NASA SBIR 2005 Phase I Solicitation

A1 Aviation Safety and Security

The worldwide commercial aviation accident rate has been nearly constant over the past two decades. Although the rate is very low, increasing traffic over the years may result in the absolute number of accidents also increasing. Without improvements, doubling or tripling of air traffic by 2017 could lead to 50 or more major accidents a year. This number of accidents would have an unacceptable impact on the air transportation system. The goal of NASA’s Aviation Safety and Security Program (AvSSP) is to develop and demonstrate technologies that contribute to a reduction in the fatal aviation accident rate. Research and technology will address accidents involving hazardous weather, controlled flight into terrain, human-error-caused accidents and incidents, and mechanical or software malfunctions. The Program will also develop and integrate information technologies needed to build a safer aviation system and provide information for the assessment of situations and trends that indicate unsafe conditions before they lead to accidents. NASA researchers are also looking at ways to adapt aviation technologies already being developed to improve aviation security. The AvSSP is focusing on areas where NASA expertise could make a significant contribution to security: 1) the hardening of aircraft and their systems, 2) secure airspace operation technologies, 3) improved systems to screen passenger and cargo information, and 4) sensors designed to better detect threats. NASA seeks highly innovative proposals that will complement its work in Aviation Safety and Security in the following subtopic areas:

Subtopics

A1.01 Crew Systems Technologies for Improved Aviation Safety

Lead Center: LaRC

NASA seeks highly innovative, crew-centered, technologies to improve aerospace system safety. Such advanced technologies may meet this goal by ensuring appropriate situation awareness; facilitating and extending human perception, information interpretation, and response planning and selection; counteracting human information processing limitations, biases, and error-tendencies; assisting in response planning and execution; and ensuring appropriate access to airspace as constrained by safety and security concerns. We require improved methods and tools for characterizing current and future users of aerospace systems, and tailoring designs to users. Such advanced technologies must be evaluated sensitively and in operationally-valid contexts. Therefore, NASA also seeks tools and methods for measuring and evaluating aerospace system operator performance, and as this performance is reflected by system performance. Technologies may take the form of tools, models, operational procedures, instructional systems, prototypes, and devices for use in the flight deck, elsewhere by pilots, or by those who design systems for crew use. Specific topical areas of interest include the following:
• Intelligent systems monitoring and alerting technologies for improved failure mode identification, recovery, and threat mitigation

• Designs for human-error prevention, detection, and mitigation

• Decision-support tools and methods to improve communication, collaborative, and distributive decision-making

• Data fusion technologies to integrate flight-related information for improved situation awareness and appropriate workload modulation

• Support for crew response planning and selection

• Computational approaches to determine and appropriately modulate crew engagement, workload, and situation awareness

• Human-centered information technologies to improve the performance of less-experienced operators, and pilots from special population groups

• Avionics designers and/or certification specialist tools to improve the application of human-centered principles

• Human-error reliability approaches to analyzing flight deck displays decision aids, and procedures;

• Presentation and aiding concepts for the display and use of data with spatial or temporal uncertainty, and of integrated streams of data with various levels of integrity

• Individual and team performance metrics, analysis methods, and tools to better evaluate and certify human and system performance for use in operational environments, simulation, and model-based analyses

Proposals should describe technologies, tools, and approaches with high potential to serve NASA program objectives, and to be developed as marketable products.

A1.02 Aviation Safety and Security; Fire, Icing, Propulsion and Secure CNS Aircraft Systems

Lead Center: GRC

NASA is concerned with the prevention of hazardous in-flight conditions and the mitigation of their effects when they do occur. Aircraft fires represent a small number of actual accident causes, but the number of fatalities due to in-flight, post-crash, and on-ground fires is large. One particular emphasis is on early, false-alarm resistant detection of the location, spread, and suppression of in-flight fires in hidden, inaccessible areas of the aircraft. Examples of hidden areas are behind cabin panels, inside ductwork, and so on. Another area of interest is in-tank monitoring of fuel /air flammability factors to provide more efficient active control of fuel tank inerting systems.

