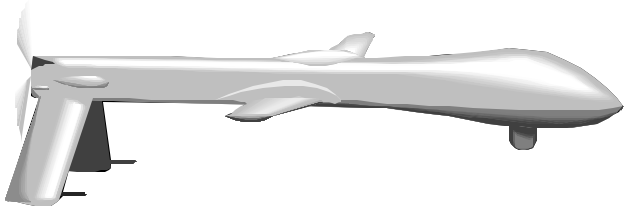
An ACT-R 5.0 Model of a Predator UAV Air Vehicle Operator

2 August 2002

Jerry Ball
Kevin Gluck
Michael Krusmark
Mathew Purtee
Stu Rodgers

Air Force Research Laboratory
Mesa, AZ

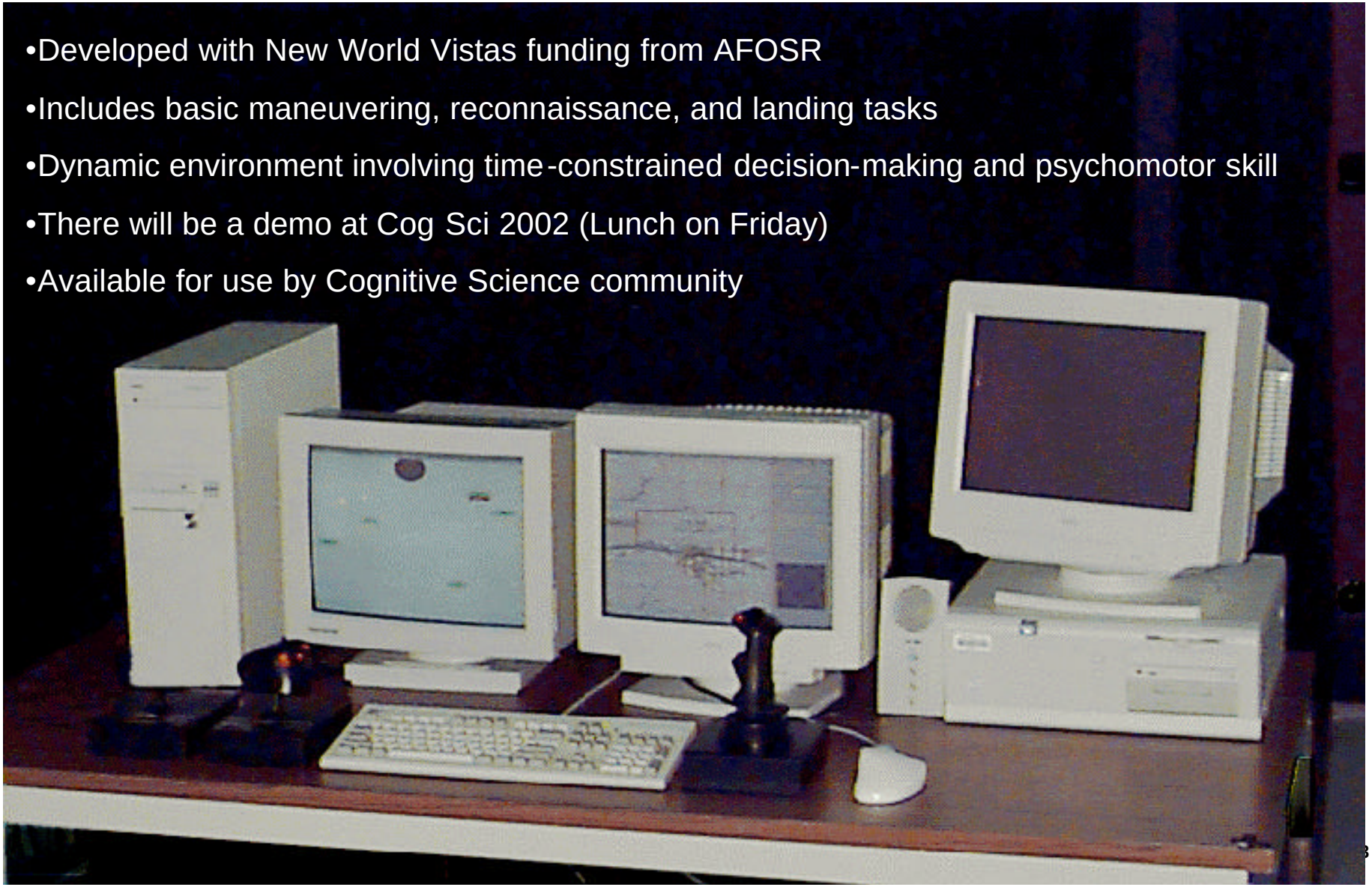
Terminology



- Predator (RQ1A) UAV
  - AKA Uninhabited Aerial Vehicle
  - AKA Unmanned Air Vehicle
- Air Vehicle Operator (AVO)
  - AKA Predator “Pilot”
- Performance and Learning Models (PALM) Lab
  - PALM Lab Subjects AKA “PALM Pilots”
- Synthetic Task Environment (STE)
  - Simulator plus built in tasks and performance data collection
- Subject Matter Expert (SME)

UAV Synthetic Task Environment

- Developed with New World Vistas funding from AFOSR
- Includes basic maneuvering, reconnaissance, and landing tasks
- Dynamic environment involving time-constrained decision-making and psychomotor skill
- There will be a demo at Cog Sci 2002 (Lunch on Friday)
- Available for use by Cognitive Science community



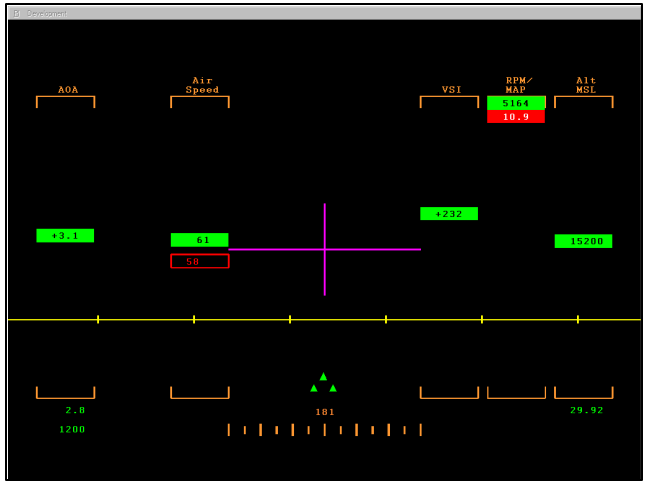
UAV STE Tasks

Task 1

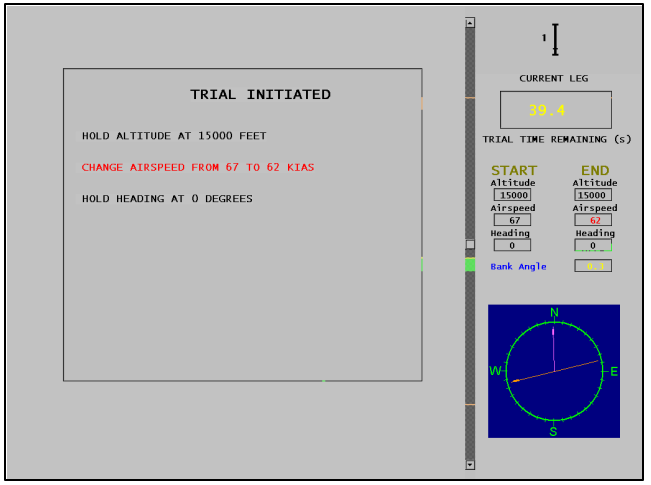
Basic Maneuvering

(We are here)

Heads-Up Display



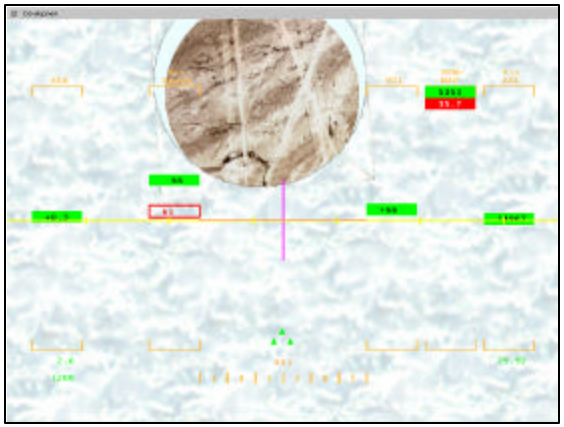
Task Screen



Task 3

Reconnaissance

Ground Camera



Tracker Map

Basic Maneuvering

Segment 1

Hold altitude at 15000 feet.

Hold heading at 0 degrees.

Change airspeed from 67 to 62 knots.

Segment 2

Hold altitude at 15000 feet.

Hold airspeed at 62 knots.

Change heading from 0 degrees to 180 degrees.

Version 3 Model does Segments 1, 2 and 3

Segment 3

Hold heading at 180 degrees.

Hold airspeed at 62 knots.

