The Aviation Safety Program — Goals and Challenges

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http://www.aeronautics.nasa.gov/programs_avsafe.htm
Outline

• Today’s National Imperatives
• Aviation Safety Program Overview
• Technical Accomplishments
• Aviation Safety Program Team
• Government, Industry & University Teaming
• Grand Challenges…
Today’s National Imperatives

- The Next Generation Air Transportation System (2006)
  - “NextGen does not modernize the existing system — it completely transforms it.”

- National Aeronautics R&D Policy (20 December 2006)
  - **Aviation Safety is Paramount** — “Every individual who enters an airport or boards an aircraft expects to be safe. To that end, continual improvement of safety of flight must remain at the forefront of the U.S. aeronautics agenda.”


- NASA Strategic Plan (2006)
  - **Strategic Goal 3**, “Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.”
  - **Sub-goal 3E**, “Advance knowledge in the fundamental disciplines of aeronautics, and develop technologies for safer aircraft and higher capacity airspace systems.”

The Three Principles

• We will dedicate ourselves to the mastery and intellectual stewardship of the core competencies of Aeronautics for the Nation in all flight regimes.

• We will focus our research in areas that are appropriate to NASA’s unique capabilities.

• We will directly address the fundamental research needs of the Next Generation Air Transportation System in partnership with the member agencies of the Joint Planning and Development Office.
Aviation Safety Goals and Focus

• The goal of the AvSafe Program is to improve the intrinsic safety of aircraft and to address safety related technology barriers that could potentially constrain the full realization of the NextGen.

• The research that the AvSafe Program conducts focuses on flight systems and structural safety spanning all vehicles.
  – Flight systems safety advances knowledge and capabilities in flight deck systems, control systems and health management systems.
  – Structural safety advances knowledge and capabilities in aging and durability of materials and structures.
Aviation Safety Projects

- Aircraft Aging & Durability
- Integrated Intelligent Flight Deck
- Integrated Resilient Aircraft Control
- Integrated Vehicle Health Management

Are your top level requirements or objectives stable and established/baselined? (Q1)
Project Technical Objectives

- **AAD**
  - Develop advanced diagnostic and prognostic capabilities for detection and mitigation of aging-related hazards.

- **IIFD**
  - Pursue flight deck technologies to ensure crew workload and situation awareness are both safely optimized and adapted to the future operational environment of the NextGen.

- **IRAC**
  - Conduct research to advance the state of aircraft flight control automation and autonomy in order to prevent loss-of-control in flight.

- **IVHM**
  - Conduct research to advance the state of highly integrated and complex flight-critical health management technologies and systems.
## AvSafe Discipline Level Research

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| **AAD** | Structural Integrity  
Non-Destructive Evaluation & Structural Health Monitoring Systems  
Mitigation Technologies  
Lifing Methods & Material Durability |
| **IIFD** | External Hazard Detection  
System Design and Analysis  
Robust Automation Human Systems  
Crew Vehicle Interfaces  
Aviation Safety Information Analysis and Sharing |
| **IRAC** | Verification and Validation Methods and Test Beds  
Integrated Dynamics and Flight Control  
Integrated Propulsion Controls and Dynamics  
Airframe and Structural Dynamics  
Intelligent Flight Planning and Guidance |
| **IVHM** | Data Mining and Information Analysis  
Propulsion Health Management  
Systems Analysis and Integration  
Airframe Health Management  
Aircraft Systems Health Management  
Verification, Validation and Predictive Capability |

[http://www.aeronautics.nasa.gov/programs_avsafe.htm](http://www.aeronautics.nasa.gov/programs_avsafe.htm)
Highlighted Accomplishments 2007

AAD —

IIFD —

IRAC —

IVHM —
Objective: Improve modeling of damage progression in metals

Approach: Combine molecular dynamics (MD) modeling and continuum modeling procedures (FEM) through the use of ESCM and CZVE.

**Result:** Demonstrate operation of coupled MD-FEM with growing grain-boundary crack. Closely reproduces pure MD results for Cohesive Zone Method. Enables efficient multi-scale modeling of damage processes.
IIFD (Collaboration with ASP)

Description:
- Simulation experiment with two-way datalink connection between CTAS and the B-747 FMS
- 3-D trajectory clearances generated by ATC
- FMS flew the new route “automatically”
- Flight crew review/accept trajectory, monitor

Results:
- Protocol defined for specifying trajectories
- Ground-based predictions beyond ten minutes
IRAC

Airborne Subscale Transport Aircraft Research (AirSTAR).
- S2 research UAV completed successful data collection flights
- Tests included Mobile Operations Station
- Real-time, high quality data transmitted via downlink at Wallops Island Flight Facility

Research Objectives:
- Data quality and bandwidth suitable for parameter identification research
- Results and an overview of the “The Quest for Onboard Real-Time Characterization of Aircraft Stability and Control,” by Dr. Eugene Morelli, are available as video podcast at: http://www.aeronautics.nasa.gov/technical_seminar.htm
A high temperature amplifier that consisting of two SiC n-channel junction field-effect transistors interconnected with three SiC n-channel resistors integrated onto less than a half a square millimeter of a SiC chip has been demonstrated and tested for extended durations.

