RQ19-9

1. **Research Title:** *Development of a Predictive Capability for Multidisciplinary Design under Uncertainty and Sensitivity Analysis for Hypersonic Systems*
2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level**
   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 problems in multidisciplinary design, analysis, and optimization under uncertainty, utilizing data from multiple information sources with multi-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 applicability and the value added.
5. **Description:** The development of advanced aerospace vehicles remains a strong focus for both military and commercial aviation. These systems are typically non-conventional and physics based computational methods are relied on to characterize them. This is especially true for hypersonic systems which are tightly coupled systems. Additionally, the uncertainty in their design is of key importance as historical systems are few and are limited in ability to inform future designs. Numerous uncertainties exist in vehicle designs and the ability to understand some of the potential variability of the system early in the design process will help to define risk. Having knowledge of risk will enable technology developments to mitigate risks. The uncertainties may be classified into three categories: parameter uncertainty which stems from lack of knowledge about input parameters in the simulation, model uncertainty which is the effect of assumptions and approximations in the physics being modeled, and numerical uncertainty which is the error associated with numerically solving the model equations. Parameter and model uncertainty are less understood and are the topic of this research. Model uncertainty in terms of multi-fidelity analyses is also another area of importance for the design of these systems. Higher fidelity models such as RANS based CFD are typically too computationally costly to rely on in early design phases. Instead lower fidelity panel/surface inclination methods are used which make many assumptions about the underlying physics and higher fidelity point checks are done. This opens up research or thesis work to also be done on the topic of developing and/or applying modern multi-fidelity surrogate methods, as well as adaptive/goal-driven computational sampling techniques. One other potential area for thesis

work to be steered towards is utilizing non-deterministic surrogates in design & optimization, as well as applying 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 and the value added.

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:** Indicate to what organizations this topic should be provided

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