Replicating HAVE PIO on the NASA Ames VMS

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Outline

- Introduction
- Experiment description
- Results
- Known simulation/flight disparities
- Conclusions

Introduction

- Ground-based simulation has not had much success in predicting PIOs
- National Research Council recommended high priority be given to validating simulation
- Previous flight-test study (HAVE PIO) offers a set of pitch data for validation

Introduction

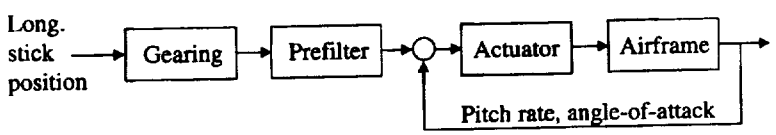
- Wright Laboratory replicated in-flight study using two fixed-base simulators
- Purpose of this study:
  - Determine if the amount of platform motion affects ability to replicate in-flight results

Experiment description

- Math model
- Task
- Visual system
- Motion configurations
- Safety pilot and miscellany

Experiment description

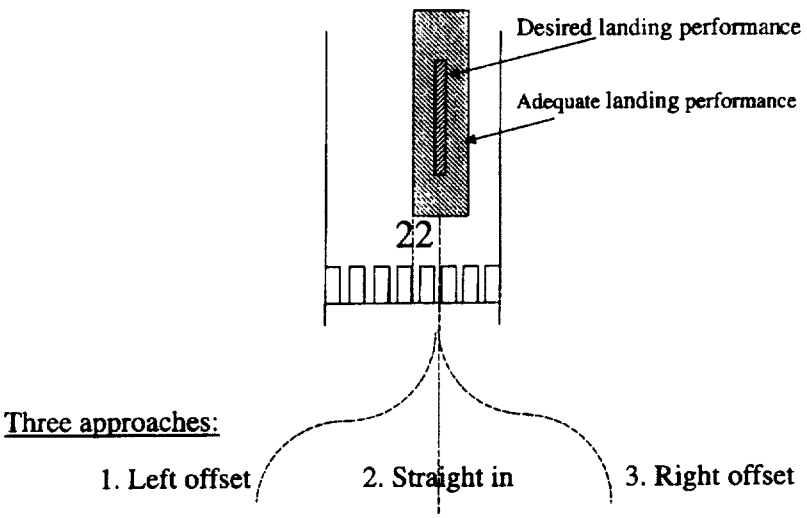
Math model



- NT-33 airframe simulated w/ stability derivs.
- 18 sets of pitch dynamics

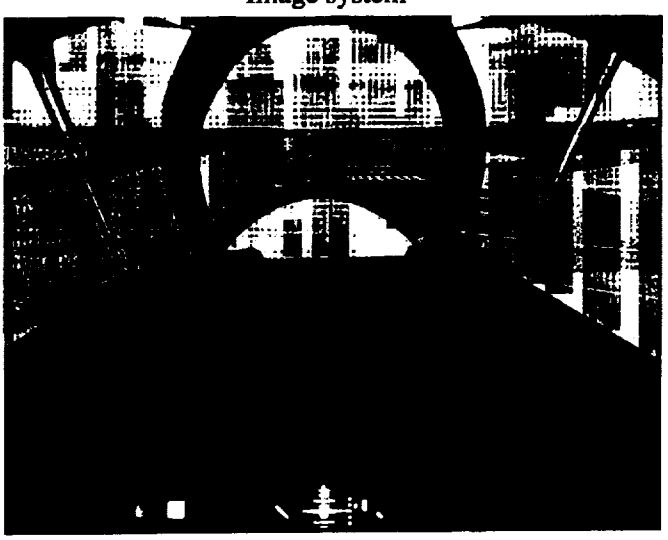
Experiment description

Task



Experiment description

Image system

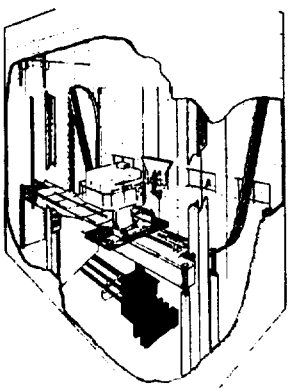


Experiment description

Motion configurations

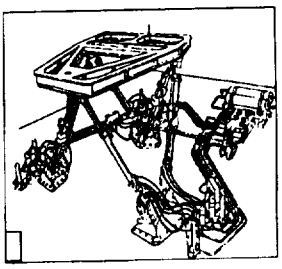
- Vertical Motion Simulator used to simulate all motion configurations

Vertical Motion Simulator displacements



Classical motion drive logic

Typical hexapod displacements (5 ft stroke)



