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# How to Train for Automation – Results from Research and Tips for Application in the Field

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# What we would like to achieve today

- Report on our compilation of automation research findings that have informed automation training guidelines
- Receive feedback from you, our audience, about existing practices and have you share other “Best Practices”
- Solicit input to finalize an Automation Training Practitioners’ Guide, composed of “Best Practices” derived from research, observation, and experience



# Background

This collaborative program of research conducted by George Mason University, Research Integrations, Inc., and the University of Central Florida, has focused on the acquisition, training, and transfer of cognitive processes required for operating automated systems.

Specifically, ... the development of enhanced training methods and tools that can be implemented in air carrier training environments have been studied.



# “Automation Training” is Still “Training”

- Example: ACRM Framework
  - Proceduralized key aspects of CRM into relevant procedures (specifically, standard operating procedures, or SOP) with focus on Communication, Workload Management, and Preparation.
  - Designed, implemented, and evaluated ACRM.
  - Found that ACRM positively affected performance in every setting.
- Best Practices:
  - Incorporate observable conditions into procedures
  - Use crew-based training that addresses the conditions whenever possible
  - Hold pilots accountable for making conditions explicit and adhering to them; in training, in evaluation, and on the line

# “Automation” is not “Automation” is not “Automation”

- Research showed contradictory “automation effects”:
  - “Automation increases crew communications”
  - “Automation decreases crew communications”
  - “Automation does nothing to crew communications”
- Solution:
  - Different findings can be explained by differences in WHAT was automated, HOW it was automated, and FOR WHOM it was automated
- Best Practices:
  - Adopt a basic framework to classify and categorize automation functions and tasks (e.g., information, control, management)
  - Do not assume that automation knowledge transfers automatically



# There are Common and Predictable “Automation Issues”

- Review of multiple sources of information
- Flight Deck Automation Issues
  - Identified 93 issues related to flight deck automation
  - Developed a database and website to present data and research related to the issues.
  - Can search database for evidence from:
    - Accidents
    - Incident studies
    - Experiments
    - Observational studies
    - Survey studies
  - Can search for all evidence on any one issue



