Follow-on Aviation Weather Safety Research & Technology Planning Status

Gus Martzaklis

Planning Lead

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MGM GRAND HOTEL • LAS VEGAS, NEVADA

Important Factors for New Safety R&D Planning

Focus will shift to:

- "Revolutionary" technologies, as well as "retrofit"
  - –Mix of next generation aircraft/technology/ATM and existing fleet
  - –Potential dynamics of less-than-anticipated industry growth
- Safety factors associated with operation in the next-generation NAS environment (e.g., distributed Air/Ground ATM)
- Space-based communications, navigation, and surveillance
- Appropriate mix aircraft types (Transport, GA, R/C, cargo, supersonic, UAV, PAV…)
- Maintenance of the aging fleet
- New pilot demographics (more inexperienced, but more computer literate)
- Precursor risk assessment, not just past accident data
- Security synergies as well as potentially conflicting requirements

Planning Strategy for New Safety Elements

FY00 **AvSP** FY05

FY05 **New Safety** FY10

Technology concepts developed to address current accident categories and precursors

- **Runway Incursion Protection System**
- **Weather Information Datalink**
- **Fast-Time Simulation of System-Wide Risks**
- **Human Factors Tools**
- **Real-Time Health Monitoring Technologies**

Integration of **RETROFITABLE** AvSP technologies/ products to address changes in NAS

- **Integrated Situational Awareness System**
- **Integrated Hazard Alerting and Avoidance System**
- **Real-Time Safety Analysis Capability**
- **Immersive Flight Deck**

REVOLUTIONARY technologies for all categories of aerospace vehicles operating in future airspace environment(s)

Themes & Strategic Foci

Theme: Aircraft Self-Protection & Preservation

Focus: Protect and prevent damage to aircraft due to abnormal operations and systems failures

- **Carrie Walker**
- **Susan Johnson**

Theme: Environmental Hazards Awareness & Mitigation

Focus: Detect and/or eliminate natural hazards that could compromise safe ATS operations

- **Mary Wadel (Aircraft Icing Follow-on)**
- **Gus Martzaklis (Weather Accident Prevention Follow-on)**

Theme: Human Error Avoidance & Mitigation

Focus: Prevent unsafe flight situations due to breakdown between human/machine interface

- **Dan Baize**
- **Sandy Hart**

Theme: System Vulnerability Discovery & Management

Focus: Identify and inform users of potential air transportation system vulnerabilities

- **Tom Chidester**
- **Frank Jones**

New Safety Planning Horizon

- ✓ NASA Program Review (September 2003)
  - ✓ "Bottom-up" planning
  - ✓ Based on WBS and objectives from the FY 2005 Budget Call
- ✓ FAA/NASA Project Reviews (November 2003)
  - ✓ Share status of Project Planning activities
  - ✓ Cross-agency check point
- ✓ Industry/OGA Planning Workshops (March 2004)
  - ✓ ASIST-like
  - ✓ Rely more on working groups (Security already up and going)
- ✓ Aeronautics Technology Subcommittee/Working Group Review (May 2004)
- ✓ NASA Strategy Team Review (On-going)
- • Weather Accident Prevention Review-Follow-On Planning (NOW)
- • FY 2006 Submission (June 2004)
- • Industry/OGA Debriefing on final portfolio
- • Non-Advocate Review (2005)
- • Project Implementation in FY 2006

NASA Aviation Safety R&D Planning Workshop

Aviation Safety Planning Workshop
March 2-4, 2004

To solicit input from industry and other Government agencies for future projects in NASA's aviation safety research and development program

