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AN EVALUATION OF AUTOMATIC CONTROL SYSTEM CONCEPTS FOR GENERAL AVIATION AIRPLANES

by

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ABSTRACT

A piloted simulation study of automatic longitudinal control systems for general aviation airplanes has been conducted. These automatic control systems were designed to make the simulated airplane easy to fly for a beginning or infrequent pilot. Different control systems are presented and their characteristics are documented. In a conventional airplane control system each cockpit controller commands combinations of both the airspeed and the vertical speed. The best system in the present study decoupled the airspeed and vertical speed responses to cockpit controller inputs. That is, the cockpit throttle lever commanded only airspeed responses, and the longitudinal wheel position commanded only significantly reduced the pilot workload throughout an entire mission of the airplane from takeoff to landing. An important feature of the automatic system was that neither changing flap position nor maneuvering in steeply banked turns affected either the airspeed or the vertical speed. All the pilots who flew the control system simulation were favorably impressed with the very low workload and the excellent handling qualities of the simulated airplane.

The following pages are reproductions of the slides used in this presentation.

SIMULATION STUDY OF EASY-TO-FLY GENERAL AVIATION AIRPLANES

by

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OUTLINE

- Background
- Control description
- Display description
- Evaluation procedure
- Results (Video)
- Conclusions
- Follow-on activities

PURPOSE

Increase utility and productivity of general aviation airplanes by

- **Making them easier to fly**
  - **-Reduce initial training requirements**
  - **-Reducing proficiency requirements**
- **Making them safer to fly**
  - **-Reducing pilot blunders**
  - **-Eliminating stalls**

RESEARCH OBJECTIVES

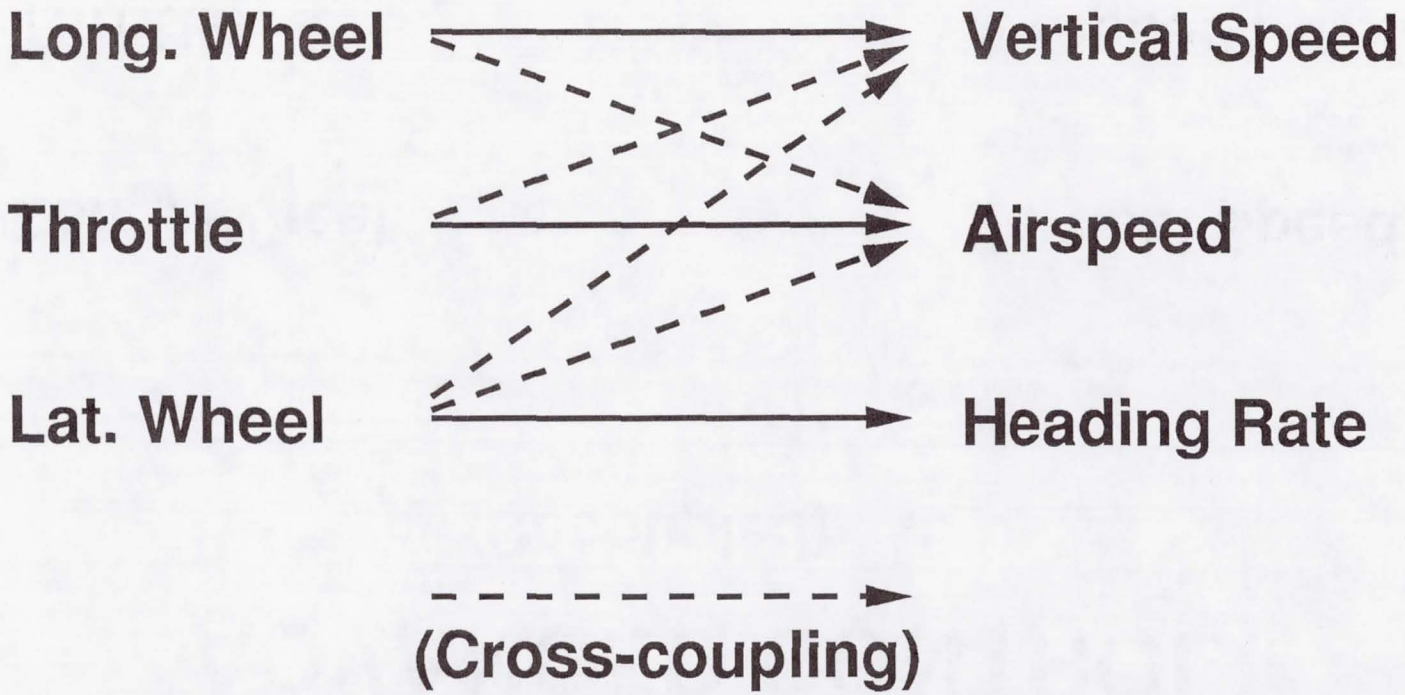
- Simplify control--more "car-like"
- Improve display--more intuitive

