The Design Of A Use(r)-Centered Pilot-IMS Interface

An Overview of the Activities and Products of the Cognitive Engineering Group

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Graduate Student: John M. McGuirl

SMART ICING SYSTEMS
Research Organization

Core Technologies

- Aerodynamics and Propulsion
- Flight Mechanics
- Controls and Sensor Integration
- Human Factors/ Cognitive Engineering
- Aircraft Icing Technology

IMS Functions

- Characterize Icing Effects
- Operate and Monitor IPS
- Inform and Advise Pilots
- Envelope Protection
- Adaptive Control

Flight Simulation Demonstration

Safety and Economics Trade Study

Cognitive Engineering

Goal: Improve the safety of flight in icing conditions.
Develop smart system to improve ice tolerance.

Objectives: Design human-centered interface that

a) informs pilots about presence/changes and performance effects of icing conditions

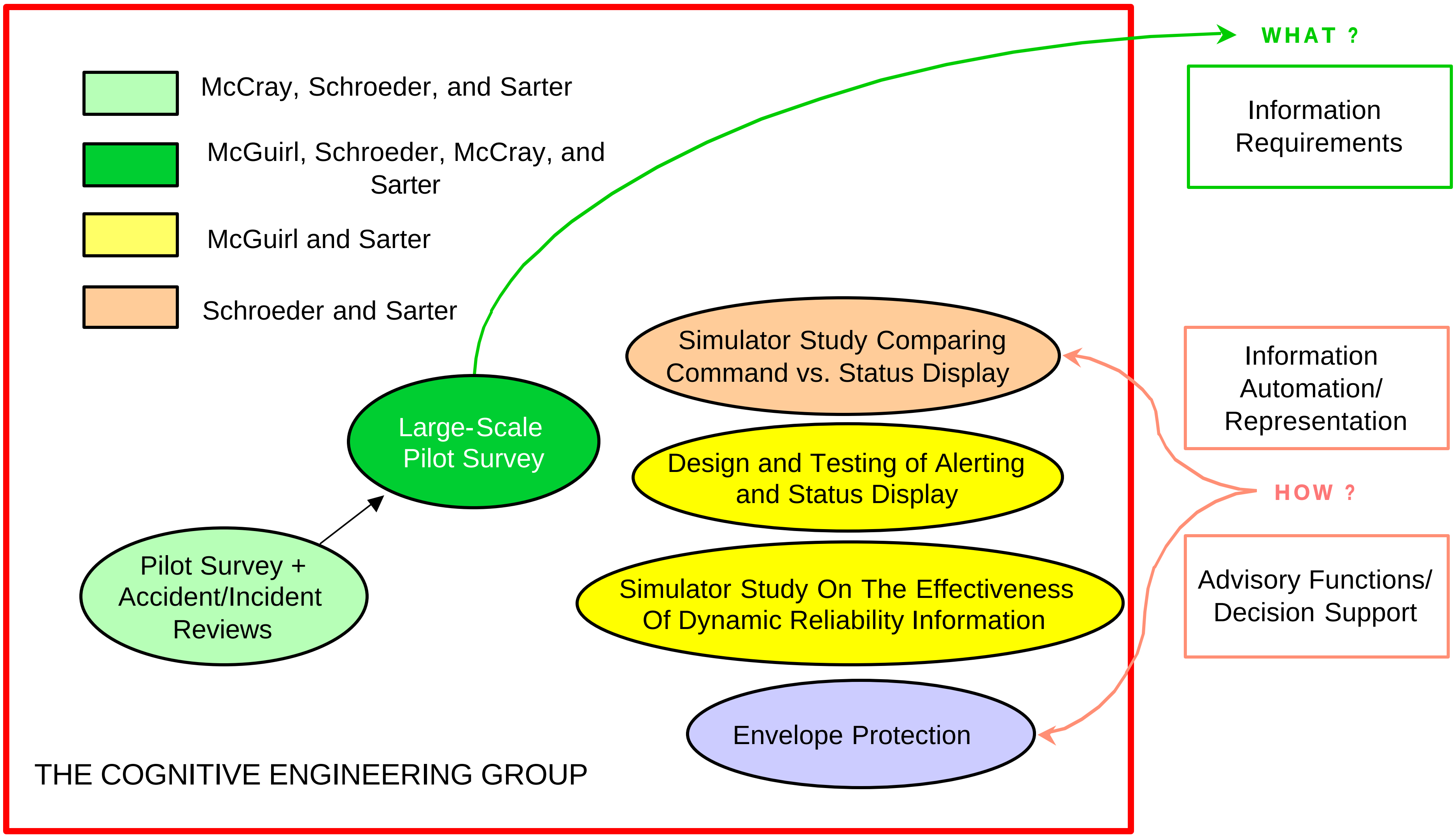
b) communicates IMS/IPS status/activities/limitations to crew in timely and effective manner

c) provides pilots with advisories for handling inflight icing encounters safely

Approach: Identify pilots' information requirements
Develop candidates for human-centered cockpit interface
Evaluate effectiveness and robustness of candidates in simulator studies

