

1. **Research Title:** Modeling and Analysis of Advanced Heat Exchangers for Military Aircraft Thermal Management Systems

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:**

Mechanical Engineering / Aerospace Engineering / Thermal and Fluid Sciences / Computational Fluid Dynamics / Heat Transfer (MS or PhD level)

4. **Objectives:** Model, analyze, and evaluate advanced heat exchanger concepts for military aircraft thermal management applications. Investigate conventional and advanced heat exchanger geometries, including conformal and additively manufactured heat exchangers incorporating Triply Periodic Minimal Surface (TPMS) structures.

Develop analytical and computational methods to characterize heat exchanger thermal hydraulic performance. Computational Fluid Dynamics (CFD) will be used to investigate fluid flow, heat transfer, pressure losses, flow distribution, and other performance characteristics of candidate heat exchanger geometries.

Investigate experimental and analytical approaches, including Wilson plot methods, for determining heat transfer coefficients and supporting validation of computational models.

Compare candidate heat exchanger concepts and geometries using relevant performance metrics such as heat transfer effectiveness, heat rejection capability, pressure drop, mass, volume, flow distribution, and thermal hydraulic performance.

The research will identify heat exchanger geometries and modeling approaches that enable improved thermal performance while reducing Size, Weight, and Power (SWaP) impacts for future military aircraft thermal management systems.

5. **Description:** Future military aircraft are expected to experience increasing thermal loads from propulsion, electrical power, and advanced mission systems. Effectively rejecting these loads while minimizing aircraft Size, Weight, and Power places increasingly demanding requirements on heat exchanger performance.

Traditional heat exchanger designs can be constrained by conventional manufacturing processes and geometric limitations. Advances in additive manufacturing provide opportunities to develop

complex internal flow passages, conformal heat exchangers, and novel heat transfer surfaces that may provide improved thermal performance and packaging flexibility.

One promising approach is the use of Triply Periodic Minimal Surface (TPMS) geometries. TPMS structures provide continuous three dimensional flow passages and large surface areas that may offer advantageous heat transfer characteristics. Additive manufacturing also enables heat exchangers to conform to available aircraft volumes rather than being constrained to traditional rectangular or cylindrical configurations.

However, these advanced geometries introduce challenges in accurately predicting thermal and fluid performance. Detailed understanding of heat transfer, pressure losses, flow distribution, and geometric effects is required before their potential aircraft level benefits can be quantified.

This research will use analytical, computational, and potentially experimental approaches to investigate advanced heat exchanger concepts. CFD will be used to characterize local and overall heat transfer and fluid flow behavior within candidate geometries. Parametric studies may evaluate the influence of geometry, flow conditions, material properties, and operating conditions on heat exchanger performance.

Analytical and experimental characterization techniques, including Wilson plot methods, may be investigated to determine heat transfer coefficients and support validation of computational predictions. Computational and experimental results may then be used to develop or improve reduced order models and performance correlations for advanced heat exchanger geometries.

The research will compare conventional, conformal, and advanced additively manufactured heat exchanger concepts to identify their relative benefits, limitations, and potential applications within future military aircraft thermal management systems.

6. **Research Classification/Restrictions:** Open to U.S. citizens only. Some aspects of this research may include ITAR restrictions.
7. **Eligible Research Institutions:** DAGSI (All DAGSI Universities).

PA Approval # AFRL-2026-1634