# NASA Phase I Project Summary

**Firm: Creare Incorporated**
**Contract Number: NNX12CD63P**
**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 required to cool the high-temperature superconductors (HTS) below their critical temperature (< 65K). 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 and result in an enabling technology for superconducting aircraft systems.

**Technical Objectives and Work Plan:**

The objective of this program is to develop an extremely lightweight, high-performance cryocooler that is optimized for cooling superconducting devices in an electric aircraft. The proposed project addresses the need for a lightweight, high-performance recuperator optimized for this application.

**Technical Accomplishments:**

During Phase I, we developed a detailed model of the recuperator and integrated it into a complete model of the turbo-Brayton cryocooler. We then optimized the recuperator as part of the system. In Phase I, we advanced the TRL of the recuperator from 2 to 3 by conducting a number of risk reduction tests to demonstrate the feasibility of our concept and to validate our modeling assumptions regarding the mass of the recuperator headers. We also completed an analysis of supporting computational fluid dynamics (CFD) results to validate our design heat transfer and pressure drop correlations. Finally, we compared the performance and materials cost of the heat exchanger to that of other heat exchanger technology.

**NASA Application(s):**

The proposed *Cryoflight* cryocooler supports NASA's long-term goal to increase aircraft efficiency and reduce emissions and noise, and will remove a key obstacle to the development of superconducting aircraft. Supporting technology development for such aircraft needs to begin now for the technology to become a viable alternative to aircraft configurations in production today. Other NASA applications include cryogen liquefaction and storage for planetary and extraterrestrial exploration, CEVs, extended-life orbital transfer vehicles, in-space propellant depots, and extraterrestrial bases. Terrestrial NASA applications include cooling for

demonstration hydrogen production and transportation systems. The highly reliable and space-proven turbo-Brayton cryocooler is ideal for these applications.

**Non-NASA Commercial Application(s):**

HTS materials have the potential to revolutionize the way we generate, transmit, and consume power. Apart from hybrid turbo-electric aircraft, other transformational initiatives that rely on HTS technologies include power transmission systems, large-scale offshore wind turbines, high-efficiency data centers, and electric ship systems. The key advantages of superconducting systems are reductions in electrical losses, system size, system cost, and system weight. While cryocoolers will be critical enabling components in any of these systems, current commercially available cryocoolers are inadequate in size, capacity, reliability, and maintenance requirements. Creare's turbo-Brayton cryocooler is 7 times lighter, 5 times smaller, virtually silent, and uses half the energy to produce the same cooling of the best existing alternative, while providing a lifetime of maintenance free operation.

**Name and Address of Principal Investigator:** (Name, Organization, Street, City, State, Zip)

Anthony J. Dietz
Creare Incorporated
16 Great Hollow Road
Hanover, NH 03755

**Name and Address of Offeror:** (Firm, Street, City, State, Zip)

Creare Incorporated
16 Great Hollow Road
Hanover, NH 03755