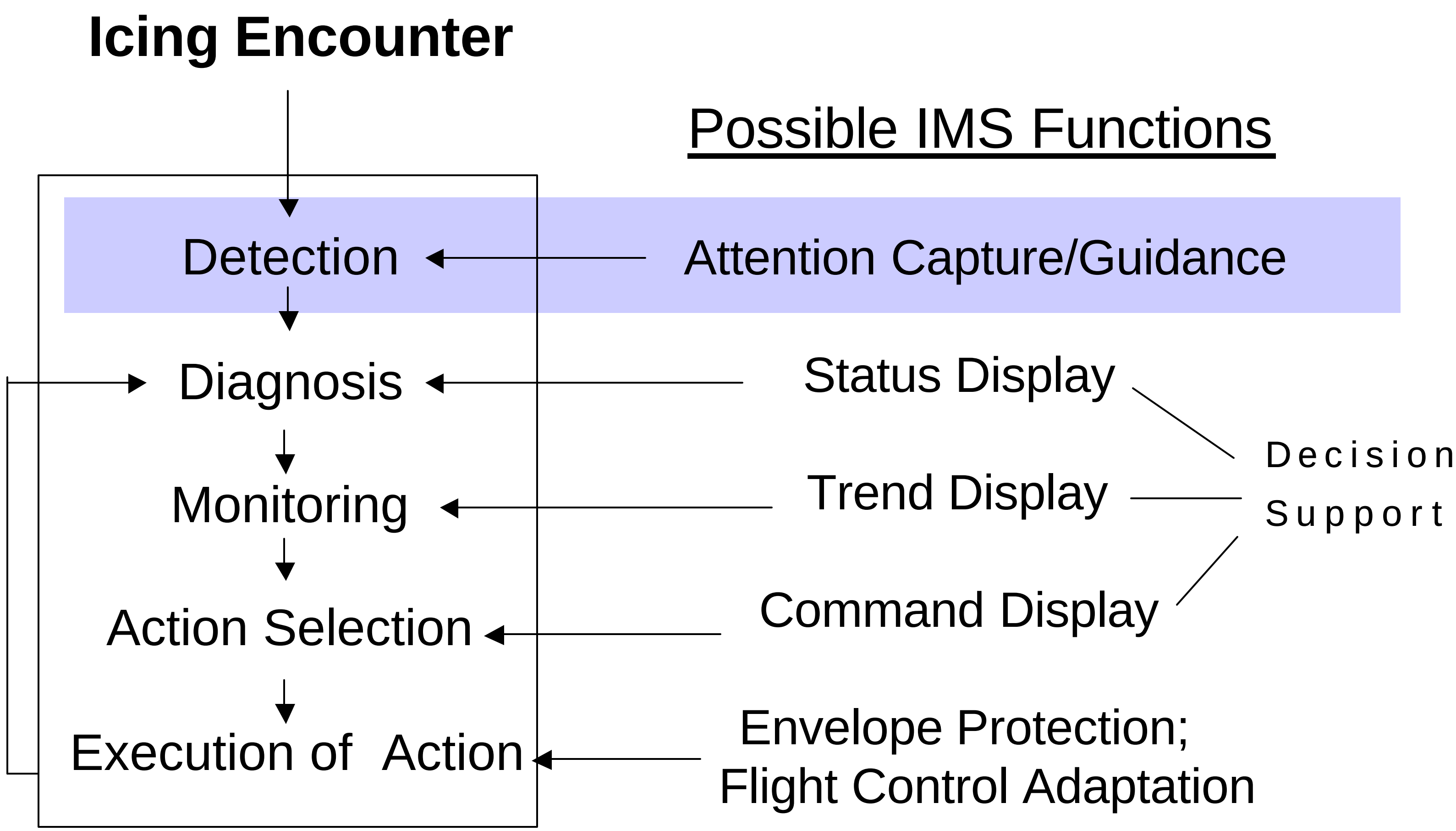
Smart Icing System Research

Smart Icing System Review, September 30 – October 1, 2002

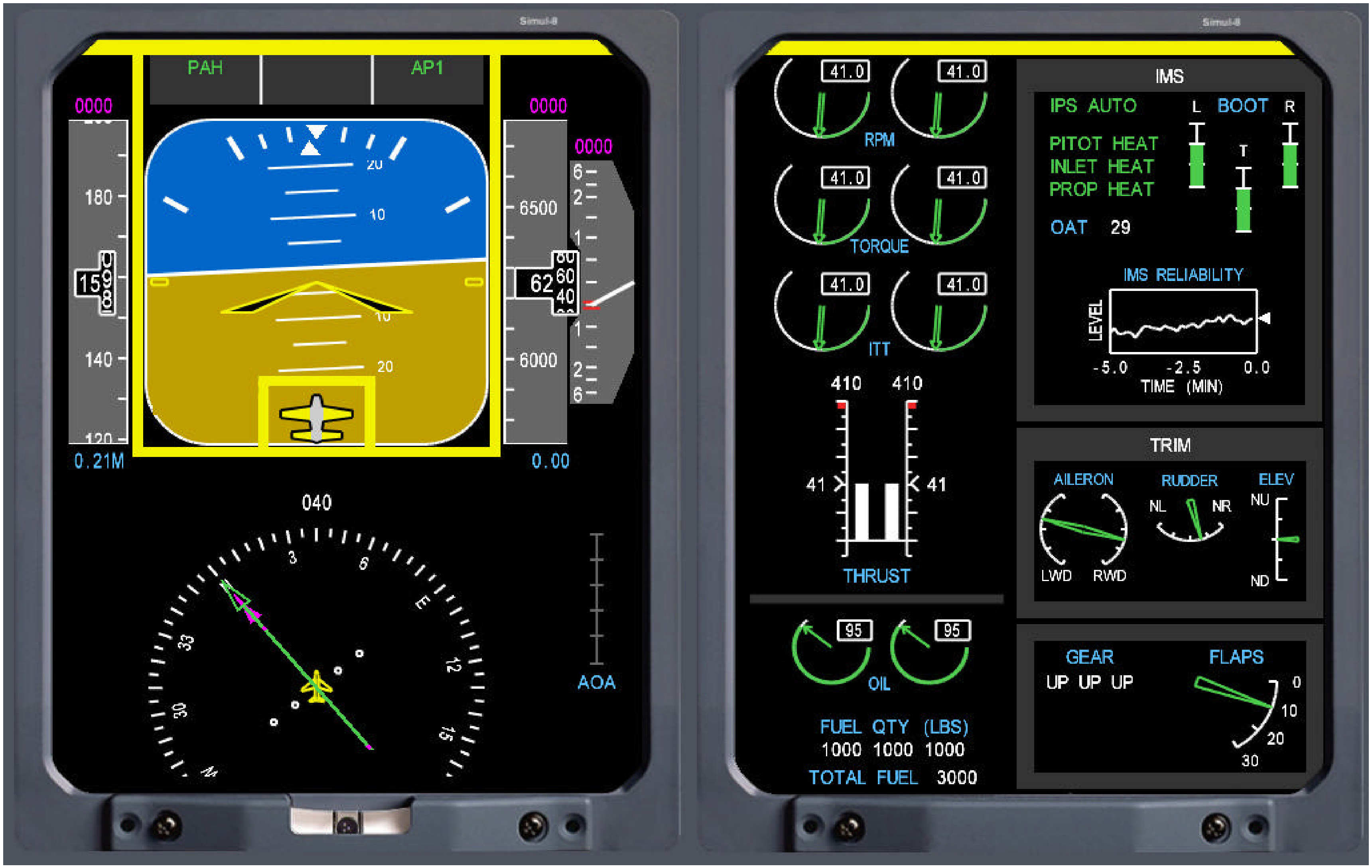


Cognitive Engineering

Smart Icing System Review, September 30 – October 1, 2002



Attention Capture and Guidance



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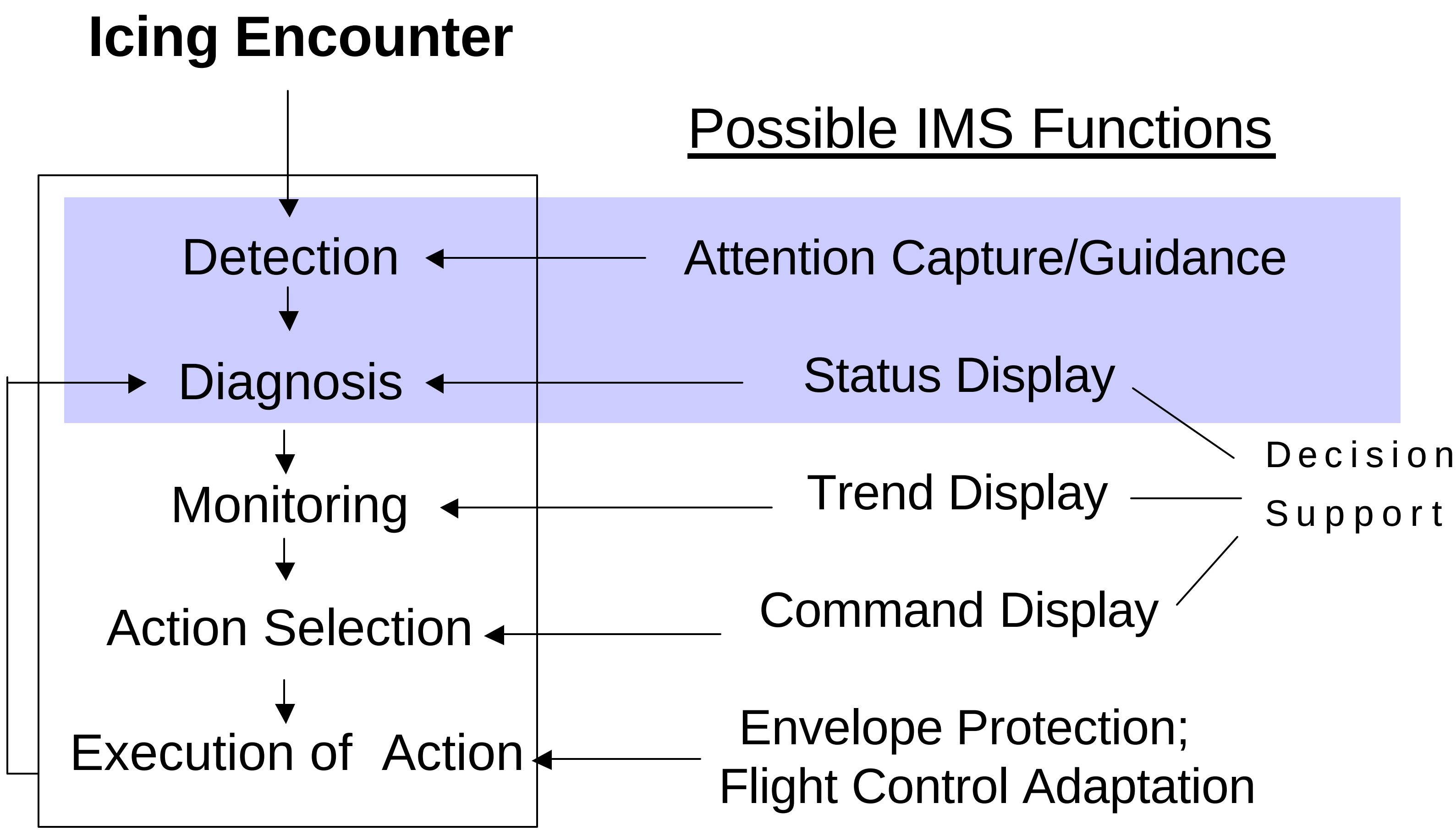


Multimodal Information Presentation

Comparison of Effectiveness of Visual and Tactile Cues For Presenting Icing-Related Information

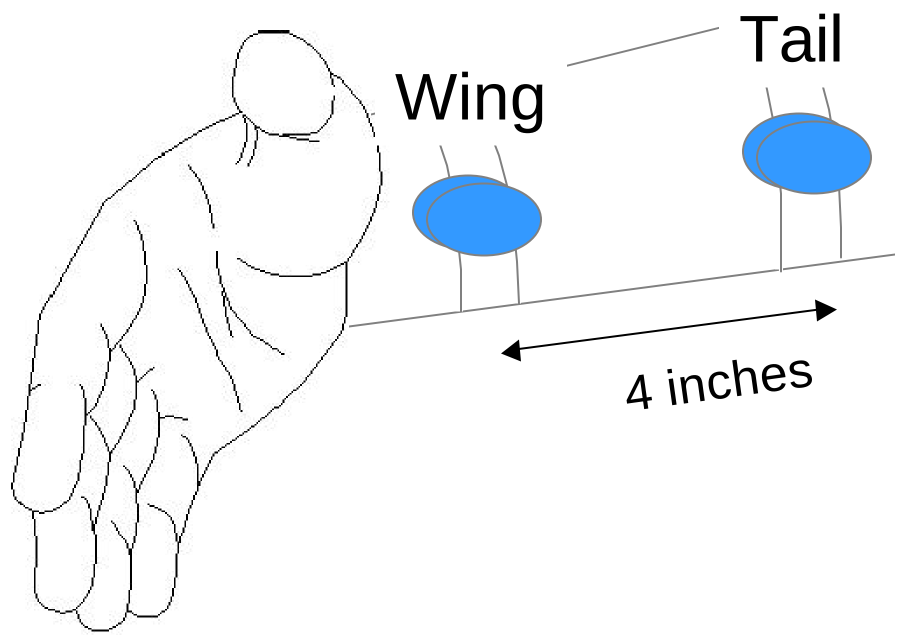
- Modern flight decks impose considerable demands on visual and auditory channels

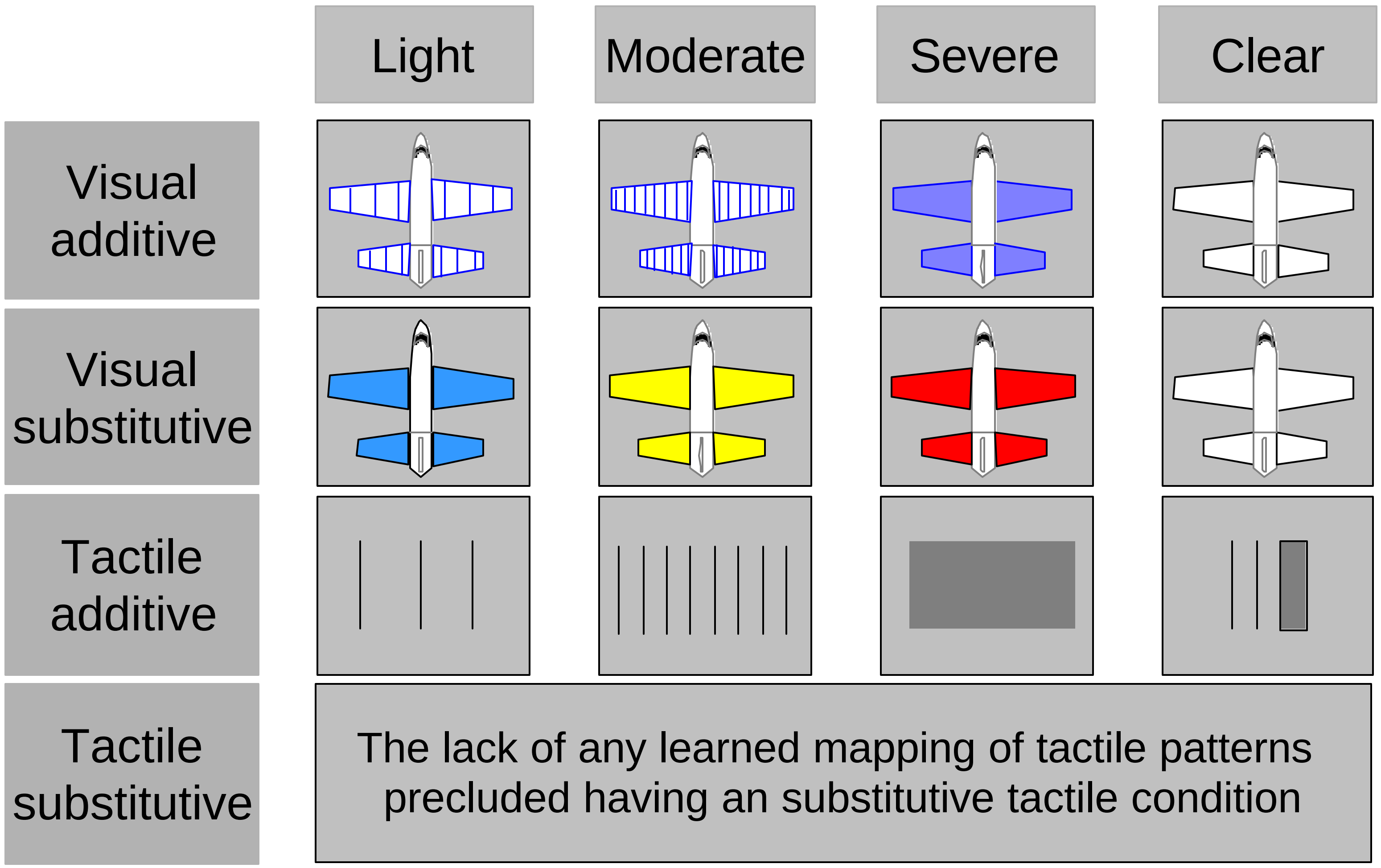
- Tactile channel is underutilized although powerful means of capturing attention and useful for providing some diagnostic information

- As more systems/data are added, multimodal information presentation becomes more important to avoid resource competition (Multiple Resource Theory)

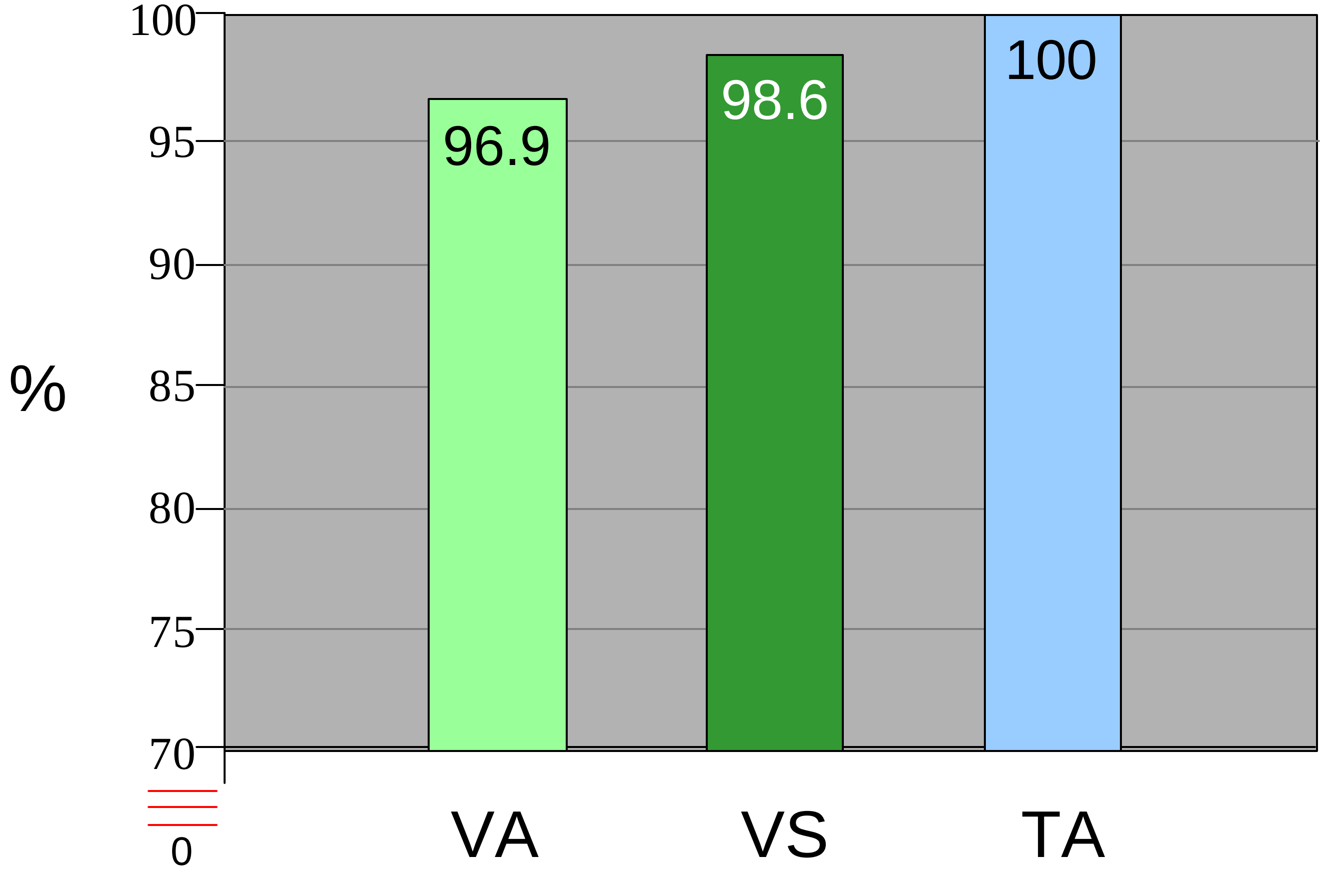
Tactile Condition

- Vibrotactors placed on inside of the forearm.
- Cues were presented sequentially
  (wing →tail)
  cycled for 5 seconds.