Back



Forward



Stop



Refresh



Home



Search

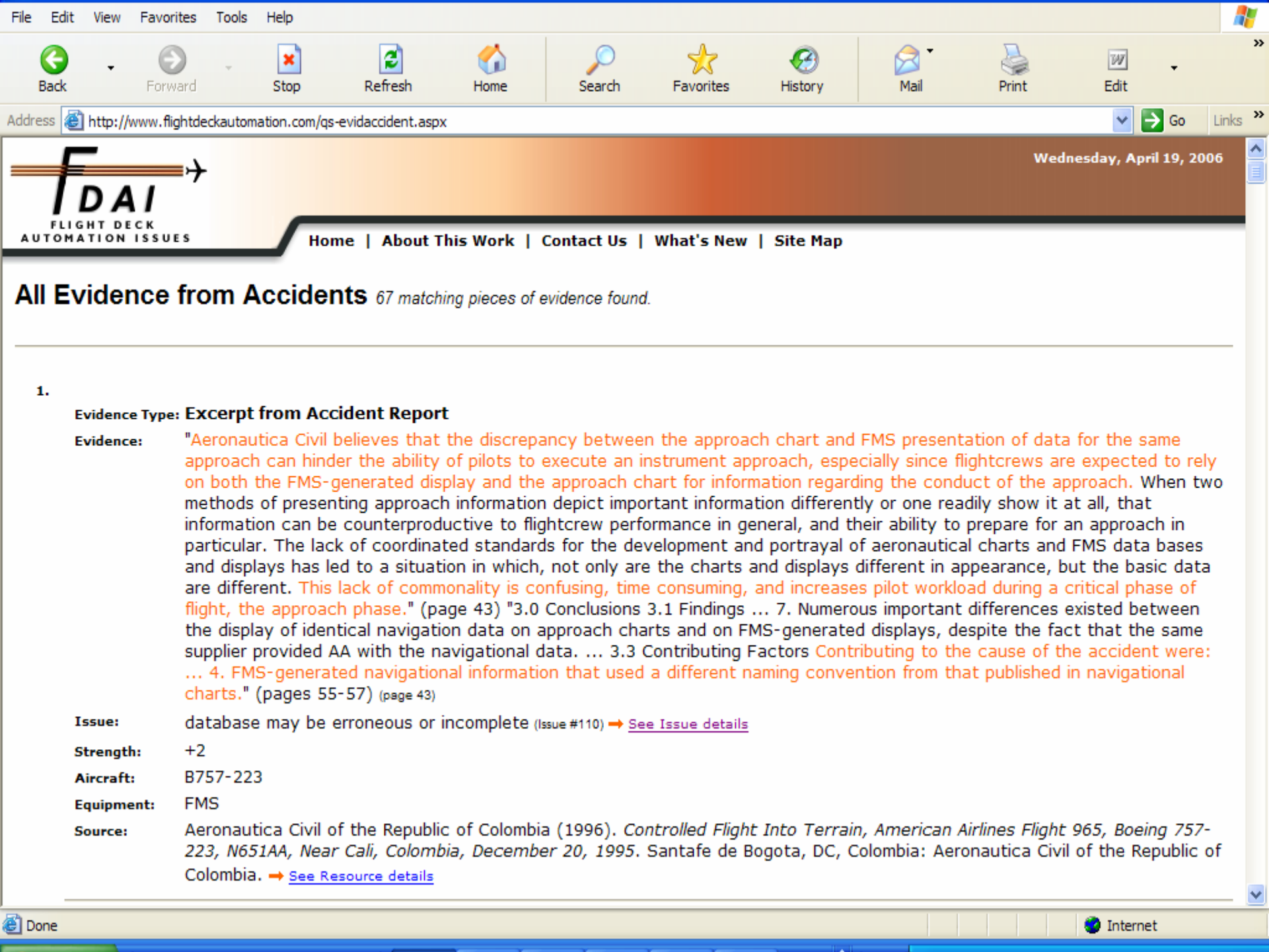


Favorites



History





Address http://www.flightdeckautomation.com/qs-evidaccident.aspx Go Links

## All Evidence from Accidents 67 matching pieces of evidence found.

1.

**Evidence Type:** **Excerpt from Accident Report**

**Evidence:** "Aeronautica Civil believes that the discrepancy between the approach chart and FMS presentation of data for the same approach can hinder the ability of pilots to execute an instrument approach, especially since flightcrews are expected to rely on both the FMS-generated display and the approach chart for information regarding the conduct of the approach. When two methods of presenting approach information depict important information differently or one readily show it at all, that information can be counterproductive to flightcrew performance in general, and their ability to prepare for an approach in particular. The lack of coordinated standards for the development and portrayal of aeronautical charts and FMS data bases and displays has led to a situation in which, not only are the charts and displays different in appearance, but the basic data are different. **This lack of commonality is confusing, time consuming, and increases pilot workload during a critical phase of flight, the approach phase.**" (page 43) "3.0 Conclusions 3.1 Findings ... 7. Numerous important differences existed between the display of identical navigation data on approach charts and on FMS-generated displays, despite the fact that the same supplier provided AA with the navigational data. ... 3.3 Contributing Factors **Contributing to the cause of the accident were: ... 4. FMS-generated navigational information that used a different naming convention from that published in navigational charts.**" (pages 55-57) (page 43)

