Aviation Safety Program
System-Wide Accident Prevention

Dr. Tina Beard

National Research Council

Washington D.C.
February 27, 2003
Outline

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- 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
SWAP uses current knowledge about human cognition to develop mitigation strategies to address current trends in accident and incident profiles.

- 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
Active SWAP Participants

- Aviation Product Designers
- Aviation Product Manufacturers
- Air Carrier Training Departments
- Maintenance Safety and Training Departments
- Incident & Accident Reports
- Flight Training Schools
- Pilots
- Maintenance Labor Organizations
- Aviation Repair Stations
- AvSP Projects

Identify user requirements up-front
- helps with user acceptance
- establishes a clear transition path to industry implementation
Approach

Field Tests (Flight tests)

Part-task & Full Mission Simulations

Computational Modeling

Accident & Incident Analysis

• Consult with subject matter experts
• Scientists are rated pilots

Lab Studies

Field Observation Data

Aviation Safety Program

Computational Modeling

Context Specifiers

Action Manager

Operator Actions

Predictions

Interpretations

[ to operator's associate interface ]

Lab Studies

Field Observation Data

Computational Modeling
### AvSP/SWAP Program & Project Milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestones</th>
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<tbody>
<tr>
<td>2000</td>
<td>Preliminary Integrated Program Assessment</td>
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<td>2001</td>
<td>Interim Integrated Program Assessment, Safety-Improvement Concepts Defined</td>
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<td>Simulation, Flight Test Evaluations of Safety Improvement Systems within AvSP Complete</td>
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<td>2003</td>
<td>Aug Reality Displays Eval., Model High Error Probability Contexts and Solutions</td>
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<td>2004</td>
<td>Integrated Full-Mission Apps. Simulations &amp; Validation</td>
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### 2.2 System-Wide Accident Prevention

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<tr>
<th>Milestone</th>
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<tr>
<td>1</td>
<td>CD-ROM Icing Training Module</td>
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<td>Proficiency Standards</td>
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<td>3</td>
<td>Model High Error Probability Contexts and Solutions</td>
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### 2.2.1 Human Performance Modeling

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### 2.2.2 Maintenance Human Factors

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<td>3</td>
<td>Task/Risk Analysis Software</td>
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### 2.2.3 Training

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<td>Pilot Wx Decision Guidelines</td>
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<td>Low Blood Sugar Performance</td>
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<td>4</td>
<td>Guidelines for Trng Icing Encounter Flt Trng</td>
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### 2.2.4 Program Human Factors

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<tr>
<td>1</td>
<td>Aviation Display Intuitiveness</td>
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<tr>
<td>2</td>
<td>Bibliography of Human Performance Research</td>
</tr>
<tr>
<td>3</td>
<td>Alerting System Integration</td>
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### Level Milestone Colors
- Blue – Roll-up to Level I #2
- Red – Roll-up to Level I #4
- Green – Roll-up to Level I #5
- Brown – Roll-up to Level I #7
- Orange – Contingency Milestone

- Level I Milestone
- Level II Milestone
- Level III Milestone
- Level II Milestone Roll-up
SWAP Project

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

- Human Performance Modeling
  David Foyle (ARC)
- Maintenance Human Factors
  Barbara Kanki (ARC)
- Training
  Immanuel Barshi (ARC)
- Program Human Factors
  Bettina L. Beard (ARC)
HPM Products

Human Performance Models
Crew Activity Tracking
MHF Products

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

Human Performance Modeling
David Foyle (ARC)

Maintenance Human Factors
Barbara Kanki (ARC)

Training
Immanuel Barshi (ARC)

Program Human Factors
Bettina L. Beard (ARC)

Maintenance Risk & Task Analysis Tools
Maintenance Resource Management (MRM)
Augmented/Virtual Reality Displays
Training Products

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

Human Performance Modeling
David Foyle (ARC)

Maintenance Human Factors
Barbara Kanki (ARC)

Training
Immanuel Barshi (ARC)

Program Human Factors
Bettina L. Beard (ARC)

Pilot Skill Training for Cockpit Automation
Training Modules and Simulators
Instructor Training & Evaluation
Watch Item - Human Factors Engineering

- Human factors engineering not fully integrated within some technology product plans
  - synthetic vision systems
  - weather accident prevention

Recommendation:
- formal human factors engineering should be accomplished for appropriate products from the very beginning of product design

Proposed AvSP Perform a Behavioral Risk Assessment, July 17, 2000

1. properly address human factors issues
2. limited budget - need assessment as to the importance of particular human factors issues as guidance to the system designer
3. include the human in 7120.5A program requirements
4. respond to IAR watch item
PHF Products

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

Human Performance Modeling
David Foyle (ARC)

Maintenance Human Factors
Barbara Kanki (ARC)

Training
Immanuel Barshi (ARC)

Program Human Factors
Bettina L. Beard (ARC)

Human Factors Tools
Aviation Safety Program

System-Wide Accident Prevention

Dr. Tina Beard

Program Human Factors Element
Outline

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The PHF Goal

Assess cross-cutting human factors issues and provide expertise and recommendations toward the individual Project’s human factors initiative.

