Aviation Safety Program

System-Wide Accident Prevention

Dr. Tina Beard

Investigation Methods and Tools Workshop
NASA Ames Research Center
July 31, 2003
- Number of hull loss accidents has steadily increased over the past 25 years
- Human factors issues have steadily accounted for ~70% of these accidents
- Introduction of new technological devices or procedures
- Trading one source of human error for another
Aviation Safety Program

Problem

- Accidents result from a chain of events
- Many distinct human error related causes of aviation accidents, due to behavior of both air and ground crew
- Degree that each of these precursors contributes to accidents varies over time
Current AvSP Program Organization

Aviation Safety Program Office
George Finelli, Acting Director
Glenn Bond, Senior Prog Analyst

Technical Integration
Frank Jones (LaRC)

Program Integration
Michael Basehore (FAA)
Carrie Walker (Hq)

Aviation System Monitoring & Modeling
Irving Statler (ARC)

System-Wide Accident Prevention
Bettina L. Beard (ARC)

Search & Rescue
Rudy Larsen (GSC)

Single Aircraft Accident Prevention
Carrie Walker (LaRC)

Synthetic Vision
Daniel Baize (LaRC)

Accident Mitigation
Robert McKnight (GRC)

Weather Accident Prevention
K. Martzaklis (GRC)

Aircraft Icing
Mary Wadel (GRC)

Human Performance Modeling
David Foyle (ARC)

Maintenance Human Factors
Barbara Kanki (ARC)

Training
Immanuel Barshi (ARC)

Program Human Factors
Bettina L. Beard (ARC)
SWAP Project

• SWAP uses current knowledge about human cognition to develop mitigation strategies to address current trends in accident and incident profiles
• Develop and provide guidelines, recommendations & tools directly to customers through --
  • Better understanding of human error and human reliability associated with tasks
  • Development of interventions and task aids that reduce human error and enhance safety and effectiveness
Continuous involvement of operational partners through all phases

- Identification of human errors
- Definition of HF requirements and risks
- Development of techniques & tools; HF interventions
- Operational validation & implementation

Helps with user acceptance
Establishes a clear transition path to industry implementation
**Approach**

1. **Identify SAFETY NEEDS**
   - Consult with subject matter experts
   - Scientists are rated pilots

2. **Apply METHODS, TOOLS**

3. **Develop INTERVENTIONS**

4. **Validate PRODUCTS**

**Aviation Safety Program**

**SWAP**

**Part-task & Full Mission Simulations**

**Computational Modeling**

**Field Observation Data**

**Field Tests**

**Lab Studies**

**Accident & Incident Analysis**

**Aviation Research**

**Literature Reviews**

**CATS**

**Operator Actions**

**Predictions**

**Interpretations**

**[to operator's associate interface]**

**Part-task & Full Mission Simulations**
HPM Products

System-Wide Accident Prevention
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Human Performance Models
Crew Activity Tracking
## Selected Modeling Frameworks

**Characteristics of selected models**

- Operator level, cognitively oriented
- Comprehensive, mature and validated systems
- Integrative frameworks facilitating fast-time simulation
- Output is generative, stochastic, context sensitive

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Research Team</th>
<th>Demonstrated Sources of Pilot Error</th>
</tr>
</thead>
</table>
| ACT-R/PM               | Low-level Cognitive with Statistical Environment Representation | Mike Byrne, Rice University, Alex Kirlik, University of Illinois | * Time pressure  
|                        |                                                  |                                                                               | * Misplaced expectations  
|                        |                                                  |                                                                               | * Memory retrieval problems |
| Air MIDAS              | Integrative Multi-component Cognitive            | Kevin Corker, Brian Gore, Eromi Guneratne, Amit Jadhav & Savita Verma, San Jose State University | * Workload  
|                        |                                                  |                                                                               | * Memory Interference  
|                        |                                                  |                                                                               | * Misperception  
|                        |                                                  |                                                                               | * Multi-crew Communication |
| A-SA                   | Component Model of Attention & Situational Awareness | Chris Wickens, Jason McCarley, Lisa Thomas, University of Illinois | * Misplaced attention  
|                        |                                                  |                                                                               | * Lowered SA |
| D-OMAR                 | Integrative Multi-component Cognitive            | Stephen Deutsch, Richard Pew, BBN Technologies | * Communications errors  
|                        |                                                  |                                                                               | * Interruption & distraction  
|                        |                                                  |                                                                               | * Misplaced expectation |
|                        |                                                  |                                                                               | * Perceptual errors  
|                        |                                                  |                                                                               | * Memory retrieval  
|                        |                                                  |                                                                               | * Inadequate knowledge |
Progressive Implementation Strategy