A second emphasis for this subtopic is on propulsion system health management, in order to predict, prevent, or accommodate safety-significant malfunctions and damage. Past advances in this area have helped improve the reliability and safety of aircraft propulsion systems; however, propulsion system component failures are still a
contributing factor in numerous aircraft accidents and incidents. Advances in technology are sought which help to further reduce the occurrence of and/or mitigate the effects of safety-significant propulsion system malfunctions and damage. Specifically the following are sought: propulsion health management technologies such as instrumentation, sensors, ground and on-wing nondestructive inspection, health monitoring algorithms, and fault accommodating logic, which will predict/prognose, diagnose, prevent, assess, and allow recovery from propulsion system malfunctions, degradation, or damage.

A third emphasis is to increase the level of safety for all aircraft flying in the atmospheric icing environment. To maximize the level of safety, aircraft must be capable of handling all possible icing conditions by either avoiding or tolerating the conditions. Proposals are invited that lead to innovative new approaches or significant improvements in existing technologies for in-flight icing conditions avoidance (icing weather information systems) or tolerance (airframe and engine ice protection systems and design tools). With these emphases in mind, products and technologies that can be made affordable and retrofitable within the current aviation system, as well as for use in the future, are sought:

- Ground and airborne radome technologies for microwave wavelength radar and radiometers that remain clear of liquid water and ice in all weather situations.

- \textit{In situ} icing environment measurement systems that can provide practical, very low-cost validation data for emerging icing weather information systems and atmospheric modeling. Measured information must include location, altitude, cloud liquid water content, temperature, and ideally cloud particle sizing and phase information. Solutions envisioned would use radiosonde-based systems.

- Ice protection and detection technology submittal must provide significant improvements over current systems or address new design needs. Areas of improvement can be considered to be: efficient thermal protection systems, including composite wing or structures applications, ice sensors that provide detection and accretion rate for all possible icing conditions, wide area ice detection, detection that serves both ground and in-flight applications, ice crystal detection probe (for non-research aircraft applications), engine icing probe (that can measure Liquid Water Content and Total Water Content inside engine passages), and de-icing systems that operate at near anti-icing performance. Any submittal must be cost competitive to current technologies.

A fourth emphasis for this subtopic is protection and hardening of the aircraft's communication, navigation, and surveillance (CNS) systems, as well as enabling new aviation security applications through improved air-to-ground data link communications and secure onboard information processing, computing, and air/ground networking. Technology is needed to harden the CNS systems, both onboard and air-to-ground, against abnormalities and deliberate attacks towards also enabling the next-generation airborne, ground- and space-based surveillance systems. Other communications related needs can be found in other NASA SBIR subtopics areas.

The final emphasis for this subtopic is on propulsion damage adaptive controls technologies and systems for new aircraft security applications. This technology is needed to enable a propulsion system to mitigate aircraft damage from hostile attacks.
A1.03 Aviation Security Technologies
Lead Center: LaRC
Participating Center(s): ARC, JPL

The NASA Strategic Plan includes requirements to enable a more secure air transportation system and to create a more secure world by investing in technologies and collaborating with other agencies, industry, and academia. NASA's role in civil aeronautics has always been to develop high-risk, high-payoff technologies to meet critical national aviation challenges.

NASA aims to develop and advance technologies that will reduce the vulnerability of the Air Transportation System (ATS) to threats or hostile acts, and identify and inform users of potential vulnerabilities in a timely fashion. Specific technical focus areas include system-wide security risk assessment and incident precursor identification; enhanced flight procedures and on-board systems to protect critical infrastructures and key assets and enable the safe recovery of a seized aircraft; definition of directed energy threats to the aircraft and on/off-board systems that will provide surveillance and countermeasures of these threats; integrated adaptive control systems to detect and compensate for vehicle damage; hardened and security enhanced aircraft networks and datalinks; remote monitoring of the aircraft environment and systems; new materials for composite fire and explosive resistant fuselage structures; advanced, airborne, in situ detection of chemical and biological terror agents; and commercial aircraft fuel tank inerting. Technologies under development are intended for the next-generation ATS; however, issues such as retrofit, certification, system implementation, and cost-benefit must be considered during the technology development process.