STUDY METHOD

- Develop control system
- Develop display
- Evaluate combined system

CONVENTIONAL CONTROL

(Coupled)



ADVANCED CONTROL

(Decoupled)

Long. Wheel	→	Vertical Speed
Throttle	→	Airspeed
Lat. Wheel	→	Heading Rate

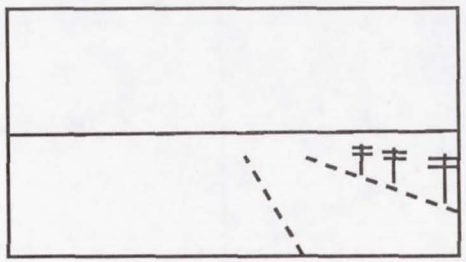
PICTURE FROM A CAR

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

PICTURE FROM AN AIRPLANE

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

HIGHWAY IN THE SKY(HITS)
POSITION GUIDANCE



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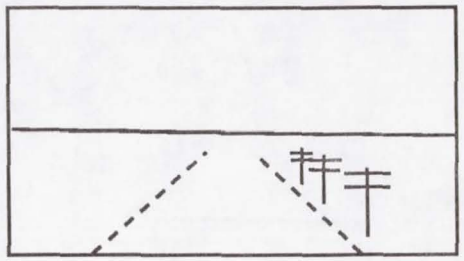

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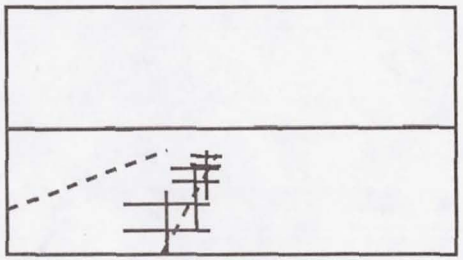

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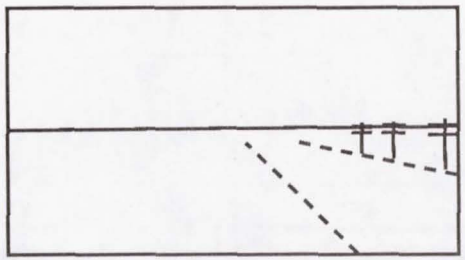

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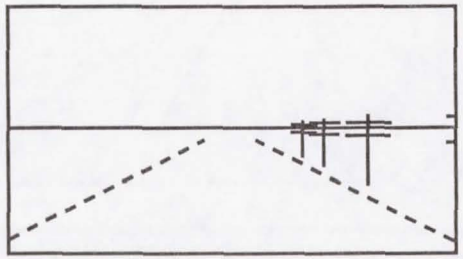
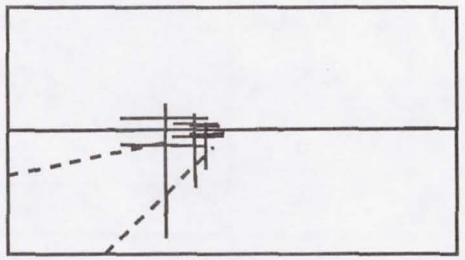