Advancing cognitive models into increasingly complex real-world applications
Taxi Navigation Modeling

Data Set
T-NASA Full Mission Simulation

Modeling Problem
Reproduce/Explain
Taxiway Navigation Errors

Scenario Specifications

- High-fidelity full motion simulation of taxi-to-gate at Chicago-O’Hare
- 54 trials run by 18 airline crews
- 9 different cleared routes -- all in low visibility (1000 RVR)
- Traffic, hold short, and route changes included in scenarios
- 12 off-route errors committed by crews and specified to modelers
Air MIDAS Simulation of Observed Error

ERROR

- Fixate, Control input stop ac communicate
- Fixate, communication, monitor progress
- Monitoring, communicating with supervisor

- Fixate, Control input Stop Aircraft, prepare for right turn
- Fixate, communication, consult clearance
- CONFIRMATION BIAS EXERCISED
- monitoring

- Fixate, Control input turn and increase speed
- Fixate, communication, monitor progress
- monitoring

- Monitoring Control input, turn aircraft
- scanning, communication
- monitoring

- Monitoring Control input (accelerate, time delay, stress, DIRECT LINE TO GATE
- scouting, communication lost SA
- monitoring

- Monitoring Control input
- scanning, communication
- monitoring

- Monitoring Control input, increased communication
- scanning, increased communication, lost SA
- CONTACT TOWER
- monitoring, communicating

- Monitoring, decision process

- Fixate internal, Control input (AC control), Cognitively missed signage
- Clean up head down, Fixate, communication, hear/write clearance, communication and navigation
- DECLARATIVE INFORMATION LOSS THROUGH INTERFERENC
- communication monitoring

- Fixate, Control input accelerate
- Fixate, communication
- communication monitoring

- Fixate, Control input turn aircraft
- Fixate, communication
- communication monitoring

- Fixate, Control input Stop Aircraft, prepare for right turn
- Fixate, communication, consult clearance
- CONFIRMATION BIAS EXERCISED
- monitoring

- Fixate, Control input (Roll out, autobrake)
- Control input (switch alarm off, disarm auto)
- verifies thrust levers, monitor ground speed, & communication (speed and sign call out)

- Monitoring (Roll out, autobrake), hearing, Control input (brake) monitor speed, communication (speed and sign call out)

- Monitoring Control input scanning, communication
- communication monitoring

- Monitoring Control input, SA verification
- scanning, communication
- communication monitoring

- Monitoring Control input scanning, communication
- communication monitoring

- Monitoring Control input scanning, communication (signage/speed monitoring)
- communication monitoring

- Fixate, Control input Wait for clearance
- Fixate, communication, hear/write clearance, clean up procedure
- communication monitoring
Modeling Nominal Approach & Landing

Data Set
Part-task Pilot-in-loop Simulation
Performance data and Eye-tracking (3 Subjects)

Other Information Provided Modelers
Detailed Cognitive Task Analysis

Modeling Problem
Develop "Normative" Model of Approach & Landing with and without Augmented Display

Scenarios

<table>
<thead>
<tr>
<th>Display Configuration</th>
<th>Baseline</th>
<th>Baseline</th>
<th>SVS</th>
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<tr>
<td>Visibility</td>
<td>VMC</td>
<td>IMC</td>
<td>IMC</td>
</tr>
<tr>
<td>Nominal Approach</td>
<td>Scenario #1</td>
<td>Scenario #4</td>
<td>Scenario #7</td>
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<tr>
<td>(nominal landing)</td>
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<tr>
<td>Late Reassignment</td>
<td>Scenario #2</td>
<td></td>
<td>Scenario #8</td>
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<tr>
<td>(side-step &amp; land)</td>
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<tr>
<td>Missed Approach</td>
<td>Scenario #3</td>
<td>Scenario #5</td>
<td>Scenario #9</td>
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<tr>
<td>(go-around)</td>
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<tr>
<td>Terrain Mismatch</td>
<td>Scenario #6</td>
<td></td>
<td>Scenario #10</td>
</tr>
<tr>
<td>(go-around)</td>
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</table>
Crew Activity Tracking System (CATS)

- Computerized engineering model of correct task performance to predict operator activities and interpret operator actions

- Provides context-dependent knowledge about the operator’s task that can support tutors, aids, and displays to enhance safety

- Supports visualization and analysis of human-automation interaction
Detecting Errors from Flight Data

Current research demonstrates how CATS can analyze flight data from the Langley B757 ARIES aircraft to detect procedural errors

*Callantine (2001a, 2001b)*

**NASA B757-ARIES**

On-board Data Acquisition System used to collect flight data

Cockpit observations verified and augmented digital data
MVF Products

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Maintenance Error Baselines
Inhouse: Crew Factors Group

HF Risk Analysis Tools
University of Idaho

Advanced Displays (VR & AR)
Clemson University
Boeing, Huntington Beach

MRM Skills, Training & Evaluation
Santa Clara University
Naval Postgraduate School & Navy Safety Center
GOAL: Establish current maintenance error baselines in order to identify safety needs. Revisit the NASA ASRS database in response to a significant increase in ASRS reporting.