Change altitude from 15000 feet to 15200 feet

-

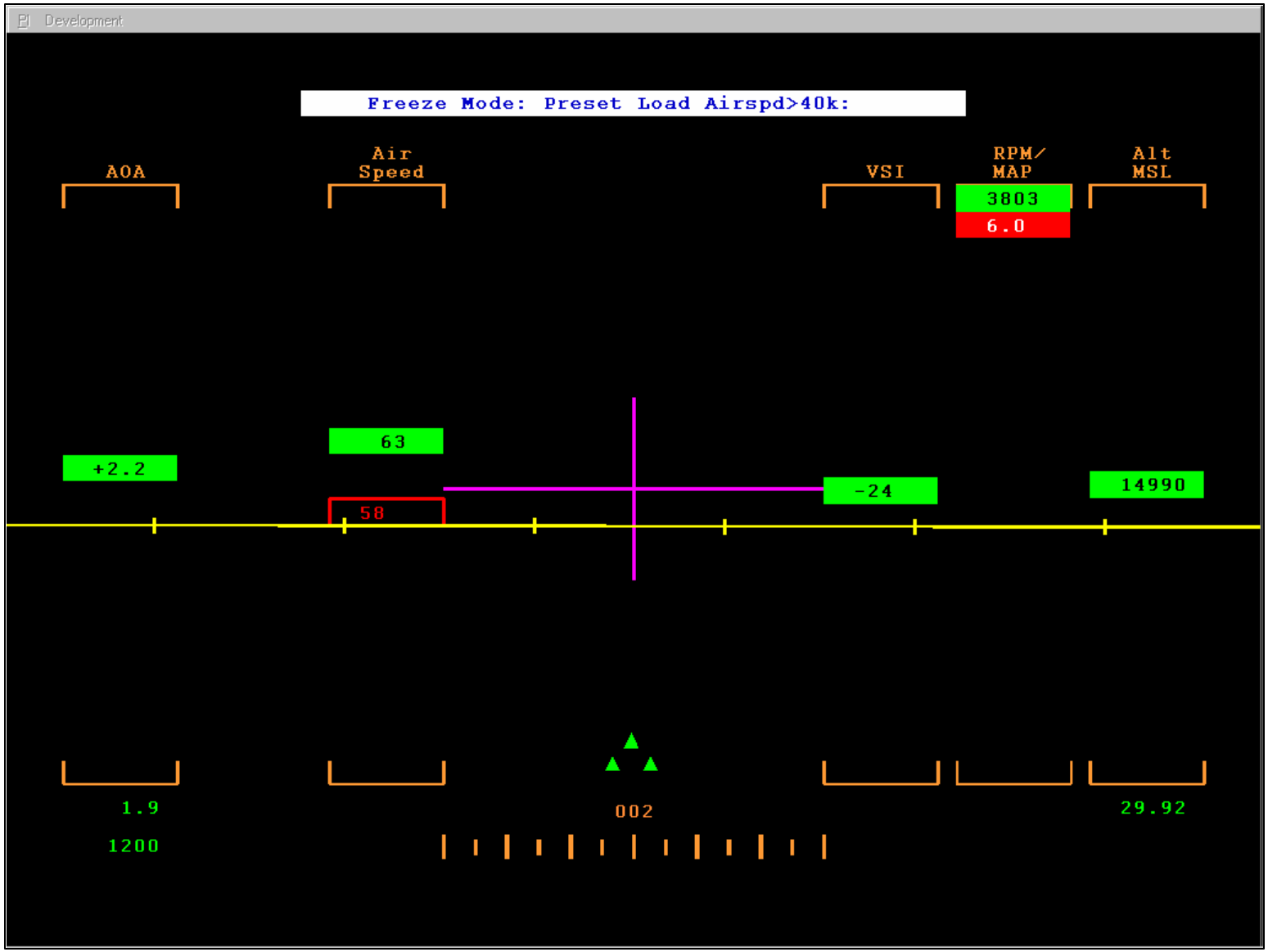
-

-

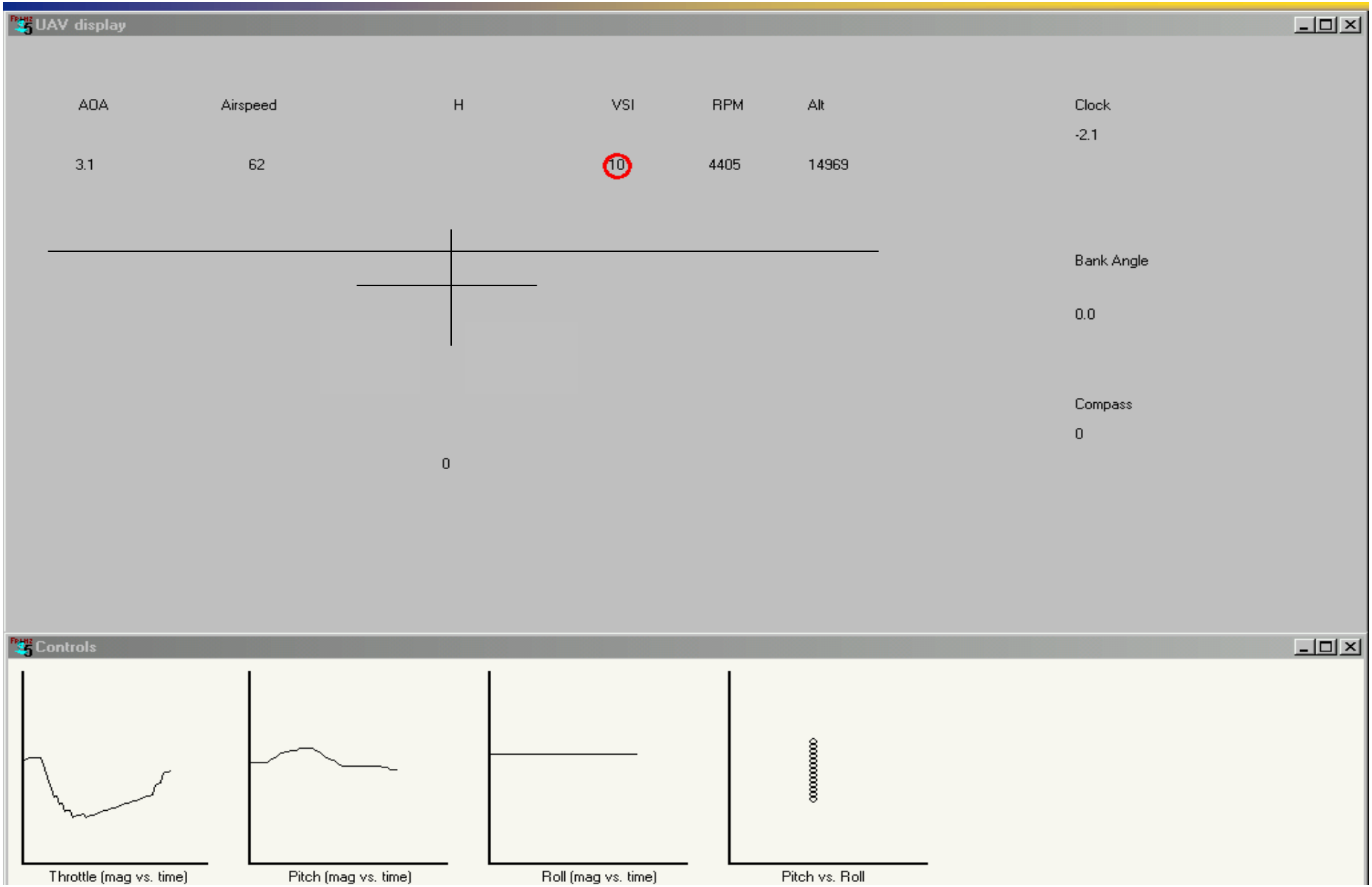
Segment 7

Change everything!