On Path



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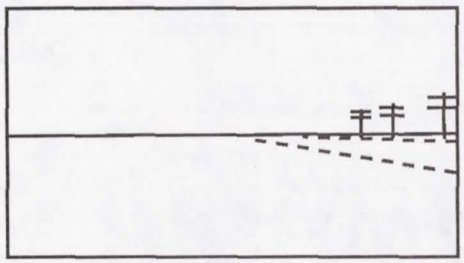

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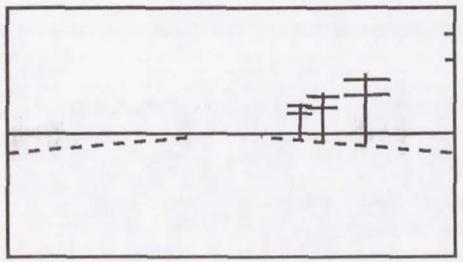

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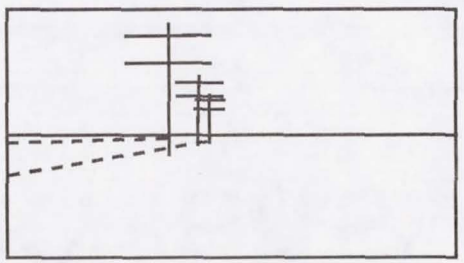