- ~200 reports during 1993-1998
- ~800 reports during 1999-2000

OBJECTIVES

- Update ASRS incident summaries applying various typologies
  - MEDA (Boeing): Emphasis on procedural errors (~44%) and related factors (e.g., the document itself, time constraints, insufficient technical support)
  - HFACS-ME: Focus on context, management, maintainer & workplace conditions

TOOLS: A standard relational database for future analyses supporting

- multiple coding strategies
- direct links from one set of analyses to another
- data transformations required for text analysis of narratives (QUORUM/PERILOG)

STUDIES IN PROGRESS

- Analysis of procedural errors
- Shift handover
- MEL document
- MX log
- Time pressure
- Relationship between error types and preconditions

San Jose State Univ Fndn – Battelle, ASRS
Partner: ATA MHF subcommittee, ASAP operators
Advanced Displays: Virtual Reality

- **GOAL:** Develop technologies that augment traditional OJT and aid tasks through enhanced information support.

- **APPROACH:** Virtual Reality (VR) simulator for A/C visual inspection training and for controlled studies of human performance.

- **PRODUCTS to date**
  - VR simulation of aft cargo bay, fuselage, wing with potential defects.
  - 3D eye movement analysis algorithm for collecting eye movement data.
  - Experimental protocol for conducting studies related to the use of feedback and feedforward for inspection training.

- **CURRENT STATUS**
  - Tested, verified, and validated performance and process (cognitive measures) data collected by the simulator.
  - Developed GUI for presenting feedforward and feedback data on process and performance measures (output measures).
  - Developed scenarios for conducting studies using data collected from industry partners.

- **Partners**
  - DAL, Fed Ex, Lockheed Martin Aircraft Centers, NASA KSC

- **NEXT**
  - Experiment evaluating various inspection training methods
  - Focus on collaborative OJT

Anand Gramopadhye - Clemson University
VR Simulation Tools

A 3D display for providing graphical cognitive feedback information

Summary of performance data

Performance and Process feedback in the VR environment
Advanced Displays: Augmented Reality

GOAL: Measurement of process improvement achieved when real-time collaboration is supported by an image-based technology

APPROACH
- Definition and selection of an implementation testbed (field site plus engineering site)
- Implementation of devices and processes for collaboration
- Measurement of system performance used to gauge the effectiveness of the process improvement to the targeted collaboration.

PRODUCT Benefits
- Efficient guidance for uncommon tasks.
- Complement training / compensate for compressed training schedule.
- Reduce cost of engineering resolutions.
- Provide views for areas of limited access.
- Reduce time away from worksite.
- Provide access to multiple sources of information.
- Synergy with multiple contributions to a solution.
- Markup on imagery may be customized for the technician.

Anthony Majoras, Boeing, Huntington Beach
Potential Partners: USAF C17
Advanced Displays: Augmented Reality: Collaborative Engineering Support Tool

Prospective Environments

Remote Collaboration and Annotated Images: A Problem-Solving System

Test at this post for current leak. If ok, attach sensor processor leads to these 4 small lugs, & and sensor signal line to +s terminal.

Detect features  Mark features
Track features  Clear all features

Instructions via Annotated Video
VCR-like interface for tracking software
(Neumann & Majoros, 1998)
MRM Skills, Training & Evaluation

☐ GOAL: Recommendations for developing, implementing & measuring the effectiveness of MRM programs

☐ APPROACH
  • Historical study of industry MRM programs
    ✓ Jim Taylor, Santa Clara University & Manoj Patankar, St Louis University
  • Case study in applied change
    ✓ John Schmidt, Navy Safety Center and Bob Figlock, Naval Postgraduate School
Training Products

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Pilot Skill Training for Cockpit Automation
Training Modules and Simulators
Instructor Training & Evaluation
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
- Vertical Flow Tunnel
- Aero Effects of Airframe Icing
- Verification

NASA Glenn-Icing Branch
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)


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?

