Department of the Navy SBIR/STTR Transition Program

**WHO**

SYSCOM: ONR  
Sponsoring Program: NAVY  
Transition Target: High Speed/Hypervelocity Demonstration(s) (NAVY; Air Force; DARPA; Army, and NASA)  
TPOC: Mr. Rick Burnes  
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**Other transition opportunities:** Air Force hypersonic program  
Railgun program

**Notes:** This solution is within Key Performance Parameter (KPP) – Energy.

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**WHAT**

**Operational Need and Improvement:** Batteries in hypersonic vehicles are cumbersome, require thermal insulation and maintenance. Leading edge thermoelectric generators (TEGs) save space and convert heat generated during hypersonic flight into electricity. Use of TEGs can reduce or eliminate need for batteries required to power on-board electronics. TEGs can be implemented in hypersonic missiles, projectiles, and other applications generating heat.

**Specifications Required:** Compact, reliable, maintenance free, high temperature capable TEGs capable of meeting expected missile form factors and combined mechanical and thermal environments with a minimum figure of merit (ZT) above 1 and high side temperatures of 1,250 degrees centigrade (degrees C) to supplement power generation.

**Technology Developed:** Through the innovative use of silicon carbide (SiC), high temperature stable aerogels and a proprietary metallization/attachment process for SiC fibers, eM-TECH has developed a reliable, compact, ultra-high temperature thermoelectric generator system that can survive exposure to temperatures up to 1200 degrees C and is ideally suited for supplementing power systems in hypersonic vehicles and projectiles. In short, it is a semiconductor device that converts heat into electricity without moving parts.

In addition, eM-TECH has developed a unique apparatus for measuring Seebeck coefficient and electrical impedance (collectively, power factor) at 1250 degrees C. This apparatus is capable measuring data with delta T of >900 degrees C and can simulate heat generated upon re-entry at hypersonic speeds.

**Warfighter Value:** The incorporation of thermoelectric generation enables a reduction in the size of thermal battery packs and other power generation approaches associated with air-breathing propulsion systems. Our TEG technology greatly reduces or eliminates the need for on-board battery power. Our robust thermoelectric generators become active and generate electricity needed for accurate navigation throughout hypersonic flight – to include vehicle reentry into the atmosphere where aerodynamic heating (at Mach 20 or higher) generates temperatures in excess of 1200 degrees C.

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**WHEN**

**Contract Number:** N68335-17-C-0060  **Ending on:** July 2, 2019

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Risk Level</th>
<th>Measure of Success</th>
<th>Ending TRL</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop TE power factor testing unit working at 1200C or above</td>
<td>N/A</td>
<td>met the requirement, measures Seebeck coefficient and electrical impedance at &gt;1200C</td>
<td>TRL 7</td>
<td>2nd QTR FY18</td>
</tr>
<tr>
<td>Preparation of robust SiC nano-fibers in aerogel matrix</td>
<td>N/A</td>
<td>the fiber/aerogel composite is stable at &gt;1000C</td>
<td>TRL 6</td>
<td>3rd QTR FY18</td>
</tr>
<tr>
<td>p or n-type doping of SiC nano-fibers</td>
<td>N/A</td>
<td>numerous docents have been explored where some boost Seebeck coefficient to &gt; 200uV/K</td>
<td>TRL 6</td>
<td>3rd QTR FY18</td>
</tr>
<tr>
<td>Metallization of SiC nano-fibers</td>
<td>N/A</td>
<td>anticipated adhesion to tungsten metal cupons</td>
<td>TRL 5</td>
<td>4th QTR FY18</td>
</tr>
<tr>
<td>Preparation of a TEG module (prototype)</td>
<td>High</td>
<td>TRL 4</td>
<td>TRL 7</td>
<td>3rd QTR FY19</td>
</tr>
</tbody>
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**HOW**

**Projected Business Model:** We are currently looking for partnerships with government test facilities to demonstrate/validate the prototype system capabilities and with prime contractors to license the manufacturing and incorporation of the technology. In addition to sale of the IP we would provide key development aid to the project until the final product is fully ready for launch.

**Company Objectives:** For direct implementation of our technology specific primes that we are interested in getting connected with are Lockheed Martin, Boeing, and Raytheon. We also would like to further expand and develop this technology for possible guidance of railgun projectiles and even power co-generation for nuclear and space systems.

**Potential Commercial Applications:** Commercial and dual applications of this technology include electrical power generators from satellites, fuel cells and combustion driven engines such as for aircraft and ground transportation. By harvesting combustion engine waste heat, the overall efficiency of these engines is improved. A further use is to provide back up to solar photovoltaic cells. Additional commercial applications of current technology will be in power co-generation from existing nuclear power plant, power generation from waste heat generated from steel mills or glass foundries. In addition to co-generation current technology can be applied to solar farms where solar thermal energy is converted into electricity. In some cases temperatures from 800 -1000 degrees C can be achieved.

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