UAV Heads-Up Display



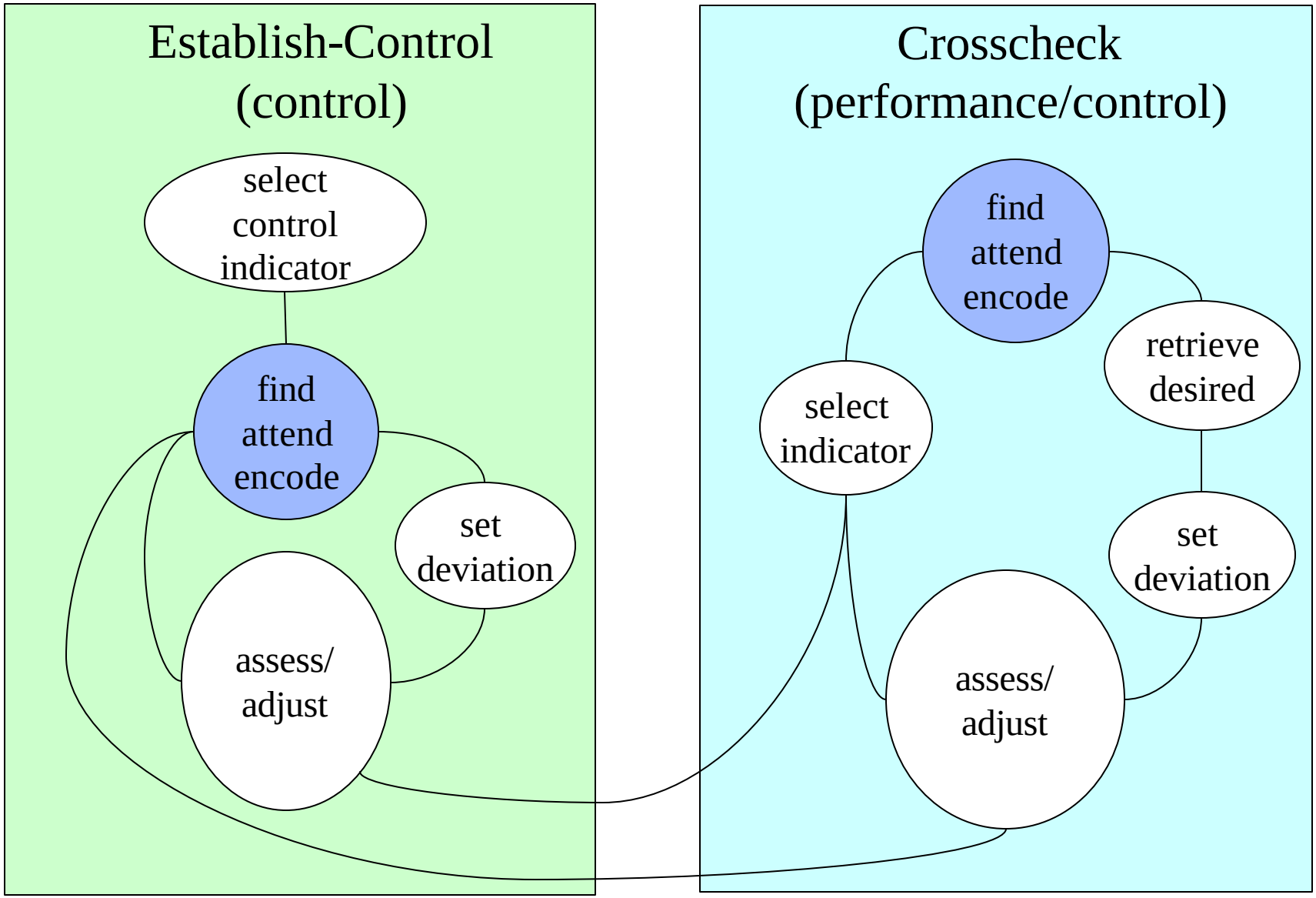
ACT-R/PM Heads-Up Display



Indicator Types

- Control – first order effect
  - Pitch
  - Bank
  - RPM
- Performance – second order effect
  - Airspeed
  - Altitude
  - Heading
  - Vertical Speed

Version 3 Model Design



Parameters

Expected gain noise	**1**
Goal activation	**1**
Latency factor/exponent	**1**
Base-level learning	**.5**
Activation noise	**.25**

Base-level activation

- estimated globally by assuming 3000 hours of flight/study time over 12 years
- used model to estimate # retrievals per minute of flight time

Human-Model Comparison Data

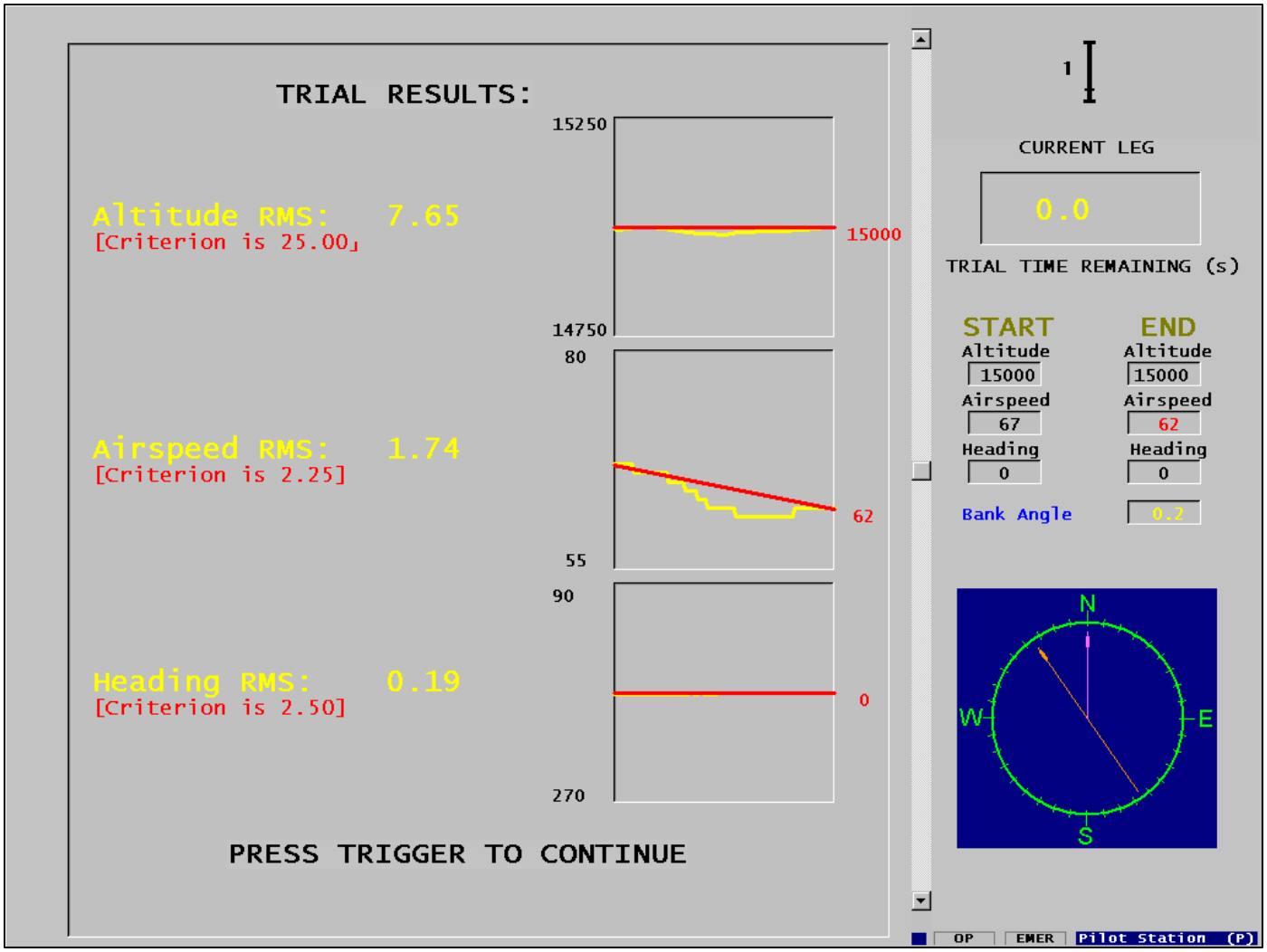
Data sources:

- **Performance Deviation**
- **Eye Tracking**
- **Verbal Protocol**

Data are from successful trials only:

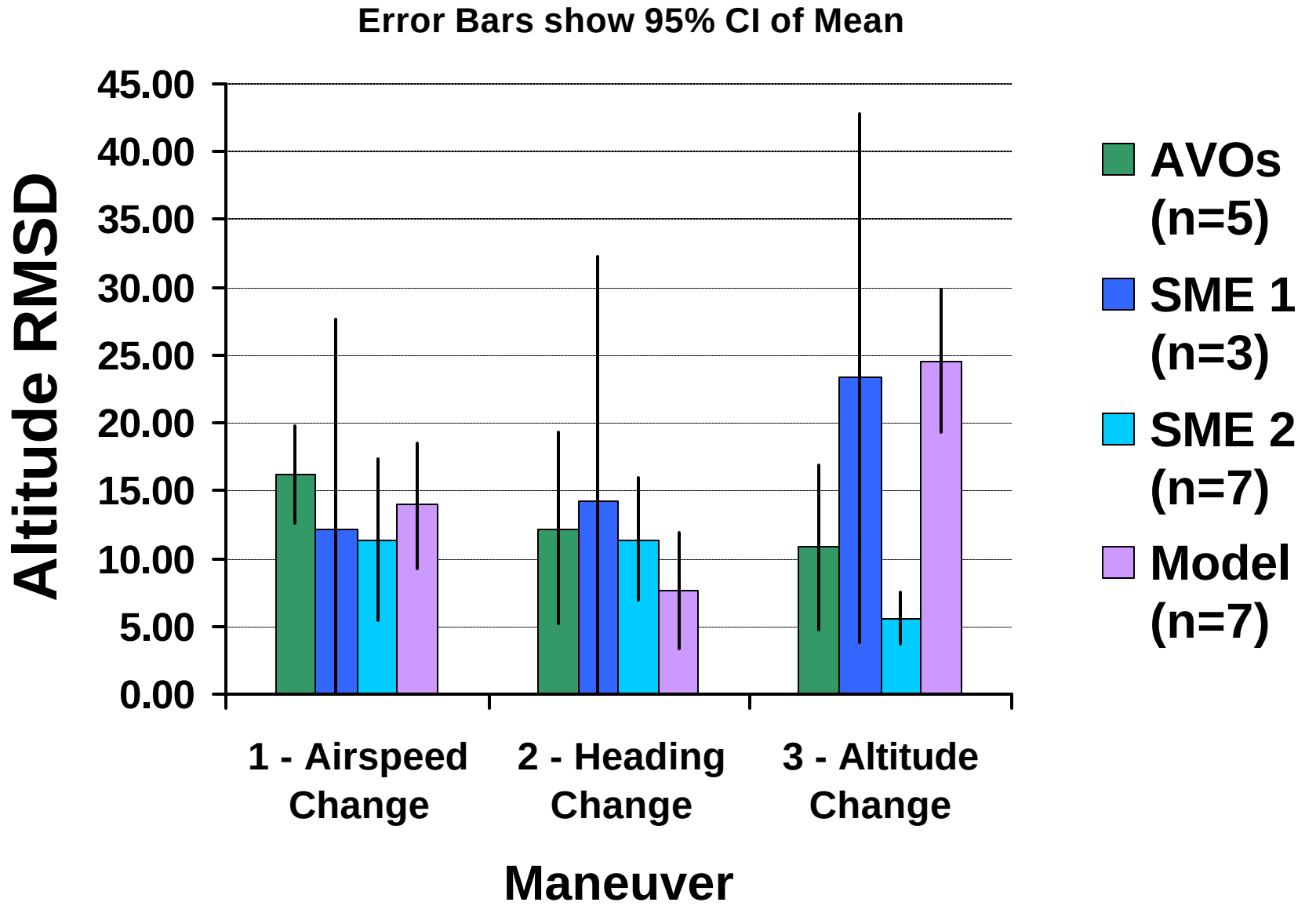
- **when pilot/model meets criteria on altitude, airspeed, & heading**

