Topic: N151-048

Physical Sciences, Inc.

High Energy, Long Life Cells for On-Board Sensors

Physical Sciences Inc. (PSI) is developing a high energy density battery that will extend the operating time or enable new capabilities of Navy devices. This battery, currently targeted for use in high data rate sensors, combines advanced materials and provides 50% more energy density than the batteries in use now. PSI's unique cell design leverages novel anode materials and coating technologies as well as innovative cell build/formation techniques to offer both increased energy density and cycle life. PSI has successfully demonstrated the ability to scale the required component and cell level technologies necessary to build and deliver the targeted high energy density battery. PSI's goal is to deliver safe, high energy batteries to meet the increased power needs of Navy sensors and equipment.

Technology Category Alignment:

Energy storage
Unmanned Ground and Sea Vehicles

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SYSCOM: NAVSEA
Contract: N00178-17-C-0011

Booth: 507
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Presenting: Apr 11th at 3:20 PM

Department of the Navy SBIR/STTR Transition Program

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NAVSEA #2018-0560

Topic # N151-048

High Energy, Long Life Cells for On-Board Sensors

Physical Sciences, Inc.

WHO

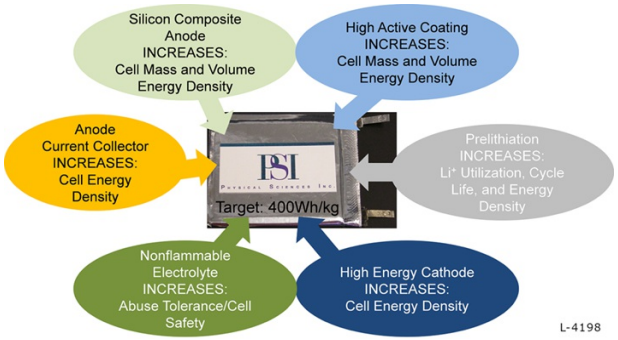
SYSCOM: NAVSEA

Sponsoring Program: PMS 450

Transition Target: PEO Submarines

TPOC:
(215) 897-1957

Other transition opportunities: Consumer electronics, electric vehicles, power sources for emergency transmission signaling devices in airplanes and watercraft, stand-by emergency power generators and reserve power packs for emergency situations.



Notes: Physical Sciences Inc. (PSI) is developing a high energy density battery that will be able to extend the operating time and capabilities of Navy devices.

This battery combines advanced materials to offer more than 50% greater energy storage density than the state of the art.

The image shows the impact of the proposed technologies on the PSI silicon based cell performance.

WHAT

Operational Need and Improvement: Shipboard wireless technologies are currently limited to sensor systems with low data rate and duty cycle requirements. The demands of more capable sensor systems would quickly deplete the power and energy in currently available batteries due to poor cycle life and energy density. PSI is developing a high energy battery that will extend the operating time and capabilities of Navy devices. This battery, initially targeted for use in high data rate sensors, combines advanced materials to offer more than 50% greater energy storage than the state of the art.

Specifications Required: The requirements guidelines for the energy storage system are: 1) 2-5V operating range; 2) "D" sized cell or smaller; 3) increased gravimetric energy density; 4) increased volumetric energy density; 5) rechargeable, with a max input power of 1 watt and retains >60% capacity after 300 charge/discharge cycles; 6) must operate in harsh conditions.

Technology Developed: PSI is developing a silicon based lithium ion cell with an energy density of 400Wh/kg. The targeted energy density will be achieved by combining together:

- PSI's patented silicon composite anode material that delivers reversible capacities >1200mAh/g.
- A high energy lithium mixed metal oxide cathode material.
- PSI's high active (HA) electrode technique which minimizes the amount of carbon and polymer in the electrodes and increases the energy and power density.
- A novel anode current collector that is <30% the mass of a standard Cu current collector.

Warfighter Value:

- Energy storage/power source for high data rate ship sensors.
- Increased energy density/mission capability for all current applications that use secondary/rechargeable batteries.

WHEN

Contract Number: N00178-17-C-0011 **Ending on:** March 30, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Demonstrate the proposed technologies can deliver the targeted performance and complete a cell design that can deliver an energy density of 400Wh/kg in the targeted operational environment.	N/A	Completion of cell design with projected energy density of 400Wh/kg.	3	February 2016
Achieve the required performance from the targeted materials. Scale the component and cell level technologies necessary to build and deliver the targeted high energy density cell.	N/A	Demonstration of basic cell performance.	4	October 2017
Demonstration of targeted cycle life performance over 100 cycles.	N/A	Less than 20% fade.	4	June 2018
Construction of cell with energy density of 400Wh/kg. Demonstration of performance over typical operating cycle.	Med	Achieve the targeted energy density.	5	February 2019
Operation of targeted sensor with the PSI battery in a representative environment.	Med	Demonstrate 15 days of uninterrupted operation	6	February 2020

HOW

Projected Business Model: PSI's goal is to deliver safe, high energy batteries to meet the increased power needs of Navy sensors and equipment.