Potential advantages:

- ID human factors issues that are stimulated by the new system
- provide Program with human factors priorities
- provide information about vulnerable aspects of product requiring further refinement
- address key integration issues of Program products into cockpit
PHF Crew Centered Con Ops

- 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

poc: Dr. Robert Hennessy
Monterey Technologies Inc.
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

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
Metrics for Display Intuitiveness Assessment (MeDIA)
To quickly assess whether a new display is intuitive

*Primary measures:*
- Presenting the information saliently
- Supporting completeness of information for task performance
- Presenting the stimuli so that it may be rapidly (re-)learned
- Minimizing the information translation required
- Supporting a high amount of information transfer
- Supporting the rapid comprehension of state transitions
- Presenting future state information

MeDIA development involves collection of part-task sim data

poc: Dr. Robert Hennessy
Monterey Technologies Inc.
PHF HF Issues Documents & Prioritization

Aviation Safety Program

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https://postdoc.arc.nasa.gov/cgi-bin/postdoc/get/download/Issues%20Checklist.xls?url_id=82514&ext=xls
## PHF HF Issues Document & Prioritization

### Human Factors Issues

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<th>Predictor or Velocity Vector</th>
<th>Photorealistic Terrain</th>
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<td>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</td>
<td>Ref: 1.1.1.1 Low cognitive integration - 1.1.8.5 High mental proximity - 1.1.5.4 FAF strategy</td>
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<td>Physical demand</td>
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<td>Ref: Long delays &amp; sickness 1.1.2.2</td>
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<td>Ref: 1.1.1.1 Low cognitive integration cost, but keyhole effect - 1.2.3.2 Few visual cues for distance to tunnel - 1.1.5.4 FAF strategy</td>
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<td>Ref: 1.1.5.2 Task complexity more powerful on ability to focus outside of cockpit than display’s novelty - 1.2.3.3 Relative position SA improved</td>
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<td>Ref: 1.2.3.6 Projection improved - 1.1.6.3 Rejoining SA, but not performance</td>
<td>Ref: 1.1.5.2, 1.2.3.3 Good spatial awareness, Awareness of secondary info on display questionable. Most wanted 2-D Nav + 3-D tunnel display</td>
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<td>Ref: 1.1.5.1 Terrain improves global SA - 1.1.5.4 Landing flare strategies</td>
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## Human Factors Issues

### Workload

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<th>ANCOA</th>
<th>Other Studies</th>
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- **Mental Demand**: 6.3.1 Need monitoring should be automated, provide indication according to their importance.
- **Physical Demand**: 6.6.2 Excessive menu navigation frustrate pilots.
- **Temporal Demand**: 6.4.2. Integration display increased time to react than with a separate display.

### Performance

- **Performance increased compared to DUATs**: 6.5.1 Reduced reliance on ground-based wx sources.
- **Performance increased with single alert without having to manually integrate**: 6.5.3.
- **Not all pilots know the value of getting wx trend information**: 6.5.1.
- **Less reliance on automation, with status showing the command display**: 6.5.1.

### Situation Awareness

- **Current situation ownership systems**: 6.5.1. Needed display to understand location or relative position of aircraft.
- **Current situation geographic**: 6.4.4. Map visualization should be track up configuration otherwise, mental rotation.
- **Current situation of weather**: 6.5.1. Trend information and location of wx increased SA.
- **Current situation in spatial/temporal**: 6.5.1. Provides visual trends to improve SA.
- **Projection/Forecasting**: 6.5.1. Automatically displays forecast for all airports/timeframe only. Selected airport based on arrival time.
- **Appropriate Feedback**: 6.5.1. Lack of SA due to lack of experience and general wx conditions.
- **Appropriate Feedback**
  - **Visual**: Provides alternative route selection.

### WxAP Concerns

- **Workload**: 6.6.2. Excessive menu navigation frustrates pilots.
- **Performance**: 6.4.2. Integration display increased time to react than with a separate display.
- **Situation Awareness**: 6.5.1. Trend information and location of wx increased SA.
- **Appropriate Feedback**: 6.5.1. Lack of SA due to lack of experience and general wx conditions.
Alert & Warning Integration

- 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

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

Research Findings

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