Performance Deviation Data
Feedback Screen

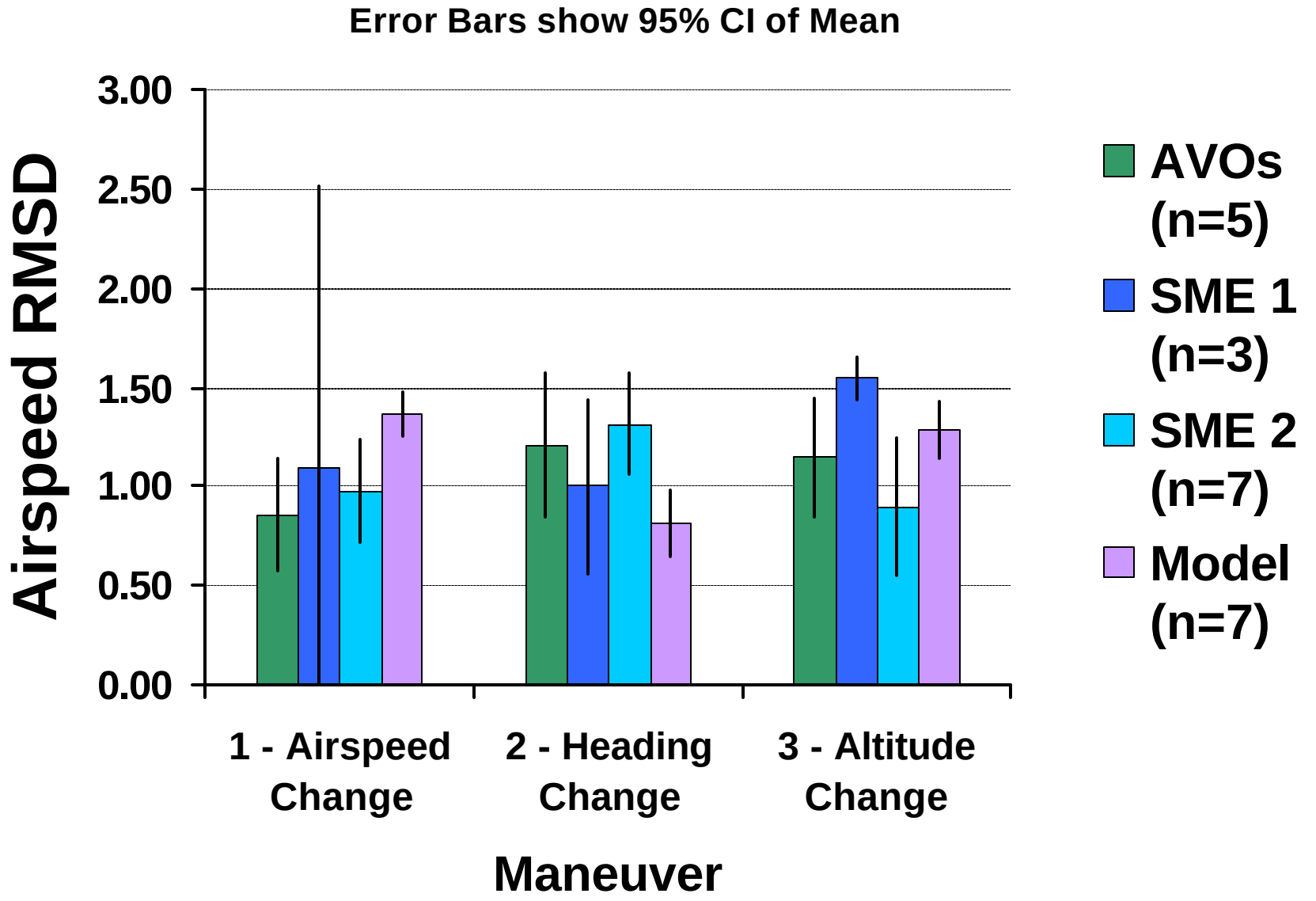


= ideal performance = actual performance RMS = Root Mean Squared Deviation

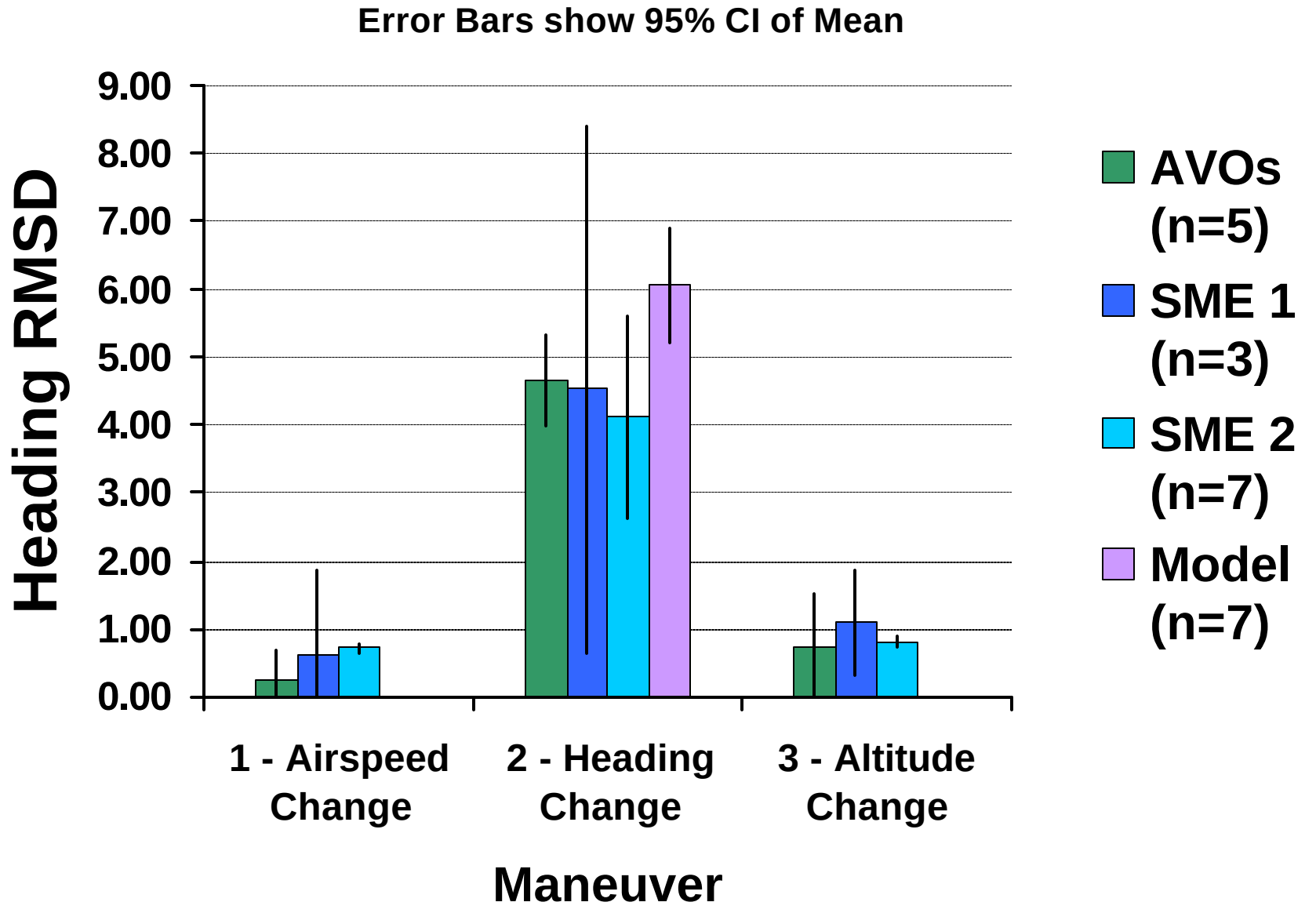
Performance Deviation Data: Mean of Altitude RMSD's



