RQ20-11

1. **Research Title:** *Predictive Capability for Multidisciplinary Design under Uncertainty and Sensitivity Analyses for Hypersonic Systems*

2. **Individual Sponsor:**

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Academic Area/Field and Education Level

a. Aerospace Engineering, Mechanical Engineering, Computer Science, or Mathematics (MS or Ph.D. level)

4. **Objectives:** The objective of the proposed thesis topic is to develop/implement state-of-the-art techniques to address challenges in multidisciplinary design, analysis, and optimization under uncertainty, utilizing data from multiple information sources with variable-fidelity. Such techniques may be in the areas of, but not limited to: adaptive/goal-driven computational sampling strategies, development and utilization of non-deterministic surrogates in design, inverse design methodologies with uncertainty, and/or multi-fidelity surrogate development considering budgets. The technique(s)/approach(es) developed under this work shall be implemented on a representative hypersonic vehicle design problem to demonstrate relevance to potential military applications.

5. **Description:** The development of high-speed aerospace vehicles remains a strong focus for both military and commercial aviation. These non-conventional systems rely upon physics-based computational methods to characterize their performance & simulation, especially true for tightly- coupled hypersonic systems. Additionally, uncertainty in their design is of key importance as historical systems are few and of limited value to inform future designs. Understanding the potential variability of the system early in the design process will help to define and mitigate risk. Uncertainties are classified into three categories: *parameter uncertainty* which stems from lack of knowledge about input parameters; *model uncertainty* which is the effect of assumptions and approximations in the physics modeled; and *numerical uncertainty* which is the error associated with numerical solutions. Parameter and model uncertainty are less understood and may be a key topic of this research. Model uncertainty in terms of multi-fidelity analyses is also of importance for the design of high speed systems. Higher fidelity models such as RANS based CFD are typically too costly in terms of computational time and resources to drive analysis in early design phases. Instead lower fidelity methods are used that simplify the underlying physics, often tuned by comparison with high-fidelity models at key points. Research work relevant to this topic includes modern multi-fidelity surrogate methods, as well as adaptive/goal-driven computational sampling techniques. Finally, non-deterministic surrogates in design & optimization, as well as similar uncertainty based methods for inverse design (i.e. given overall vehicle performance characteristics necessary to meet certain requirements, what does this levy on systems/subsystems and what levels of uncertainty can be tolerated at the lower levels of the

system hierarchy). Any methodology developed and/or implemented shall be used on a representative hypersonic vehicle design problem to demonstrate applicability to appropriate applications.

6. **Research Classification/Restrictions:** U.S. Citizens only. Most aspects of this research fall under the 6.1 basic research classification. However, some aspects, in particular those dealing with vehicle configurations and performance parameters, are FOUO with ITAR restrictions.

7. **Eligible Research Institutions:**

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

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