RQ 20-46

1. **Research Title:** Residual Stress Engineering Technologies for Airframe Life Extension

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Mechanical, Aerospace, or Civil Engineering / Solid Mechanics or Structural Mechanics or Computational Mechanics (MS or Ph.D. level)

4. **Objectives:** The objective of this research area is to develop and validate modeling frameworks for understanding and quantifying the uncertainties, risks, and reliabilities associated with exploiting residual stress (RS) during aircraft design and sustainment. The emphasis is on developing robust methodologies for achieving aircraft performance criteria (design) and "lifing credit" (sustainment) for RS processing that accounts for initial conditions, RS treatment, loading, and probabilistic considerations.

5. **Description:** The intentional introduction of residual stresses, through processes such as ultrasonic peening, laser shock processing, and low plasticity burnishing, to the design or sustainment of aircraft structure can have manifold benefits: increased fatigue life, enhanced safety, reduced operational costs, and improved system performance. To fully realize these benefits there is a need for validated physics based models that explicitly include the induced residual stresses and enable the exploration and quantification of risk, reliability, error, and uncertainty. These models should be capable of including the full 3D residual stress state, along with processing-induced deformations, in order to accurately characterize system performance, including fatigue crack growth and structural static and dynamic response, as examples.

   To attain this goal, research opportunities exist in the general area of structural design and life prediction for aircraft components enhanced with residual stress processing. Specific topics include: (1) development of validated models and design tools for optimizing the benefits of introducing engineered residual stresses, including but not limited to laser shock processing and low plasticity burnishing, into aircraft structural components. A successful methodology will be capable of accounting for residual stresses during the static, dynamic, and fatigue analysis in structural components containing both applied and residual stresses; and (2) development of an incorporated methodology for predicting lower bound fatigue behavior due to the material damage and residual stress states surrounding cracks. A successful methodology will account for component initial conditions, including pre-existing residual stresses and prior fatigue exposure, relaxation effects stemming from loading or crack growth, and will allow for a probabilistic consideration of fatigue life.

6. **Research Classification/Restrictions:** This research is unclassified and for public distribution.

7. **Eligible Research Institutions:** All DAGSI Universities.