Performance Deviation Data: Mean of Airspeed RMSD's

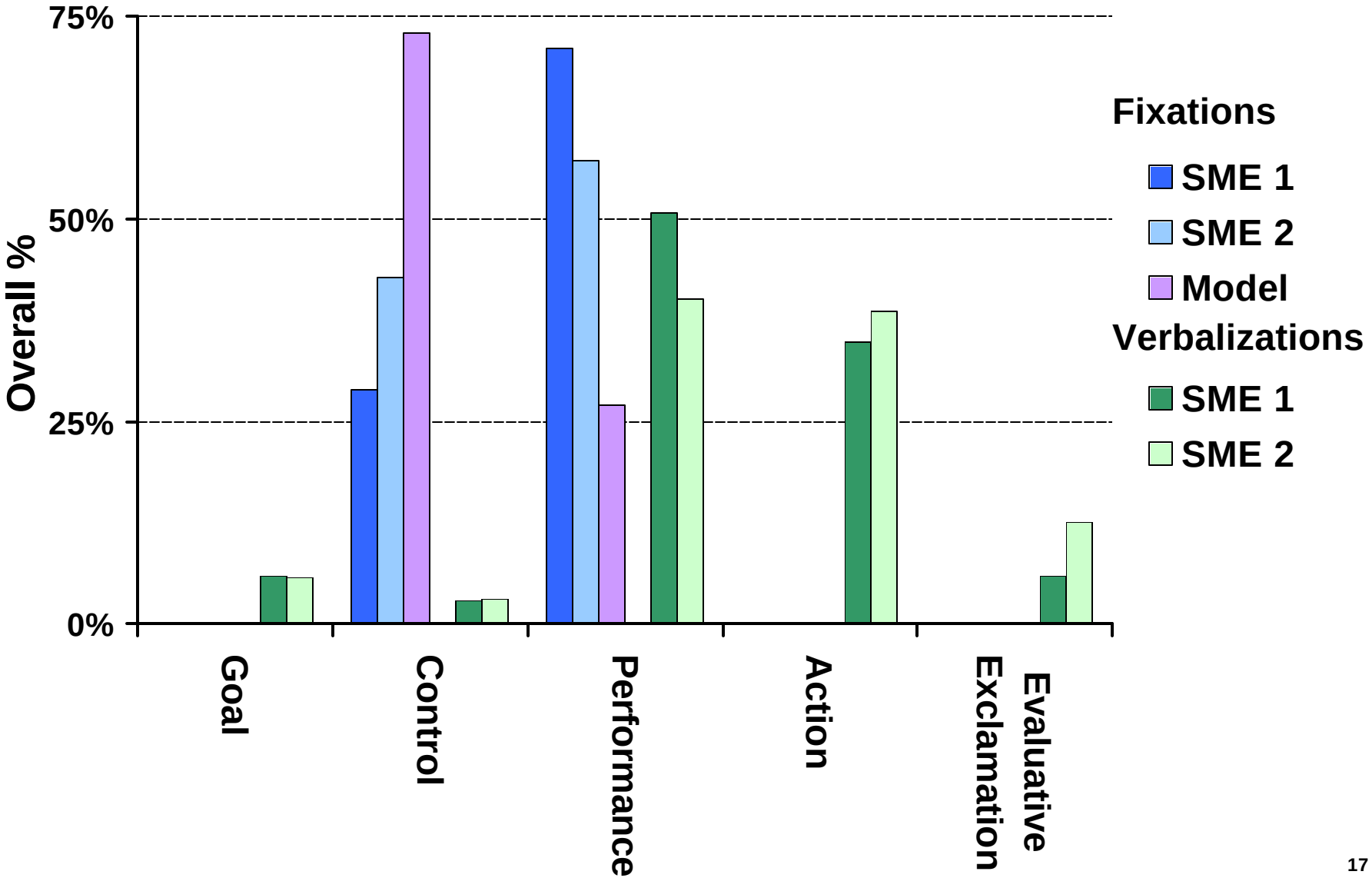


Performance Deviation Data: Mean of Heading RMSD's



Point of Regard & Concurrent Verbal Report Data

Fixation & Verbalization Data
Maneuvers 1, 2, & 3



Model Achievements

- **Implemented the UAV Operator Model in latest version of ACT-R (5.0)**
- **Implemented a “Mock” HUD using the new perceptual-motor component of ACT-R 5.0**
- **Linked the UAV Operator Model directly to a complex, high-fidelity simulation environment that was not originally designed for interaction with external software.**
- **Version 3 of the model performs basic maneuvering segments 1 to 3 in a manner comparable to expert human performance**

Model Achievements Version 3

- **Model distinguishes establishing control from normal crosscheck** (combination of proactive and reactive behaviors more consistent with SME interviews and Air Force Manual on Instrument Flight)
- **Model has declarative representation of differing performance and control requirements across time segments**
- **Model distinguishes different goal** (straight and level flight) **during lead-in period from rest of trial**
- **Following lead-in period, model now initiates actions based on requirements for segment** (e.g. initiate right turn, initiate climb)

Continuing Model Challenges

- **Synchronization of logical time with STE** (really a system architecture issue, not an ACT-R issue)
- **Model too slow – clearly not processing the screen as fast as a human can**
  - may need more “efficient” model implementation to take full advantage of parallelism in 5.0
- **Implementation of goal inheritance hierarchy seems unwieldy**
  - Not clear what better implementation is, that provides enough information to model for real-time aircraft control

And now for something completely different …

Shameless Recruiting Effort

- **The Air Force Research Laboratory (AFRL) is expanding its investment in cognitive science, modeling, and engineering.**

- **Relevant production rule:**

  IF you are a person who works in cognitive science, modeling, or engineering (at any level from recently-completed undergrad to full professor)

  AND you are a U.S. citizen who is curious about the various forms an AFRL position might take (gov't, contractor, National Research Council)

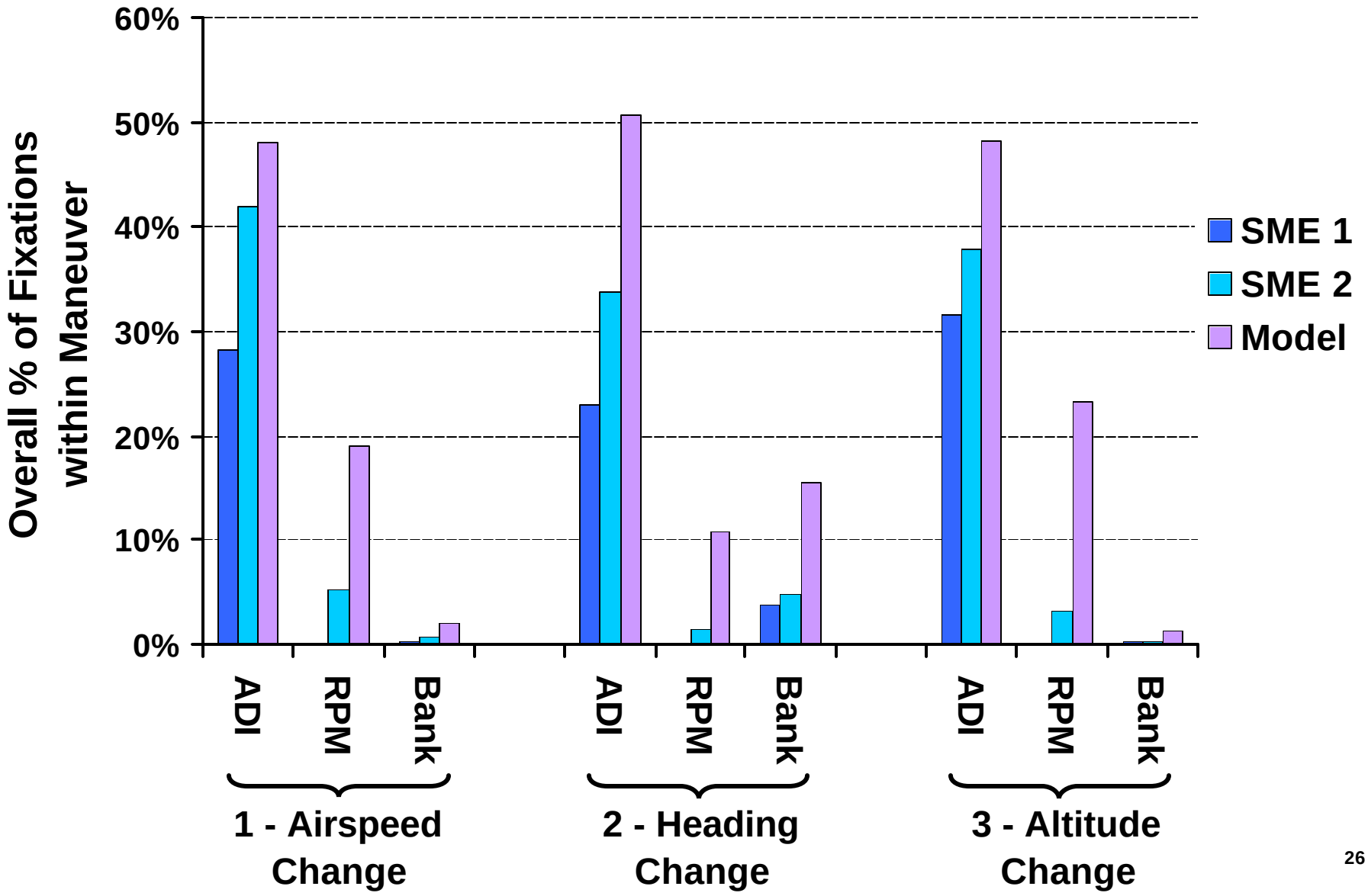
  THEN talk with Kevin Gluck about the opportunities

Questions?

