberg et al. 2014; Hallermann and Morgenthal 2014; Hallermann et al. 2014; Khan et al. 2015; Sa et al. 2015). Different remote sensing technologies have been employed in tandem with UAVs. The most common technologies are based on optical and thermographic cameras. A number of potential applications for UAVs in infrastructure inspection have been identified, including quantitative measurement of displacement of structures (Ellenberg et al. 2014; Hallermann et al. 2014; Khan et al. 2015), detection of both surface and subsurface damages (e.g. cracks, spalling and scale of concrete, delamination) (Chen et al. 2011; Eschmann et al. 2013; Ellenberg et al. 2014), geo-referencing the collected images (Harwin and Lucieer 2012; Hallermann et al. 2014), 3D reconstruction of structures (Eschmann et al. 2013; Mauriello and Froehlich 2014; Sa et al. 2015), etc. Given the unique potential of UAV based remote sensing technology, the proposed research aims to develop and demonstrate a UAV-based bridge inspection framework (Fig. 1). This research is expected to provide the bridge management sectors (e.g. state DOTs) with a highly

	efficient, cost-effective, quantitative and safe proof-of-concept for bridge inspection. The ultimate goal of this research theme is to develop an automated and quantitative bridge inspection procedure that requires minimum human intervention. The automated procedure includes data (images) acquisition using the UAV, 3D reconstruction of surface models of bridges, identification, localization and quantification of structural damage and documentation of the geo-referenced bridge inspection data in database. This end goal will be achieved in two phases of studies. The first phase is the feasibility study, while the second phase is the development of machine learning tools to fully automate the data post-processing and damage identification process. This proposal will address the first phase of this research theme. Research Objectives: 1. Study the feasibility of UAV based data (optical and/or thermographic images) acquisition for bridge inspection, especially for bridges in remote and difficult to access locations. 2. Develop geo-referenced three dimensional (3D) surface models of bridges using images collected by UAV and evaluate the feasibility of damage identification/condition assessment using 3D surface models. 3. Develop a guideline for integrating the developed technology in current bridge inspection practice. (1) In the feasibility study, the UAV flight around bridges will be tested to evaluate the flight time, battery life, and the ability to access various components of bridges. The efficiency of image collecting and quality of the images will also be evaluated. (2) A three dimensional (3D) surface model of a testing bridge will be developed. The possibility of identifying/localizing damage through the model will be tested. (3) A guideline for conducting the UAV enabled bridge inspection will be developed, including the equipment requirements, data acquisition and post processing procedures.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	
Web Links • Reports • Project Website	