NASA SBIR 2004 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 takes a crew-centered approach to improving aviation safety and, therefore, specifically investigates human error roots of accidents and incidents to identify the basis for innovating crew-centered automation and interface technologies. These technologies must be evaluated sensitively and in operationally-valid contexts. NASA develops evaluation methodologies and tools to sensitively and robustly assess aviation safety technologies. Finally, to ensure adoption, NASA investigates how innovative aviation safety technologies can be effectively used in airspace operations and be supported by pilot procedures and instruction.

NASA seeks highly innovative technologies to improve airspace safety with a crew-centered focus. Such advanced technologies may meet these goals 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 individuals have access to use the airspace system as appropriate. In addition, NASA seeks tools and methods for measuring and assessing pilots' and collaborating operators' performance in complex, dynamic systems. 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. Technologies should have a high potential for emerging as marketable products, of which there are a number of examples:

- Novel technologies to improve information presentation;
- 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 disparate sources of 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 pilots and pilot populations with special requirements;
- 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, and designs that consider presentation of uncertain data; and
- Individual and team performance metrics, analysis methods, and tools to better evaluate and certify human and system performance for use in operational airspace environments, simulation, and model-based analyses.

A1.02 Aviation Safety and Security: Fire, Icing and Propulsion-Safe and Secure CNS Aircraft Systems

Lead Center: GRC

NASA is concerned with the prevention of hazardous conditions and the mitigation of their effects when they do occur. One particular emphasis is on the prevention and suppression of in-flight fire and explosions, as well as fuel tank explosions and post-crash fires. 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.
A second emphasis is on mitigating the safety risk and collateral damage due to unexpected failures of rotating components. Although the FAA mandates a blade containment and rotor unbalance requirement (FAR Part 33, Section 33.94) as part of the airworthiness standards for turbine aircraft engines, there are substantial potential (aircraft-engine) system benefits to be gained by enabling safety assured, lighter weight, lower cost, and more damage-tolerant designs for engine case/containment systems and associated (primary load path) structures.

A third emphasis for this subtopic is on propulsion system health management, in order to 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.

A fourth 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).

A final 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. Technology is needed to harden the CNS systems, both onboard and air-to-ground, and to provide next-generation airborne, ground- and space-based surveillance systems.

With these emphases in mind, products and technologies that can be made affordable and retrofittable within the current aviation system, as well as for use in the future, are sought:

- Technology for prevention and suppression of potential in-flight fires in fuel tanks, cargo bays, insulation, and other inaccessible locations due to accidents or deliberate acts.
- Technology to provide fuel tank vapor flammability reduction and onboard oxygen generation.
- Technology to minimize fire hazards in crashes and to prevent or delay fires.
- Advanced material or structural configuration concepts to prevent catastrophic failures of engine components, or to ensure fragment containment.
- Computational tools for analyzing blade-loss events and designing structural components and systems accordingly.
- Health management technologies such as instrumentation, ground and on-wing nondestructive inspection, health monitoring algorithms, and fault accommodating logic, which will predict, diagnose, prevent, assess, and allow recovery from propulsion system malfunctions or damage.
- Ground and airborne radome technologies for microwave wavelength radar and radiometers that remain clear of liquid water and ice in all weather situations.
• *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, wide area ice detection, detection that serves both ground and in-flight applications, and de-icing systems that operate at near anti-icing performance. Any submittal must be cost competitive to current technologies.

• Next generation capabilities for remote monitoring of onboard systems and the aircraft environment.

• Secure onboard information processing, computing and air/ground networking.

• Technologies to harden aircraft communication, navigation, and surveillance systems against abnormality and deliberate attack.

A1.03 Technologies for Improved Aviation Security

Lead Center: LaRC
Participating Center(s): ARC

Following the attacks on September 11, 2001, NASA recognized that it now shared the responsibility for improving homeland security. 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, and ensuring the security of the nation from terrorist attacks is a high priority national challenge.

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 onboard 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 data links; 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 retrofitting, certification, system implementation, and cost-benefit analysis 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 (WMD); 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 data link systems, intrusion-
tolerant communications networks and communications systems to support emerging aviation security applications;
tools to support real-time management of security information; and chemical and biological sensor development.
Technologies may take the form of tools, models, techniques, procedures, substantiated guidelines, prototypes,
and devices:

- Intelligent systems monitoring and alerting technologies;
- Technologies that enable secure communications, navigation, and surveillance onboard the aircraft;
- 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;
- 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;
- 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;
- Decision-support tools and methods to improve communication, collaborative, and distributive decision-
  making;
- Data fusion technologies for integrating disparate sources of flight-related information;
- Computational approaches to monitoring crew health, stress level, state of duress, and performance; and
- Validation methods and tools for advanced safety and security critical systems.

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

Lead Center: AFRC
Participating Center(s): ARC

Online health monitoring is a critical technology for improving transportation safety in the 21st century. Safe,
affordable, and more efficient operation of aerospace vehicles 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. 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, Sensor Arrays 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;
- Automated nondestructive evaluation for faulty structural components;
- Electrical system monitoring and fire prevention;
- Applications that exploit wireless communication technology to reduce costs;
- Model-reference or model-updating schemes based on measured data, which operate autonomously;
- Proactive maintenance schedules for rocket or turbine engines, including engine life-cycle monitors;
- Predicting or detecting any equipment malfunction;
- Middleware or software toolkits to lower the cost of developing online health monitoring applications; and
- Innovative solutions for harvesting, managing, archival, and retrieval of aerospace vehicle health data.