UTC Project Information	
Project Title	MPC-449 – Determining the Uncertainty in the Current Condition of Bridges for Use in Risk Based Inspection and Management
University	Colorado State University
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Project Duration	3 Year
Brief Description of Research Project	The US has a large inventory of aging and deteriorating bridges. Preserving (or enhancing) the overall performance of the bridge network depends on effective asset management. Two important steps in the bridge asset management process are 1) inspection of bridges and 2) decision making about future maintenance and repair programs. Current research and development relevant to both of these steps is moving in the direction of risk and performance based practices. The ongoing NCHRP project Developing Reliability Based Bridge Inspection Practices (NCHRP 12-82) is working to develop a more rational approach to bridge inspection in order to improve safety and more efficiently allocate inspection resources. A preliminary project presentation indicates that the project will provide justification for having bridge specific inspection intervals (rather than using two years for all bridges), and provide for more detailed and structure appropriate inspections (Washer 2013). With regard to bridge asset management more generally, MAP 21 is requiring states to develop risk and performance based asset management plans for bridge and pavement assets on the National Highway System (FHWA 2013). When incorporating risk and performance into inspection planning and asset management of bridges, being able to

	quantify the current condition of the existing structure and the uncertainty in that condition are both very important. For example, in order to determine the risk a particular bridge poses to the network (allowing for risk based prioritization) it is necessary to quantify the 1) likelihood of loss of bridge performance and 2) the consequences of that loss of performance. Knowledge of bridge condition is needed particularly to assess the likelihood, but may also contribute to an understanding of consequences. Furthermore, when considering a performance basis for inspection planning, it should be recognized that inspection is conducted in order to provide information about structural condition that can be used for decision making. If the condition is known with very little uncertainty, there is probably little need to conduct additional inspection and management decisions can be made with a greater level of confidence. On the other hand, a structure whose condition is not well understood may be a strong candidate for more frequent or detailed inspection so that appropriate management decisions can be made. There are many factors that contribute to uncertainty in our knowledge about the condition of an existing structure. Inspection findings are one important source of uncertainty. Visual inspection results have been shown to have a significant level of variability (Phares, 2004), and MPC project 394 "Quantifying Uncertainty in Nondestructive Bridge Inspection Methods for use in Performance Based Inspection" conducted a literature review and solicited expert opinion to understand the levels of uncertainty in NDE evaluations of bridges. There is also uncertainty introduced in the process of interpreting inspection results and relating them to a structural condition. Furthermore, management practice relies on predicting the future condition of a bridge, making uncertainty in future loading and in deterioration modeling important to understand. In order to allow for risk and performance based inspection planning and bridge management it is important to understand and, to the extent possible, quantify how these various sources of uncertainty interact to produce an overall level of uncertainty in structural condition. Research Objectives: The goal of this project is provide descriptions of uncertainty in structural condition that can be used to improve the timing of bridge inspections and bridge management practice in a risk or performance based framework. In order to achieve this goal, this project will pursue the following objectives. 1. Identify all significant sources of uncertainty that are present in our knowledge of an existing bridge and affect understanding of bridge condition and performance. 2. Quantify the effect of these sources individually using literature review and parametric studies. 3. Investigate ways to combine the various sources of

	uncertainty into an overall level of uncertainty for a given structure. 4. Provide a simple demonstration of how this definition of uncertainty in bridge condition can be implemented in a framework for risk and performance based inspection planning. Attempting to achieve objectives 2-4 for all bridge types would imply a very large project scope, thus based on the quantity and quality of information that can be collected for different types of bridges, a narrow range of structural types will be selected for detailed study. At this point we anticipate selecting slab and girder bridges with RC deck slabs and steel, RC or precast girders.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	This research project was basic in nature and explored a completely new approach for inspection planning. Preliminary findings are promising. The next step in the process is to investigate the potential for cost-savings associated with use of the new inspection planning technique. Data about potential cost savings will provide an important incentive to shift to a new inspection planning method. A follow-up study to evaluate the lifecycle costs associated with different inspection planning techniques is just getting underway.
Impacts/Benefits of Implementation (actual, not anticipated)	The anticipated impact of this research is a new means of planning inspections that will save money while also providing a better understanding of bridge condition. A follow-up study investigating life-cycle costs associated with inspection is expected to provide a quantitative measure of the potential benefits.
Web Links • Reports • Project Website	https://www.ugpti.org/resources/reports/details.php?id=916