Company Objectives: PSI develops advanced technologies and products for the military, aerospace, industrial process, energy, telecommunications, environmental, and medical markets. PSI is strongly committed to developing products and services based on innovative technologies to support the missions of the Department of Defense.

Potential Commercial Applications: The PSI battery could be utilized to enable increased energy density for all commercial and DOD applications by reducing the size and volume of current energy storage systems. Potential commercial applications include consumer electronics, electric vehicles, power sources for emergency transmission signaling devices in airplanes and watercraft. The system may also be used in stand-by emergency power generators and reserve power packs for emergency situations.

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Topic: N161-030

Bettergy Corp.

A Safe High Energy Density Power Source for Undersea Applications

Bettergy, founded in 2008 to conceive, develop and commercialize innovative energy technologies for both military and civilian applications, has developed a number of novel energy storage technologies. Bettergy is developing a very high energy density air-independent power source to meet Navy requirements for use in sensors and other undersea applications. The battery is much lower cost than existing technologies and, due to the use of non-flammable components, is safe for transport and the environment. The battery is long duration, has a long shelf life and is adaptable to different form factors. Having successfully demonstrated its technology, Bettergy's plan is to transition this energy storage technology to U.S. Naval operations. Other potential applications for this technology include unmanned undersea vehicles (UUVs) and other undersea applications.

Technology Category Alignment:

Energy storage
Power Generation/Energy Conversion

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SYSCOM: NAVSEA
Contract: N00178-17-C-8018

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Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N00178-17-C-8018

Department of the Navy SBIR/STTR Transition Program

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NAVSEA #18-556

Topic # N161-030

A Safe High Energy Density Power Source for Undersea Applications

Bettergy Corp.

WHO

SYSCOM: NAVSEA

Sponsoring Program:

Transition Target: PMS 485, Maritime Surveillance Systems, Deployable Surveillance System (DSS)

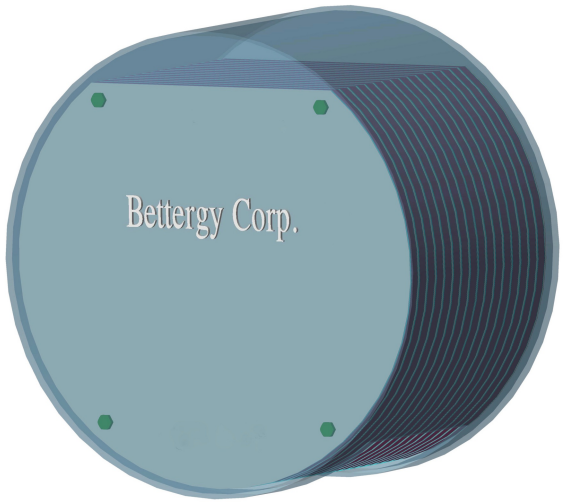
TPOC:
(619)553-1804

Other transition opportunities: Any undersea application that requires safe, high-density power

UUVs, sonobuoys, sensors, emergency beacons

Department of Homeland Security (DHS) in monitoring ports and coastal waters

Oil and gas industry, oceanographic surveying, salvage ships



WHAT

Operational Need and Improvement: Develop a novel power source that can provide electrical energy to the Deployable Family of Systems (DFoS) for as long as technologically feasible.

Specifications Required:
Reduce total operating cost
Reduce total volume
Increase power output
Compliant with Navy safety standards
Decrease the number of units required to complete the surveillance mission.

Technology Developed: Bettergy has developed a very high energy density, air-independent battery that has 3 to 5 times more power than that provided by the current lithium primary batteries. Bettergy's battery is low cost, safe, and can be produced in different form factors and adapted for different undersea applications.

Warfighter Value: Enhances and increases overall system persistence
Increases operating efficiency by reducing the number of units required
Reduces total operating cost by increasing the area covered by each unit
Safe--utilizes non-flammable components and meets Navy transportation requirements

WHEN

Contract Number: N00178-17-C-8018 **Ending on:** September 25, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Demonstration of Performance of Cell Stack	N/A	Stack meets performance requirements	3	May 2018
Breadboard System Developed	Low	System meets performance targets	4	September 2018
If Option Exercised, Prototype Developed	Low	Prototype delivered that meets performance requirements and is verified by independant Navy testing	5	September 2019
If Option Exercised, Field Testing	Med	Ten prototypes delivered; verified by independant Navy testing	6	September 2020
If Phase II.5 awarded, Manufacturing Transition	Med	Manufacturing plan established and put in place	8	September 2021

HOW

Projected Business Model:
Bettergy has the capacity and capability to manufacture batteries to meet initial production demand. In order to meet increased demand we will seek strategic partners to produce certain components and/or manufacture the battery directly or, alternatively, manufacture the battery through a company with existing battery manufacturing capability or enter into a strategic partnership with an industrial partner. The batteries will be sold directly to the Navy.

