Transfer-of-Training Research at NASA Ames Research Center

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Outline

- Part I – Human Systems Integration Division
  - Research
  - Simulation Facilities (NASA SimLabs)

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  - Study 2: Transfer of Stall Recovery Training (NASA Aeronautics Research Program)
  - Discussion

Part I

Human Systems Integration Division

Human Systems Integration Division

The **Human Systems Integration Division** advances human-centered design and operations of complex aerospace systems through analysis, experimentation, and modeling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency, and mission success.

http://humansystems.arc.nasa.gov

Research Overview

Flight Deck Display Research Laboratory

The FDDRL develops both prototypes and guidelines for advanced interfaces which integrate displays, decision support tools, and flight deck automation.

Operationally Based Vision Assessment

The primary objective of the OBVA program is to correlate clinical vision standards to aircrew operational performance using a high fidelity synthetic environment to simulate operational visual tasks.

Vibration Laboratory

The objective of the Human Vibration Laboratory is to assess whole-body vibration impacts on visual, cognitive, and manual performance, understand the mechanisms contributing to vibration-induced performance deficits.

Research Overview

Airspace Operations Lab

The Airspace Operations Lab evaluates ATM concepts and explores human-system interaction issues in a simulation environment designed to allow rapid prototyping of NextGen concepts.

Human Perception and Cognition Research

Advance the fundamental understanding of how people perceive and process visual, vestibular, and auditory information.

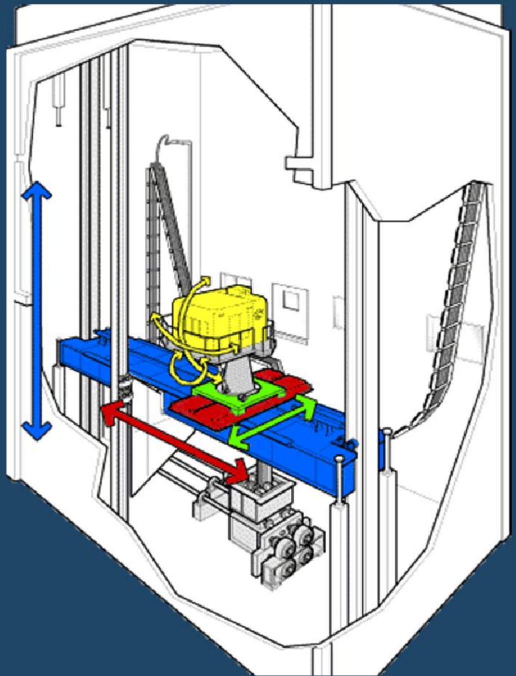
Automation Interaction Design Group

The development of methods and tools to support design and Human-Computer Interaction analysis of complex, safety-critical automated systems.

Simulation Facilities (SimLabs)

1. Vertical Motion Simulator (VMS)
2. Advanced Concepts Flight Simulator (ACFS)
3. B747-400 simulator
4. FutureFlight Central

http://simlabs.arc.nasa.gov



Part II

Transfer-of-Training Research

Introduction

The problem:

1. There is still no consensus on the value of motion in pilot training

2. There are no objective motion cueing criteria

Introduction

Why do simulators move?

1. Motions adds to pilot acceptance
2. Research shows a subjective preference for motion
3. Myriad of cue combinations leads regulators to adopt a conservative approach

Introduction

Previous work to determine the value of motion in flight simulation:

1. Effects of motion on skill-based manual control behavior in tracking tasks
2. Transfer-of-training research:
   a) Task performance in realistic flight tasks
   b) Performance and control behavior in tracking tasks

Introduction

Transfer-of-training research:

1. True transfer of training

2. Quasi transfer of training

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Study 1

Transfer of training on the Vertical Motion Simulator

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FAA Study Goal

Two research questions:

- Does objective evidence exist for the value of training with platform motion?
- Are recently proposed objective motion criteria effective in determining the value of motion for training?