Working Groups recommend prioritized investments for FY 06-10

~300 Industry & Government participants

Working Groups (Reflect NASA strategic foci) for Safety R&D

Aircraft Self-Protection & Preservation

System Vulnerability Discovery & Mgmt

Environmental Hazards Awareness & Mitigation

Human Error Avoidance & Mitigation

Proposed NASA Research Plans Presented at Workshop

NASA Core Planning Team

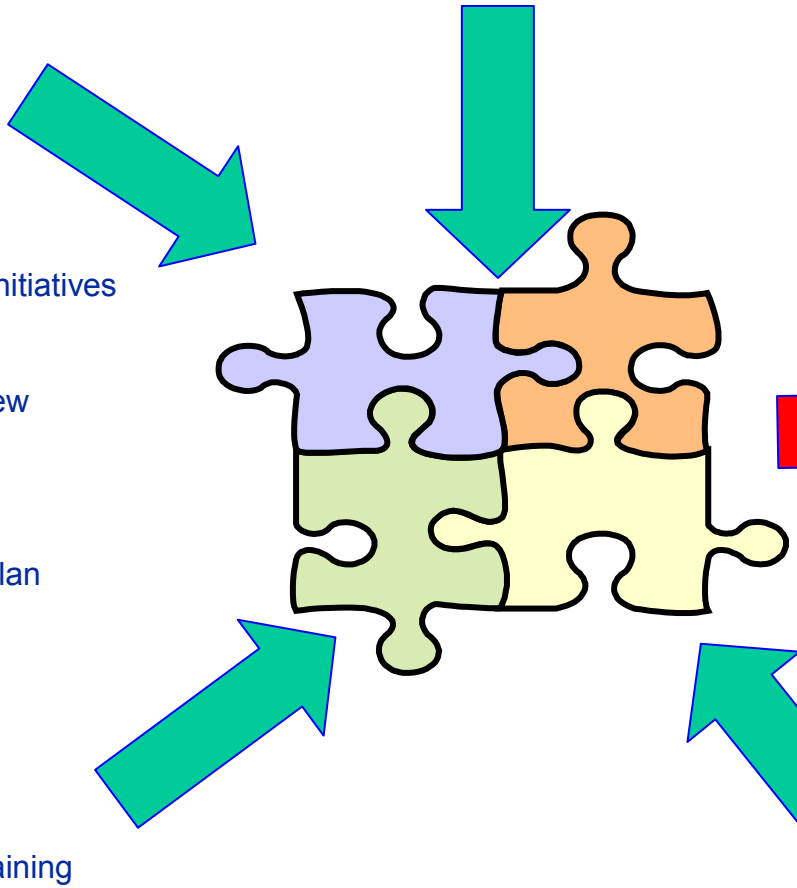
- Jim Griner (GRC)
- Dave Hamilton (LaRC)
- Mike Jarrell (GRC)
- Gus Martzaklis (GRC)
- John Murray (LaRC)
- Phil Schaffner (LaRC)
- Paul Stough (LaRC)
- Ed Teets (DFRC)
- Jim Watson (LaRC)

Weather Follow-on Planning Approach

External Customer Requirements:

- CAST
- 2004 Industry Workshop
- ASIST
- FAA Flight Plan
- FAA Safer Skies
- OFCM National Weather Initiatives
- NASA/FAA AvSafety JWG
- WxAP 2002 Industry Review
- WxAP 2004 Review
- NRC Review
- JPDO National Wx R&D Plan

Balance of Low/High TRL



Implementation Strategy:

- Strong collaboration with partners
- Resource leveraging (cost-share, in-kind..)
- Planning and development through Joint Development Teams

The Right R&D Portfolio !!!

NASA-led Joint Planning Teams

Phase I Remaining Technical Objectives

NASA Unique Contribution

Remaining Aviation Weather R&D Needs

- Terminal area operations (vs. en-route)
  - Tactical decision-making (vs. strategic)
  - Multipurpose sensors
  - Critical datalinks
- Further improvements to nowcasts/forecasts
  - Satellite-enhanced aviation weather products
- Address additional aircraft classes
  - Regional jets, rotorcraft, cargo..
  - Sensors, communications
- Improved sensors, communications
  - Extend range, warning time, capacity,
  - Address additional hazards
  - Reduce cost

Remaining Aviation Weather R&D Needs

- Enable Aviation Weather Digital Database (AWDD)
  - Sensor web (ground, satellite, airborne observations)
  - Gridded data formats/packaging
- Airborne integration of sensor information
  - Uplinked from ground (current obs, nowcasts & forecasts)
  - Satellite observations
  - In-situ
  - Forward-looking
  - For ownship use as well as E-PIREP/AutoMet to other aircraft and ground users
- Address additional operational regimes
  - International and oceanic operations
  - Flight levels
  - Sensors, communications

Technology Objective:

- Improve aviation weather nowcast and forecast products via the provision and infusion of satellite data into atmospheric models

Approach:

- Develop techniques to incorporate current and future generation satellite observations into aviation weather products
  - Ensure full utilization of existing NASA Earth Science and NOAA satellite data
  - Shift focus to development of high resolution applications using technologies of new satellites (e.g., hyperspectral soundings, lidar, microwave, lightning detection, space weather, etc.)
- Integrate satellite, surface and airborne observations as elements of an Earth Observation Sensor Web to serve as the data engine for the JPDO requirement for an Aviation Weather Digital Database
- Partner with NASA Earth Science Enterprise, FAA Aviation Weather Research Program (AWRP) and the Interagency JPDO.
- Conduct product evaluations
- Develop operational transition plans

Key Deliverables & Technology Risk Level

Advanced Satellite Aviation-weather Products

Product	*Technology Risk Level*
Enhanced aviation weather products: •In Flight Icing •Oceanic Convection, Winds and Turbulence •Volcanic Ash and Gas •Precise Flight Level Temperature (for fuel freeze mitigation) •Space Weather •Etc..	Medium
Earth Observation Sensor Web	High
Product evaluations	Medium
Benefits Assessments and Operational Transitions Plans	Low