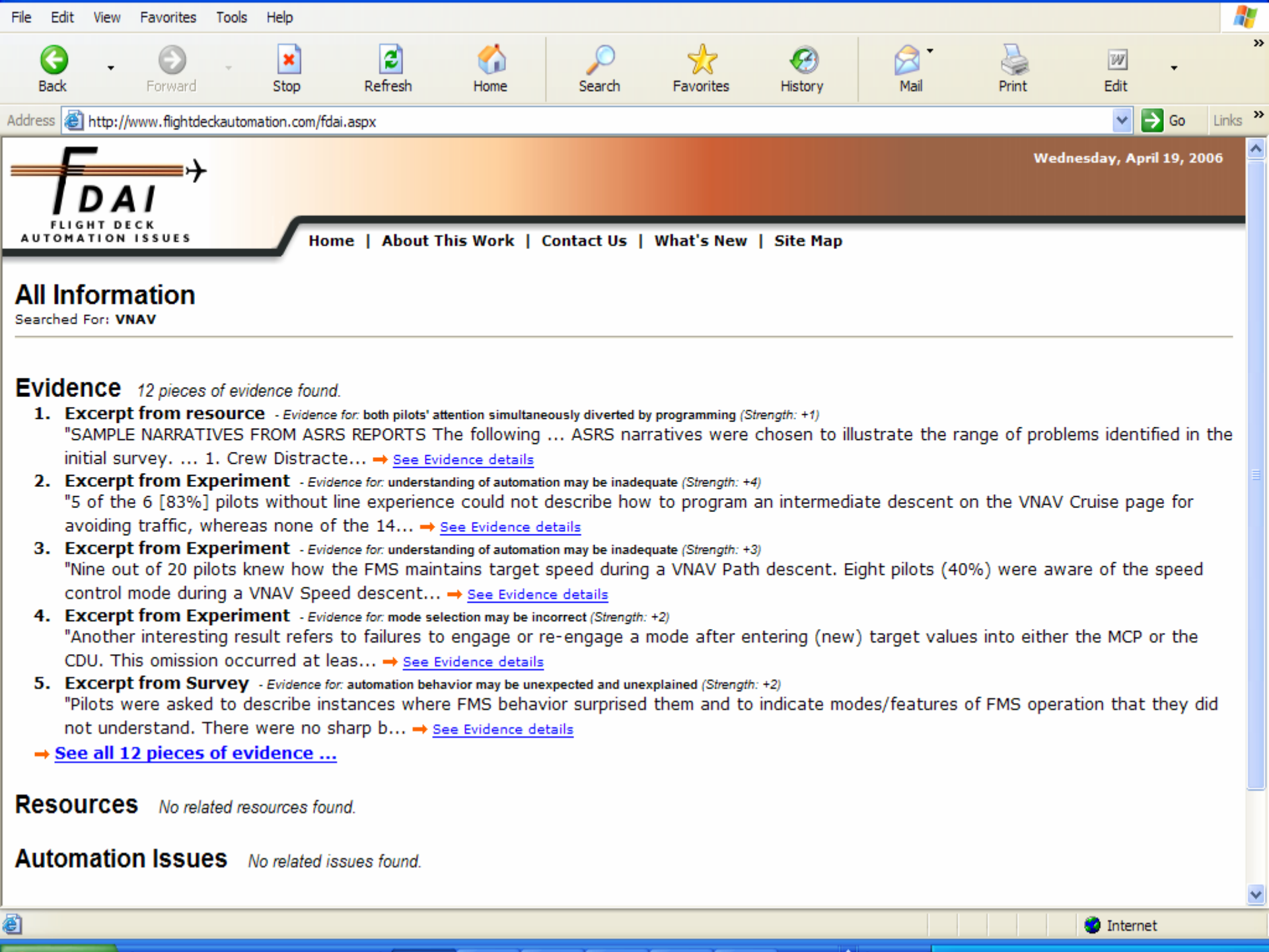
**Issue:** database may be erroneous or incomplete (Issue #110) → [See Issue details](#)

**Strength:** +2

**Aircraft:** B757-223

**Equipment:** FMS

**Source:** Aeronautica Civil of the Republic of Colombia (1996). *Controlled Flight Into Terrain, American Airlines Flight 965, Boeing 757-223, N651AA, Near Cali, Colombia, December 20, 1995.* Santafe de Bogota, DC, Colombia: Aeronautica Civil of the Republic of Colombia. → [See Resource details](#)



### All Information

Searched For: **VNAV**

### Evidence *12 pieces of evidence found.*

- Excerpt from resource** - Evidence for: both pilots' attention simultaneously diverted by programming (Strength: +1)  
"SAMPLE NARRATIVES FROM ASRS REPORTS The following ... ASRS narratives were chosen to illustrate the range of problems identified in the initial survey. ... 1. Crew Distracte... → [See Evidence details](#)
  - Excerpt from Experiment** - Evidence for: understanding of automation may be inadequate (Strength: +4)  
"5 of the 6 [83%] pilots without line experience could not describe how to program an intermediate descent on the VNAV Cruise page for avoiding traffic, whereas none of the 14... → [See Evidence details](#)
  - Excerpt from Experiment** - Evidence for: understanding of automation may be inadequate (Strength: +3)  
"Nine out of 20 pilots knew how the FMS maintains target speed during a VNAV Path descent. Eight pilots (40%) were aware of the speed control mode during a VNAV Speed descent... → [See Evidence details](#)
  - Excerpt from Experiment** - Evidence for: mode selection may be incorrect (Strength: +2)  
"Another interesting result refers to failures to engage or re-engage a mode after entering (new) target values into either the MCP or the CDU. This omission occurred at leas... → [See Evidence details](#)
  - Excerpt from Survey** - Evidence for: automation behavior may be unexpected and unexplained (Strength: +2)  
"Pilots were asked to describe instances where FMS behavior surprised them and to indicate modes/features of FMS operation that they did not understand. There were no sharp b... → [See Evidence details](#)
- [See all 12 pieces of evidence ...](#)