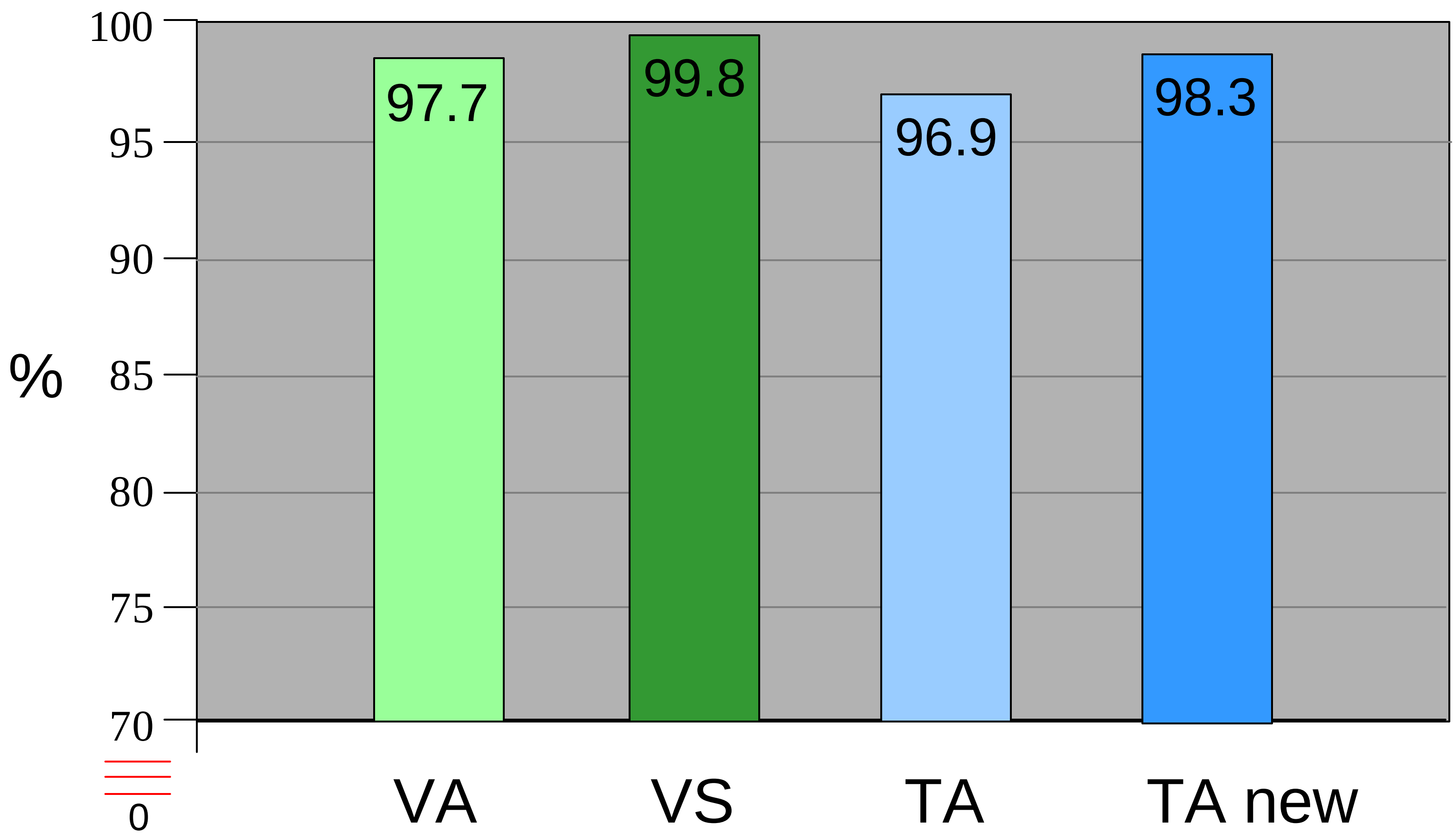

Light
Moderate
Severe
Clear
Visual additive
Visual substitutive
Tactile additive
Tactile substitutive
The lack of any learned mapping of tactile patterns precluded having an substitutive tactile condition

Detection of Icing Cues



Tactile group performed as well as the two visual groups

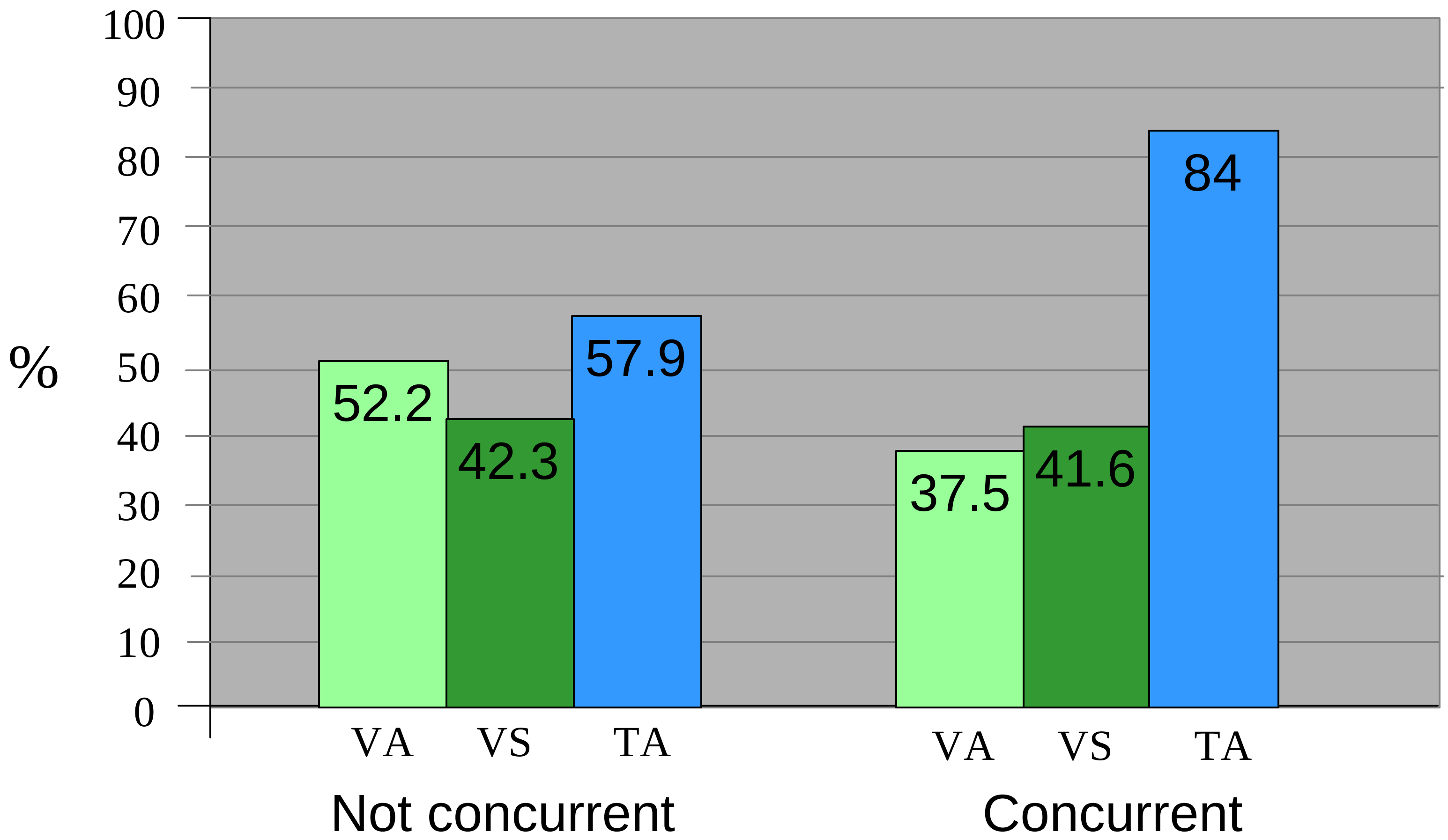
Accuracy in Identifying Icing Cues



61% of misidentifications involved light and medium icing levels

Refinement to tactor cues resulted in a 59% reduction in misidentifications

Secondary Visual Task Performance



Tactile cues afforded better divided attention

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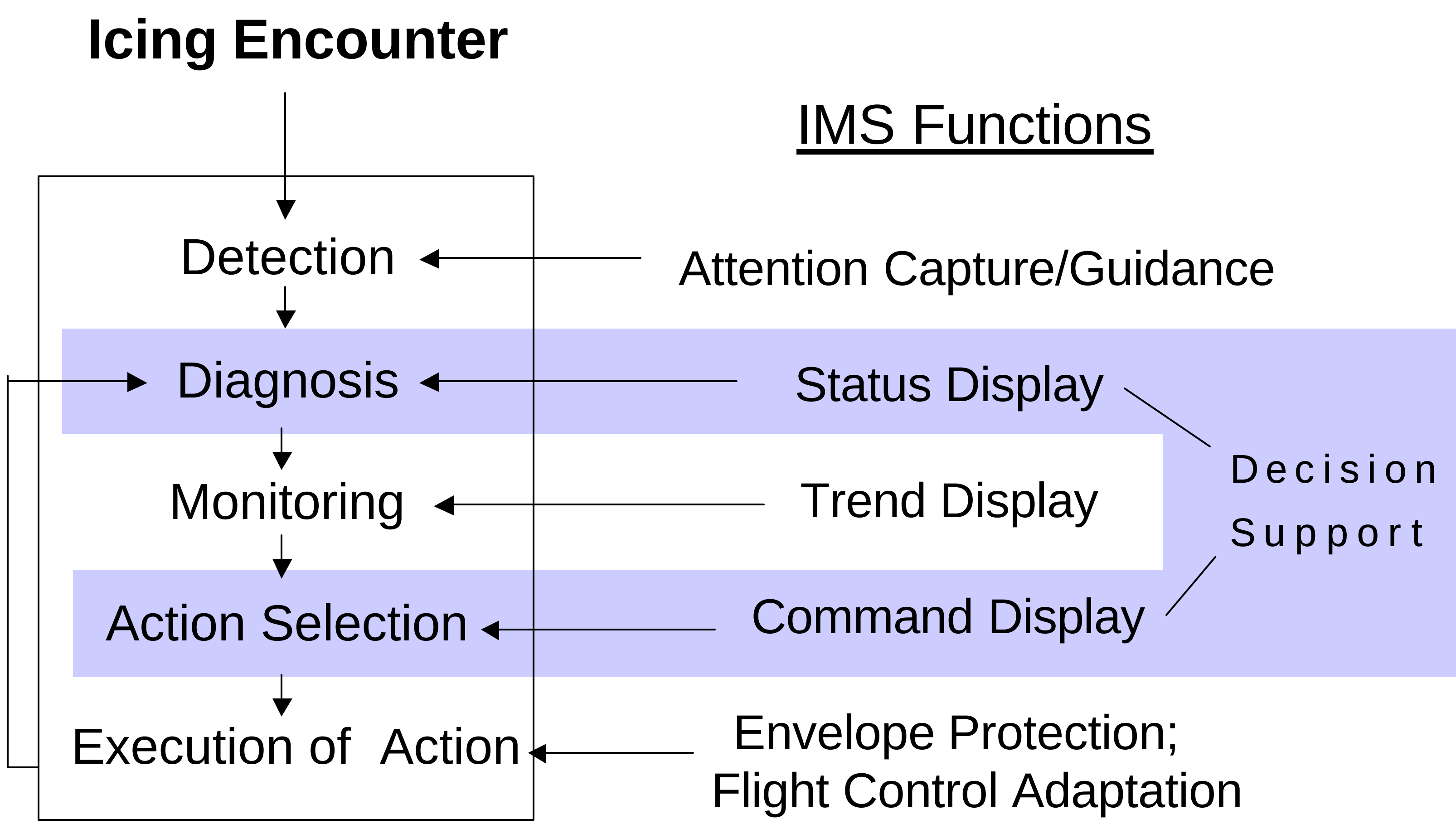