Technology Objectives:

- Develop active and passive multipurpose sensor systems to reduce risk associated with remaining airborne weather safety hazards
  - CAT/CIT, volcanic ash, turbulence mitigation flow field sensor, improved wind hazard detection, etc..
- Enhance capabilities of current sensors and expand to address additional operator classes & flight phases
  - Extended range/warning time
  - Terminal area, approach/landing
  - Regional jets, rotorcraft..
- Develop optimal methods for integrating on-board in-situ and forward-looking airborne observations with uplinked ground and satellite data to:
  - Identify weather hazards for flight crews
  - Downlink to ground users (e.g. to improve aviation nowcasts and forecasts)

Key Deliverables & Technology Risk Level

Airborne Sensor Development & Data Fusion

Product	*Technology Risk Level*
Multipurpose Aviation-weather Hazard Sensors •CAT •Flow Field Sensor for Turb. Mitigation •Volcanic Ash •Improved wind hazard	High
Enhanced Weather Hazard Sensors & Concepts	Medium/High
Weather Hazard Sensor Data Fusion Concepts & Algorithms	Medium

Weather Dissemination

Technology Objectives:

- Develop communications technologies for the dissemination of critical weather information to improve decision-making in tactical environments
- Develop communications cross-link concepts and solutions for atmospheric hazard Electronic-Pilot Reporting (E-PIREP) for increased situational awareness of weather hazards
- Develop link-efficient data packaging guidelines to enable dissemination of 4-dimensional atmospheric grid data enabling construction of customized, integrated weather products
- Develop viable, affordable weather hazard avoidance communications system for minimally-equipped VFR aircraft operations

Technology Objectives (Continued):

- Expand capabilities of current and emerging datalinks for broadband communications for GA through regional jet aircraft classes
- Develop low-cost broadband communications capability for non-commercial transport aircraft in international/oceanic regions for weather information
- Expand airborne communications reporting capabilities to accommodate dissemination of on-board weather radar data to other aircraft and ground applications
- Develop satellite communications architectures to enable direct delivery of weather satellite observations to aircraft

Key Deliverables & Technology Risk Level

Weather Dissemination

Product	*Technology Risk Level*
Tactical Weather Communications Concepts and Datalinks	High
Atmospheric E-PIREPS Communications System Concepts and Datalinks	Low/Medium
Link-efficient Data Packaging Guidelines for 4-D Atmospheric Gridded Data	High
Weather Hazard Avoidance Communications System for VFR Operations	High
General Aviation/Regional Jet Broadband National Weather Datalink	Medium
Broadband Oceanic/International Weather Datalink for GA and Cargo	Medium/High
On-board Weather Radar Dissemination to other Aircraft & Ground	High
Direct-to-aircraft Delivery of Satellite Weather Observations	High

Workshop Summary and Results

Workshop Process

- Looked at NASA Contributions to Date (understand NASA competencies) and Proposed (Phase 2) NASA R&D Portfolio
- Heard from Aviation Weather Experts (panel members and ad hoc presenters)
- Open Floor Discussions
- Individual Surveys of Priorities and Gaps
- Industry group decided to have NASA Tri-Leads develop brief-out package

Minimum Workshop Group Outcomes

1. Industry prioritized list of NASA aviation safety elements or products

2. Industry list of concerns/issues/recommendations with regard to follow-on safety program's proposed products and/or directions

3. Identification of R&D gaps in proposed AvSSP portfolio

Product Priority Criteria

1. Must meet the current and/or emerging national aviation safety needs as well as the goals of the Aviation Safety and Security Program.

2. Products must show substantial degree of NASA contributions

3. Must have a balanced reflection of both low (more revolutionary) to high technology (more evolutionary) readiness level products.

4. Must have the potential for large user community acceptance and in most cases user involvement

5. Technologies should be crosscutting for several vehicles classes.

Program Issues Identified

1. The Program and Weather Theme should perform true Safety Risk Analysis/Assessments to
   a) Properly define and change program/project portfolio content
      - Cost-to-Benefit Analysis
      - Projected Safety Risk/Accidents Reduction
   b) Understand when success is achieved or when problem is solved

2. Need an integrated view and plan across multiple programs (i.e. Aviation Safety/Security and Airspace System (capacity initiatives)

3. Aviation Weather Products/Information conveyed to the pilot should be fully integrated in the cockpit with other equipage both current and future.

4. Address certification needs in product development. Good certification increases safety.

Program Issues Identified

5. Ensure end user participation in planning and implementation.

6. Avoid products that could become outdated before coming into fruition (e.g. electronic components obsolete due to heavier reliance on consumer technologies).

Observations & Recommendations

1. Weather sensor development should be integrated across current and future weather system(s) to minimize stand-alone products.