NASA seeks highly innovative and commercially viable technologies that will improve aviation security by addressing threats to air vehicles as well as the ATS. Specific areas of focus include: preventing aircraft from being used as a weapon of mass destruction; protection from man-portable air defense systems (ManPADS) and electromagnetic energy (EME) attacks; light-weight, fire and explosive resistant composite materials; explosive resistant fuel systems; ground-based decision support tools needed to monitor airspace security concerns; reporting systems to monitor security violations; secure encrypted datalink systems, intrusion-tolerant communications networks and communications systems to support emerging aviation security applications; tools to support real-time management of security information; and Chem/Bio sensor development. Technologies may take the form of tools, models, techniques, procedures, substantiated guidelines, prototypes, and devices:

- Intelligent Systems monitoring and alerting technologies;
- Secure communications systems to support emerging aviation security applications;
- Onboard and ground surveillance and interception systems for aircraft immunity to electromagnetic interference and electromagnetic pulse intrusions;
- Flight control systems that accommodate vehicle damage relative to changes in aircraft stability, control, and structural load characteristics;
- Material systems, fuselage structural concepts, and fuel systems that are resistant to fire and explosions;
- Fuel system technologies that prevent or minimize in-flight vulnerability of civil transport aircraft due to small arms or man-portable defense systems type projectiles;
- Computational approaches to monitoring crew health, stress level, state of duress, and performance;
- Validation methods and tools for advanced safety/security critical systems;
• Technologies that enable secure communications, navigation, and surveillance on-board the aircraft;

• Technologies and methods to provide accurate information and guidance to enable pilot avoidance of protected airspace, maintain positive identity verification of aircraft operators, determine pilot intent, and deny flight control access to unauthorized persons;

• Decision-support tools and methods to improve communication and collaborative and distributive decision-making; and

• Data fusion technologies for integrating disparate sources of flight-related information.

A1.04 Automated On-Line Health Management and Data Analysis

Lead Center: ARC

Participating Center(s): AFRC

Online health monitoring is a critical technology for improving air transportation safety in the 21st century. Safe, affordable, and more efficient operation of aircraft requires advances in online health monitoring of vehicle subsystems and information monitoring from many sources over local- and wide-area networks. Online health monitoring is a general concept involving signal-processing algorithms designed to support decisions related to safety, maintenance, or operating procedures. The concept of online health monitoring emphasizes algorithms that minimize the time between data acquisition and decision-making. This subtopic seeks solutions for online aircraft subsystem health monitoring and prognostics. Solutions should exploit multiple computers communicating over standard networks where applicable. Solutions can be designed to monitor a specific subsystem or a number of systems simultaneously. Resulting commercial products might be implemented in a distributed decision-making environment such as onboard diagnostics and management systems, or maintenance and inspection networks of potentially global proportion.

Proposers should discuss who the users of resulting products would be, e.g., research/test/development, manufacturing; maintenance depots, flight crew, Unmanned Aerial Vehicles/Remotely Operated Aircraft (UAV/ROA) aircraft operators, airports, flight operations or mission control, or airlines. Proposers are encouraged to discuss data acquisition, processing, and presentation components in their proposal. Proposals that focus solely on sensor development should not be submitted to this subtopic. Such proposals should be addressed to sensor development subtopics such as the Flight Sensors and Airborne Instruments for Flight Research subtopic.

Examples of desired solutions targeted by this subtopic follow:

• Real-time autonomous sensor validity monitors;

• Flight control system or flight path diagnostics for predicting loss of control;

• Automated testing and diagnostics of mission-critical avionics;
- Structural fatigue, life cycle, static, or dynamic load monitors;

- Methods and tools for remaining life estimation and prognostics for critical aircraft components;

- Automated nondestructive evaluation for faulty structural components;

- Electrical system monitoring and fire prevention;

- Architectures for online monitoring, including architectures that exploit wireless communication technology to reduce costs;

- Model-reference or model-updating schemes based on measured data, which operate autonomously;

- Proactive maintenance concepts for aircraft engines, including engine life-cycle monitors;

- Predicting or detecting any equipment malfunction;

- Middleware or software toolkits to lower the cost of developing online aircraft health monitoring applications; and

- Innovative solutions for harvesting, managing, archiving, and retrieving aircraft health data.