**Resources** *No related resources found.*

**Automation Issues** *No related issues found.*

# NOT all “Automation Issues” are unique to Automation

- Example: VNAV and pilots’ knowledge of vertical flight path control
  - Assessed pilots knowledge of flight physics and vertical flight path control.
  - Used qualitative and quantitative analyses.
  - Found:
    - Mismatch between concepts and actual structure of VFP.
    - Different attribution between manual and automated control.
    - Mismatch between heuristics and explicit control laws.
- Best Practices:
  - Focus not just on the automated function (e.g., VNAV), but also on the fundamental issue (e.g., vertical flight path control)
  - Make the origin of heuristics and VNAV modes explicit
  - Have pilots explain the flight physics of a particular maneuver and how it is realized in the automation



# A Simulator is a Piece of Hardware, not a Training Program

- Training devices often include full functionality of automated systems and allow pilots to use them in all the ways that they may or may not be able to use them in the aircraft.
- Best Practices:
  - Use event-based/scenario-based/line-oriented approach for as many practice opportunities as possible
  - Try to avoid unstructured “free play,” especially in the early stages of training.

# Airlines Are Finding Training Solutions Every Day

- Summary of Airline Training Experiences
  - Interviewed automated airplane training and checking teams at all major airlines and two aircraft manufacturers
  - Objectives were to understand:
    - Which training practices are effective
    - Which have been shown not to be effective





# Example Airline Best Practices

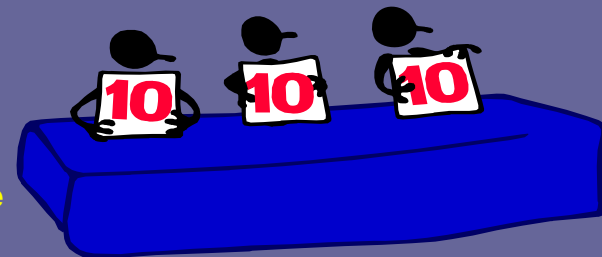
- Information for flying the basic aircraft should be effectively included in the training program.
- Pilots should be provided hands-on experience with the automation as early in the program as possible.
- Automated systems should be taught and integrated throughout the training program.
- Crew-based training should be used whenever possible.

# Evaluation is Not Limited to Written Tests and Simulator Scenarios

- Example: Knowledge and Attitudes Towards Automation
  - Evaluate pilots' FMS knowledge to determine the best crew combination for training based on hours with fleet and flown.
  - Found that the best combination of FMS knowledge would be to pair a medium experience First Officer with very experienced Captain.
- Example: Assessment of Complex Understanding
  - Developed practical structural knowledge assessment tools, tested their validity and assessed the methods' relationship between other performance measures.
  - Found that the tools are practical and related to other traditional classroom assessment methods, and can identify misconceptions.
- Best Practices:
  - Use a multi-faceted approach to evaluating “automation” knowledge and skills

# Evaluation of Automation Training Requires Good Evaluators

- Inter Rater Reliability (IRR)
  - Evaluations based on observation often lack inter-rater reliability.
  - Developed a set of metrics, an appropriate visualization for each metric, and a training program.
  - Found that IRR metrics improved instructor reliability.
- Best Practices:
  - Inform instructors/evaluators of automation philosophies, practices, and procedures
  - Bring line-experiences back to instructors/evaluators at regular intervals
  - Hold regular instructor meetings to evaluate and improve reliability of assessments



# Summary: Lessons Learned

- General Training Techniques
  - Carefully analyze task structure that is taught.
  - Instructor should always be available for feedback.
  - Present material in a consistent and standardized way.
  - Assess trainee's needs throughout training.



# Summary: Lessons Learned

- Automation Training Techniques
  - Evaluate basic understanding of automation at the beginning of training.
  - Do not automatically reduce training sessions just because pilots have flown another automated aircraft before.
  - Distribute automation training across entire footprint.
  - Use crew-based training for automation where possible
  - Use scenario-based training, from classroom through part-task trainers, to simulators.
  - Develop structured, hands-on interactions with automation.

# Summary: Lessons Learned

- Automation Training Techniques (Cont'd)
  - Provide training and practice that includes monitoring of the automation.
  - Emphasize “normal” events that may become emergencies when timely responses are lacking.
  - Ask pilots to not only “do,” but to explain “why”.
  - Translate automation tasks into procedures wherever possible.
  - Use available tools and methods beyond written tests and simulator observations to evaluate trainee progress and inform training refinement
  - Standardize evaluation process and increase inter-rater reliability among evaluators



Please share your lessons learned and best practices for automation training

# What's Next?

- Incorporate today's findings and your input
- Finish summary report on best practices
- Will be made available:
  - Through an accessible website
  - Through publications in aviation journals (e.g., Flight Safety Digest) and magazines (e.g., pilot)
  - Through presentation and publication in scientific outlets
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