Company Objectives:
Bettergy's objective is to develop and commercialize innovated energy technologies for both military and civilian applications. The specific objective with respect to this battery technology is to develop, optimize and manufacture the battery so that it can be deployed for use in Naval operations.

Potential Commercial Applications:
Applications requiring a very long duration undersea power source, including commercial and maritime operations involving undersea surveillance, sonobuoys, sensors, UUVs and emergency beacons. Other potential users include the US Coast Guard, and US Customs and Border Protection.

Contact: Guy A. Longobardo, Chief Operating Officer
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Topic: N151-073

K2 Energy Solutions, Inc.

Enhanced Cell Designs for Improved Internal Heat Transfer for High Rate and Power Capable, Large-Format Batteries

The anticipated deployment of electric-powered weapons systems on Navy ships and increasing power demands of radar and electronic warfare systems will place a highly variable and unpredictable demand on shipboard power systems. Issues associated with this can be greatly mitigated by integrating energy storage into the power system. However, this energy storage system must be capable of very high charge and discharge rates without excessive internal heating that can reduce both performance and battery life. The technology being developed will enable such an energy storage device, by combining proven high power, long-life electrode and cell designs with internal and external thermal management technology that prevents excessive temperature rise without degrading battery performance.

Technology Category Alignment:

Energy storage
High Energy Lasers (HEL)
Radio Frequency Weapons (RFW)
Power and Energy

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Department of the Navy SBIR/STTR Transition Program

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ONR Approval #43-4388-18

Topic # N151-073
Enhanced Cell Designs for Improved Internal Heat Transfer for High Rate and Power Capable, Large-Format Batteries
K2 Energy Solutions, Inc.

WHO

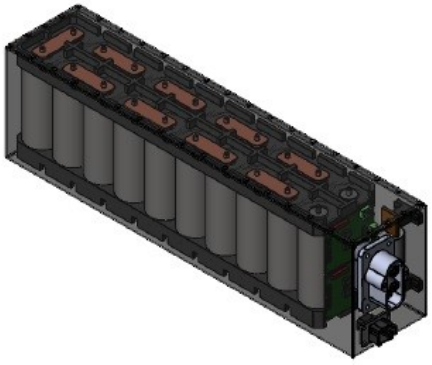
SYSCOM: ONR

Sponsoring Program:

Transition Target: Multi-Mission Energy Storage FNC, Railgun INP

TPOC:
Dr. John Heinzel
john.heinzel@navy.mil

Other transition opportunities:



WHAT

Operational Need and Improvement: Energy storage is a key enabling subsystem for supporting future shipboard electrical loads. However, the capability of legacy high energy cells need to be increased to meet the needs of envisioned future shipboard applications. Improved internal cell-level thermal management of large-format, high power batteries will facilitate the development of simplified, more manageable large-scale battery systems.

Specifications Required: Develop, fabricate and demonstrate a 20Ah, 1000V cell and battery design and Battery Management System (BMS):
- suitable for operation at 1000V and 10C (threshold) to 30C (objective), using 40°C liquid cooling only.
- suitable -for compact racking and operation in tight applications and in spaces with ambient temperatures up to 60°C.
- able to transfer heat to the cooling media in such a manner that upon completion of a full discharge (=80% DOD) at rated conditions, the cells can immediately undergo charge at a 2C rate (threshold) or higher (15C, objective), repeatedly.

Technology Developed: 1) Electrode designs that both minimize cell internal resistance to reduce heat generated during high power operation and maximize heat conduction away from active materials that generate heat during that same high power operation; 2) Cell terminal designs that maximize both thermal and electrical conduction to minimize cell temperature rise during high power operation; and 3) Passive thermal management technologies that rapidly dissipate heat away from individual cells and cell casing and internal jellyroll interfaces that efficiently transfer heat to the external thermal management structure.

Warfighter Value: Batteries fabricated with the cells being developed under this project will be capable of continuous, high power operation on both charge and discharge, which will enable their use as shipboard energy buffers. This will be critical in the increasingly electrified warships of the future, where electric weapon systems and more powerful radar and communications systems will place high demands on the ship's power system. The presence of an "energy buffer" in the form of a high-power energy storage system will enable to operation of these advanced systems without compromising the performance of other critical ship systems.