AIAA-2014-2206

FAA Study Setup

Experiment design:

- Independent variable: 4 training motion groups (no mot., hex lo, hex hi, VMS)
- Tasks: 4 challenging flight tasks
- Participants: 61 pilots without commercial transport experience
- Aircraft model: enhanced for more representative aircraft response in the stall and overbank tasks

FAA Study Setup

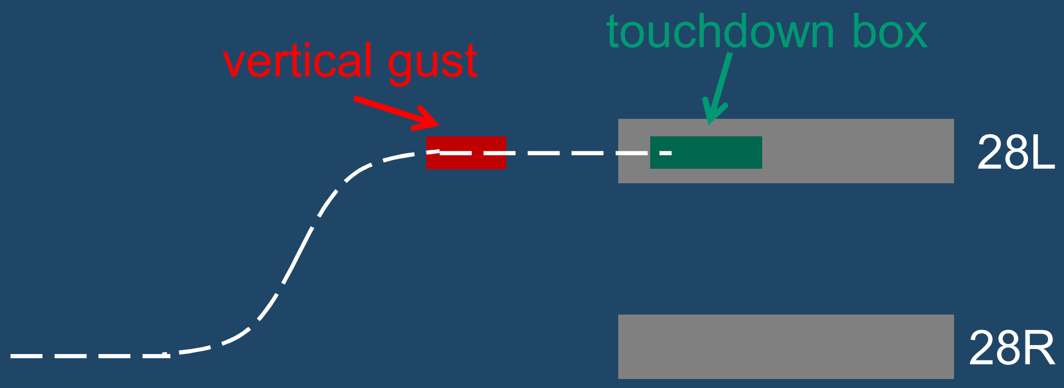
Experiment design (continued):

- Training: until proficient (minimum of 3, maximum of 6 runs)
- Check run: only 1 try
- Evaluation: instructor pilot in right seat and experiment observer in control room
- Cockpit: T-CAB with B777 PFD

FAA Study Setup

Task 1: Approach and landing with sidestep:

1. Track the GS and LOC to SFO RWY 28R maintaining 141 KIAS
2. Perform sidestep to RWY 28L at ATC command
3. Continue visual to RWY 28L maintaining GS
4. Flare and touchdown 750 –1,500 ft from the threshold
5. Task evaluation ends at touchdown



FAA Study Setup

Task 2: High-altitude stall recovery at FL 410:

1. Retard throttle to idle
2. Roll left to a 15 deg bank angle
3. Pull up to decelerate at approximately 4 kt/s
4. Continue deceleration through stick shaker until a sink rate develops
5. Apply nose down pitch, roll as needed, power as needed to return to steady-state flight

FAA Study Setup

Task 3: Overbank upset recovery at 5,000 ft:

1. Hands off controls as computer flies the aircraft to 120 deg left bank and 20 deg nose down pitch attitude

2. At the command "your airplane", unload, roll wings level, and then apply nose-up pitch rate similar to a takeoff rotation rate to recover safely to level flight

FAA Study Setup

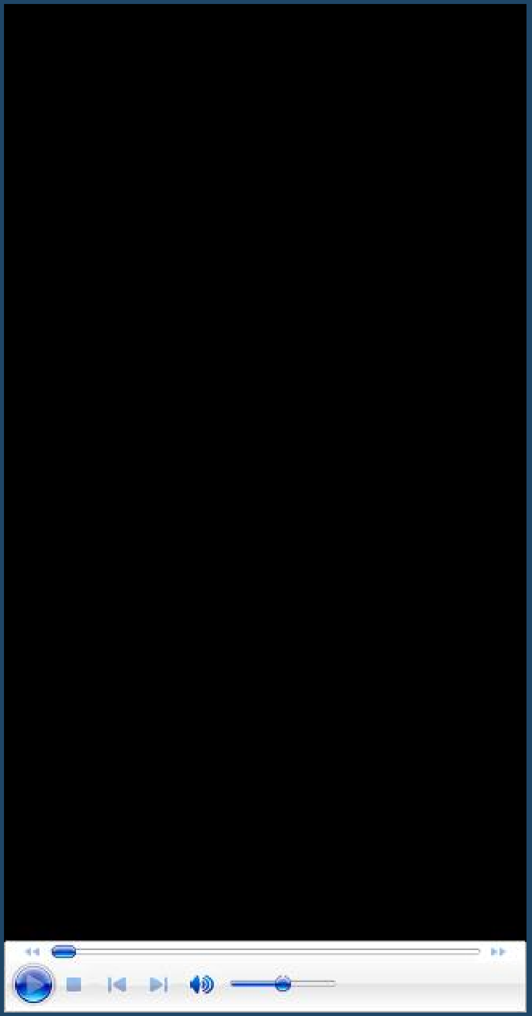
Task 4: Engine out on takeoff:

1. Advance throttles to takeoff thrust (60% N1)
2. Maintain centerline
3. Rotate at Vr = 128 kts to a pitch attitude of 10 degs and establish speed of V2 + 10
4. Maintain heading and speed after single engine failure