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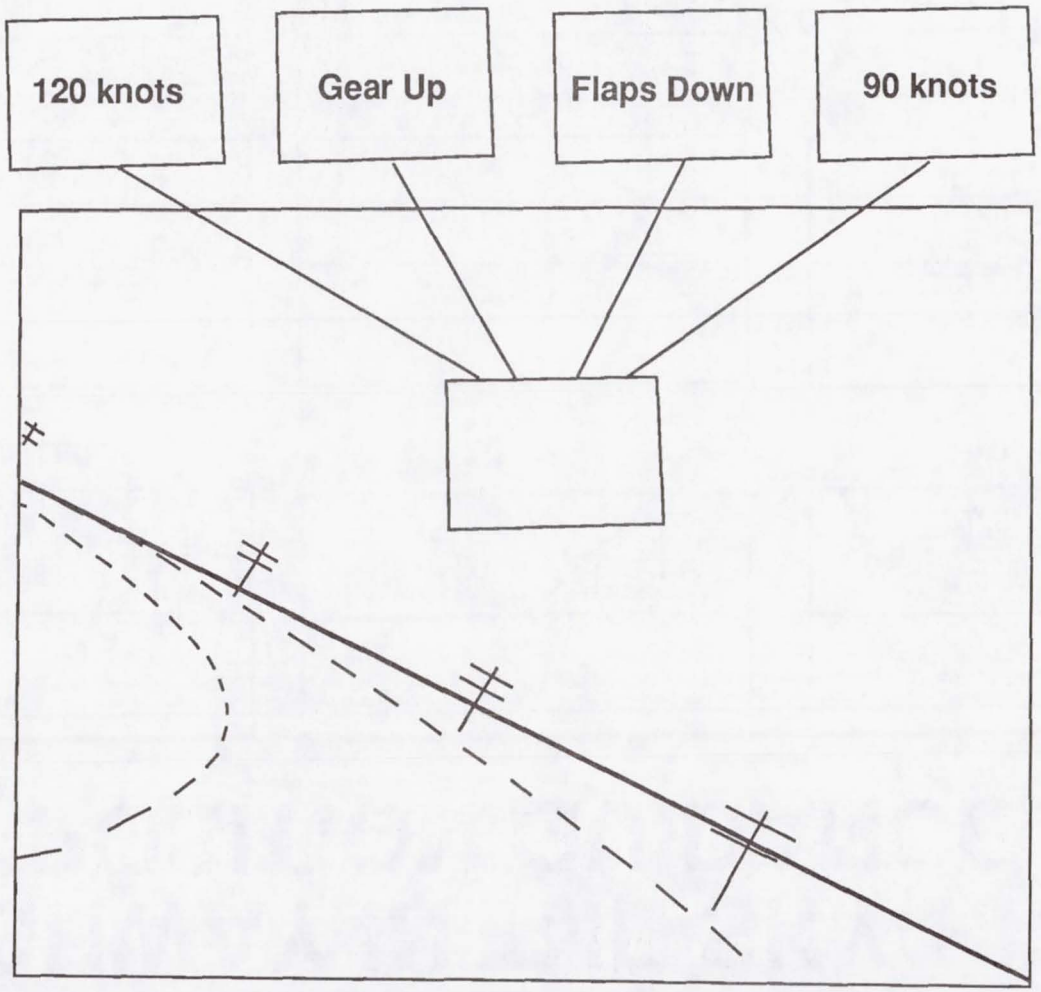
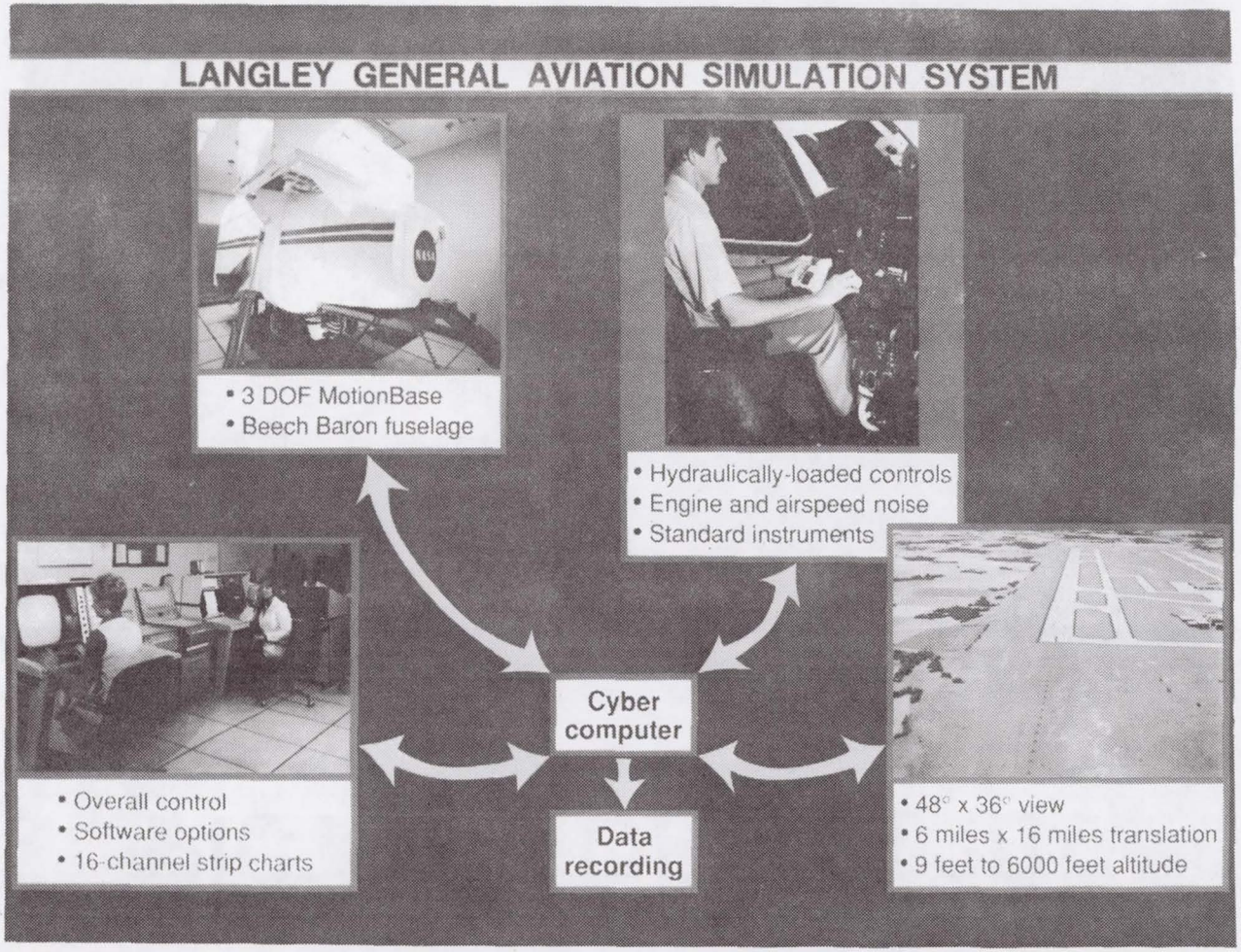
HIGHWAY IN THE SKY (HITS) FORMAT