WHEN

Contract Number: N68335-17-C-0051 **Ending on:** June 25, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Preliminary cell design review	Med	Cell performance validation testing	4	1st QTR FY19
Preliminary battery module design review	Med	Module performance validation testing	4	2nd QTR FY19
Final cell design reivew	Med	Cell performance validation testing	5	3rd QTR FY19
Final battery module design review	Med	Module performance validation testing	6	3rd QTR FY19

HOW

Projected Business Model: As a developer and manufacturer of lithium iron phosphate cells and batteries, it is K2's intent to manufacture the cells and batteries developed under this project. This will require that the company set of a dedicated facility within the US to manufacture these cells (presently, K2 manufacturers small format cylindrical cells at our facility in China). To this end, we have already begun to purchase equipment for this projected manufacturing line and are targeting an initial manufacturing volume of ~500 large-format cylindrical cells per day.

Company Objectives: K2's overall goal is to be the premier domestic supplier of lithium-ion cells and batteries and we see supplying both COTS and custom batteries to the U.S, military as critical to meeting that goal. K2 was selected as the sole source supplier of batteries to the Navy for its electromagnetic railgun development program, is the sole source supplier of batteries to the Marines GREENS program, and and is a significant supplier of cells and modules to a number of OEM's making UPS systems for the U.S. military. We see the cells and batteries being developed under our Phase II project as a key pathway for keeping the company competitive in the energy storage arena, which is rapidly evolving in both military and commercial sectors.

Potential Commercial Applications: The electric utility industry uses large battery bank installations in lieu of "peaker plants" in order to level load the power generation requirements during peak time of day. The automotive and marine industries are transitioning to electric drive. These large-format high-power batteries would be directly relevant for these applications and would furthermore reduce Department of Defense (DoD) procurement costs with the economy of scale of manufacturing for multiple industrial sectors.

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Topic: N151-068

eM-TECH, Inc.

Ultra-High Temperature Thermoelectrics

Hypersonic vehicles require reliable, maintenance free, compact, high temperature capable power sources – requirements that are difficult to attain using battery-based systems. eM-TECH's Thermoelectric Generator (TEG) system technology meets those requirements. In addition, it also increases the temperature limits of legacy TEG systems from approximately 600 C to 1250 C while achieving a figure of merit (ZT) above 1 through the innovative use of silicon carbide and stable aerogels. eM-TECH, Inc. specializes in providing advanced technology solutions to problems of critical importance within the fields of materials chemistry, thermal management, adhesives, composites, and ultra-high heat to electricity conversion. We seek 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.

Technology Category Alignment:

Aircraft Propulsion, Power and Thermal
High-Speed/Hypersonics
Power Generation/Energy Conversion
Manufacturing Technology for Affordability
Radio Frequency Weapons (RFW)

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SYSCOM: ONR
Contract: N68335-17-C-0060

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Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-17-C-0060

Department of the Navy SBIR/STTR Transition Program

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ONR Approval #43-4388-18

Topic # N151-068

Ultra-High Temperature Thermoelectrics

eM-TECH, Inc.

WHO

SYSCOM: ONR

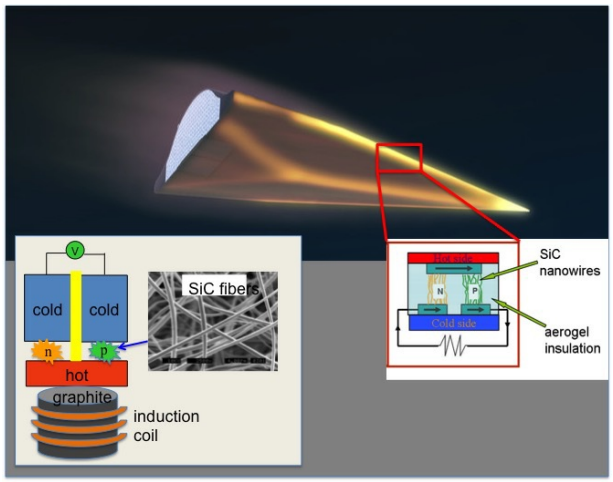
Sponsoring Program: NAVY

Transition Target: High Speed/Hypervelocity Demonstrator(s) (NAVY; Air Force; DARPA; Army, and NASA)

TPOC:
Mr. Rick Burnes
richard.burnes@navy.mil

Other transition opportunities: Air Force hypersonic program
Railgun program

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



eM-TECH depiction of the Seebeck coefficient measurement apparatus with nanofibers and schematic of the TEG device on leading edge of the hypersonic vehicle. Copyright eM-TECH, 2018

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.

WHEN

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

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

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 in to electricity. In some cases temperatures from 800 -1000 degrees C can be achieved.

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