1. **Research Title:** Computational Design, Analysis and Integration of Aircraft Power and Thermal Management Subsystems

2. **Individual Sponsor:**

Dr. Soumya S. Patnaik, AFRL/RQQI
Bldg. 18, 1950 Fifth Street
WPAFB, OH 45433-7333
Soumya.Patnaik.1@us.af.mil

3. **Academic Area/Field and Education Level**
Aerospace/Mechanical/Electrical/Computer Engineering (MS or Ph.D.)

4. **Objectives:** Development of computational methods and models to support the design, analysis, and integration of electric power and thermal management subsystems onboard an aircraft.

5. **Description:** An aircraft may be viewed as a collection of interacting energy subsystems which support various functions required to sustain various flight conditions and mission requirements. For modern aircraft with advanced mission capabilities, highly integrated subsystems, and the adoption of electric power to replace historical power sources (i.e. pneumatic, hydraulic, etc.), traditional design paradigms fail to achieve vehicle level optimum designs. The design of electric power and thermal (P&T) management subsystems have been particularly challenging due to the issues of power quality and stability, increased heat generation commensurate with modern avionics, and their coupling to the propulsion system. For a given mission, transient analysis of the subsystems and vehicle dynamics using a system approach is typically required to monitor performance, and detect the emergence of undesirable behavior.

As expected, integrating subsystems with vehicle dynamics results in a non-intuitive multi-dimensional tradespace where computational methods can provide reliable means of efficiently exploration. Accurate numerical simulations require the determination of suitable fidelity models for complex physical phenomena, resolution of widely varying spatial and/or temporal scales, as well incorporating the effect of non-trivial subsystem interactions to quantify the impact on both subsystem and vehicle level performance. Advancements in algorithmic performance (computational time, parallelization, design sensitivities, etc.), accuracy (physics fidelity, capturing multiple physics domain and time scales, etc.) and uncertainty quantification (capturing modeling errors, propagating parametric uncertainty, etc.) are all envisioned as necessary components to produce reliable P&T management systems for modern aircraft. Research opportunities are available in multiple disciplines, including:

a. Novel design strategies for dynamic simulation to evaluate P&T subsystem performance;
b. Multidisciplinary design optimization for transient systems;
c. Application of uncertainty quantification and sensitivity analysis to transient systems;
d. Surrogate modeling and machine learning for transient systems;
e. Novel model verification and validation;
f. Efficient thermodynamic design exploration of novel system architectures (ex. hybrid electric propulsion systems).

Access to several commercial and in-house developed codes and computing resources at the AFRL DoD Super Computing Resource Center is available.

6. **Research Classification/Restrictions:** This research is unclassified. U.S. citizenship is required for this position.

7. **Eligible Research Institutions:** All DAGSI.

8. **PA Approval #** 88ABW-2020-2816