RQ18-20

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 airframe fatigue life extension via residual stress (RS) exploitation. The emphasis is on developing robust methodologies for achieving "lifing credit" for RS processing that accounts for initial conditions, RS treatment, loading, and probabilistic considerations.

5. **Description:** The introduction of residual stresses, through processes such as ultrasonic peening, laser shock processing, and low plasticity burnishing, can potentially increase the fatigue life of aircraft structural components, with attendant benefits of enhanced safety, reduced operational costs, and improved performance. However, to fully realize these benefits there is a need for validated fatigue life prediction models that not only explicitly include the induced residual stresses but also allow for 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 crack growth behavior. Such models, when used in conjunction with or linked to reliability analyses can help build assurance for updating NDI (non-destructive inspection) intervals based on the enhanced stress state.

   To attain this goal, research opportunities exist in the general area of life prediction for aircraft structural 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 stress concentrations as well as allowing for the prediction of fatigue behavior in components containing both applied stresses 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:** Indicate to what organizations this topic should be provided.

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

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