The IMS as a Decision-Support System: A Simulator Study Comparing Status and Command Displays

Beth Schroeder and Nadine Sarter

Note: Thesis document is included on the CD

Decision Support

- Participants: 27 instructor pilots
- Flight experience: average: 777 (827) hrs
  range: 200-4,600 hrs
- 3 conditions:
  - baseline (no aid, except for icing probe)
  - status display
  - command display
- Medium-fidelity simulation of twin-engine aircraft

Decision Support

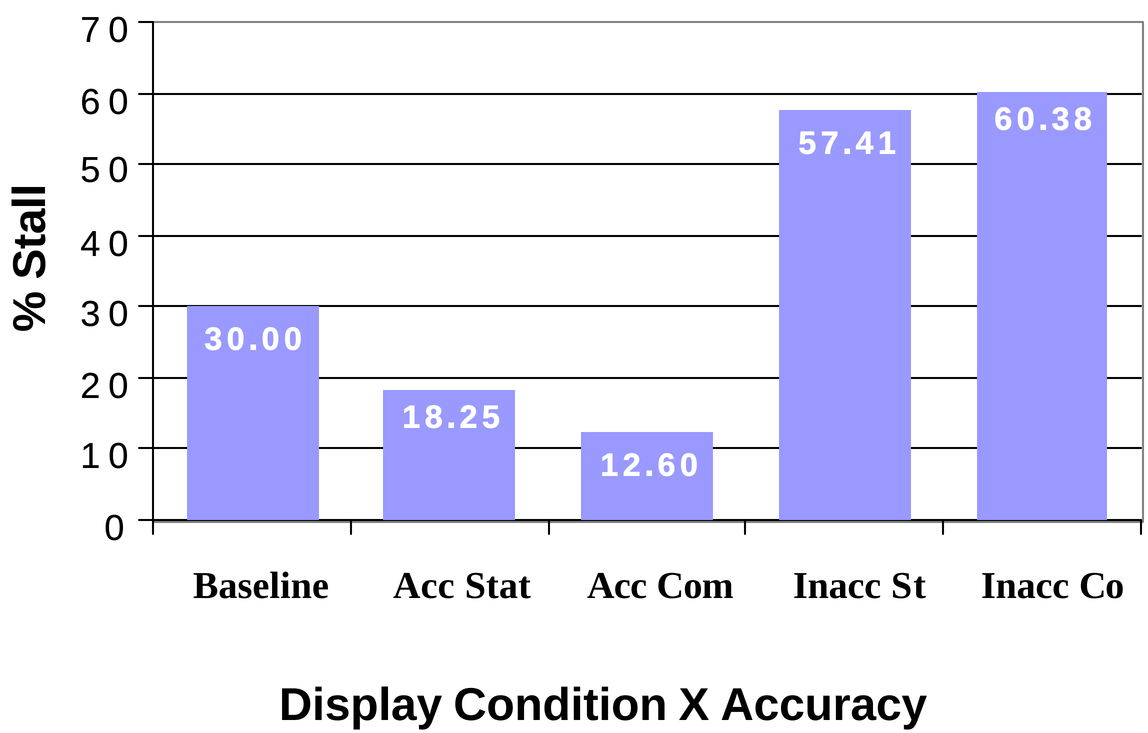
The Status Display

Decision Support

<u>The Command Display</u>

Decision Support

Stall frequency as function of display condition
and accuracy of IMS information



Decision Support

Summary

- Status display appears to be preferable.
  - equally beneficial with accurate information
  - less vulnerable to effects of inaccurate information than command
  - fewer recovery errors

- Still need better support for trust calibration as well as long-term planning and decision-making

Supporting trust calibration:
The case for dynamic reliability feedback

John McGuirl

Note: Thesis document is included on the CD

Trust Calibration

Use of automated systems, such as decision aids, has been linked to several factors including:

- users' confidence in performing the task
- task complexity
- risk involved in task
- perceived and actual reliability of the automation

Trust calibration refers to how closely perceived reliability matches actual reliability

Trust Calibration Experiment

Participants: 30 U of I instructor pilots

Flight experience: Average: 825 hrs
Range: 275-2400 hrs

Session 1 (1 hour)

- introduction to icing symptoms, simulator, and experiment

Sessions 2 and 3 (2 hours each)

- simulator practice
- 14 data trials (7 cruise + 7 ILS approaches)
- debriefing at the end of Session 3

Trust Calibration Experiment

Between-subjects variable

- reliability information (static vs dynamic)

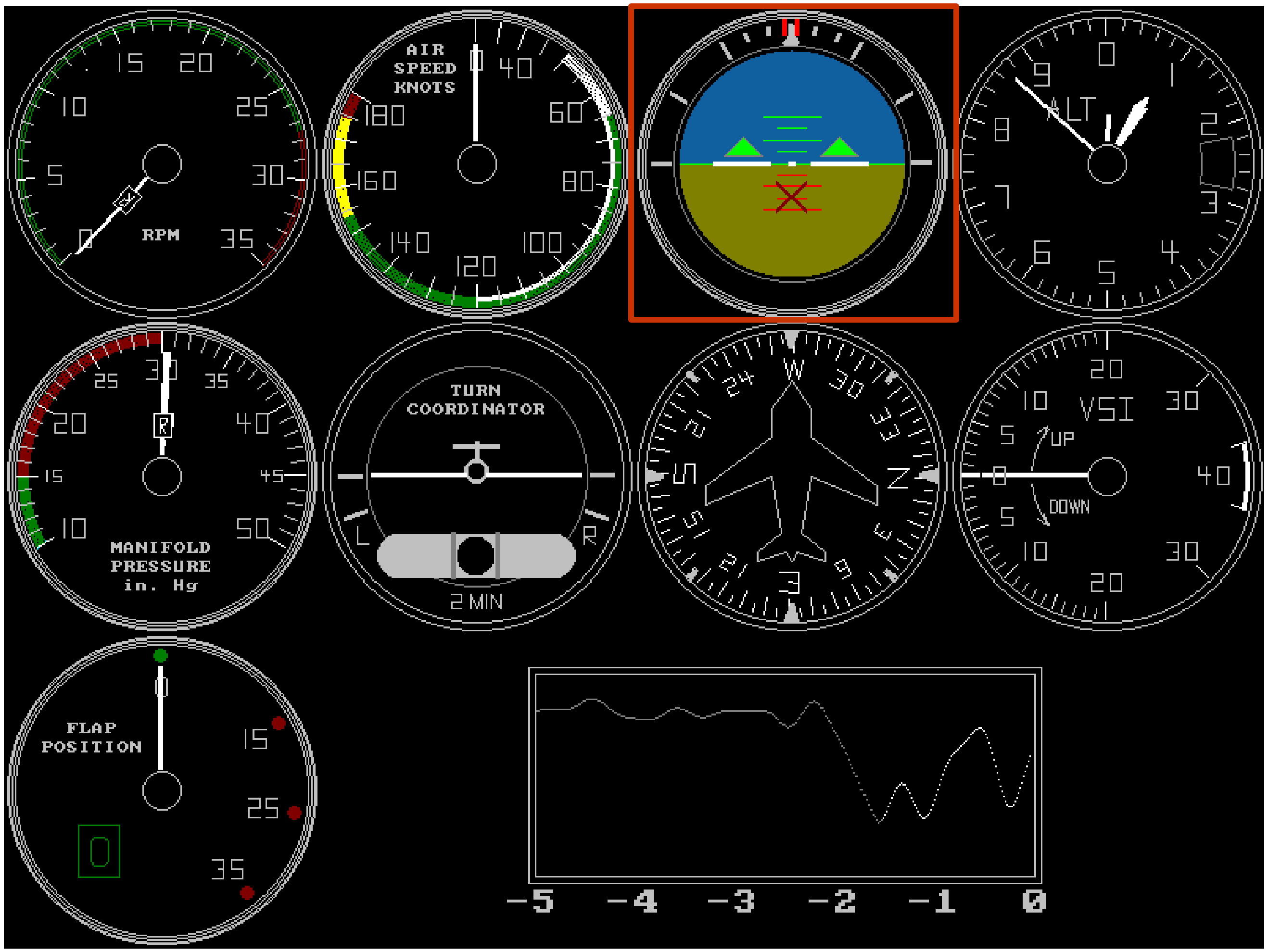
Within-subjects variables

- type of DSS (command vs status)
- accuracy of decision aid (correct vs incorrect)
- familiarity with situation (wing vs tail icing)
- taskload (cruise vs ILS approach)

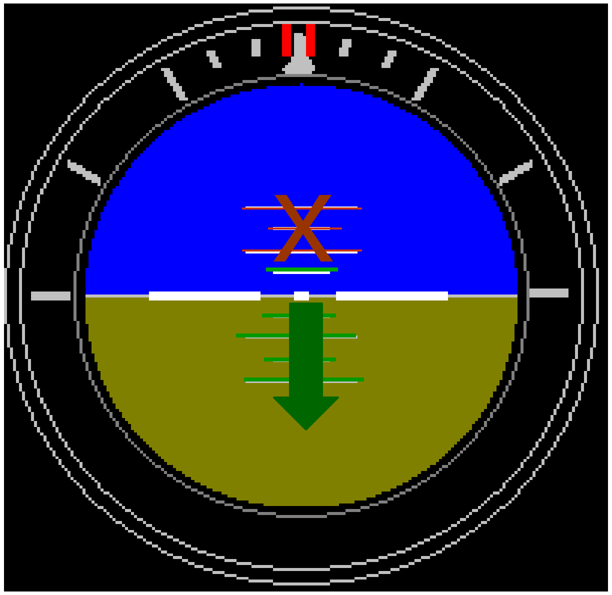
- reliability level (high,low, variable)
- reliability display availability (continuous vs on-demand)

