System-Wide Accident Prevention
Aviation Safety Program

Training Element

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Outline

- Introduction to the Training Element
- Collaborative Work with NASA Glenn
- Major Areas of Current Research:
  - Interruptions and Distractions Countermeasures
  - Automation Training
  - Aviation Weather Decision Making
  - Pilots' Cognitive Performance and Blood Sugar Level
  - Emergency and Abnormal Situations
- Summary

The "Training" Element

Domain:

Deliverables:

- New training methods and techniques
- Better operating procedures
- More informative line checks
- Scientific knowledge

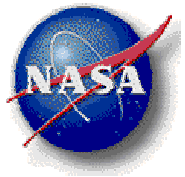
Problem Statement

The Challenge:

- Most aviation accidents attributed to human error
- Technology is not a magic bullet
  - » New systems can improve performance but also introduce new opportunities for error
- Human performance is most complex issue in science
- Many issues - cannot address all, no matter how critical

The Goal:

- Reduce the probability of making errors that can cause accidents
- Manage in-flight problems caused by system failures, design limitations, errors made by ground personnel, and hazardous weather conditions



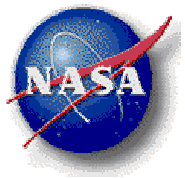
Problem Statement, continued

The Approach:

- Conduct rigorous and novel research informed by the latest scientific knowledge in aviation human factors in collaboration with industry and academic partners
- Bring together information from field studies, lab studies, part-task and full-task simulations, industry interviews, and incident and accident reports
- Develop and implement products with immediate, real-world application to operational problems and concerns

Assets:

- Recent advances in basic cognitive science relate to human factors applications
- Historic close relationship with airline industry, starting with CRM and LOFT
  - » Direct route to implementation
- Field abundant with targets of opportunity



AvSP Training Element Projects

NASA Research Announcement Awards:

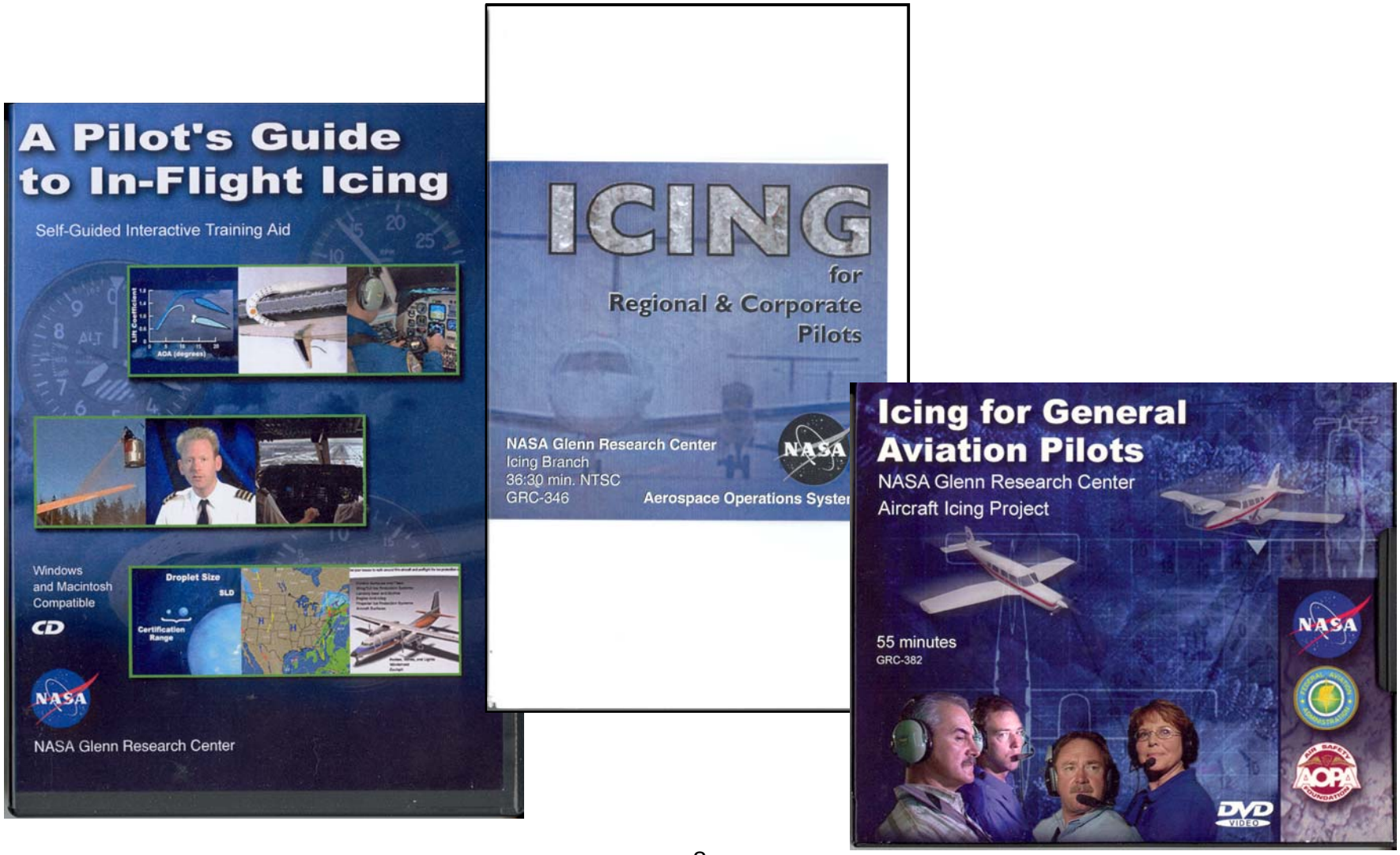
- **Veridian Corporation:** Airplane Upset Training Evaluation
- **University of Otago:** Learning from Case Histories in General Aviation
- **San Francisco State University:** Training for Automation Use in Regionals
- **George Mason University:** Abatement of Automation Errors - Cognitive Model
- **University of Illinois:** Transfer of Training Effectiveness of Aviation Training Devices
- **Boeing Corporation:** Analysis of Automation Monitoring Skills