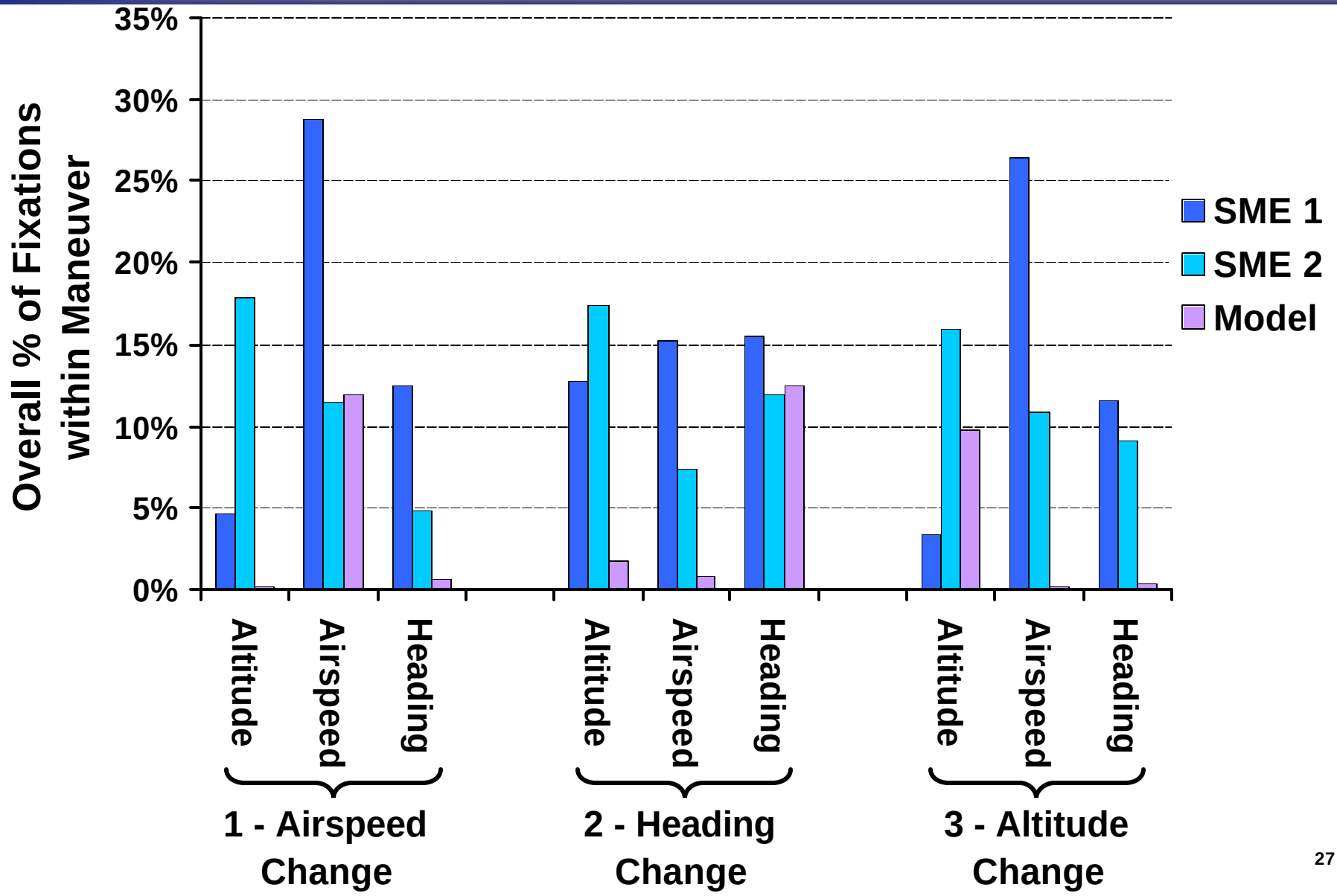
AIR FORCE RESEARCH LABORATORY

Backup Slides

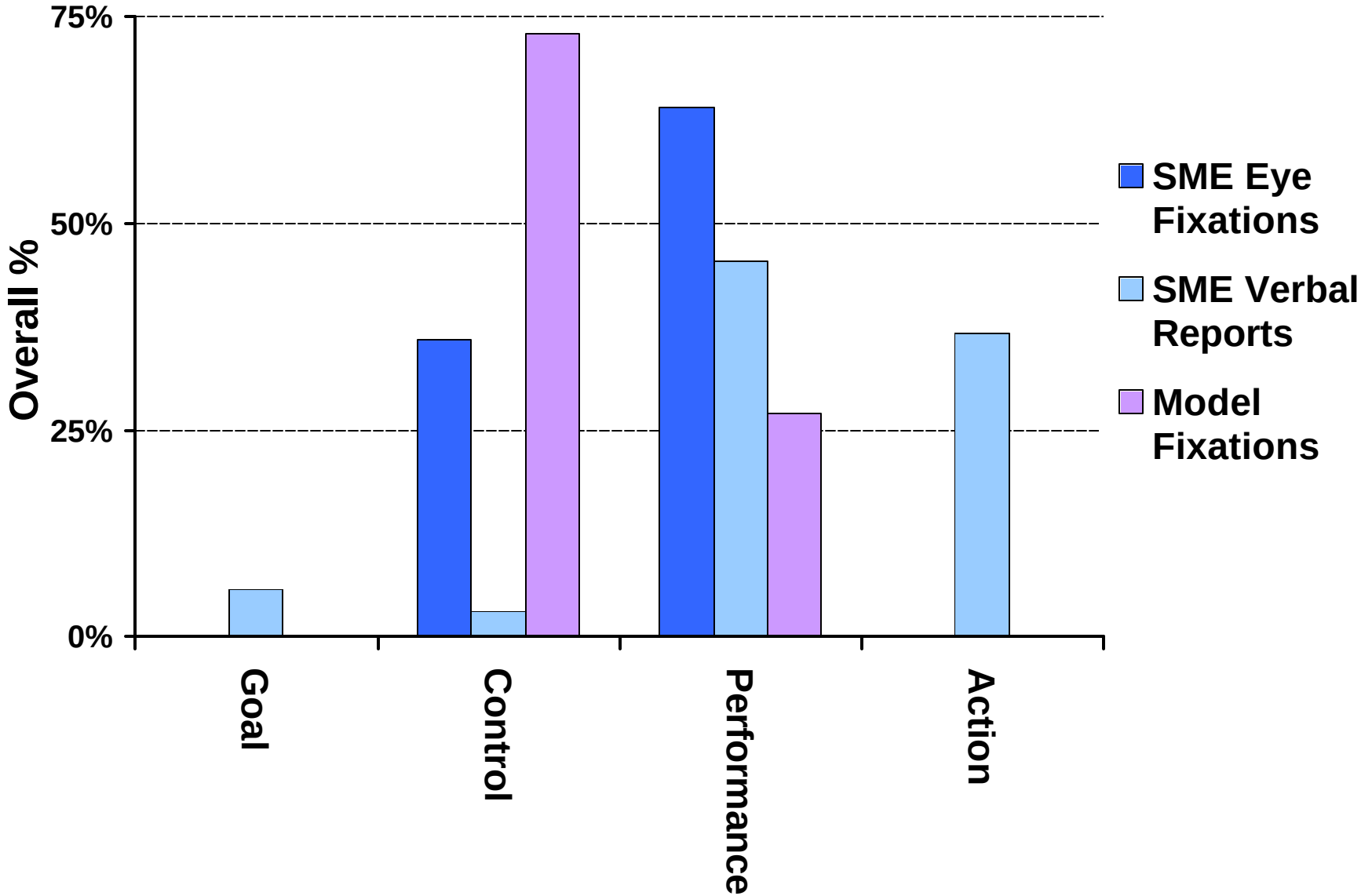
Fixation Data: Control Instruments