\- dynamic group only

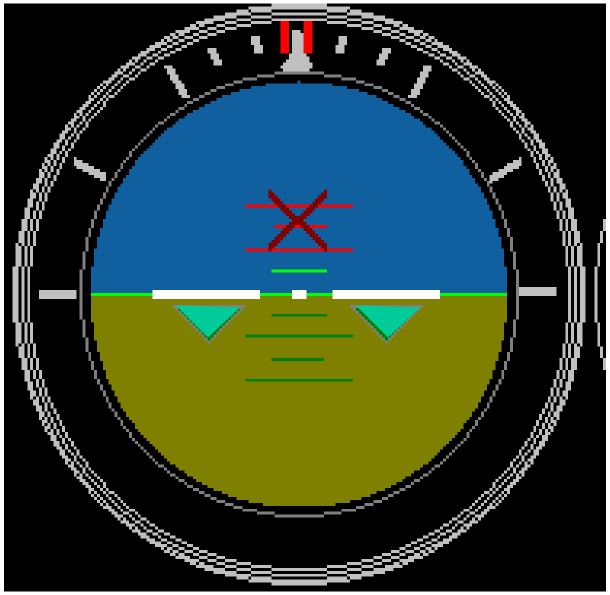
Cockpit Display



Trust Calibration Experiment



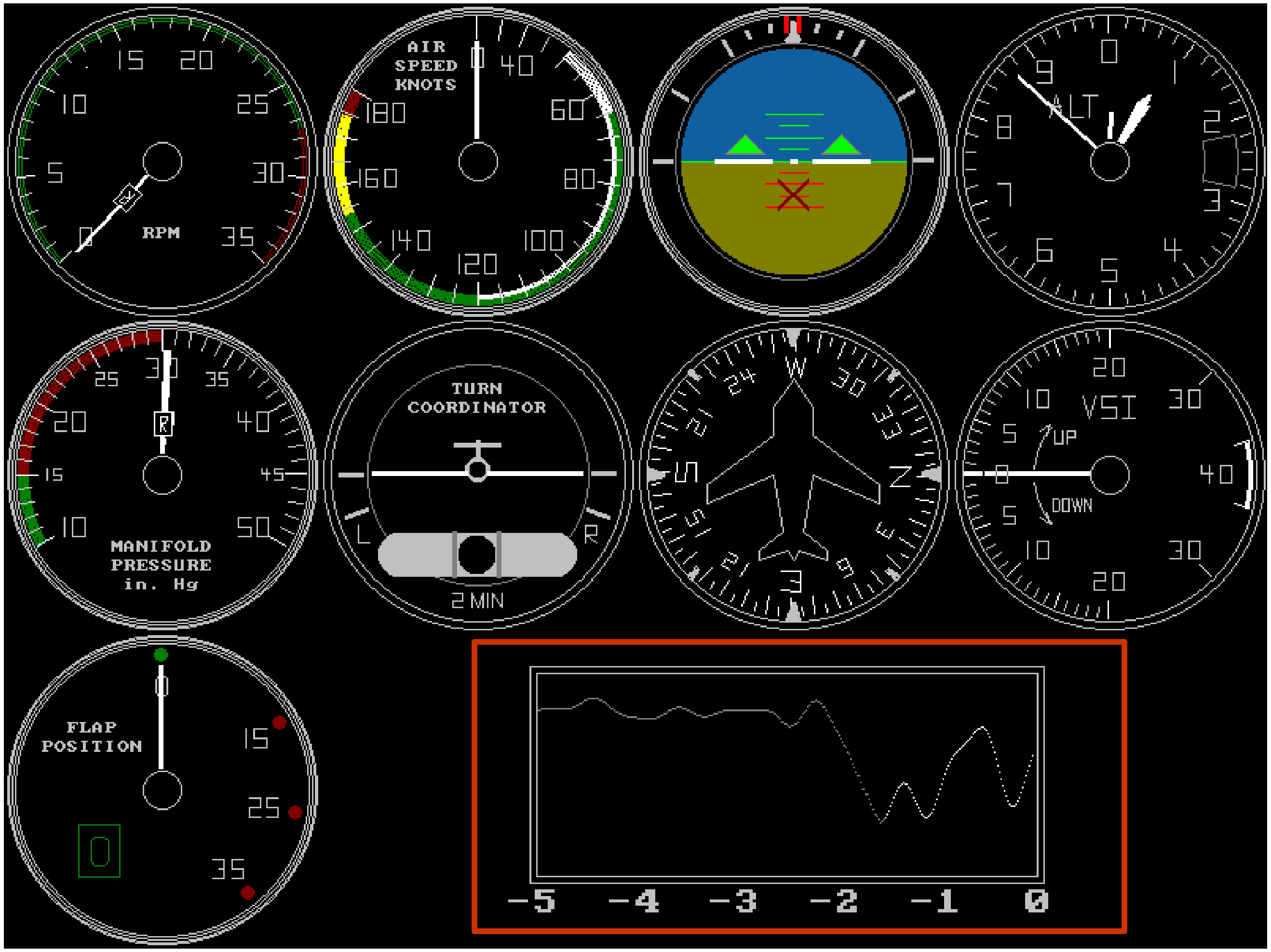
Pitch command
(Schroeder 2000)



Pitch command
(McGuirl 2002)

De-briefing indicated the potential to mis-interpret the arrow length to indicate magnitude of required pitch input

Cockpit Display



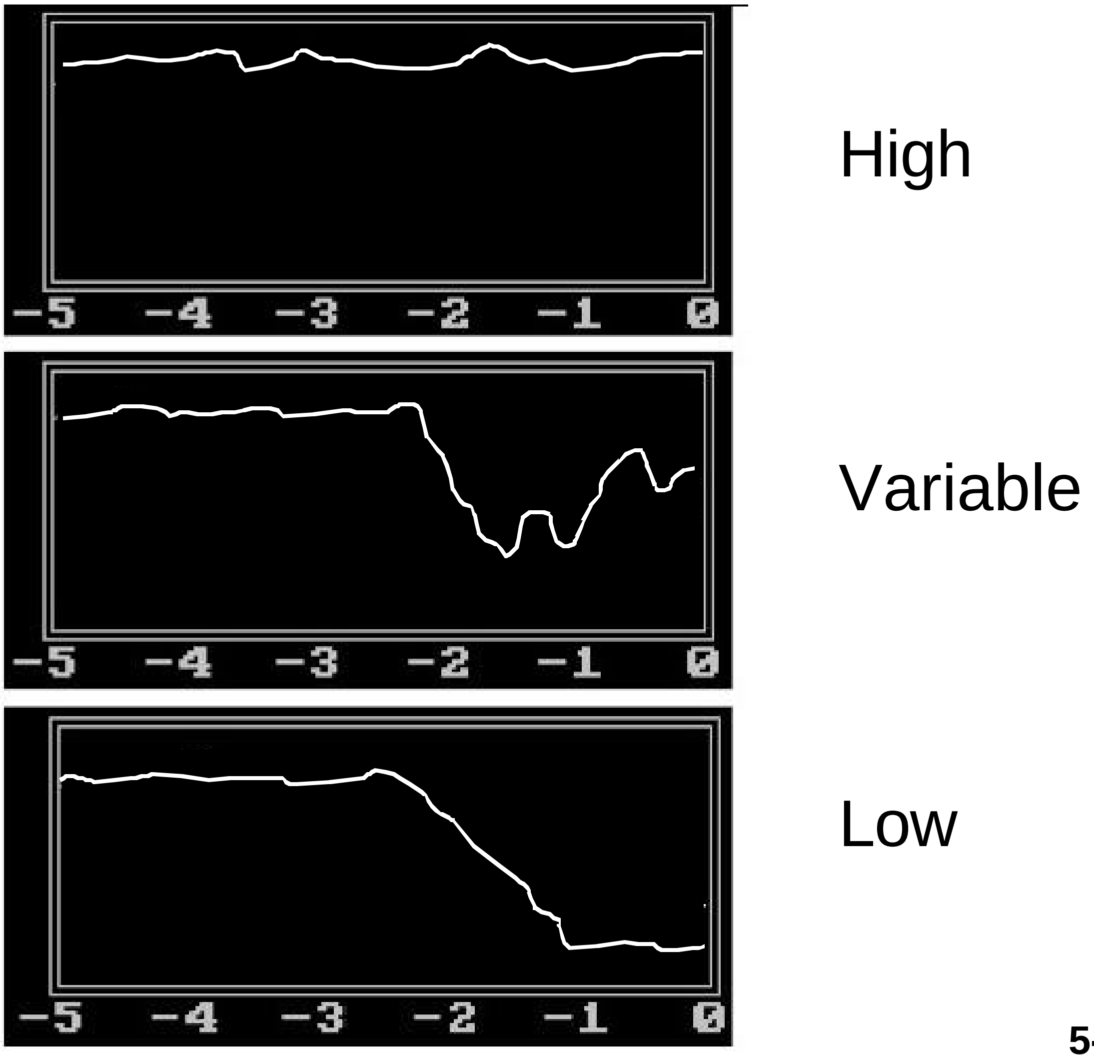
Trust Calibration Experiment

Reliability Trend Display

Provided a 5-minute history of reliability

Y- axis values omitted to avoid fixation on a particular value

Reliability was high for the first minute of each trial



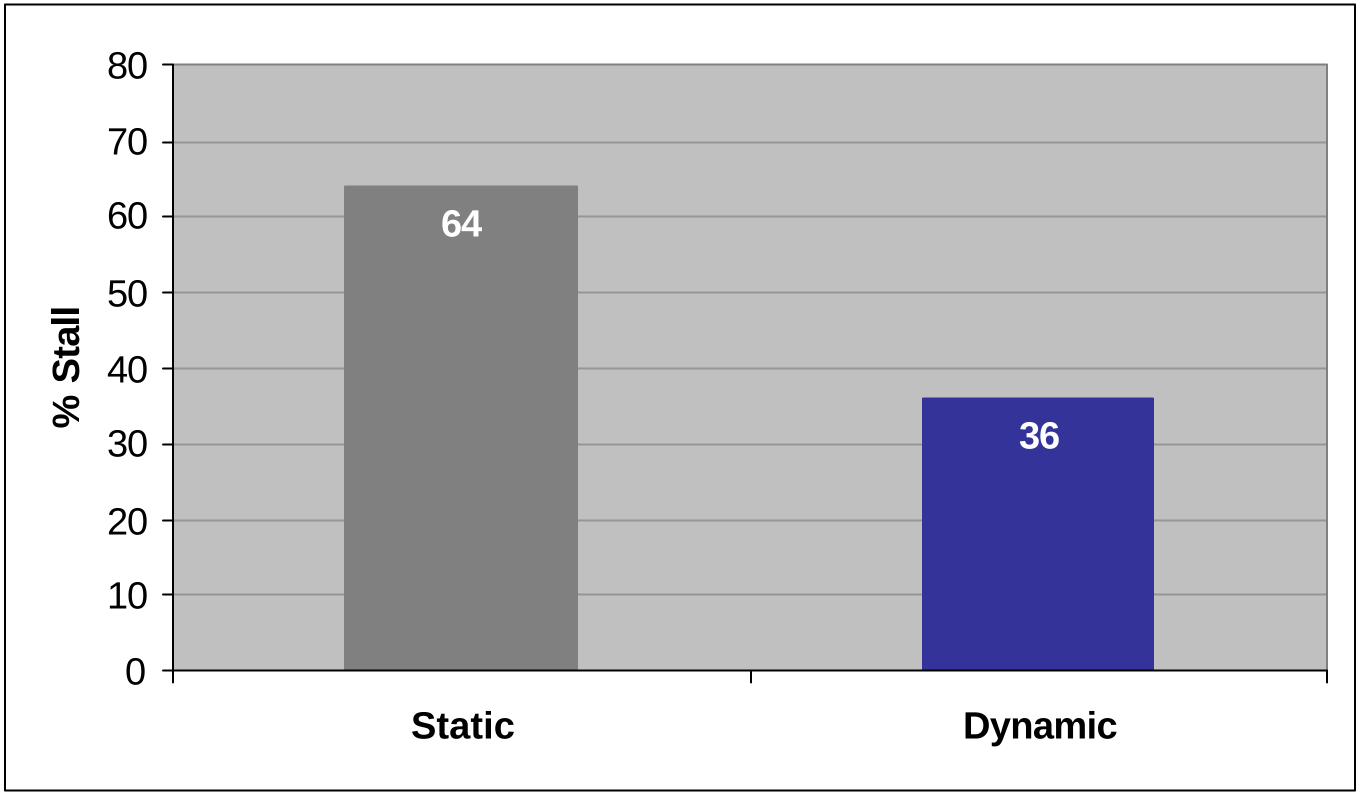
Trust Calibration Experiment

Dependent Variables

- appropriateness of initial and secondary response to icing
- stall events
- tracking performance
- detection of navigation-aid failures