Main University Collaborators:
Furman University
University of New Mexico
California Polytechnic State University

Main Industry Collaborators:
Continental Airlines
Southwest Airlines
Automation Training

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

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

Cockpit Automation Curriculum and Textbook

Teaches fundamentals of cockpit automation use
- Procedures
- Underlying concepts

INSTRUCTIONAL DVD
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?
# Aviation Weather 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)

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**Main University Collaborators:**
- University of Illinois
- University of Alaska - Anchorage

**Main Industry Collaborators:**
- FAA - Capstone Project
- NIOSH
- Alaska Flight Safety Foundation
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.
The Emergency Situation

- ATM
- WX
- Airport Company
- Flight Crew
- Cabin Crew
- Dispatch
- Maintenance
Emergency and Abnormal Situations

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
PHF Products

Human Factors Tools
Many AvSP technologies impact cockpit.
The crew position is the unifying viewpoint for the benefit of AvSP Program as a whole.
Notional description of cockpit equipment and procedures from crew viewpoint that assumes presence of technical products of AvSP
Other developments that will influence character of cockpit and procedures identified.
Baseline flight task description completed
Explicit descriptions and scenario showing future character of cockpit and procedures for AvSP technologies.

https://postdoc.arc.nasa.gov/postdoc/t/folder/main.ehtml?url_id=82510
The website allows the user to:

- View all citations in the bibliography
- Perform simple or advanced searches
- Extract to file or print results
- Submit citations for inclusion
- Contact the curator

http://avsp.larc.nasa.gov/new.html

Features:

- Multiple Search Criteria
- Keyword search
- Variety of formats for results
- Tailorable formats
- Built in online help

POC: Dr. Bettina Beard
Bettina.L.Beard@nasa.gov
There is a proliferation of alerting on the flight deck. Current and new systems have separate alerts and notification philosophy for informing the crew. 
The ANCOA (Alerting and Notification of Conditions Outside the Aircraft) program has begun to look at these issues and has demonstrated the integration under a common framework. ANCOA provides guidance to how information gets filtered, categorized, prioritized, and represented to the crew.
Recommend a clear alerting philosophy and notification scheme for the integration information, particularly terrain and weather.
Generate design specifications
Implement specifications in software
Review integrated system with expert pilots

poc: Dr. Trish Ververs
Honeywell Technologies
Integrated Alerting System prototype indicating overlay of weather, terrain, and traffic on a single display

Research Findings

Data supports the integration of currently disparate systems onto a single display with performance requiring fewer pilot inputs and lower workload scores

POC: Dr. Trish Ververs
trish.ververs@honeywell.com
Tech transfer to industry underway, e.g.:

