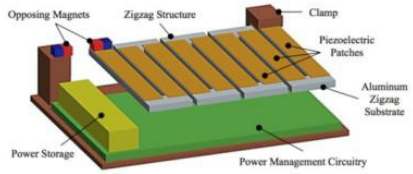
Compact Energy Conversion Module, Phase II Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

This STTR project delivers a compact vibration-based Energy Conversion Module (ECM) that powers sensors for purposes such as structural health monitoring (SHM). NASA customers include the Rocket Propulsion Test (RPT) program, the ISS, and the Orion deep space vehicle, all of which need wireless sensors to monitor and assess structural health. The ECM represents a major advancement in the use of wireless and self-powered devices by enabling the miniaturization of vibration-based energy harvesting devices suitable for powering sensors. Implications of the innovation There exist two basic problems in reducing the size of vibration-based harvesters that plague all current commercially available devices—both are addressed here. The first is addressed by eliminating the problem of frequency matching in compact devices. The second is addressed by providing a broadband device capable of energy conversion across a range of frequencies. Technical objectives Our existing prototype is a TRL 5 unit that we used to demonstrate our ability to convert kinetic energy to useful electrical power. This prototype combines piezoelectric beam transducers with artificially induced magnetic fields to force a nonlinear broadband behavior. Phase II uses this approach for compact sizing of low center frequency transducers with the objective of delivering a field-validated compact ECM that provides a near order-of-magnitude improvement over current energy harvesters. Research description Phase I created an efficient prototype and established feasibility. In Phase II we build a fully operational unit and perform field validation-tests compatible with SSC test beds. Anticipated results Anticipated results include a reduction in the amount of battery waste generated by self-powered devices that enables long-term wireless deployment. Phase I completed a TRL 5 prototype and tested its performance in relevant vibration environments. Phase II validates and delivers a TRL 6 unit.



Compact Energy Conversion Module

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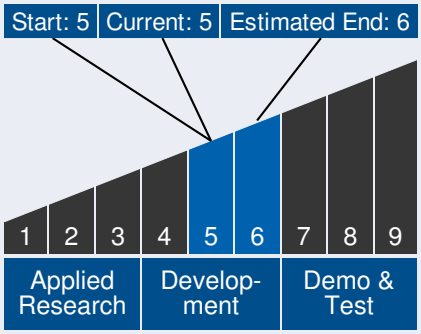

Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

Program Manager:

- Carlos Torrez

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ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: Energy consumption is now often the most significant problem discussed whenever technology is considered. As the energy efficiency of computational devices increases, self-power via harvested energy becomes increasingly viable for a host of electronic devices for sensing and other applications. The ECM kinetic energy harvester provides self-power for a variety of wireless sensors that include those for in situ SHM of NASA vehicles and infrastructure like that supporting the RPT program. ECM directly supports non-destructive evaluation (NDE) systems for safety assurance of future vehicles. There is a major effort within NASA, the FAA, and the military to develop integrated vehicle health management (IVHM) technology that uses SHM information for computer controlled recovery actions aimed at avoiding catastrophe. ECM provides enabling technology for this effort. ECM supports the NASA Engineering and Safety Center with tools for independent testing, analysis, and assessment of high-risk projects. NASA applications include self-health monitoring of future exploration vehicles and support structures like habitats and Composite Overwrapped Pressure Vessels (COPVs). ECM-powered sensors reduce maintenance, minimize crew interaction, and reduce spaceflight technical risks and needs. ECM is directly responsive to Topic T3.01, which calls for innovative and compact systems to harvest and convert kinetic energy sources.