AvSP Training Element Projects, continued

NASA Intramural Research and Collaboration:

- **Glenn Research Center:**
  - » Pilot Training Simulator for In-flight Icing Encounters
- **Ames Research Center:**
  - » Ab Initio Cockpit Automation Curriculum
  - » Development of Cockpit Automation Expertise
  - » Gold Standards to Train Instructors to Evaluate Performance
  - » Alertness Management Training Module for GA Pilots
  - » Pilot Weather-Related Decision-Making
  - » Emergency and Abnormal Situations
  - » Low-blood Sugar and Aviation Pilot Performance
  - » Remembering to Complete Interrupted Tasks

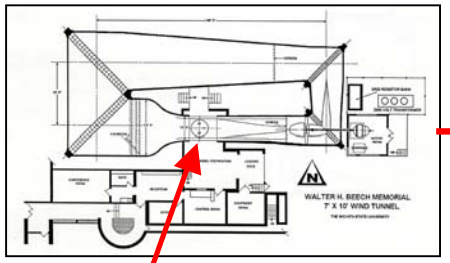
Icing Training
with NASA Glenn



Development of a Pilot Training Flight Simulator for In-flight Icing Encounters

Development Process of an Icing Effects FTD Concept Demonstrator

Low Speed Wind Tunnel



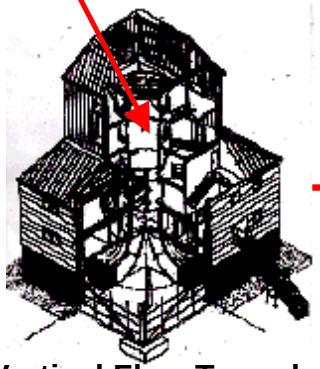
Full-scale Aircraft Flight Test

Flight Training Device Demonstrator

Sub-scale Complete Aircraft Model

Aero Effects of Airframe Icing

Verification



Vertical Flow Tunnel

Flight Sim Model development & testing

Interruption and Distraction Countermeasures

Ames Research Team:

Key Dismukes
- Principle Investigator

Ben Berman

Rahul Dodhia

Jon Holbrook

Kim Jobe

Loukia Loukopoulos

Jessica Lang Nowinski

Main University Collaborators:

Furman University

University of New Mexico

California Polytechnic State University

Main Industry Collaborators:

Continental Airlines

Southwest Airlines

Remembering to Complete Interrupted Tasks

- **Uncompleted procedures:**
  - "Probable cause" of several major accidents (e.g., NW255, Detroit, Aug '87)
  - Show up in ASRS reports every month (e.g., failure to set take-off flaps)

- **Interruptions during flows/ checklist a major factor in failure to complete actions (Dismukes et al., 1998)**
- **Interruptions especially frequent during pre-start and taxi (Loukopoulos, et al, 2001, 2003)**

Approach/Status

- **New study (FY02)**
- **Draws upon AOS project: Jumpseat observation of Concurrent Task Demands**
- **Review of ASRS and NTSB reports: recently completed (Nowinski et al., 2003; Berman et al., in preparation)**
- **Review of scientific literature on prospective memory (remembering to complete deferred actions): complete**
- **Laboratory experiments underway:**
  - Why are interrupted tasks not resumed?
  - What factors influence probability of remembering to complete task?
  - What countermeasures would reduce pilots' vulnerability to interruptions?

