NASA SBIR 2008 Phase I Solicitation

A1.11 Integrated Diagnosis and Prognosis of Aircraft Anomalies

Lead Center: ARC

Participating Center(s): AFRC, GRC, LaRC, SSC

The capability to identify faults and predict their progression is critical to determining appropriate mitigation actions to maintain aircraft safety. This effort is to develop innovative methods and tools for the diagnosis and prognosis of aircraft faults and failures. Proposals are sought for the development of a health management methodology which integrates a prognosis approach with the nature, severity, and uncertainty information from the diagnosis of the faulted system.

Diagnosis: The diagnosis element of IVHM includes the development of integrated technologies, tools, and techniques to determine the causal factors, nature, and severity of an adverse event and to distinguish that event from within a family of potential adverse events. These requirements go beyond standard fault isolation techniques. The emphasis is on the development of mathematically rigorous diagnostic technologies that are applicable to structures, propulsion gas path monitoring, software, and other subsystems within the aircraft. Technologies developed must be able to perform diagnosis given heterogeneous and asynchronous signals coming from the health management components of the vehicle and integrating information from each of these components.

The ability to actively query health management systems, use advanced decision making techniques to perform the diagnosis, and then assess the severity using these techniques are critical. As an example, the mathematical rigor of the diagnosis and severity assessment could be treated through a Bayesian methodology since it allows for characterization and propagation of uncertainties through models of aircraft failure and degradation.

Computational demonstrations using realistic data or prototype hardware implementations of the diagnostic capabilities would be expected at the conclusion of a Phase 2 effort. Other methods could also be employed that appropriately model the uncertainties in the subsystem due to noise and other sources of uncertainty. The ability to actively query the underlying health management systems (whether they are related to detection or not) is critical to reducing the uncertainty in the diagnosis. As an example, if there is ambiguity in the diagnosis about the type and location of a particular failure in the aircraft structure, the diagnostic engine should be able to actively query that system or related systems to determine the true location and severity of the anomaly. Where possible, a rigorous mathematical framework should be employed to provide a rank ordered list of diagnoses, an assessment of the severity of each diagnosed event, along with a measure of the certainty in the diagnosis. Understanding and addressing the system integration and validation issues are critical components of this effort.

Prognosis: The prognosis element of IVHM includes the development of technologies, tools, and techniques to determine, given information from detection and diagnosis health management systems and other systems, estimates (with a measure of confidence) of the remaining useful life (RUL) of candidate faults generated by diagnostic engines. The assessment of the RUL could be used by other aircraft systems to place additional restrictions, such as a new operating envelope on the flight control systems. Areas of interest include developing methods for making predictions of RUL which take the uncertainties provided by a candidate diagnostic engine into account, representing and managing uncertainties inherent in such predictions, and developing and applying assessment methodologies for comprehensive and objective evaluation of prognostic algorithm performance.

Research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path toward a Phase 2 technology demonstration. Proposals are solicited that address aspects of the following areas:

Research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path toward a Phase 2 technology demonstration. Proposals are solicited that address aspects of the following areas:

- The development of an integrated approach for diagnostics and prognostics that demonstrate a mathematically rigorous method for propagating diagnostic uncertainty and its effect on subsequent estimates of remaining useful life.
- Physics-based damage propagation models for one or more relevant aircraft subsystems such as composite or metallic airframe structures, engine turbo-machinery and hot structures, avionics, electrical power systems, electromechanical systems, and electronics. Proposals that focus on technologies envisioned for next generation aircraft are strongly encouraged.
- Novel approaches to assess the quality and accuracy of remaining useful life estimates through the fusion of different models, active probing of components, etc.
- Uncertainty representation and management methods. Proposers are encouraged to consider uncertainties due to measurement noise, imperfect models and algorithms, as well as uncertainties stemming from future anticipated loads and environmental conditions.
- Mathematically rigorous methodologies for assessing the quality of remaining useful life predictions and associated uncertainties.
- Verification and validation methods for prognostic algorithms.