2. Core capabilities in aircraft icing are a national asset that must be maintained.

3. Need to better integrate Weather, Aircraft Icing and other activities.

4. Limited airframer, operator participation in Group 2.

5. Develop technology development roadmap for networking weather information.

Observations & Recommendations

6. Emerging threats to safety in future operations should be a key consideration for the goal not just fatal accidents
   -Wake vortex, use of composite materials, micro-jets…

7. Given the cross-cutting nature of aviation weather- technology integration between safety, capacity and efficiency should be considered

8. Assure alignment to JPDO weather national plan(s).

9. Consider revolutionary technologies that makes weather transparent to aviation operations.

10. User driven system approach to addressing focused aviation hazards (cradle-to-grave)

Top Products (Prioritized)

1. Weather Dissemination/Communication (GAP)
2. Airborne Sensor Development and Data Fusion (includes icing, turbulence, volcanic ash, winds, space weather…)
   - Towards a 5-D Aviation Weather Digital Database (GAP)
3. Advanced Satellite Aviation Weather Products
4. Icing Simulation Tools for Design and Certification
   - To include Ice Shedding/Engine Icing
5. Advanced Ice Protection Technologies
6. Hazard Classification (GAP)
7. Lightning, ERF and EMI (GAP)
8. Realistic Icing Training Environment Concepts
9. Space Radiation (GAP)
10. Ground De-Icing (GAP)
11. Wake Vortex (GAP)
12. Intelligent Aircraft Icing Systems (GAP)

Priority not influenced by resource limitations

Note: If you roll up the Icing activities including those related to sensors/fused products as one it would rank #2

Current Status of Plan

WEATHER INFORMATION SENSING, DESSIMINATION, AND OBSERVATION MODEL ENHANCEMENT PROJECT

AvSSP Phase II Sub-Project Objective Statements from POP 2006 Budget Call	Post-Workshop Objective Statements	Post-Workshop In-Guide Products	Over-Guide and Proposed *New Products*
Weather Dissemination • Develop communication technologies for the dissemination of critical weather information to improve decision making in tactical environments • Develop communication cross-link concepts and solutions for atmospheric hazard Electronic-Pilot reporting for increased situational awareness of weather hazards • Develop link-efficient data packaging guidelines to enable dissemination of 4-dimensional atmospheric grid data enabling construction of customized, integrated weather products • Develop viable, affordable weather hazard avoidance communication system for non-equipped VFR aircraft operations	**Weather Dissemination** • Develop communication technologies for the dissemination of critical weather information to improve decision making in tactical environments • Develop communication cross-link concepts and solutions for atmospheric hazard Electronic-Pilot reporting for increased situational awareness of weather hazards • Develop link-efficient data packaging guidelines to enable dissemination of **5-dimensional** atmospheric grid data enabling construction of customized, integrated weather products • [4th Objective Deleted]		• Tactical Weather Communications Concepts and Datalinks • Atmospheric E-PIREPS Communications System Concepts and Datalinks • Link-Efficient Data Packaging Guidelines for 4-D Atmospheric Gridded Data • Broadband datalinks for national and international operations of additional aircraft classes

Current Status of Plan

AvSSP Phase II Sub-Project Objective Statements from POP 2006 Budget Call	Post-Workshop Objective Statements	Post-Workshop In-Guide Products	Over-Guide and Proposed *New Products*
Airborne Sensor Development & Data Fusion • Develop active and passive sensor systems to reduce remaining airborne weather safety hazards; enhance capabilities of current sensors and expand to address additional operator classes • Develop optimal methods for integrating in-situ and forward looking airborne, ground and satellite observation data to identify weather hazards and improve aviation nowcast and forecasts	• Develop active and passive sensor systems to reduce remaining airborne weather safety hazards such as *turbulence*; enhance capabilities of current sensors and expand to address additional operator classes • Develop optimal methods for integrating in-situ and forward looking airborne, ground and satellite observation data to identify weather hazards and improve aviation nowcast and forecasts	• Multipurpose Aviation-weather Hazard Sensors: 1. CAT Sensor 2. Flow Field Sensor for Turbulence Mitigation 3. Volcanic Ash 4. Improved Wind Shear • Enhanced Weather Hazard Sensors and Concepts • Weather Hazard Sensor Data Fusion Concepts & Algorithms	
Advanced Satellite Aviation-Weather Products Improve aviation weather nowcast and forecast products via the provision and infusion of satellite data into atmospheric models		• Enhanced Aviation Weather Products: 1. In-Flight Icing 2. Oceanic Convection, Winds & Turbulence 3. Volcanic Ash & Gas 4. Precise Flight Level Temperature 5. Space Weather • Aviation Weather Product Evaluations • Benefits Assessment and Operational Transition plans	• *5-D Aviation Weather Digital Database (AWDD)* • Earth Observation Sensor Web