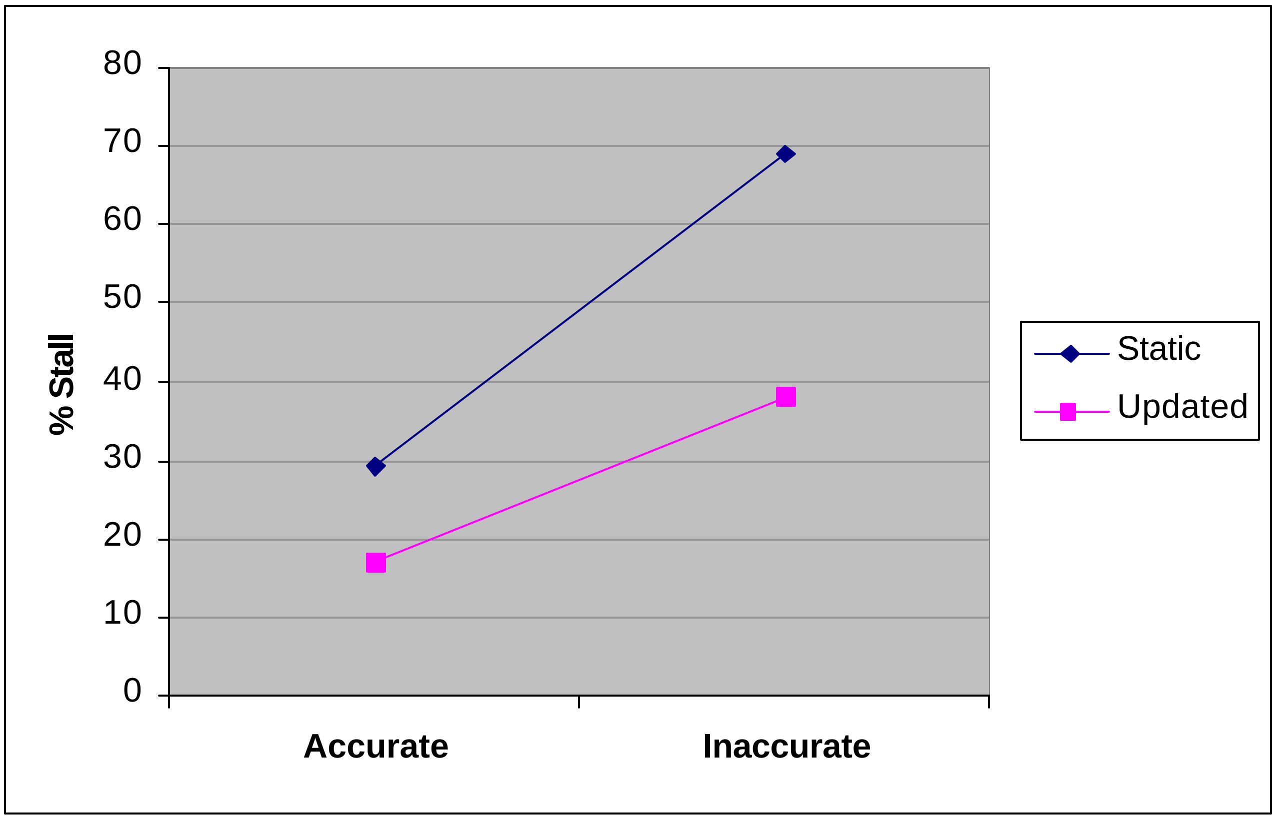
- reliability display sampling (dynamic group only)

Stall frequency as a function of availability of reliability information



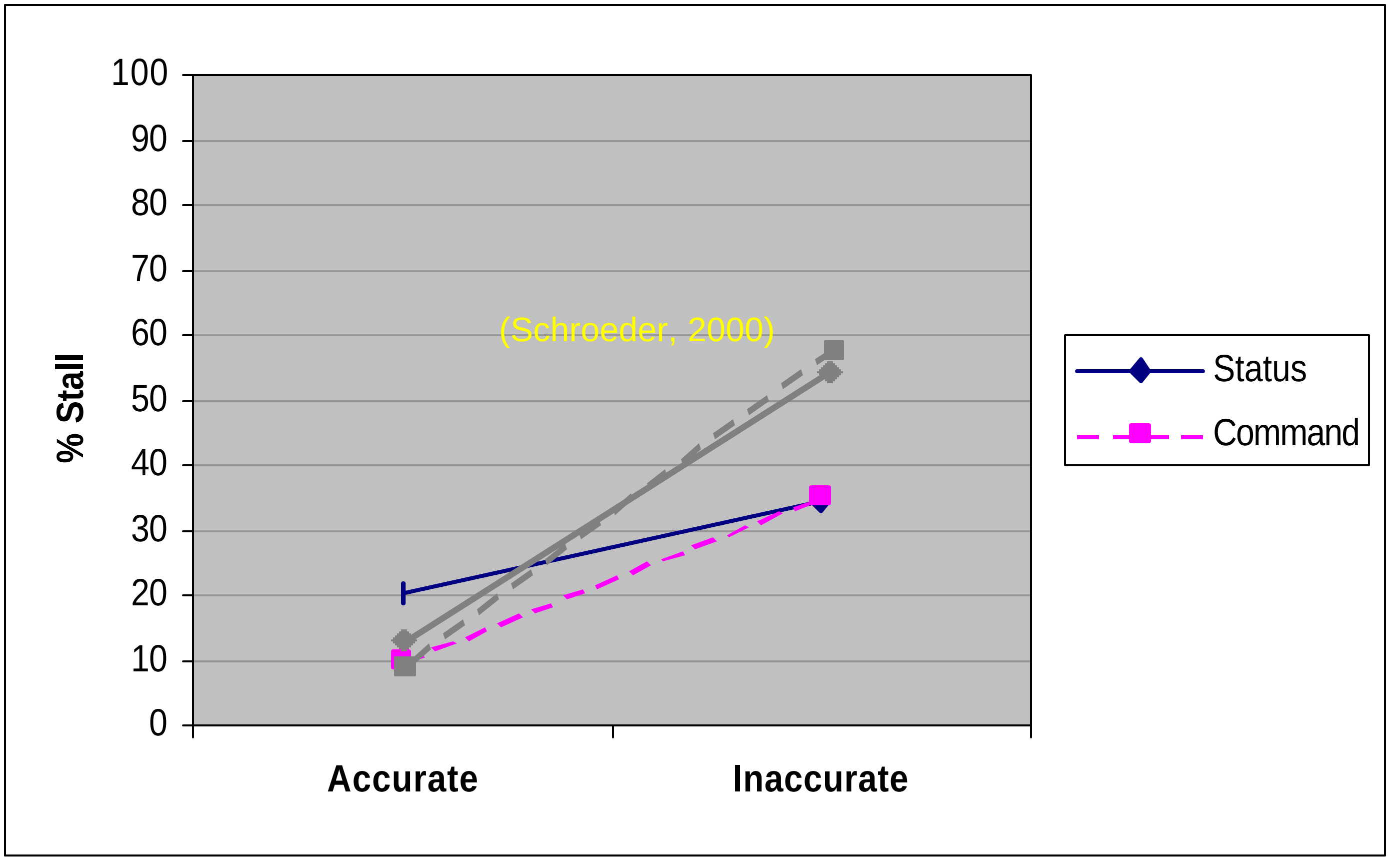
Trust Calibration Experiment

Stall frequency as a function of reliability information and decision aid accuracy

