NASA SBIR 2006 Phase I Solicitation

A1.03 Aircraft Aging and Durability

Lead Center: GRC

Participating Center(s): AFRC, ARC, LaRC

Aircraft aging is a significant national issue that is being addressed by government agencies, manufacturers, operators, and academia. NASA's contribution to solving the problem is research on aging and damage processes in "young" aircraft, rather than life extension of legacy vehicles. Its emphasis is on new and emerging material systems/fabrication techniques and the potential hazards associated with their aging-related degradation. The intent is to identify aging-related hazards before they become critical, and develop technology to anticipate aging and maintenance needs in the design of future aircraft.

NASA performs multi-level research in aging science leading ultimately to multi-disciplinary analysis and optimization capabilities that will enable system-level integrated detection, prediction and mitigation of aging-related hazards in future civilian and military aircraft. To further the fundamental understanding of the underlying physics and to develop an ability to model the physical processes, foundational research is conducted in the following areas: sensing and diagnostic technologies; physics-based modeling; continuum-based models and computational methods; material science (metals, ceramics, composites); and characterization/validation test techniques. Building upon foundational research yields discipline-based products: nondestructive evaluation (NDE) systems; structural integrity tools; lifing methods; and concepts to mitigate aging-effects. By integration of discipline-based tools, multi-disciplinary methods and technologies are developed; e.g., detection capability is enhanced by coupling NDE with structural integrity analysis, prediction capability is enhanced by applying NDE (and vehicle health monitoring data) to improve model input and provide improved predictions of remaining life and strength, and mitigation capability is enhanced by applying predictive models to help develop advanced mitigation concepts.

Specifically, NASA requests proposals that assimilate the above multi-layer approach, which provide innovative solutions to one of the following problems:

- The use of integral metallic structure in airframe application provides unique crack growth and fracture characteristics that are not consistent with traditional metallic structure characteristics. Computational methods for elasto-plastic crack propagation, including non-self-similar growth and bifurcation of 2D and 3D cracks, are needed for predicting crack growth in complex metallic geometries. Computational methods must be incorporated into a user interface software tool.
- Computational methods for the prediction of strength of composite and metal/composite hybrid skin-stringer fuselage present the following technical challenges: numerical regularization techniques to improve convergence of delamination propagation simulation; and X-FEM for failure prediction that address interaction between in-plane and interlaminar failure modes. Solutions to these two challenges are sought.
- Novel techniques for large-area nondestructive evaluation (detection of damage and material degradation) of metallic and composite fuselage and wing structure are needed.
- Adhesive bonds are critical to integrity of built-up structure. Disbonds (i.e., gaps) can often be detected, but the strength of the adhesion between surfaces in contact is not obvious. Methods to detect bond...
degradation, predict disbond growth, and characterize weak bonds are needed.

- Advanced composite concepts for jet engine containment structures have unknown long-term service/environment effects. Better models and tools are needed for understanding these effects and for predicting engine blade-off event physics (i.e., the high strain-rate impact) to reduce risk and cost.

- New nickel-based superalloys which enable higher turbine disk operating temperatures have been developed. However, tools to understand and mitigate the long term durability and aging characteristics (e.g., microstructural instability and corrosion) of these alloys are needed.

- Degradation and damage that develops over time in engine hot section components can lead to catastrophic failure. Methods and sensors for characterization of degradation processes of these components (including ceramics) in harsh environments during system development are needed.

- Faults and hazards in aging vehicle wiring persist as a problem in legacy vehicles, and will pose risks in new vehicles. Novel methods (i.e., have not already been researched by FAA and DoD) are sought to detect and characterize degradation, and to predict useful life of wiring systems.

Technology innovations may take the form of tools, models, algorithms, prototypes, and devices.