RQ14-1

1. **Research Title:** *Optimization of Compact Gas-phase Heat Exchangers for Aero Engine Integration*

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Mechanical Engineering, Aerospace Engineering, or equivalent (MS and/or Ph.D. level)

4. **Objectives:** Develop new capabilities for preliminary design, analysis and performance enhancement of compact gas-phase heat exchangers, especially to support design trades and integration with small propulsion and power systems. Demonstrate and validate capabilities through simulation and experimental testing of heat exchangers.

5. **Description:** Known scaling challenges for component efficiencies greatly diminish overall Brayton Cycle thermal efficiency of small propulsion and power (P&P) systems (e.g. below ~500 core HP) as compared to large turbine engine experience. Cycle analysis has identified key trends, including the strong potential of a special class of heat exchangers (HEX), known as recuperators, to dramatically improve small engine efficiency (3-4x), meeting or even exceeding that of large engines.

   Recuperators capture excess thermal energy from the exhaust stream and transfer it to the cooler compressor discharge stream, prior to entering the combustor. This approach has found significant application in ground-based P&P systems, but historically it has not traded favorably for large aero engines due to weight, volume and cost implications.

   Multiple factors suggest the feasibility and system performance benefits of recuperators may be much greater for small-scale P&P, and may be a key enabler for more sustainable uninhabited air vehicles (UAVs). Ongoing HEX fabrication trials with emerging manufacturing techniques also show great potential, as do their experimental performance. However, technical challenges remain. New capabilities are needed to enable more optimal HEX design and aero-propulsion system integration.

   Desired research areas and capability improvements include:

   a. New/improved tools for preliminary design, including rapid, early HEX sizing and performance estimation; design of engine systems with conformal HEX integration; estimation of HEX weight and/or cost; and ultimately enabling early system-level trades and optimization.

   b. Research into surface features, especially as enabled by new manufacturing technology, for air/gas-phase HEX heat transfer enhancement.

c. New/improved tools for unprecedented HEX aero/thermal detailed design flexibility and optimization. Tools which better leverage the potential of less-constrained manufacturing techniques, such as 3D printing for conformal integration and internal feature tailoring, are of particular interest.

d. Detailed performance modeling and experimental characterization of recuperators.

6. **Research Classification/Restrictions:** U.S. citizens only. Conduct of research may require regular interface to ITAR restricted data.

7. **Eligible Research Institutions:**

■ DAGSI (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, University of Cincinnati)

PA Approval #: Topics submitted to DAGSI must be approved for public release.

☐ AFIT (only)

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☐ Yes ☐ No