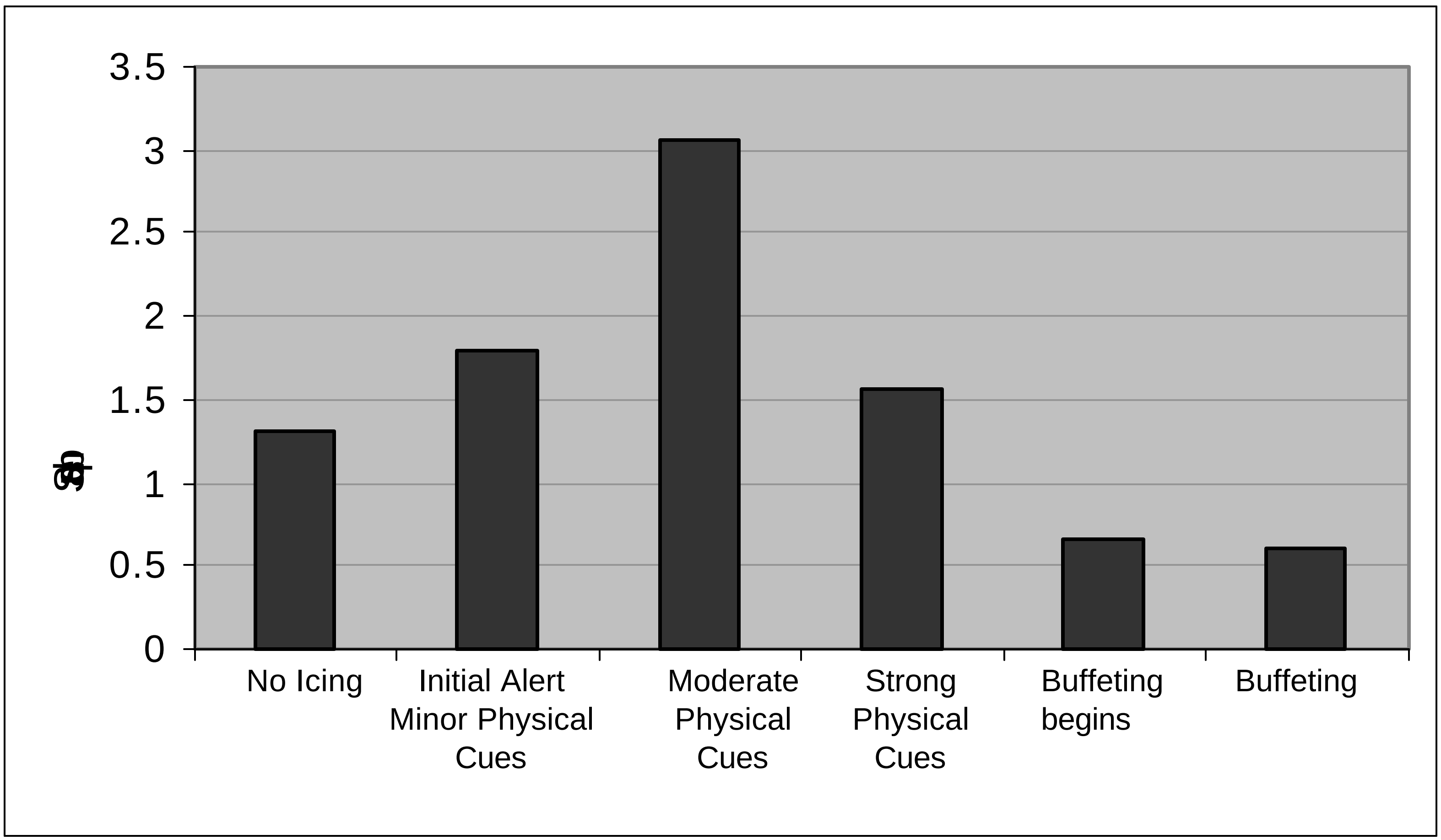


Trust Calibration Experiment

Stall frequency as a function of decision aid type and decision aid accuracy

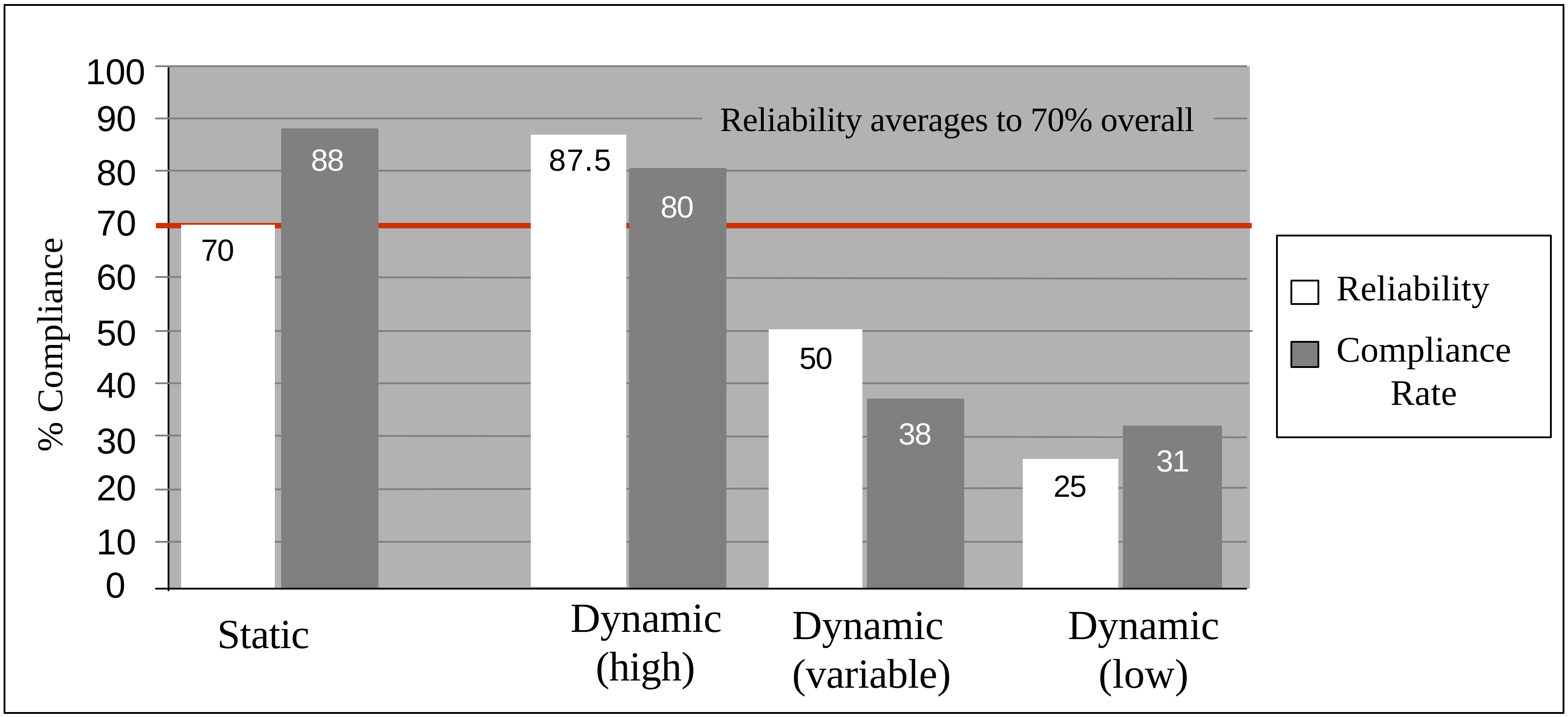


Trend Display Sampling



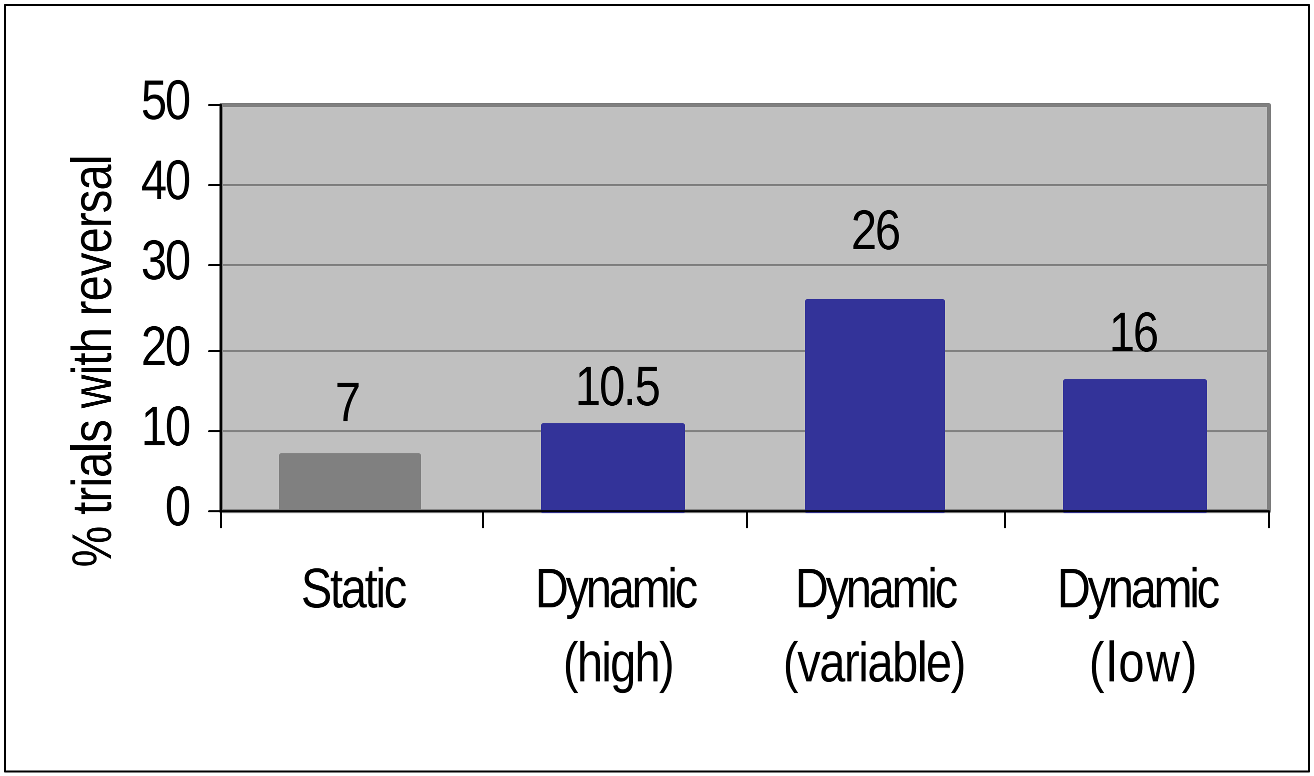
Icing Phase

Pilot compliance with decision aid vs. DSS accuracy



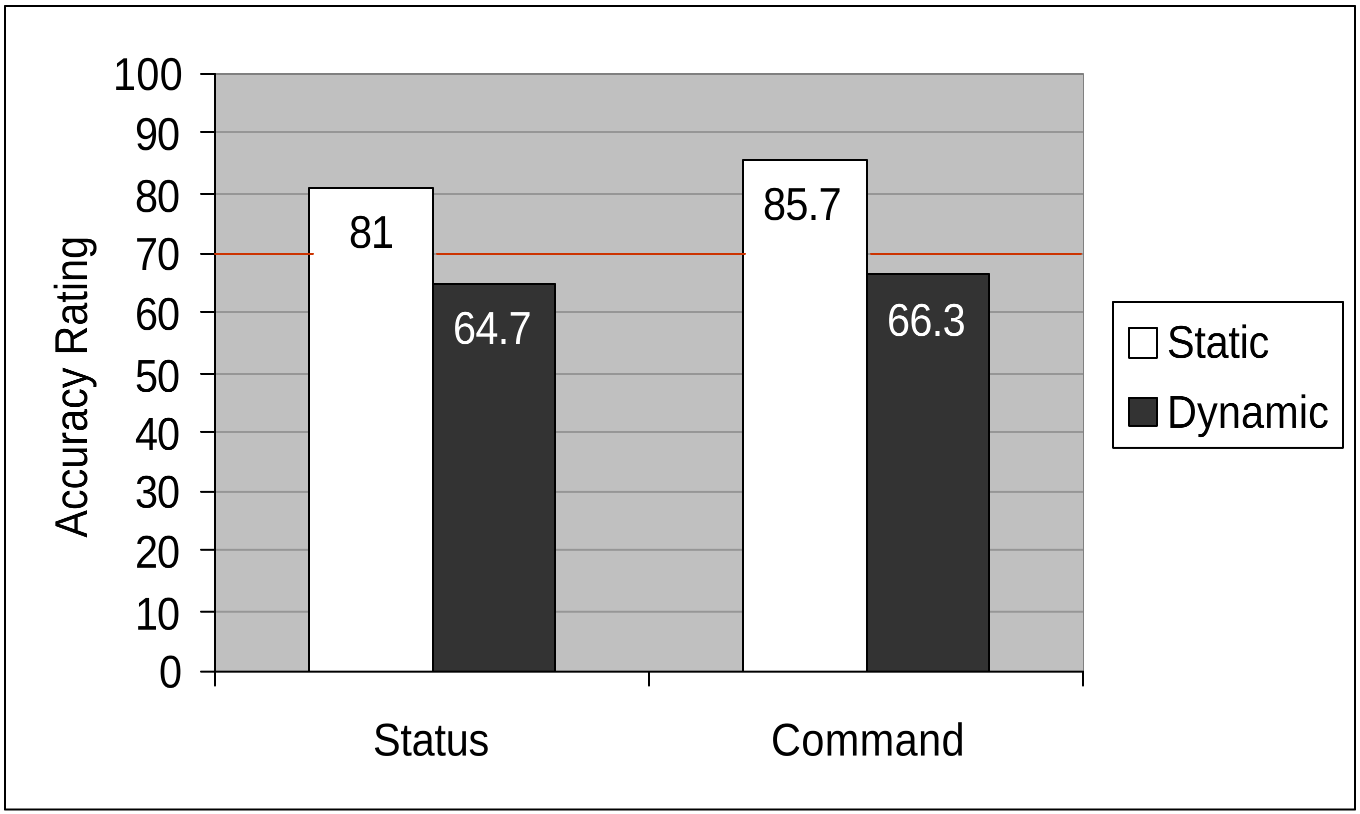
Trust Calibration Experiment

Reversal of compliance as a function of reliability information display



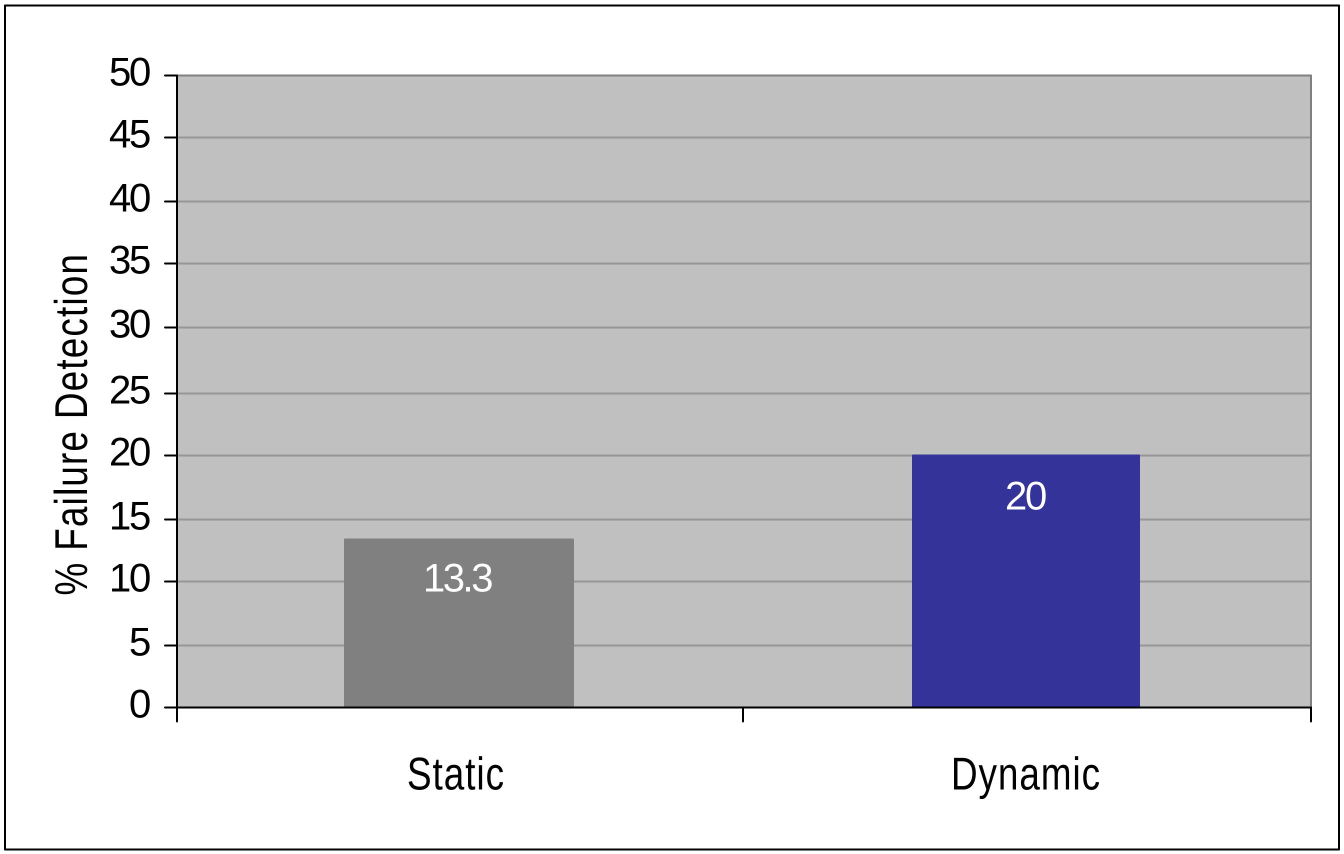
Trust Calibration Experiment

Perceived accuracy as a function of DSS and information type



Trust Calibration Experiment

Detection of navigation-aid failure as a function of reliability information type