Coordinated adaptive motion drive logic

No motion

Experiment description

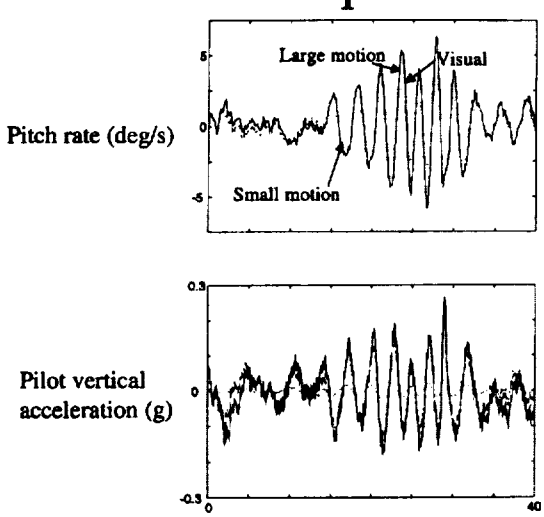
Safety pilot and miscellany

- Automated safety pilot assumed command if situation deemed hazardous
  - Nosegear sink rate > 8 ft/sec when below 12 ft
- Stick ergonomics and force-feel closely matched aircraft
- Five test pilots (3 NASA, 1 FAA, 1 Boeing) flew all combinations of motion and aircraft configurations (randomized)

Results

- Example PIO
- Handling qualities ratings
- Pilot confidence ratings
- PIO ratings
- Touchdown velocities

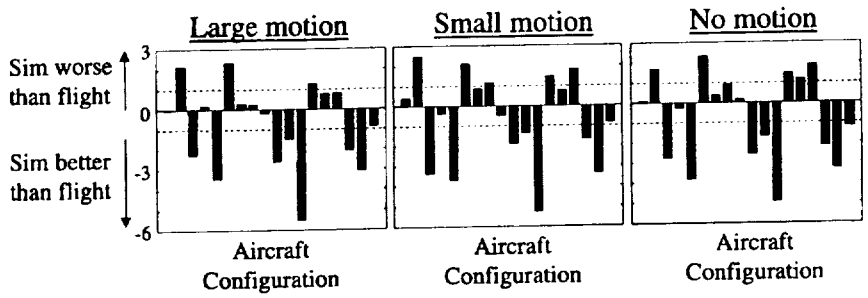
Example PIO



Large motion satisfactorily simulates pilot normal acceleration

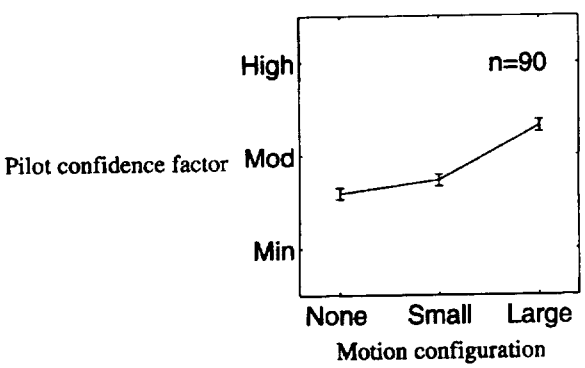
Handling qualities ratings

Simulation versus flight



Large motion had more ratings within +/- 1 of flight rating

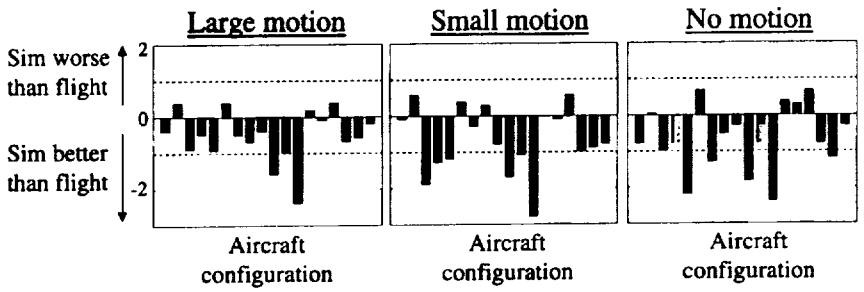
Pilot confidence factors



More confidence in rating with more motion

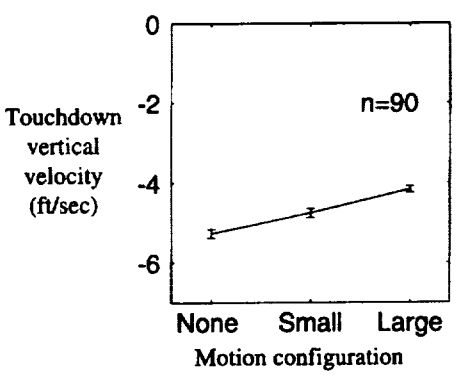
PIO ratings

Simulation versus flight



Large motion had more ratings within +/- 1 of flight rating

Touchdown velocities



Large motion allowed better touchdown sink rate control

Known simulation/flight disparities

Likely top 5

- Stress-induced environment
- Visual content
- Different evaluation pilots
- Simple automatic versus real safety pilot
- Field-of-view

Conclusions

- With large motion:
  - handling qualities ratings correlated best with flight
  - higher pilot confidence ratings achieved
  - PIO ratings correlated best with flight
  - lower touchdown velocities resulted
- Only large motion provided high fidelity vertical motion cues
- List of disparities between simulation and flight suggests future work