Automation Training

Ames Research Team:

Steve Casner
- Principle Investigator

Karen Jones

Antonio Puentes

Homi Irani

Main University Collaborators:

University of California - San Diego

Purdue University

Embry Riddle Aeronautical University

Main Industry Collaborators:

Bel Air Aviation

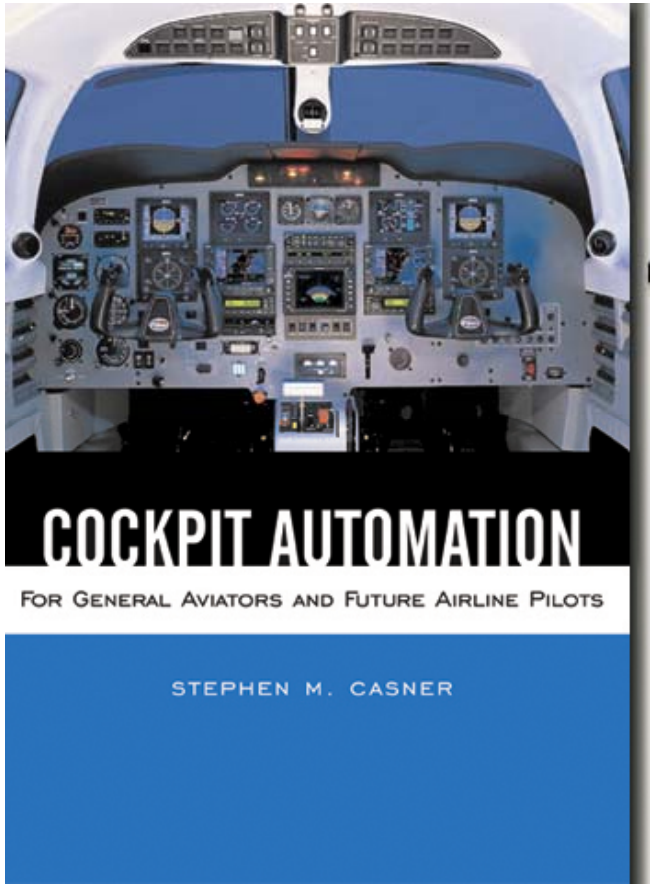
Sky West

American Flyers

Automation Training

Low-time, general aviation pilots transitioning to glass cockpit jets … with no automation training or experience.

Cockpit Automation Curriculum and Textbook



Teaches fundamentals of cockpit automation use

- Procedures
- Underlying concepts

INSTRUCTIONAL DVD

Automation Training

Technical (procedural) skills taught together with crew concepts and human factors

- Sharing flight deck responsibilities with automation systems
- Electronic flight planning
- Importance of reviewing work performed by the computer.
- Monitoring basics (staying in the loop)
- In-flight route modifications
- Descent planning
- Approaches, missed approaches, and holds.
- Levels of automation
    - Managed guidance modes vs. tactical modes
    - Knowing when to turn it off
- Human factors challenges of cockpit automation.

Aviation Weather Decision Making

Ames Research Team:

Judith Orasanu
- Principle Investigator

Roberta Bernhard

Steve Farlow

Jon Holbrook

Steve Johnson

Dave Schwartz

Yuri Tada

Main University Collaborators:

University of Illinois

University of Alaska - Anchorage

Main Industry Collaborators:

FAA - Capstone Project

NIOSH

Alaska Flight Safety Foundation

Aviation Weather Decision Making

THE PROBLEM: Bad weather is a major factor in aviation accidents, especially for Pt. 91 and Pt. 135 operations. Alaska weather and terrain are most extreme in the U.S. Alaska accidents account for 40% of U.S. total.

BACKGROUND

- Focus on Plan Continuation Errors (continuing with original plan in face of changing conditions).
- NTSB (1994) found that #2 contributing factor to fatal accidents was tactical decision errors, most of which involved PCEs.

RESEARCH ISSUES

WHY do pilots enter or continue in bad weather?

- Inadequate weather information
- Contextual factors: Wx, time and economic pressures
- Pilots' risk attitudes and decision strategies

HOW to improve safety of pilot decision making?

