AFRL CALL FOR RESEARCH

1. **Research Title:** *Development of a Predictive Capability for Multidisciplinary Uncertainty and Sensitivity Analysis*

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Aerospace or Mechanical Engineering / Computational Physics and Numerical Analysis (BA/BS, MS or Ph.D. level)

4. **Objectives:** To implement state-of-the-art techniques for error quantification and provide systematic uncertainty analysis in multidisciplinary numerical calculations. Specifically, this project will develop and implement a systematic uncertainty analysis procedure that can quantify the expected differences between computational and experimental data (solution validation). To *quantify and control the uncertainty and sensitivity of a predictive capability* for multidisciplinary computation with a systematic process for uncertainty analysis.

5. **Description:** The development of advanced aerospace vehicles remains a strong focus for both military and commercial aviation. Experimentation in a laboratory or wind tunnel is difficult and flight tests are expensive. Computational methods serve as critical tools in the analysis and design of advanced aerospace systems. Numerous uncertainties in the design, manufacture and operation of high performance military vehicles must be addressed to facilitate their certification. Those uncertainties may be classified into three categories. *Parameter uncertainty* comes from the lack of knowledge about the values of input parameters to the simulation. *Model uncertainty* has to do with the effect that assumptions and approximations in the model have on the accuracy of the results compared to physical system modeled. *Numerical uncertainty* is the error associated with numerically solving the model equations. The latter numerical uncertainty falls into the domain of mathematicians who establish error bounds and convergence rates for various numerical methods. It is arguably the best understood type of uncertainty but also the most benign. Larger uncertainty typically comes from parameter and model uncertainty. These areas are the subject of this research effort. Uncertainties associated with flight loads, material properties, and manufacturing tolerances should be addressed as common parameter uncertainties. Model uncertainty is the most intractable source of uncertainty to quantify. One way to address it is to consider variable fidelity models of the same system to quantify the effect of simplifying assumptions made in modeling. The interacting disciplines in a multidisciplinary design include structural mechanics, static and dynamic aerodynamics, aeroelasticity, and fracture mechanics. Once realistic uncertainty models are established for inputs to the analysis and for errors due to assumptions, reliability analysis should quantify the level of uncertainty in the analytical results with respect to the physical component. This is quite distinct from the typically more benign uncertainty in the numerical solution of the analytical model to which mathematicians have devoted considerable effort. An accurate reliability assessment tool will help develop a methodology for targeted testing (through numerical or physical experiments). Specifically, reliability analysis provides the sensitivities of the safety of a system to the uncertain variables and to the safety of the components. This information is important for identifying critical uncertainties and components that most influence the system safety and for developing targeted tests that focus on these uncertainties and components. This methodology should allow us to selectively test the most critical components and the most critical conditions.

6. **Research Classification/Restrictions:** None.

7. **Interest in Summer USAFA Cadet:** No

8. **Eligible Research Institutions:**

[X] Universities (DAGSI)   [X] AFIT (only)   [ ] USAFA