PHASE IIE PROJECT SUMMARY

Firm: **Creare LLC**
Contract Number: **NNX13CC07C**
Project Title: **A Turbo-Brayton Cryocooler for Aircraft Superconducting Systems**

Identification and Significance of Innovation:

Hybrid-electric aircraft with superconducting electric generators and motors have the potential to revolutionize air transportation. A key enabling technology will be efficient, lightweight cryocoolers, which will be required to cool the high-temperature superconductors (HTS) below their critical temperature (< 65 K). The weights of current commercial cryocoolers are too high, and their efficiencies are too low to be practical for aircraft. To address this challenge, Creare developed the *Cryoflight* cryocooler concept, an innovative turbo-Brayton cryocooler optimized for both low weight and high efficiency. Central to this concept is the need for a compact, lightweight, recuperative heat exchanger with mass and performance targets that are beyond those available from commercial heat exchangers. Here, we propose to develop a new heat exchanger that will meet these targets and result in an unparalleled reduction in cryocooler mass, thus providing an enabling technology for superconducting aircraft systems.

Technical Objectives and Work Plan:

Our overall objective is to develop an extremely lightweight, high-performance *Cryoflight* cryocooler that is optimized for cooling superconducting devices in an electric aircraft. This specific project addresses the need for lightweight, high-performance recuperators optimized for this application. During the Phase II project, we matured our compact, lightweight recuperator technology.

Technical Accomplishments:

In the Phase II project, we completed a number of risk reduction trials, including fabrication and performance tests, and used the results to update our design models. We then used these models to optimize the design of our Laminated Slotted-Plate heat exchanger. We have fabricated components for one heat exchanger module but experienced a critical failure in the heat exchanger core during final assembly. We devoted the remainder of the project to testing to optimize the design of the heat exchanger.

NASA Application(s):

Creare's *Cryoflight* cryocooler development effort supports NASA's long-term goal to increase aircraft efficiency and reduce aircraft emissions and noise. The highly reliable and space-proven turbo-Brayton cryocooler is ideal for this application. By optimizing the cryocooler to meet the aggressive power density target required for aircraft systems, we remove a key obstacle hindering the development of superconducting aircraft. Superconducting generators, motors, and transmission lines enable hybrid electric aircraft, where power generation is decoupled from thrust generation, which opens the design space and makes blended-wing body configurations with distributed thrust feasible and major reductions in fuel burn, noise, and emissions possible.

Non-NASA Commercial Application(s):

Transformational initiatives that rely on HTS technologies include power conditioning and power transmission systems, large-scale offshore wind turbines, high-efficiency data centers, Navy ship systems, and turboelectric aircraft. While the latter is the target application for the proposed cryocooler, the other applications represent potential near-term markets for the technology. Other potential markets beyond HTS applications include laboratory- and industrial-scale gas separation, liquefaction, cryogen storage and cryogen transportation systems, liquid hydrogen fuel cell storage for the automotive industry, and commercial orbital transfer vehicles and satellites.

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