Research Problem Statement

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I. TITLE

17-041 Exploration of the use of Power Harvesting Technology for Sensing Applications across the ODOT State System

II. PROBLEM

As a civilization, we strive to use digital resources to make our world easier, safer, and more efficient. Within transportation infrastructure, sensors are deployed to monitor the structures upon which we travel, as well as manage the traffic which flows across them. These sensors come in a variety of shapes, forms, and functionalities, but they do share one thing in common: a need for power. Providing a power source to sensors that exist underneath a bridge that constantly carries highly congested traffic is not only challenging, but often requires closures to access the sensors often causing motorist delay and exposing maintenance workers to undesirable/unnecessary risks. In addition, as our infrastructure ages and traffic congestion increases, there is increased demand for sensing equipment that can provide real time traffic and asset health data, from more or less remote locations to allow for real time mitigation actions to such developments. Nonetheless, such equipment requires some sort of power source to operate, and keeping the power source within working parameters, particularly in remote locations, can be challenging and costly.

III. PROPOSED RESEARCH, DEVELOPMENT, OR TECHNICAL TRANSFER ACTIVITY

While the monitoring of transportation assets and motorways are certainly not novel ideas, the use of a small footprint sustainable/self-powered sensor to accomplish these tasks certainly is. Solar, a common technology used for sustainable monitoring sensors, requires ample sun exposure and bulky equipment to harness and store power. The device developed in this work does not have such limitations enabling deployment in locations that were previously deemed inaccessible due to power requirements. The innovative technology explored by this research has the potential to transcend the sensor industry, as the power harnessing abilities of this device transfer to all manner of electromechanical sensors.

Over the past several years, a handful of researchers across the country have been investigating the use of power harvesting technology for transportation applications in rail, bridge, and traffic monitoring. In 2008, researchers developed a power harvester to drive a sensor designed to measure the vibration and forces applied to a brake beam in a rail car. More recently, also in the railway field, researchers developed an electromagnetic energy harvester with a mechanical motion rectifier designed to recover power from the vibrations and track deflections caused by passing trains. In the area of pavements, laboratory tests have shown that pyroelectric materials within Portland cement can be used to capture heat energy from pavements which can be stored in capacitors and used to power electronic devices. Researchers funded through the IDEA program experimented with power harvesting technology using Micro-Electrical Mechanical System technology to harness the vibrations in a bridge structure to power a sensor designed to remotely transmit structural health data. Specifically in the area of traffic sensors, researchers at Northern Arizona University developed and deployed a prototype traffic counting device that uses Magnetic Shape Memory Alloys for sensing and power generation.

This research problem statement proposes developing a framework for the use of using power harvesting technology across the ODOT system. This research would begin by investigating the benefits and drawbacks of all existing power harvesting technologies, followed by a thorough documentation of sensor needs throughout various ODOT departments. The researchers would then develop the above referenced framework from this documentation. With TAC guidance, one implementation would be selected and a prototype developed and deployed on the state system.

IV. POTENTIAL BENEFITS

When realized and implemented, power harvesting technology has an untold potential to save ODOT dollars not only in the area of electricity for various sensors, but also in reduced construction and traffic control costs as deployment of sensors not dependent on power sources inherently reduces utility needs and technician time in the street. Completion of this work will leave ODOT with a straw man for implementation and further

investigation, as well as a prototypical device on which future developments and deployments may be based. From a wider point of view, this work would help to continue the sustainable operational model employed with the I-205 solar highway.

V. IMPLEMENTATION

Implementation of the self-powered sensing device and of the guidelines developed in this work could commence upon completion of the project. A successful proof of concept of this technology would help provide support from higher levels of Oregon state government for additional investigation and technology deployment in this area.

VI. LIST OF REFERENCES *(optional)*

Socie, D. and Barkan, C. "Smart Sensor System for Monitoring Railcar Braking Systems." High Speed Rail IDEA Program Project Final Report. Transportation Research Board, Washington D.C., June 2008.

Lin, T., Wang, J, and Zuo, Lei. "Energy Harvesting from Rail Track for Transportation Safety and Monitoring." UTC Final Report, State University of New York, Stony Brook; February 2014.

Bhattacharjee, S, Batra, A, Meseret, S, and Cain, J. "High-Performance Single and Polycrystal-Based Pyroelectric Smart Materials for Energy Harvesting from Pavements." Transportation Research Record: Journal of the Transportation Research Board. Issue 2252, p. 75-82, Washington, D.C., 2011.

Lian, Kun. "Developing Embedded Wireless Strain/Stress/Temperature Sensor Platform for Highway Applications." NCHRP IDEA Project 129 Final Report. Wachington, D.C., March 2010.

Baldwin, J. David, Roswurm S, Nolan J, and Holliday L. "Energy Harvesting on Highway Bridges." ODOT SPR Item Number 224 Final Report, Oklahoma City, OK, 2011.

Dikes, J., Guiel, R., Smaglik, E., and Ciocanel, C. - Experimental Feasibility Analysis of Self-Powered Magnetic Shape Memory Alloy Devices, Presentation given at the 2015 SPIE Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, 8 – 12 March, San Diego, CA, 2015.

VII. CONTACT INFORMATION

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