## Topic: N161-071

## Applied Optimization, Inc.

Additive Manufacturing Development of Naval Platform Heat Exchangers

Applied Optimization, Inc. (AO) is developing Integrated Computational Materials Engineering (ICME) models and software to support additive manufacturing (AM) development of conformal heat exchangers (HeX) for power electronics hardware. The conformal geometry of cooling channels is optimized to attain higher thermal efficiency. ICME optimization ensures the manufacturability of quality metallic parts from a variety of AM machines at different geographic locations. AO's team of scientists, engineers, and software developers' modeling and simulation capabilities has advanced the understanding of the state-of-the-art in additive manufacturing (AM) processing. Employment of AM leads to innovative HeX designs capable of more efficiently removing heat because these designs eliminate or severely reduce joints. AO seeks to identify DoD Prime contractor and Programs focused on AM and thermal management optimization.

## Technology Category Alignment:

Advanced Electronics
Test, Evaluation, Validation, and Verification
Engineered Resilient Systems (ERS)
Materials & Manufacturing Processes

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**SYSCOM:** ONR
**Contract:** N68335-17-C-0563
Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-17-C-0563

# Department of the Navy SBIR/STTR Transition Program

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Additive Manufacturing Development of Naval Platform Heat Exchangers

Applied Optimization, Inc.

## WHO

**SYSCOM:** ONR

**Sponsoring Program:** Office of Naval Research Code 33 Sea Warfare and Weapons

**Transition Target:** Office of Naval Research (ONR) Future Naval Capabilities (FNC) Program Enterprise Platform Enablers (EPE) Quality Metal Additive Manufacturing (Quality Made), EPEFY17-03

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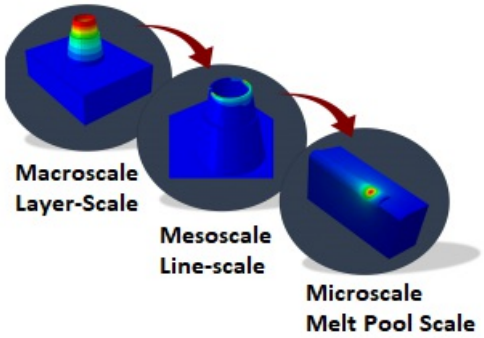
**Other transition opportunities:** DoD-wide Additive Manufacturing (AM) application focused on Thermal Optimization






## WHAT

**Operational Need and Improvement:** Additive Manufacturing (AM) is a disruptive manufacturing process that enables reliable and cost-effective low volume manufacturing to increase Fleet readiness. Technology development is required to reduce the time and cost associated with deploying qualified/certified AM metallic components for use in Naval Air, Sea, & Ground platforms.

**Specifications Required:** T = Threshold and O = Objective requirements

- Property prediction capability as a function of process and part geometry: Measured value shall be within ± 10% (T) or ± 5% (O) of predicted ICME value with the confidence level specified
- Accuracy of the process and sensor control values defined by ICME are maintained within 90% (T) and 95% (O) with the confidence level specified
- Accuracy of as-fabricated microstructure and anomalies (e.g. porosity) across varying geometries: 90% (T) and 95% (O) of predicted with the confidence level specified
- Mechanical properties (static and dynamic) of the as-fabricated part: meet or exceed those of castings (T), and match wrought with the confidence level specified (O)

**Technology Developed:** Integrated Computational Materials Engineering (ICME) to develop a conformal design heat exchanger (HeX) for power electronics hardware cooling components. Where the conformal geometry is optimized to attain higher thermal efficiency and the cross-section is evaluated for manufacturability using selective laser melting (SLM) processes. The SLM process design is performed using thermal computational fluid dynamics (CFD) analysis of the melt pool physics and thermal finite element analysis (FEA) to identify residual stresses and perform distortion analysis of the build. The ICME procedure is employed to determine potential failure locations and the HeX design is modified to include sensor ports to support data collection, leveraged to support qualification.

**Warfighter Value:** Naval platforms are challenged by limited supply sources, reducing readiness and causing unacceptable logistical delays. Currently, maintenance depots make limited production parts to meet operational demands. Naval Warfare Centers, maintenance depots, and Fleet Readiness Centers plan to use additive manufacturing to produce small quantities of out-of-production or long lead-time metallic components. Technology solutions are needed to ensure the manufacturability of quality metallic parts from a variety of AM machines and at different geographic locations.

## WHEN

**Contract Number:** N68335-17-C-0563 **Ending on:** November 29, 2019

| Milestone | Risk Level | Measure of Success | Ending TRL | Date |
|---|---|---|---|---|
| Apply ICME tools to metal AM processing, to predict design limits (for minimizing wall thickness and HeX weight) | Low | Prototype demonstration of ICME | TRL-4 | 2nd QTR FY18 |
| Validate ICME tools and predictive analysis capabilities by comparing the physical, metallurgical and mechanical properties of an AM heat exchanger with a heat exchanger fabricated by traditional means | Low | Thermal performance design improvements | TRL-4 | 1st QTR FY19 |
| Correlate non-destructive methods against with destructive examinations. | Med | Correlation between NDI and destructive test samples | TRL-5 | 1st QTR FY20 |

## HOW

**Projected Business Model:** The Additive Manufacturing (AM) team at Applied Optimization, Inc. (AO) focuses on research and development in metallurgy and metals processing. AO plans to work with government and Department of Defense (DoD) prime contractors to develop viable solutions to complex problems in the area of metal additive manufacturing (3D printing metal) in order to meet DoD AM component performance requirements.

**Company Objectives:** Since 1995, Applied Optimization, Inc. (AO) has collaboratively developed innovative solutions in material science to address the technical challenges for industry, NASA, and the DoD. Offering the right balance between critical thinking and non-conformity, AO's team of scientists, engineers, mathematicians, and software developers strive to further the understanding and state-of-the-art of additive manufacturing (AM), materials processing. AO intends to leverage the DoD SBIR program to develop software capabilities that optimize AM process parameters, mitigating defects in build parts and processes.

**Potential Commercial Applications:** Heat Exchangers are universal and employed in numerous commercial systems that reject heat for engines, electronics, and other heat-producing devices. Application of ICME thermal CFD and thermal FEA optimizes HeX designs, making them more efficient at removing heat, and eliminating or severely reducing the number of joints. The same AM designed optimizations employed for components qualified for the Navy can be applied or adapted for commercial application.

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