SIMULATOR SYSTEM



ORIGINAL PAGE
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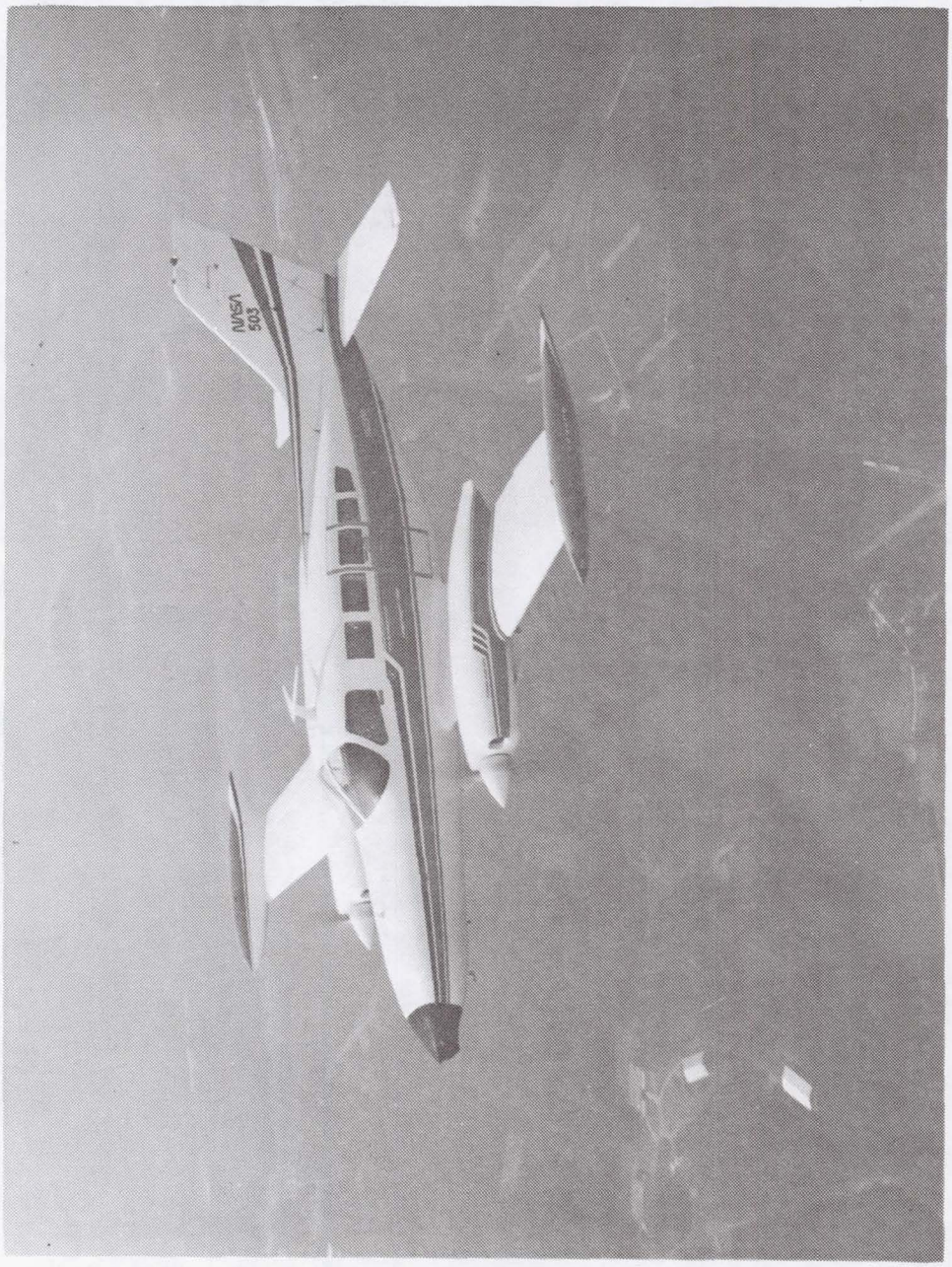
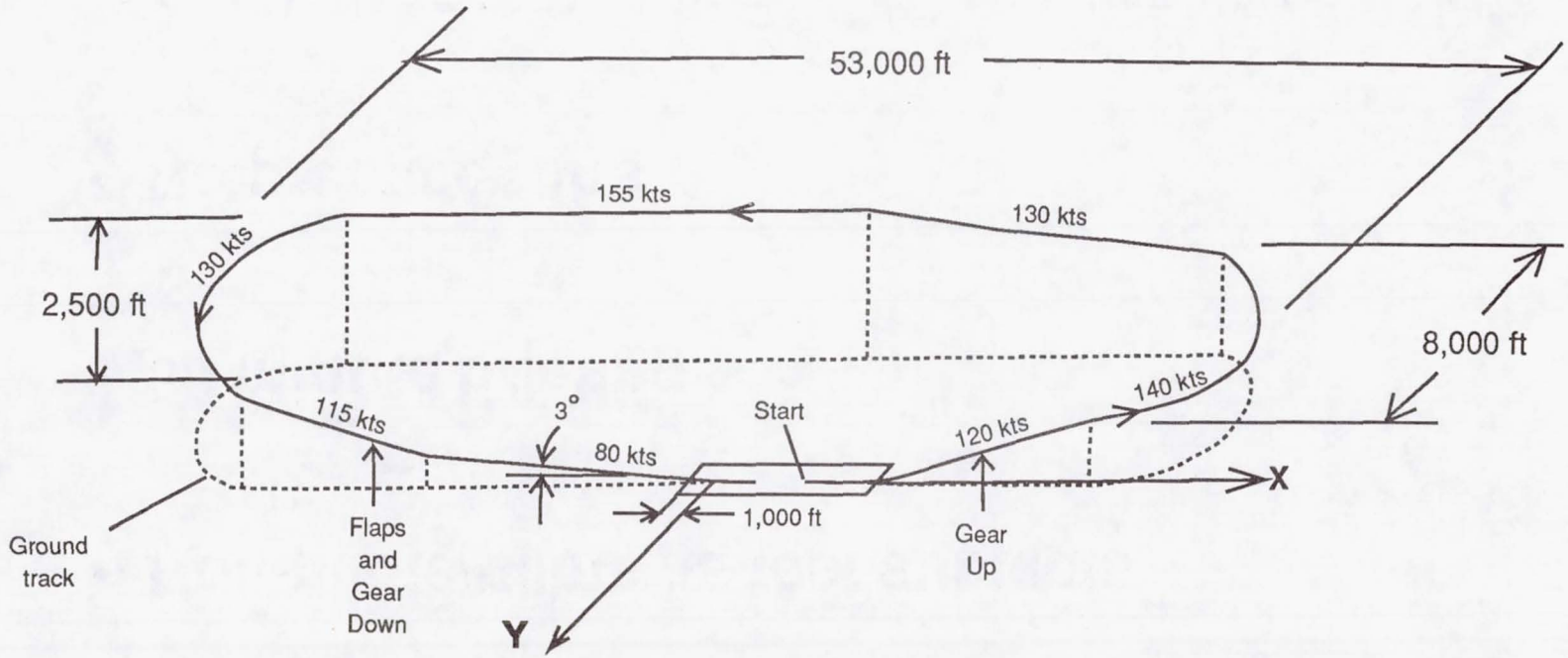
PICTURE OF C-402B



EVALUATION PROCEDURE

- Non-pilots/pilots as test subjects
- 30 minute briefing
- No practice runs
- 1 st run: Display & Decoupled Control
- 2 nd run: Display & Conventional Control