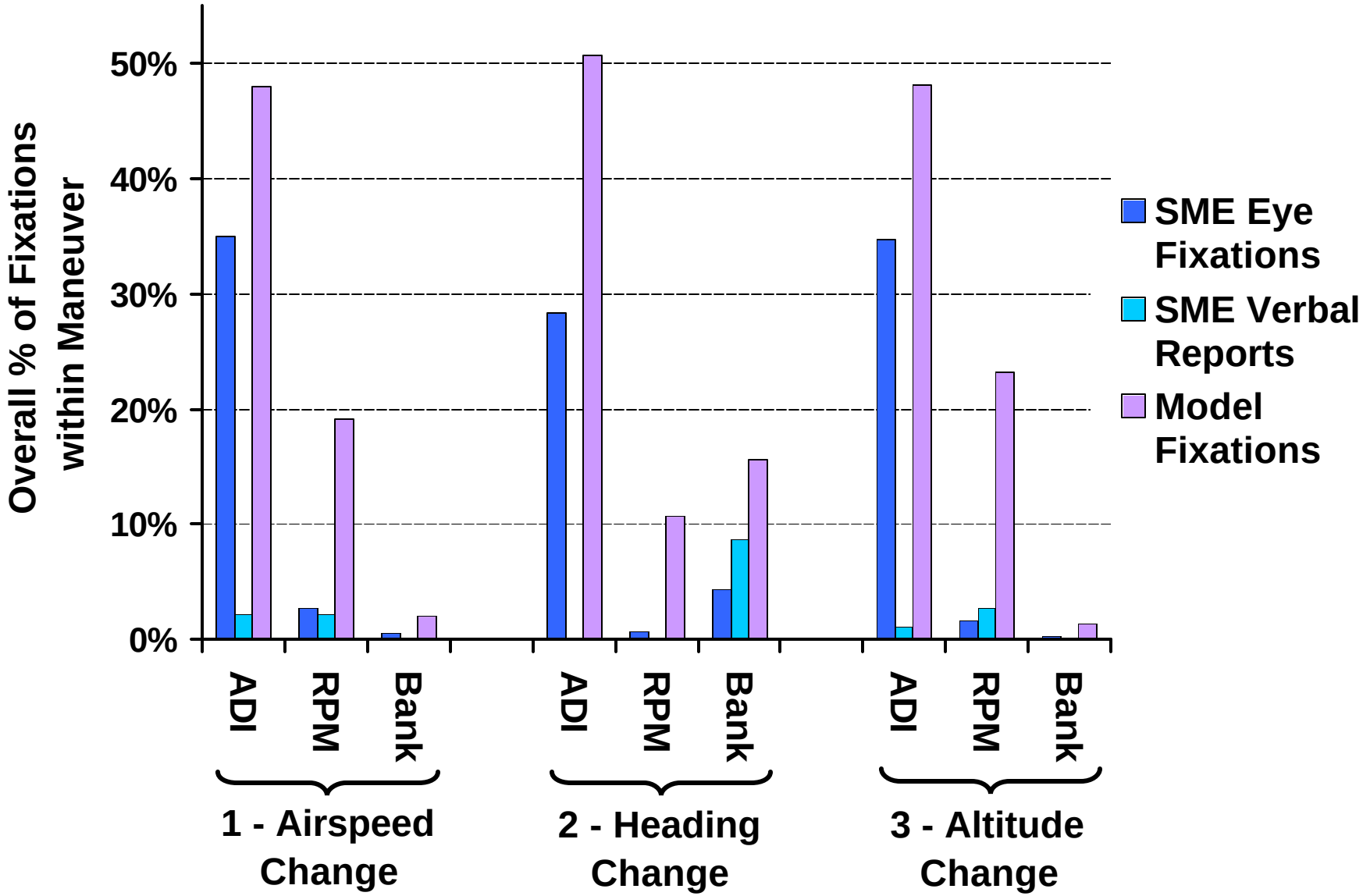
Fixation Data: Performance Instruments



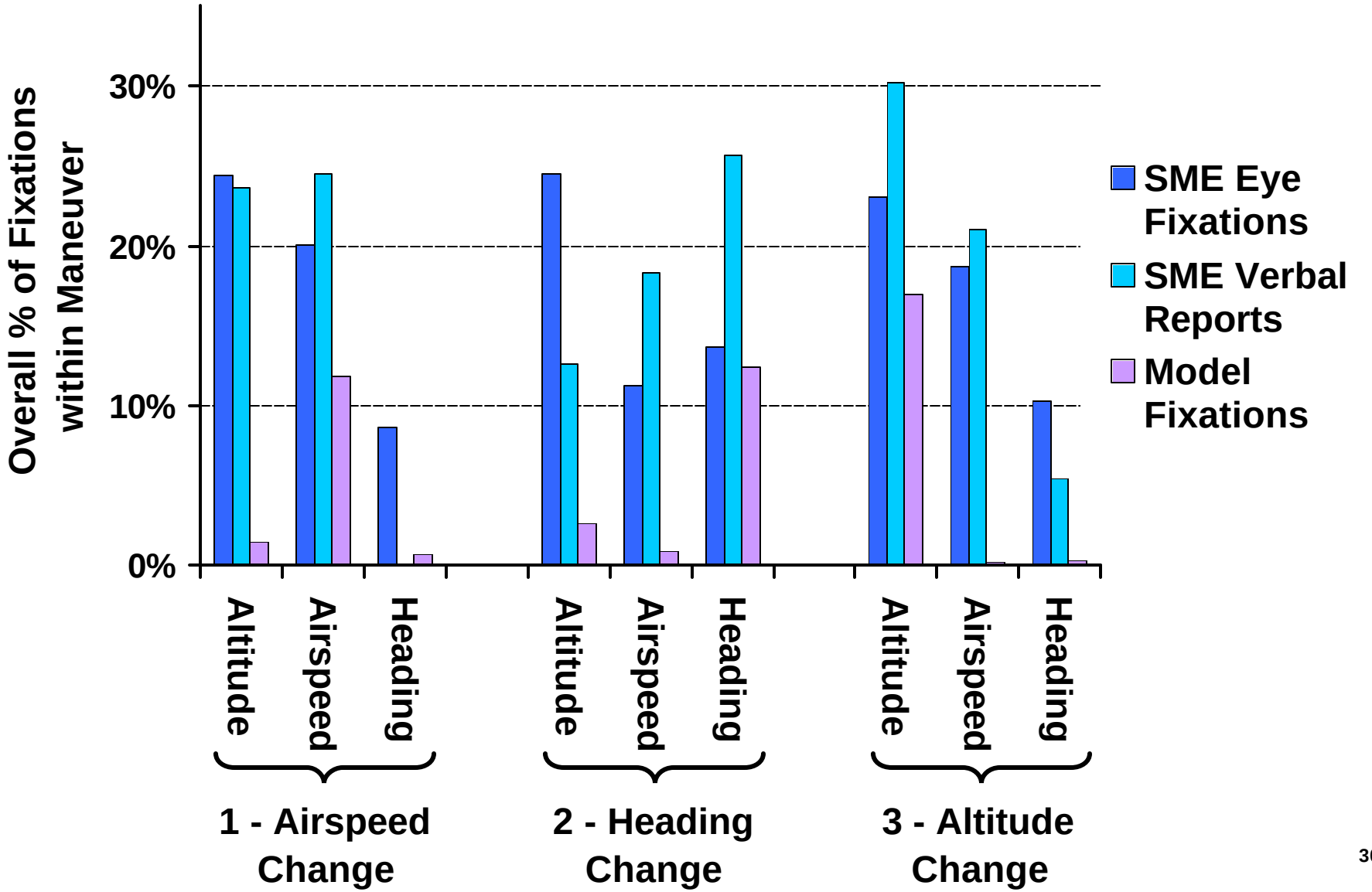
Fixation & Verbalization Data Maneuvers 1, 2, & 3



