NASA SBIR 2007 Phase I Solicitation

A1.07 Advanced Health Management for Aircraft Subsystems

Lead Center: GRC

Participating Center(s): AFRC, ARC, LaRC

The purpose of this solicitation is to seek highly innovative and commercially viable technologies that will improve aircraft safety for current and future civilian and military aircraft, and to overcome aircraft safety technological barriers that would otherwise constrain the full realization of the Next Generation Air Transportation System (NGATS). Specifically, this subtopic seeks technologies in support of the Integrated Vehicle Health Management Project (IVHM) that will contribute to the reduction of aircraft system and component failures and malfunctions that cause and contribute to aircraft accidents and incidents.

The goal of IVHM is to develop technologies to determine system/component degradation and damage early enough to prevent or gracefully recover from in-flight failures in both the near-future and next-generation air transportation systems. These technologies will enable nearly continuous on-board situational awareness of the vehicle health state for use by the flight crew, ground crew, and maintenance depot. To achieve this, NASA will advance the state-of-the-art technology in on-board health state assessment to enable the continuous diagnosis and prognosis of the integrated vehicle's health status. To help meet this goal, NASA seeks innovative technology development activities in the following areas:

- Airframe Health Management - including self-awareness and prognosis, anomaly detection and identification, and in-flight damage, degradation and failure mitigation;
- Propulsion Health Management - including self-awareness and prognosis of gas path, combustion, and overall engine state (containment systems and rotating and static components), and fault-tolerant system architectures;
- Aircraft Systems Health Management - including state-awareness and prognosis of landing gear, hydraulic and pneumatic systems, electrical and power systems, fuel and lubrication systems, avionics/communications, navigation, surveillance/flight critical and flight management systems, and robust, distributed, fault-tolerant, self-recoverable architectures for flight critical aircraft applications;
- Environmental Hazard Management - including the prevention, detection, and mitigation of hazards such as ice accretion, lightning strikes, EMI/EMC, and ionizing radiation, as well as the direct and indirect effects of these hazards;
• IVHM Architectures and Databases - including system design, analysis and optimization, information management, data flow and communication, control and reconfiguration, architecture development and validation, and database development and management;

• Validation and Predictive Capability Assessment - including analysis, simulation, ground testing, flight testing, environmental testing, and software assurance.

NASA’s IVHM research will ultimately yield integrated, multi-disciplinary analysis and optimization capabilities that enable system-level designs providing graceful recovery from in-flight failures, computationally efficient tools for in-flight prognosis of aircraft health including integrated predictive and sensor capabilities, and preventative and adaptive systems for in-flight operability and informed logistics and maintenance. Innovative technology solutions are being sought for the following IVHM technical challenges:

• Large-scale distributed anomaly, fault, malfunction, degradation, and failure detection with data/decision/information fusion (multiple sensors, actuators, and processing nodes);

• Prevention, detection, isolation, and mitigation of multiple independent/correlated anticipated and unanticipated failures (modeling of correlated failures and system/vehicle effects, diagnosis and prognosis, real-time processing and decision-making for very large state spaces, and health state reasoning);

• Adaptive diagnostic and prognostic algorithms (adapts as systems and components age, are repaired, or replaced);

• Analytical methods to set local decision criteria so that global performance criteria are met (multi-dimensional optimization);

• Performance optimization in distributed systems (high probability of detection, low probability of false alarm);

• Vehicle-wide state and function monitoring of systems and structures (including digital avionics, auto-flight and control, propulsion, hydraulic, mechanical, pneumatic, electrical, and power generation and distribution systems);

• Large-scale distributed adaptive fault-tolerant processing architecture that is robust in adverse operating environments (EMI/EMC, ionizing radiation, low/high temperatures);

• Distributed hierarchical threat-tolerant self-healing embedded sensors and systems (embedded self-recovery mechanisms, adaptive, programmable and reconfigurable devices);

• Technology integration, verification, and validation (diagnostic and prognostic flight, airframe, and propulsion systems, environmental hazard management, advanced sensors and system architectures, Verification and Validation (V&V) with predictive capability).

Technology innovations may take the form of tools, models, algorithm, prototypes, and/or devices.