FAA Study Setup

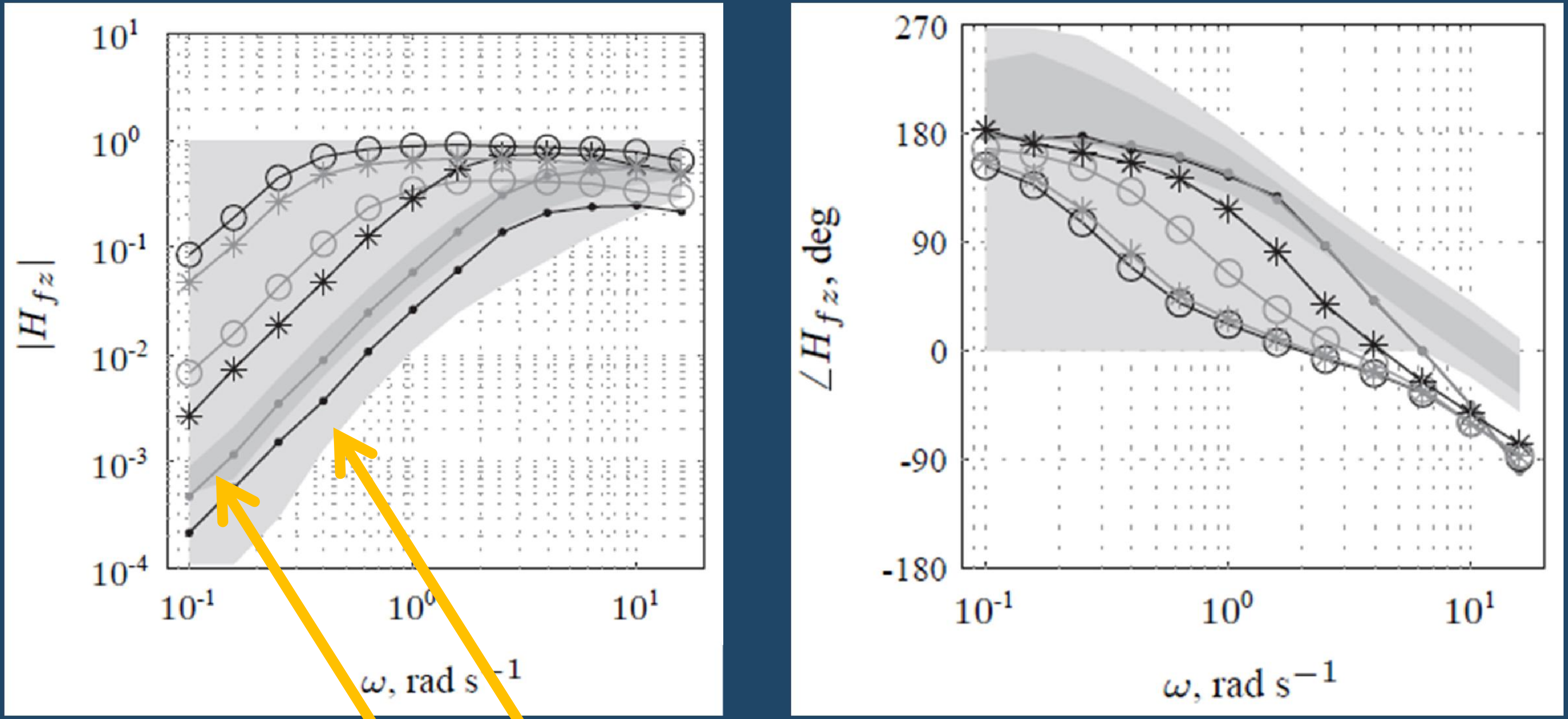
Motion conditions:

Condition	Description
NOM	no-motion for all tasks
HLO	small hexapod motion for all tasks
HHI	large hexapod motion for all tasks
SIDE	VMS motion for sidestep task
HALT	VMS motion for stall task
OVER	VMS motion for overbank task
TOFF	VMS motion for takeoff task



FAA Study Setup

Objective Motion Cueing Test:



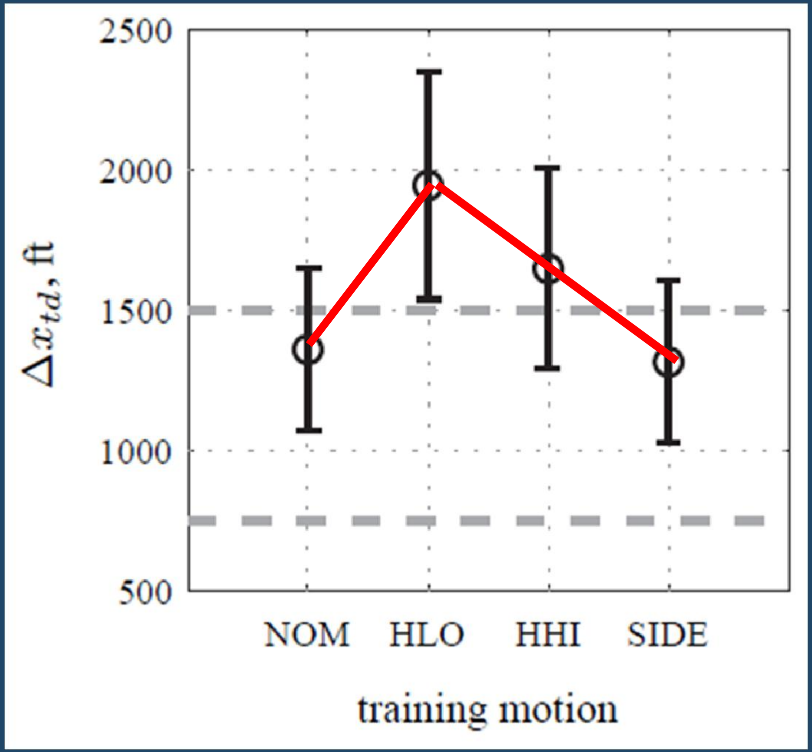
fidelity region

preliminary OMCT data

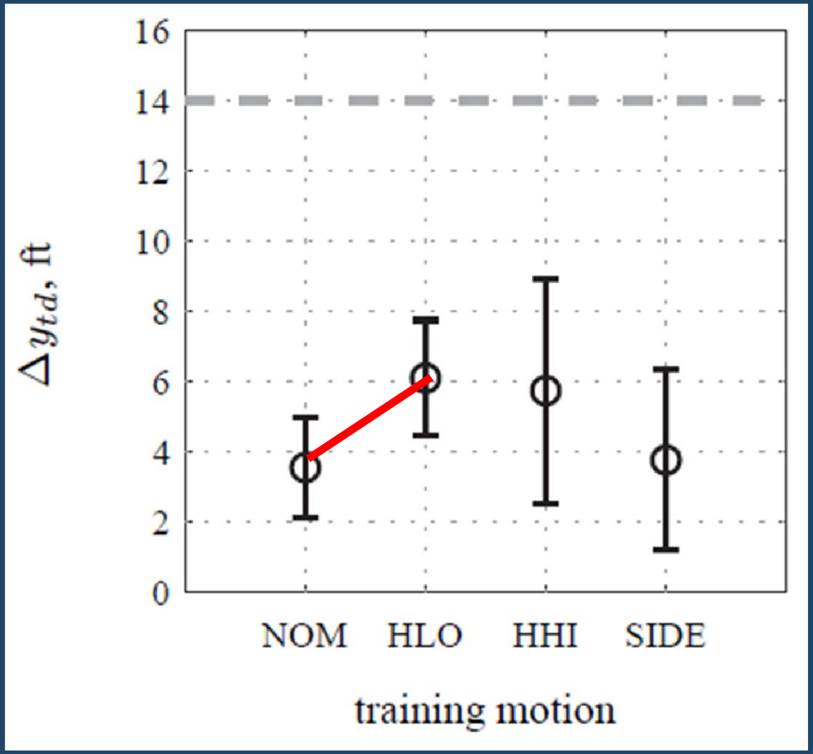
FAA Study Results

Approach and landing with sidestep:

longitudinal deviation



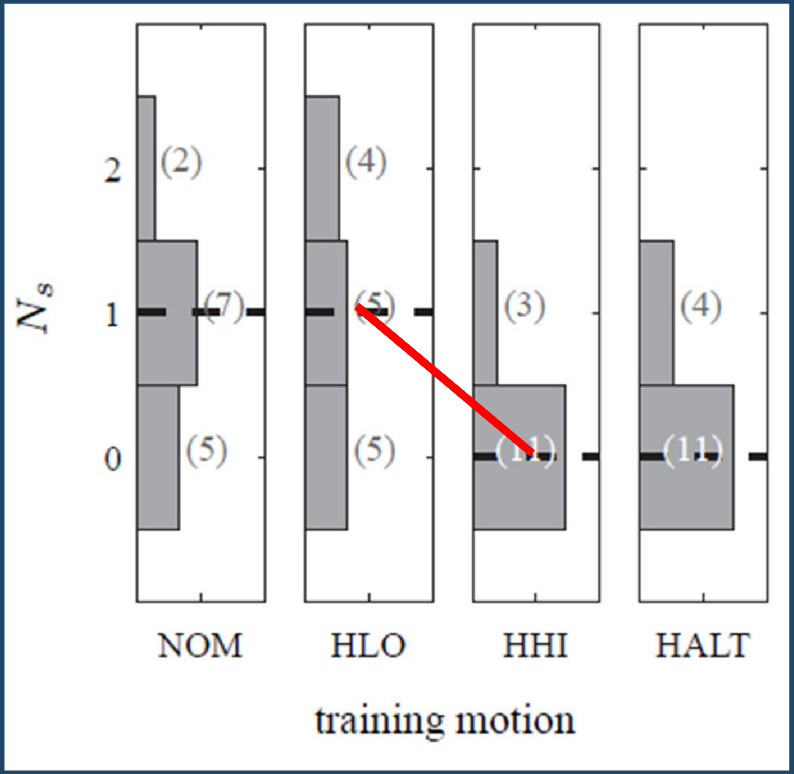
lateral deviation



FAA Study Results

High-altitude stall recovery:

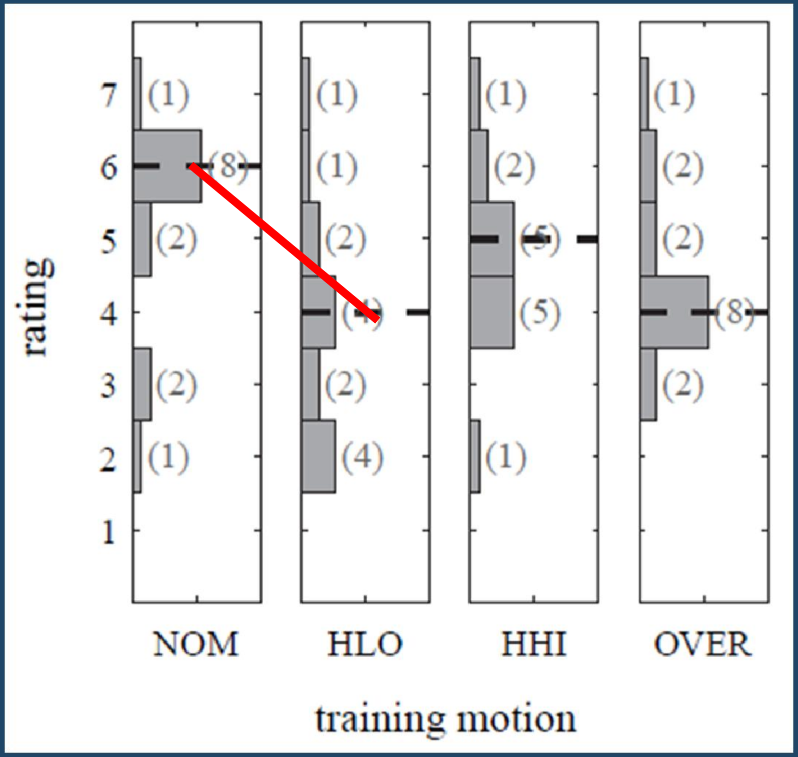
stick shakers



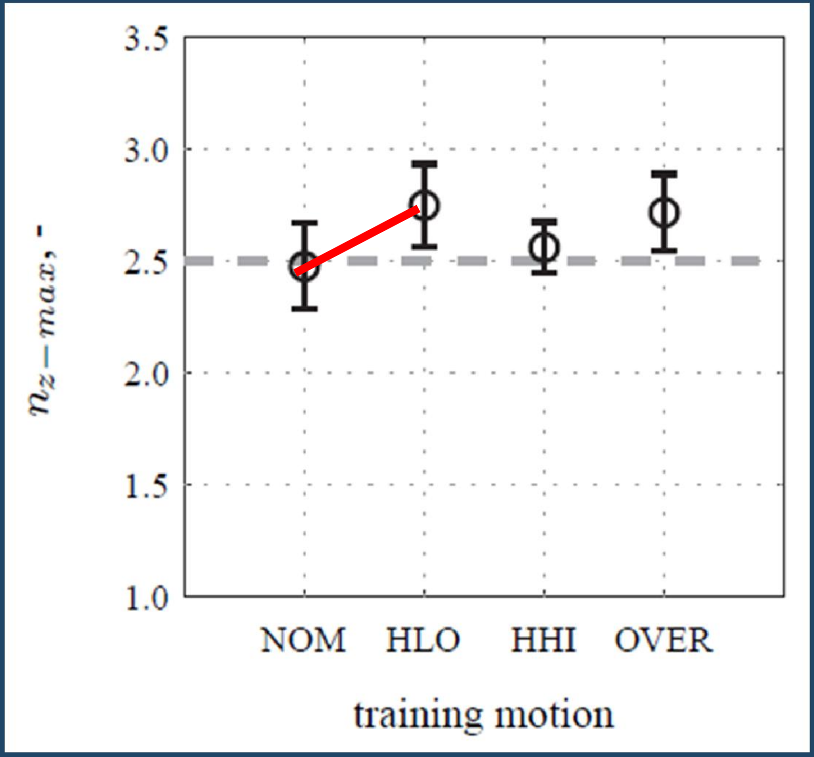
FAA Study Results

Overbank upset recovery:

pilot rating



load factor



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FAA Study Results

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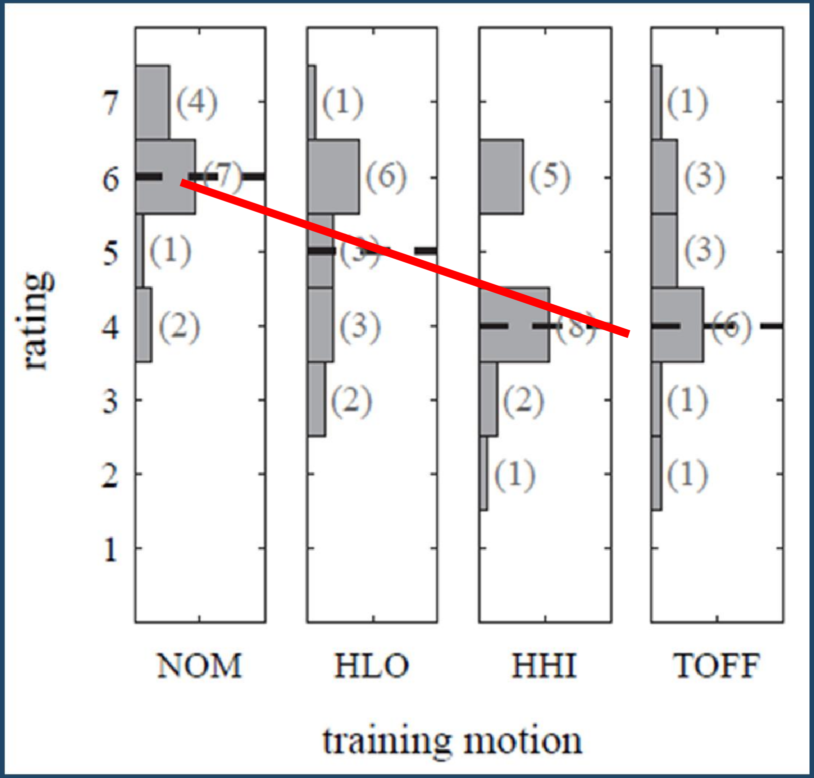
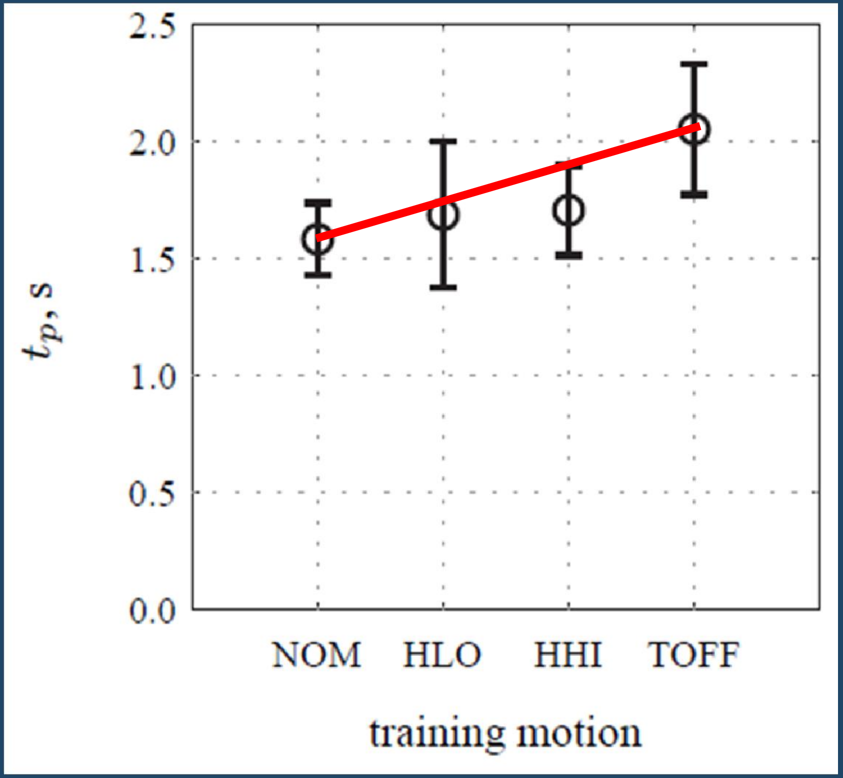
Engine out on takeoff:

pilot rating



reaction time



FAA Study Discussion

We found objective measures that depend on the motion condition in training

However, we found a limited number of significant effects:

- Results are from single runs
- Pilots not familiar with aircraft dynamics
- No familiarization with tasks
- Scripted nature of tasks
- Criteria not strict enough
- Task performance might not be the best measure

FAA Study Discussion

Objective motion cueing criteria show early promise

However, some improvements can be made to the OMCT and the newly proposed criteria:

- One-size-fits-all approach is not always appropriate
- Self checks should be introduced to validate results
- In some axes less sensitive compared to Sinacori Criteria
- Criteria not valid for more exotic motion filters

FAA Study Conclusions

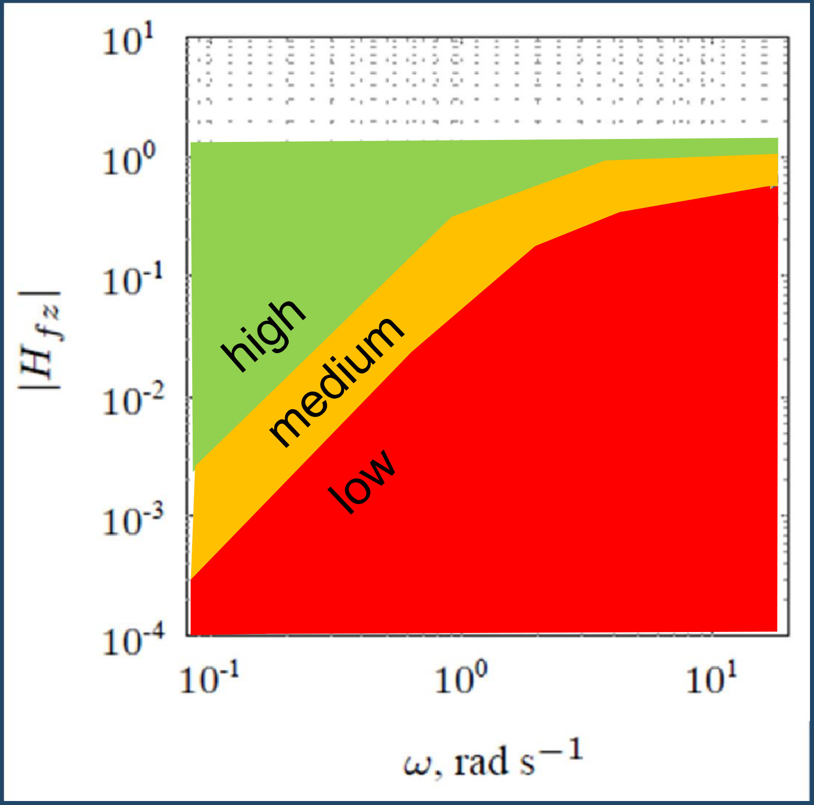
Two principal conclusions:

1. The study found objective measures that depend on the motion condition in training

2. The new objective motion criteria may offer valid standardization benefits, as increases in the training motion fidelity, as predicted by the criteria, resulted in expected trends in pilot ratings and objective performance measures after transfer

FAA Study Future Research

The objective of the next experiment (end 2014) is to refine the new motion criteria:



Study 2

Transfer of Stall Recovery Training

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Stall Recovery Training Introduction

In early 2014, the FAA issued an update to AC 120-109, covering stall prevention and recovery training