Trust Calibration Experiment

Summary

Providing system reliability feedback afforded better trust calibration, resulting in less over-reliance and fewer stall events

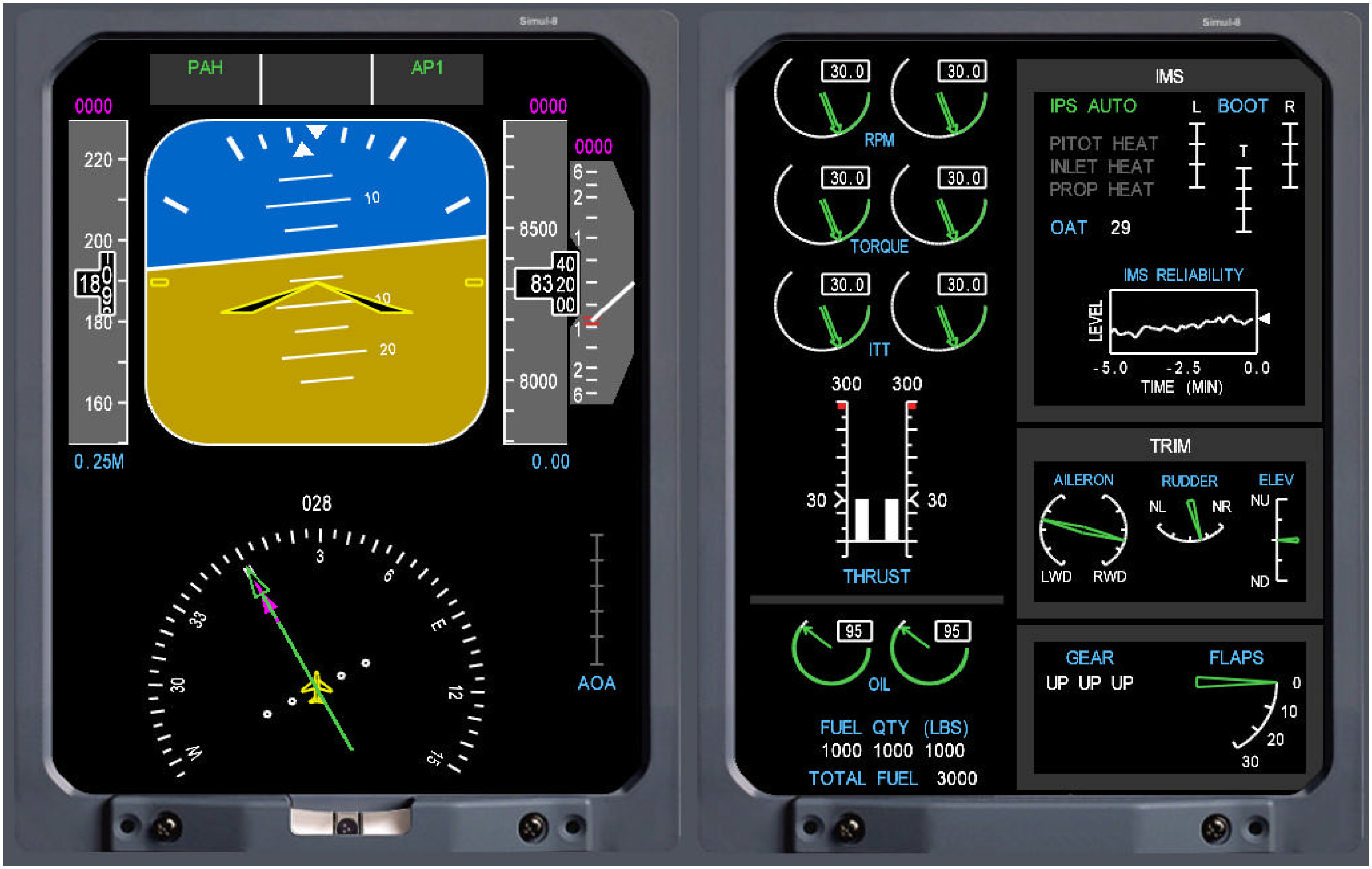
Also appears to have reduced automation bias, allowing for more flexible, adaptive responses for error recovery

Given the added information, command display may be more desirable

Further work is needed to explore situations which contain
- less predictable reliability feedback
- larger number of possible diagnoses

Overall Design Concept

Sample Sequence of Possible Icing Encounter and Associated IMS Indications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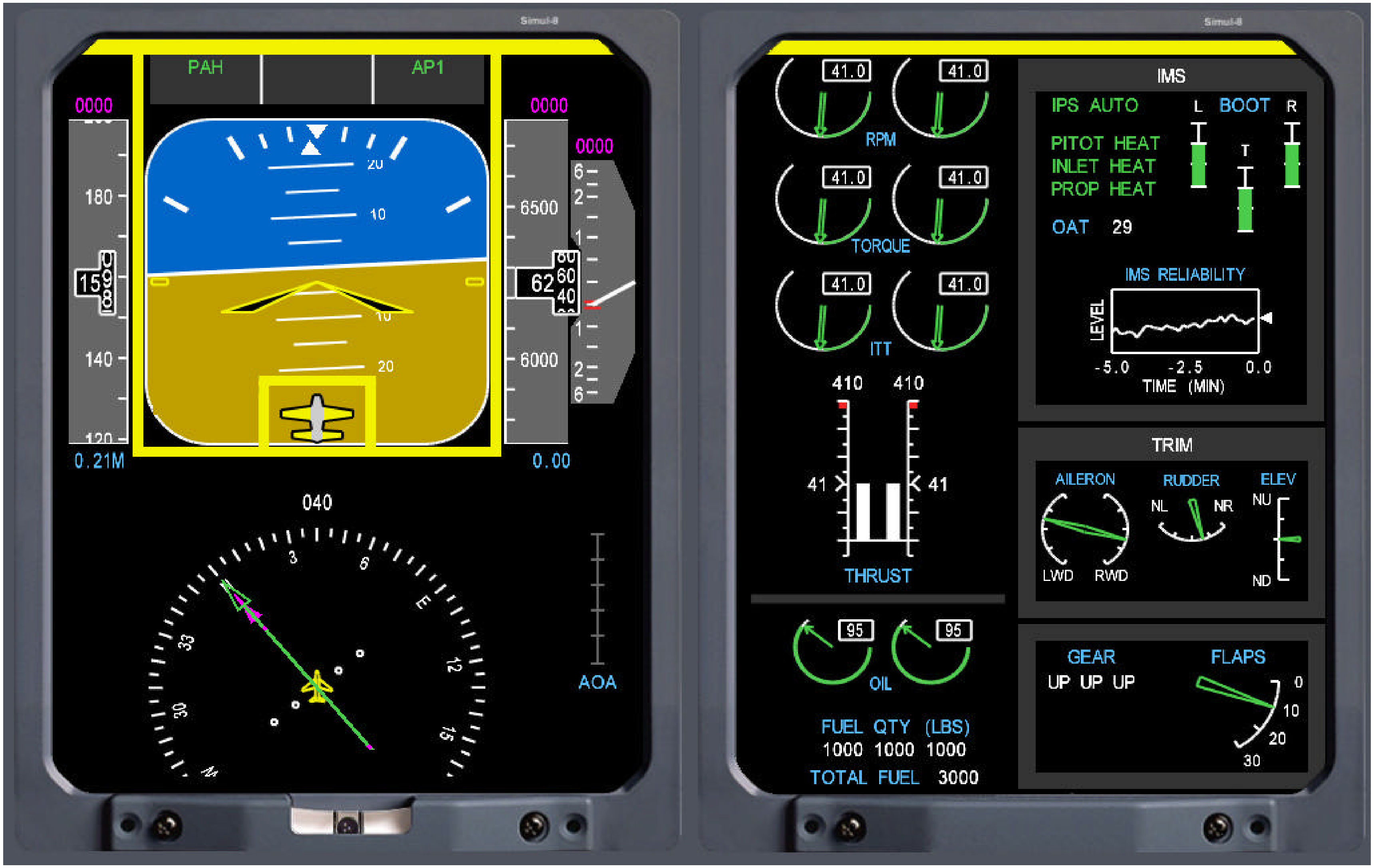
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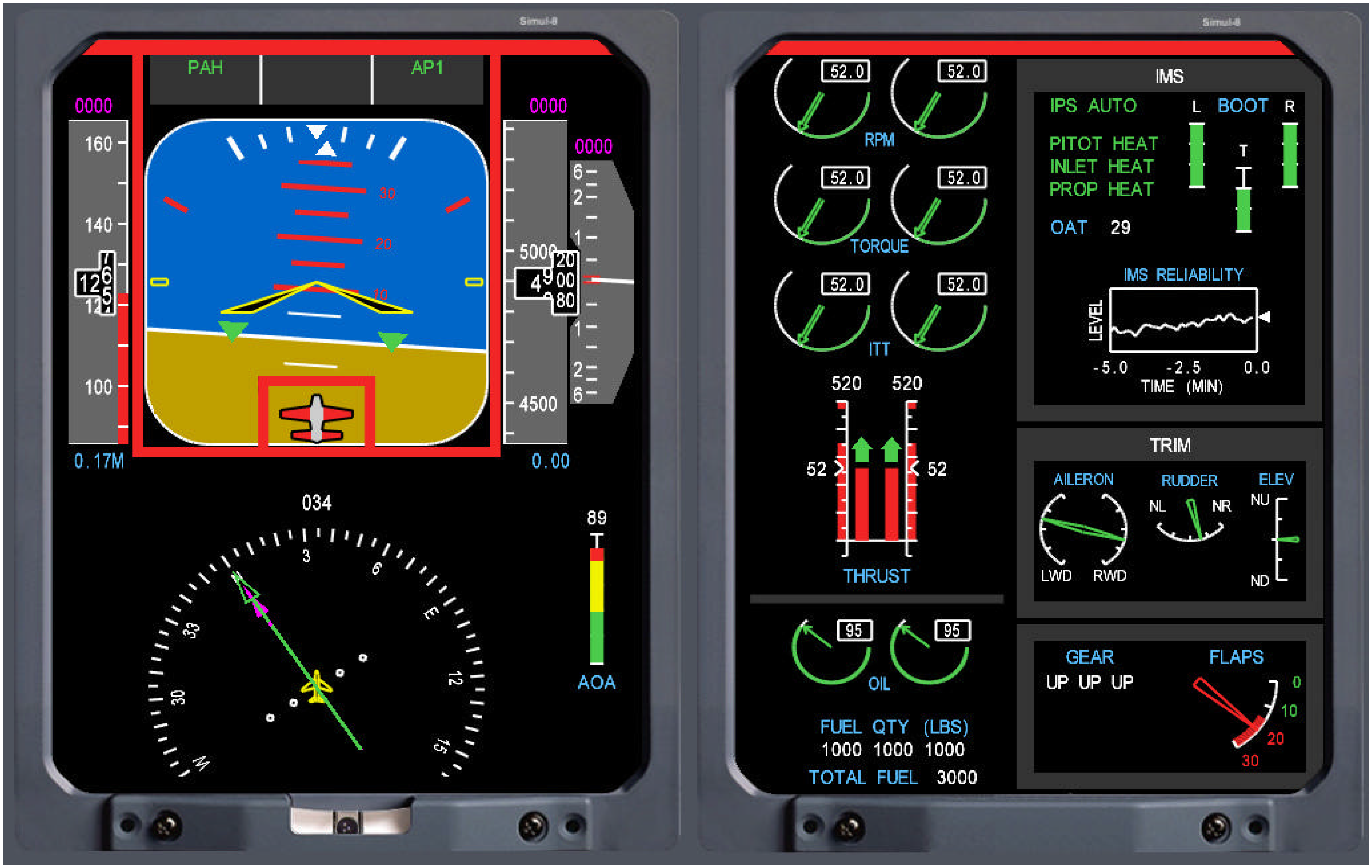
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Future Work

- Addition/substitution/integration of auditory and tactile feedback for supporting time-sharing and attention management
- Review and evaluation of SIS interface concept from a systems engineering perspective
- Collaboration with other team-members on the refinement of the envelope protection/flight control adaptation approach and indications