

UTC Project Information	
Project Title	MPC-378 – MEMS Sensors for Transportation Structures
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Funding Agencies	USDOT, Research and Innovative Technology Administration
Agency ID or Contract Number	DTRT12-G-UTC08
Project Cost	\$92,000
Start and End Dates	January 1, 2012 – December 31, 2013
Project Duration	2 Years
Brief Description of Research Project	<p>Research Needs: Non-destructive infrastructure monitoring includes the capability to remotely determine local or global changes in the fundamental character of transportation structures (Abdel-Ghaffar 2001, Xu 2004, Engel 2004). These changes are nearly always negative and usually occur because of 1) changes in geometry or material continuity from usage distress, and 2) degradation in material properties from corrosion or other environmental factors. Deploying micro-electromechanical systems (MEMS) devices at strategic points within the structure can provide real-time behavioral characteristics of variables including quasi-static deflection, vibration frequency, or wave propagation speed.</p> <p>It has been rather common to accomplish indirect detection of structural character by measuring and interpreting induced motion or vibration of the structure as a result of outside forcing functions (Hill 2000). The most common method for doing so has been to use conventional piezoelectric accelerometers, which link mechanical motion to induced electric response, directly wired to data acquisition systems. The challenges of this sort of system are nearly all related to cost: 1) the initial installation and instrumentation, including the necessary wiring, 2) the cost to maintain the system over a reasonable period of time, and 3) the up-front costs of the required equipment.</p> <p>There are alternatives. MEMS cantilevered devices at the micron scale, when optimized to detect these measure associated with structural response, will provide real-time information collected at remote hubs for analysis and synthesis with other health monitoring devices. This approach removes the need for frequent manual inspections and prioritizes decision-making for</p>

	<p>the most cost-effective remedy. Existing MEMS research focuses on combining these devices with radios and energy harvesting systems to form wireless mesh communications networks for uploading the sensor data, and removing the reliance on batteries. However, such wireless networks place a heavy burden on the integrated device cost and size due to the need for long communications distance and high energy harvesting rates.</p> <p>Research Objectives: This proposed effort removes most existing burdens by utilizing connected vehicles as a mobile gateway between the sensors and the remote processing units. Sensors need only communicate across several feet instead of hundreds of feet, which reduces their transmission power, antenna size, energy harvesting requirement, and overall cost. To reduce energy consumption even further, sensors transmit available data only when the excitation from moving vehicles awakens the radio circuits.</p> <p>Implanted MEMS devices monitor structural health factors but may not necessarily measure the impact of pavement roughness on moving vehicles. Therefore, vehicles equipped with GPSvibration sensors to monitor pavement conditions may combine surface roughness measurements with the received MEMS data from their GPS-tagged location.</p> <p>This effort develops the analytical framework and proof-of-concept for utilizing such a combined system of in-situ MEMS sensors and dynamic pavement condition monitoring within a connected vehicle environment. Assessing the effectiveness of this solution will lead to further MEMS design refinement, implementation, and field-testing.</p>
<p>Describe Implementation of Research Outcomes (or why not implemented)</p> <p>Place Any Photos Here</p>	<p>Implementation of research outcomes are still under development based on the cost and manufacturing issues related to fabrication of these devices.</p>
<p>Impacts/Benefits of Implementation (actual, not anticipated)</p>	<p>As MEMS devices grow in complexity, there is very little information available related to fundamental mechanics behavior. This study provides much-needed data on the range of use of these systems along with being able to develop ranges of operation in terms of frequency and amplitude estimates for sensing and actuation use.</p>
<p>Web Links</p> <ul style="list-style-type: none"> • Reports • Project Website 	<p>https://www.ugpti.org/resources/reports/details.php?id=915</p>