- Alertness management module for GA posted on Web
- Icing videos, CBT, DVD
- Cockpit automation for general aviation and future airline pilots textbook
- Boeing analysis of automation monitoring skills
- Gold standards to train instructors to evaluate crew performance
- Evaluation of airplane upset training
- Guidelines for the integration of alerts in the cockpit
- MRM tools and guidance
- HFACS-ME data analysis tool for maintenance
- Risk assessment and ROI tools for maintenance
| PHF HF Issues Document & Prioritization |
|------------------|------------------|------------------|------------------|------------------|
| **Human Factors Issues** | **SvS Concerns** | **Predictor or Velocity Vector** | **Photorealistic Terrain** | **Wireframe terrain** | **Egocentric 3-D View** |
| **Workload** | | | | | | |
| Mental demand | Ref: 1.2.1.1 Predictor workload not as high as FMA | Ref: 1.1.5.3 terrain provided spatial awareness - 1.1.7.2 Terrain improved SA, not performance - 1.1.8.4 Terrain slope perception - 1.1.5.4 Landing flare strategies | Ref: 1.1.5.3 terrain provided spatial awareness - 1.1.7.2 Terrain improved SA, not performance - 1.1.8.4 Terrain slope perception - 1.1.5.4 Landing flare strategies | Ref: 1.1.1.1 Low cognitive integration - 1.1.5.4 High mental proximity - 1.1.5.4 Perception & Density |
| Physical demand | N/A | Ref: Long delays & sickness 1.1.2.2 | Ref: Long delays & sickness | Ref: 1.1.1.1 No cost of visual scanning |
| Temporal demand | Ref: 1.2.1.1 Predictor workload not as high as FMA | Not tested | Not tested | |
| Performance | Ref: 1.2.1.1 Predictor not as accurate as FMA - 1.1.5.3 altitude judgement | Ref: 1.1.7.2 Terrain improved SA, not performance - 1.1.5.4 Landing flare - 1.1.5.2 Telepresence and performance - 1.1.5.3 Improved altitude judgements | Ref: 1.1.7.2 Terrain improved SA, not performance - 1.1.5.4 Landing flare - 1.1.5.2 Telepresence and performance - 1.1.5.3 Improved altitude judgements | Ref: 1.2.1.1 path acquisition accuracy - 1.1.1.1 Better orientation than distance judgements |
| **Situation Awareness** | | | | | | |
| current situation awareness systems | Not tested | Not tested | Not tested | Ref: 1.2.3.2 Better trend tracking accuracy |
| current situation geographic | Ref: 1.1.6.3 Guidance symbology - 1.2.3.3 SA improved | Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare | Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare | Ref: 1.1.5.1 Depth ambiguity, better orientation judgements - 1.1.5.5 Reduced global SA - 1.2.3.3 Improved SA, representative of terrain outside |
| current situation environmental | Ref: 1.1.6.3 Guidance symbology - 1.2.3.3 SA improved | Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare | Ref: 1.2.3.3, 1.2.3.5 Improved SA - 1.1.5.4 Landing flare | Ref: 1.2.3.2 Task complexity. More powerful on ability to focus outside of cockpit than display’s novelty - 1.2.3.3 Orientation position SA improved |
| current situation spatial temporal | Ref: 1.2.3.6 Rejoining pathway - 1.1.6.3 Guidance symbology | Ref: 1.2.3.6 Projection improved - 1.1.6.3 Rejoining pathway - 1.1.5.4 Landing flare | Ref: 1.2.3.6 Projection improved - 1.1.6.3 Rejoining pathway - 1.1.5.4 Landing flare | Ref: 1.2.3.3, 1.2.3.6 Improved SA - 1.1.5.5 Reduced global SA - 1.2.3.3 Good spatial awareness. Awareness of secondary info on display questionable. Most wanted 2-D Nav + 3-D tunnel display |
| Projection prediction | Ref: 1.2.3.6 Rejoining pathway - 1.1.6.3 Guidance symbology | Ref: 1.2.3.6 Projection improved - 1.1.6.3 Rejoining pathway - 1.1.5.4 Landing flare | Ref: 1.2.3.6 Projection improved - 1.1.6.3 Rejoining pathway - 1.1.5.4 Landing flare | Ref: 1.2.3.3, 1.2.3.6 Rejoining pathway |
| **Appropriate Feedback** | | | | | | |
| Operating Feedback | Ref: 1.1.6.3 direction indication & preview - 1.2.6.2 current nav error | Ref: 1.1.5.1 Terrain improves global SA - 1.1.5.4 Landing flare strategies | Ref: 1.1.5.1 Terrain improves global SA - 1.1.5.4 Landing flare strategies | Ref: 1.1.5.1 Keyhole effect, visual impairment w/ OTW - 1.1.5.1 Reduced global SA |
| Mode Feedback for Operating | Visual | Visual | Visual | Visual |
| Field Wide Feedback | Nothing currently exists | Nothing currently exists | Nothing currently exists | Nothing currently exists |
| Alerts | Nothing currently exists | Nothing currently exists for a single SVS display | Nothing currently exists | Nothing currently exists |
PHF HF Issues Document & Prioritization

Aviation Safety Program

Human Factors Issues

WxAP Concerns

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<th>GWS</th>
<th>AWE</th>
<th>ANCOA</th>
<th>Other Studies</th>
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<td>Aviation/Wx Analysis and Reporting Enhancements</td>
<td>Graphical Wx Information System</td>
<td>Aviation/Wx data visualization Environment</td>
<td>Averting and Notification of Conditions Outside the Aircraft</td>
<td>Ruskangas - NASA, Rockwell Collins</td>
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</table>

Workload

- Mental Demand
  - 6.5.3: Wx monitoring should be automated, provide indication according to their importance.
  - 6.4.2: Integration display increased time to react than with a separate display.
- Physical Demand
  - 6.4.2: Excessive menu navigation frustrate pilots.
- Temporal Demand
  - 6.5.1: Not all pilots know the value of getting wx trend information.
  - 6.5.2: Less reliance on automation, with status displays than command displays.
- Performance
  - 6.5.1: Reduced reliance on ground-based wx sources.
  - 6.3.1: Performance increased with a single alert without having to mentally integrate.
- Situation Awareness
  - 6.5.1: Increased reliance on position of aircraft.
  - 6.5.1: Trend information and location of wx increased SA.
- Attention
  - 6.5.1: Subject didn’t understand location of wx relative to position of aircraft.
- Appropriate Feedback
  - 6.5.1: Provided wx trends to improve SA

Appropriate Feedback

- Operating Feedback
  - Provides alternative route selection.
- Displayed Feedback for Operating
  - Visual
  - Ouet