However, current flight simulators do not represent aircraft behavior in upset situations that take the aircraft out of its normal flight envelope

Stall Recovery Training Introduction

Main focus of previous research:

- The development of useful post-stall aircraft model characteristics
- Increasing the realism of motion stimuli in upset recovery simulation
  - No focus on training

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Stall Recovery Training Introduction

NASA

Importance of motion during an approach to and recovery from a stall:

- Approach: buffeting, reduced pitch and roll control effectiveness, reduced or negative roll stability, wing drop
- Recovery: sensitive pitch control (amount of back pressure is important)

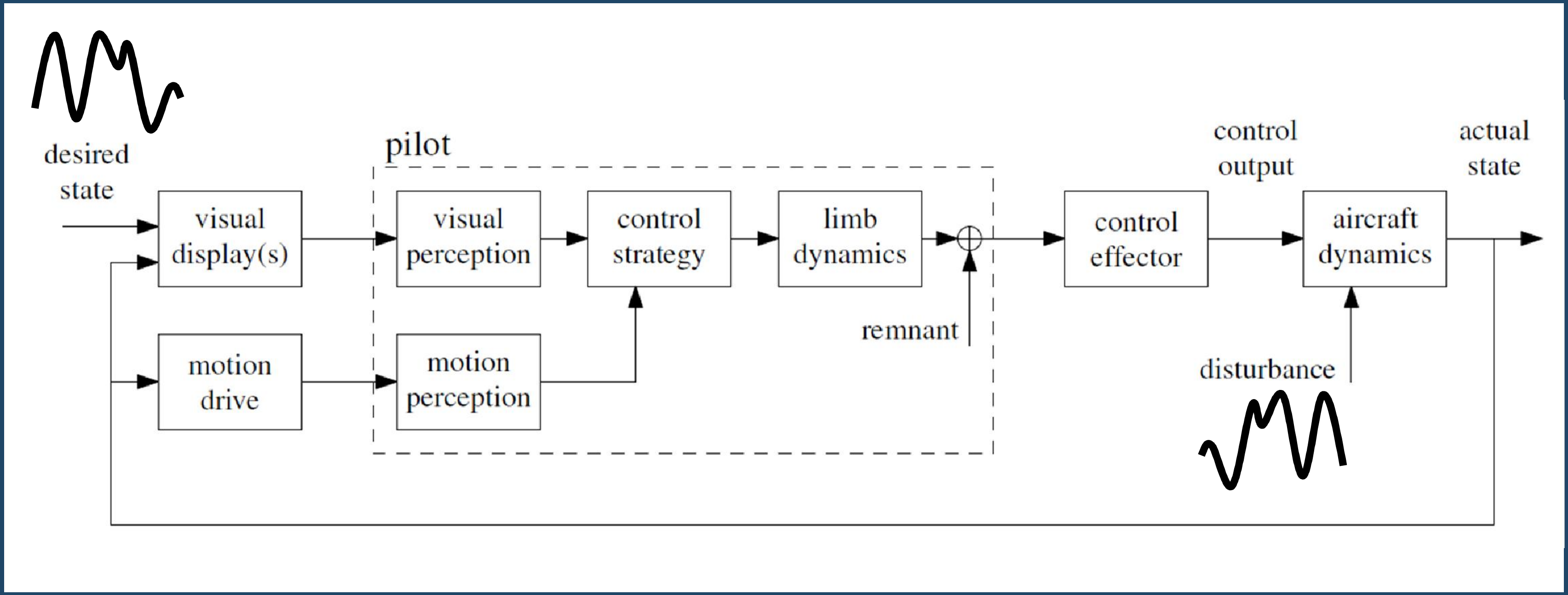
Stall Recovery Training Study

Main objective:

- Optimize motion cueing for maximum transfer of stall recovery training using a cybernetic approach

Stall Recovery Training Study

Cybernetic approach:



Stall Recovery Training Study

Planning:

1. Preliminary experiments in a part task simulator to optimize our identification and modeling techniques (July/August)
2. VMS experiment on motion and visual cue integration in training (September/October)
3. VMS experiments on stall recovery training

Summary

Two approaches in transfer-of-training research:

1. Task performance in realistic flight tasks
   – Limited benefits of motion found
   – More relevant for authorities and training institutes
2. Skill-based behavior and performance in tracking tasks
   – Motion improves skill acquisition and performance after transfer
   – Less relevant for authorities and training institutes

Discussion and Questions

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