Input sinewave (black) and amplified output test waveforms after 1 hour (blue) and 500† hours (red) of continuous SiC integrated circuit amplifier operation at 500°C.

SiC integrated circuit differential amplifier voltage gain measured as a function of frequency at after 1 hour (blue) and 500† hours (red) of continuous 500°C electrical operation.

† — The chip exceeded 2,300 hours of operation since 28 June 2008.
Technical Plans for FY2008

• **AAD**: Develop analysis methods for predicting crack growth versus load…
  – Use selected metallic structures
  *Improve ultimate failure load prediction by 20% over SOA methods assessed in 2007.*

• **IIFD**: Complete study of active operator assistance in approach and landing…
  – Identify technologies with predicted potential to support selected NextGen applications
  – Enable 90% reduction in automation interface time
  – Eliminate mode confusion
  – No degradation in operator awareness of critical decision points
  *All compared to baseline conditions established in 2007.*

• **IRAC**: Assess adaptive controls for aircraft in damage/failure conditions…
  – Improved stability:
    • 60% within a gain margin of 5dB and phase margin greater than 35°
    • 30% within a gain margin of 3-5dB and phase margin in the range of 25-35°
  – Conduct piloted evaluations in a high-performance research aircraft.
  *Compare results to experimental results from 2006.*

• **IVHM**: Develop and validate sensor integration technologies…
  – Use a landing gear testbed to represent current generation electro-mechanical system
  – Improved diagnostic robustness
  – Ability to distinguish sensor failures from true component failures
  *No more than 20% false negative and 20% false positive rates.*
Disseminating Results

- Encouraging peer-reviewed papers of results
  - Focus on quality: produced 23 Journal articles or NASA Technical Papers
  - Two Books
  - Best of Session Conference Paper awards

- Hosting Conferences & Seminars
  - AAD: Aging Aircraft Conference, April 2007
Other Government Agency Teams

• **JPDO:**
  - Safety Working Group
  - Aircraft Working Group

• **FAA:**
  - Directly: Collaborations with FAA safety and research offices
  - Supportive: Participation in technical standards committees

• **USAF-NASA Executive Research Committee**
  - Established by a NASA-Air Force MOU to foster collaboration
  - Coordinate and status NASA research activities and Air Force Future Long Term Challenges
  - All four projects have planned activities that complement one or more Air Force FLTC

• **Joint Council on Aging Aircraft:**
  - Directly supporting through AAD
Industry Teams

Program works with **Commercial Aviation Safety Team** (CAST) and **International Helicopter Safety Team** (IHST) at systems design level for needs and requirements.

Projects work with **Industry Working Groups** at fundamental level for knowledge and capabilities:

**Principles:**
- Facilitate knowledge transfer between working group and the Aviation Safety Program.
- Ensure that fundamental knowledge and understanding underpins new technology development.

**Working Groups:**
- Databases
- Modeling and Simulation
- Sensors
- Verification & Validation
- Algorithms and Signal Processing
- Vehicle State Awareness, Recovery & Control
- Flight Deck
- Aircraft Aging Challenges
NASA Research Announcement

- Over 25 cooperative agreements or contracts with Universities and industry R&D companies as of 31 July.
  - IIFD Rounds 1, 2 & 3.
  - AAD Rounds 1 & 2.
  - IVHM Round 1.

- Round 2 IVHM and Round 1 IRAC selections completed, negotiations for awards are underway.
Aviation Safety Grand Challenges

• V&V of Complex Systems
  – Identify the research challenges associated with validation and verification of complex systems. Current efforts extend techniques developed for simpler systems by compartmentalization or reduction of the order of the complexity.

• Data Mining
  – A need to progress to diagnostic and prognostic analyses of integrated information to enable proactive management of safety risk. Automatically extract and fuse reliable information from the distributed, heterogeneous (continuous digital, discrete digital, analog, and textual) aviation-safety data sources to discover system-level safety vulnerabilities.

• Others…
Questions?

- Aviation Safety on the web...
  http://www.aeronautics.nasa.gov/programs_avsafe.htm

...or by mail...

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