Research Strategy

- Given that PCEs are associated with aviation accidents, identify patterns of conditions and pilot actions in *incidents* that may be *precursors to accidents*
  - » Identify flight conditions, precipitating events, contextual features, and decisions associated with PCEs
- Compare Pt. 91 with Pt.135 data
- Compare Alaska with continental U.S. data

Data Sources

- ASRS Reports (1994-97) -*"In-flight encounters with weather"*
- Critical decision interviews and surveys AK pilots (n = 52)

Pilots' Cognitive Performance and Blood Sugar Level

Ames Research Team:

Immanuel Barshi
- Principle Investigator

Sean Belcher

Jolene Bischoff

Richard Geven

Todd Kowalski

Main University Collaborators:

University of Oregon

Main Industry Collaborators:

A Major U.S. Air Carrier

Pilots' Cognitive Performance and Blood Sugar Level

- **Sugar is the fuel of the brain. We must make sure that the pilots' brains have sufficient fuel for the complex cognitive operations they must perform during flight.**

- **It is often difficult for flight crews to eat right during normal line operations.**
  - Most airlines no longer provide food for their crews.
  - Crews usually depart in the morning before restaurants open; afternoon crews usually return after restaurants close.
  - Duty days can be long, and quick turn-arounds may not allow sufficient time to find food near the gate.
  - Many airport restaurants are located on the other side of security checkpoints
  - Some pilots complain about reduced performance, headaches, or just hunger. But it's possible that most pilots are adversely affected by this practice even if they are not always aware of it.

- **The purpose of this study is to determine whether or not cognitive performance of pilots in routine line operations is affected by the limited availability of food to the flight crew.**

Pilots' Cognitive Performance and Blood Sugar Level

Emergency and Abnormal Situations

Ames Research Team:

Immanuel Barshi
- Principle Investigator

Sean Belcher

Barbara Burian

Richard Fariello

Richard Geven

Todd Kowalski

Main University Collaborators:

University of Oregon

University of Colorado

Main Industry Collaborators:

Numerous - see following slides

The Challenge

- Emergency and Abnormal Situations are:
  - Often time critical, complex, and/or ambiguous
  - High stress, high workload, and a great deal is at stake
  - Require exceptionally high levels of coordination inside and outside of the airplane

- Emergency and Abnormal Procedures are:
  - Generally focused on aircraft systems rather than on the situation as a whole
  - Practiced seldom (once a year or less) and used rarely
  - Often highly dependent upon fragile cognitive processes
  - But, when needed, are crucial and must be performed correctly

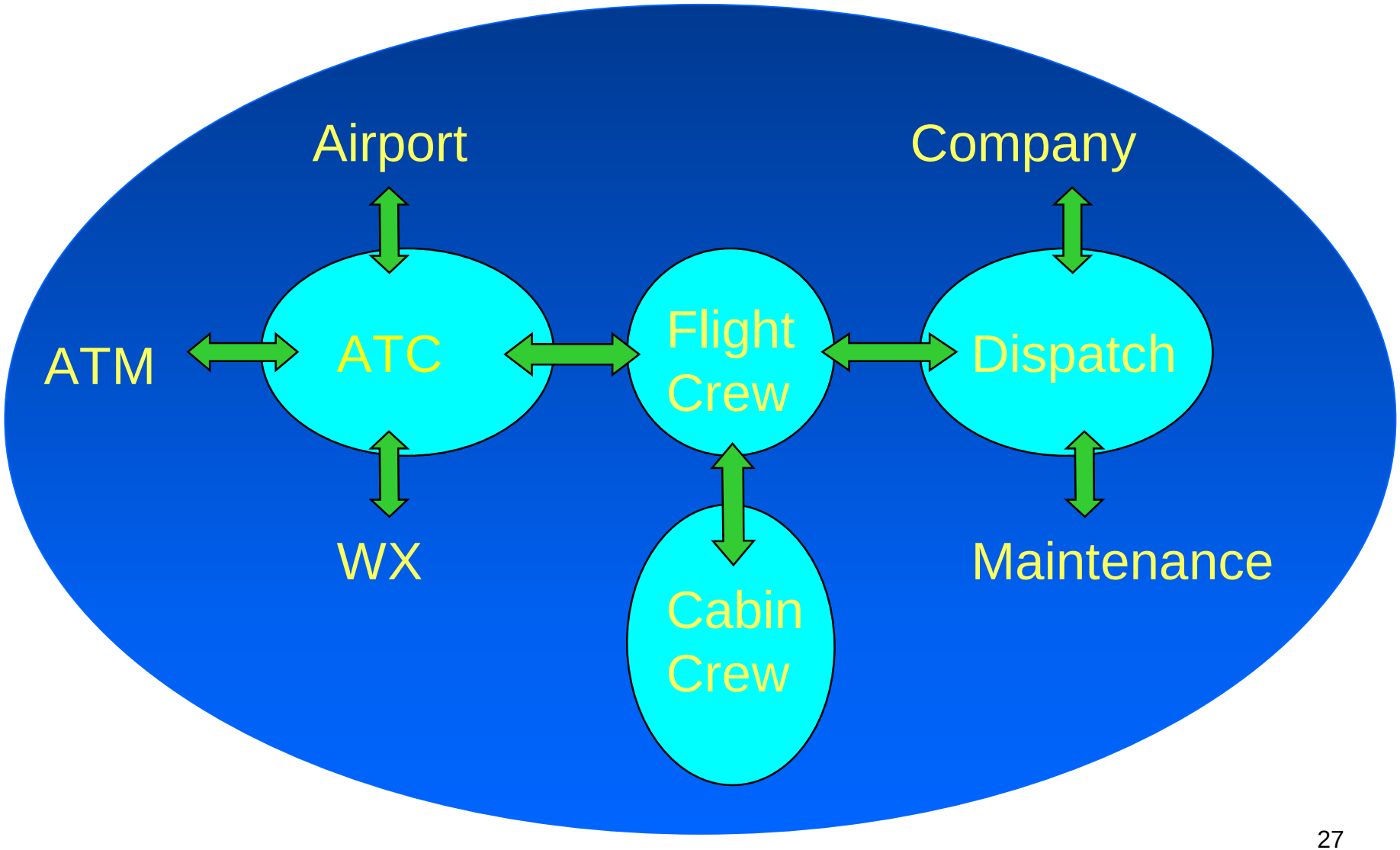
A Subset of Industry Contacts and Consultants