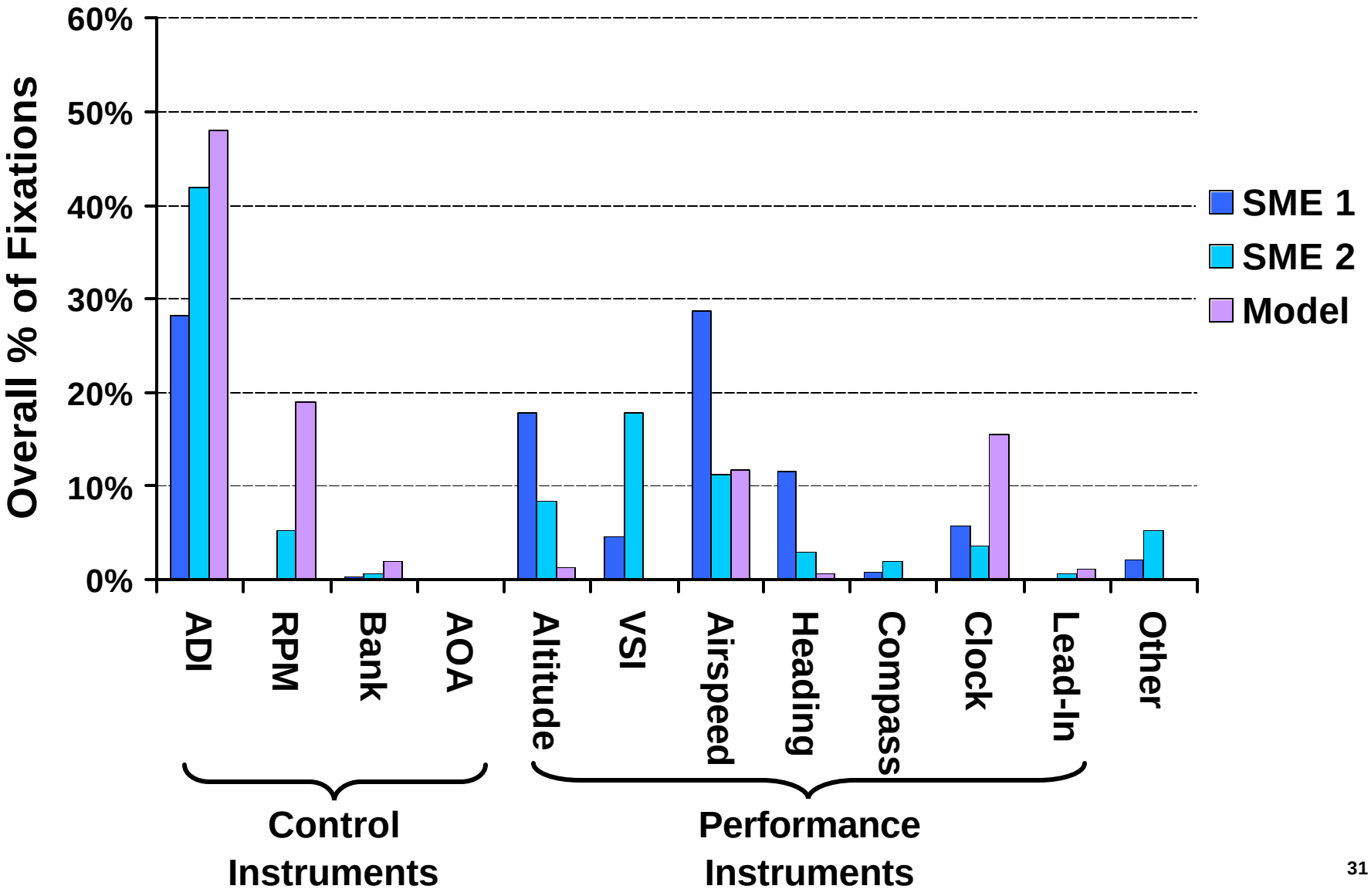
Fixation Data: Control Instruments



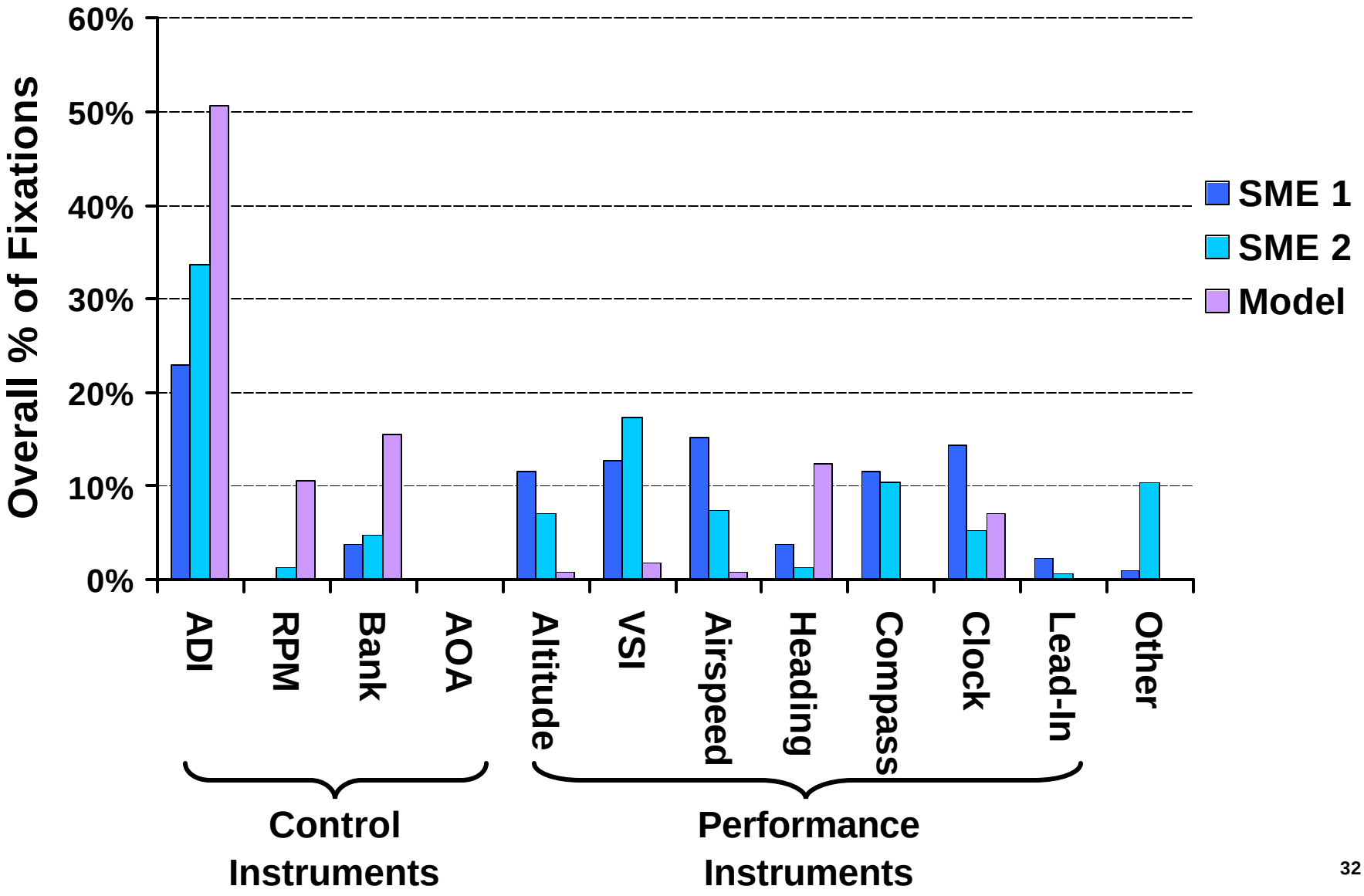
Fixation Data: Performance Instruments



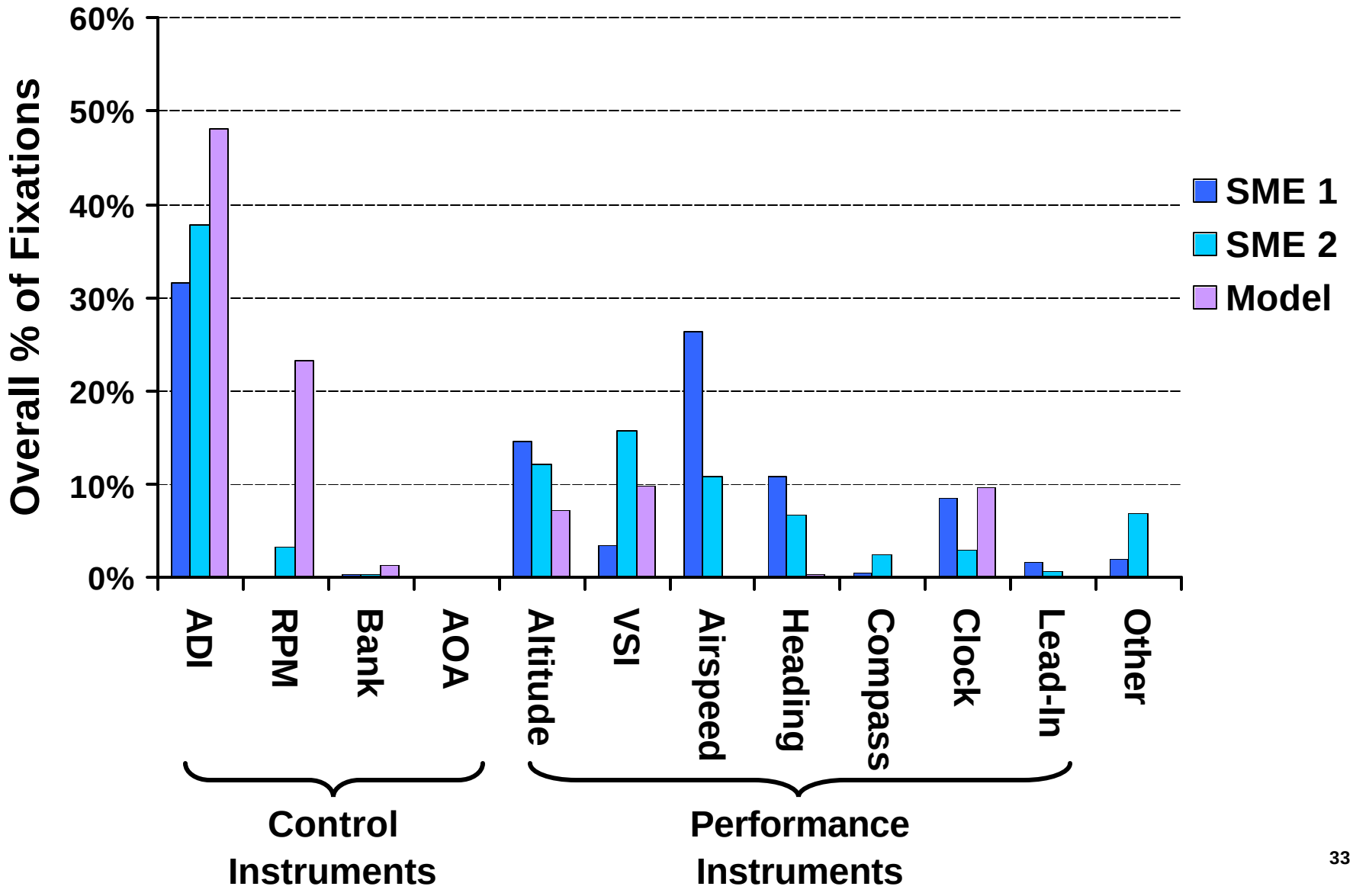
Fixation Data
Maneuver 1 – Airspeed Change



Fixation Data
Maneuver 2 – Heading Change



Fixation Data
Maneuver 3 – Altitude Change



Goal Chunk Hierarchy – Single Inheritance

Fly-aircraft – context, state, segment, intent, clock…

- **Crosscheck-goal** – renames Fly-aircraft
  - **Crosscheck-current-control** – current-pitch, current-bank, current-rpm…
    - **Crosscheck-control** – desired-pitch, desired-bank, desired-rpm…
      - **Establish-control** – renames Crosscheck-control
      - **Crosscheck-control-current-perf** – current-airspeed, current-altitude…
        - **Crosscheck-control-perf** – desired airspeed, desired-altitude…
          - **Crosscheck** – renames Crosscheck-control-perf