To the commercial space industry:

Potential Non-NASA Commercial Applications: The current market is seeing increased communication between equipment within an intelligent network that can automatically manage tasks in smart buildings, logistics, and monitoring. Within this so-called "Internet of Things" (IoT) the majority of sensors and devices will eventually be connected to other devices and the Internet. Implementing this vision requires portable devices that

Management Team *(cont.)*

Principal Investigator:

- Robert Owen

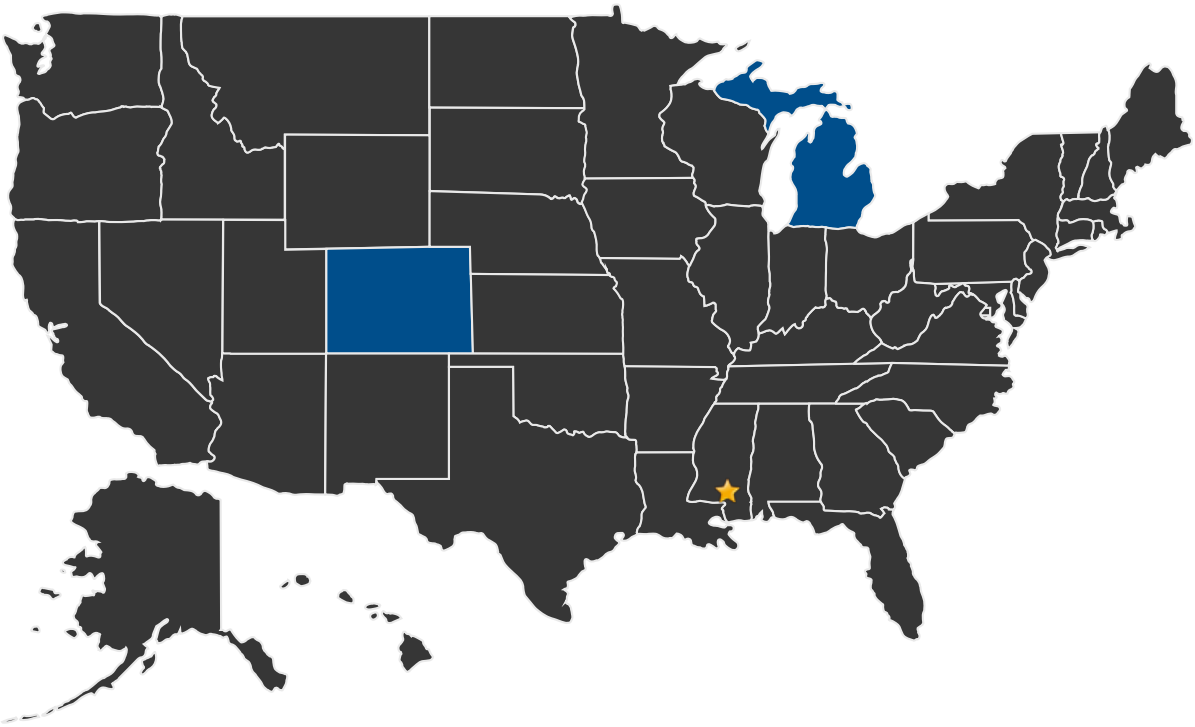
Technology Areas

Primary Technology Area:
Human Exploration Destination Systems (TA 7)
└ Sustainability and Supportability (TA 7.2)
  └ Autonomous Logistics Management (TA 7.2.1)
    └ Power Scavenged Wireless Sensor Tag Systems (TA 7.2.1.3)

Secondary Technology Area:
Space Power and Energy Storage (TA 3)
└ Power Generation (TA 3.1)
  └ Energy Harvesting (TA 3.1.1)

can be applied wherever needed, which introduces a significant challenge—how can these millions of distributed devices be powered? One path to success is energy harvesting wireless technology. Furthermore, the current dependence on batteries to power pacemakers, defibrillators, and other medical devices raise numerous safety and reliability concerns. Energy harvesting promises to eliminate bulky batteries and the risk of battery-related defects. Besides medical, applications for wireless sensors include Homeland Security structural analysis to mitigate threats (preparedness) and assess damage (response), smart structures, and SHM of civil and military structures. This broader impact includes widespread monitoring with the potential for preventing catastrophic failures and saving lives. Civil structures include bridges, highway systems, buildings, power plants, underground structures, and wind energy turbines (alternative and renewable energy). SHM applications are also driven by a desire to lower costs by moving from schedule-based to condition-based maintenance.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Stennis Space Center

Other Organizations Performing Work:

- Extreme Diagnostics, Inc. (Boulder, CO)
- The Regents of the University of Michigan (Ann Arbor, MI)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/17800)

DETAILS FOR TECHNOLOGY 1

Technology Title

Compact Energy Conversion Module