- Boeing: Dan Boorman, Bill McKenzie, Dr. Curt Graeber
- Airbus Industries: Michel Tremaud, Jean-Jacques Speyer
- BAE Systems: Captain D.J. Gurney
- FAA: Phyllis Kayten, Steve Boyd, Win Karish, Keeton Zachary
- NTSB: Ben Berman, Nora Marshall, Dr. Robert Molloy
- ALPA: Captain Robert Sumwalt
- ATA: Captain Rick Travers
- TSB of Canada: David Curry, Don Enns, Elizabeth McCullough
- ICAO: Captain Dan Maurino
- CAA (UK): Steve Griffin, Captain Stuart Gruber, Dr. Sue Baker
- Airlines: Southwest Airlines, United Air Lines, Continental Airlines, TWA, Fed Ex, Aloha Airlines, Hawaiian Airlines, Air Canada, Cathay Pacific, Airborne Express, Midwest Express

Themes from Industry Interviews

- **Industry lacks substantive human performance guidelines for the creation, validation, certification, and training of procedures for emergency and abnormal situations**
- **Challenge to design procedures to reflect real-world ambiguities, workload demands, time constraints, and cognitive limitations**
- **Training provides limited opportunity to practice procedures in context of full real-world demands**
  - LOFT/LOE: one scenario/year
  - Recurrent training focuses on practicing procedures not on concurrent demands (e.g., coordination with ATC, dispatch, and maintenance)

The Emergency Situation



Goal

Develop guidance for procedure development, training, crew coordination, and situation management based on knowledge of human performance limitations and cognitive vulnerabilities and the operational context

Deliverables

Intermediate Products: Reports, Articles, Presentations, Sponsoring Industry-Wide Meeting – June 2003

End Products: *Field Guides* for

- Training Entities and Instructors
- Operators
- Manufacturers
- Regulatory Agencies (Certification, POIs)

SWAP Training Element - Summary

Products

- Articles in peer reviewed journals and presentations at scientific meetings
- Presentations to the aviation industry
- Books, text books, training modules and curricula, instructional videos and DVDs, computer-based and web-based training programs
- Guidelines regarding structure of and approach to pilot training and the design and use of procedures
- Real-time advice to the operational community regarding how to use research results and implement suggestions

SWAP Training Element - Summary

- Most projects are five-year studies
- Some tech transfer to industry already underway, e.g.:
  - Alertness management module for GA posted on Web
  - Icing videos, CBT, DVD
  - Cockpit automation for general aviation and future airline pilots
  - Boeing analysis of automation monitoring skills
  - Gold standards to train instructors to evaluate crew performance
  - Evaluation of airplane upset training
- Training element milestones will all be met

But many aviation human performance issues remain to be addressed