MANEUVER



Note: Not to Scale

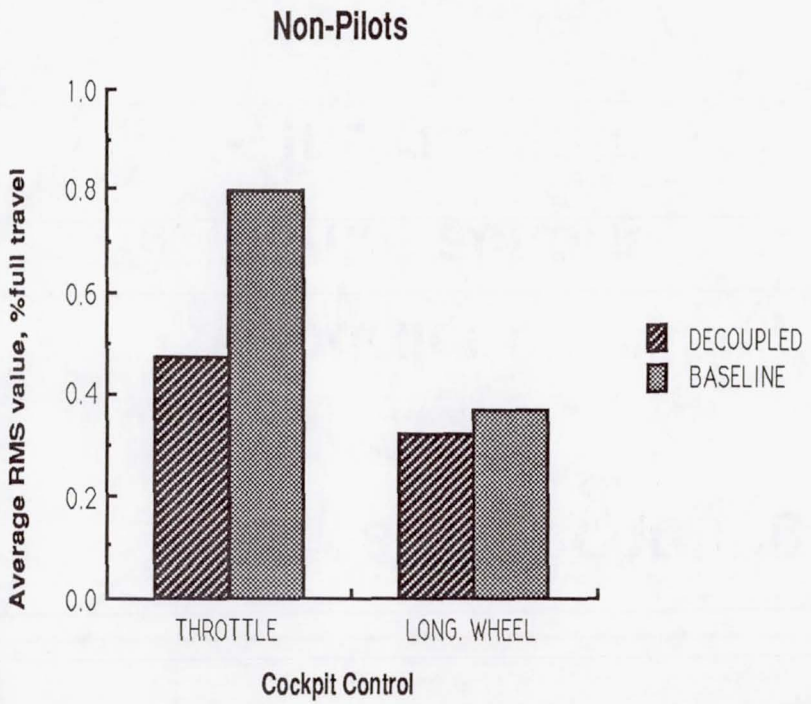
(Cloud ceiling =200 feet)

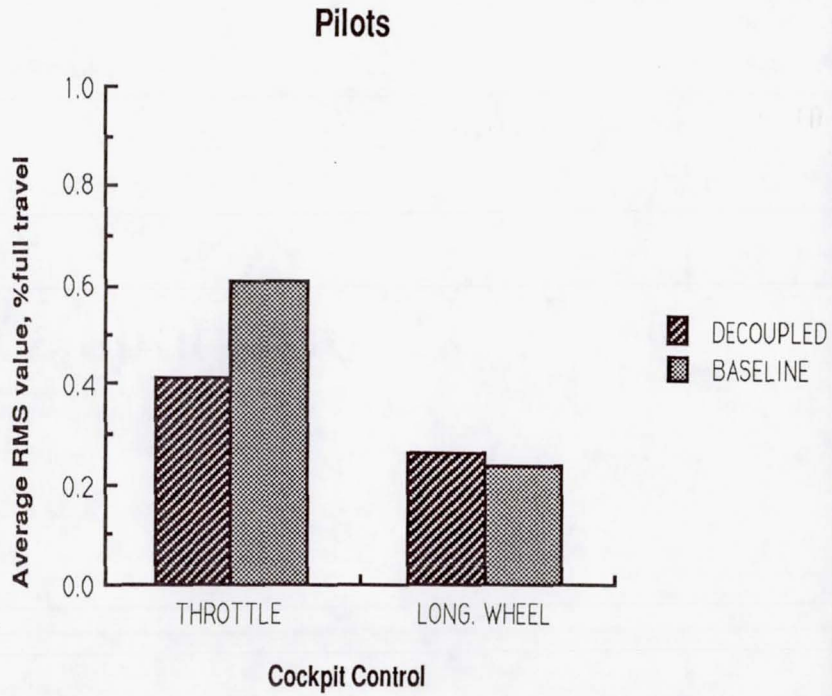
VIDEO

- Research recording
- Recorder over the pilot's shoulder
  - Pilot actions
  - Instruments
- Superimposed visual scene in upper right corner

CONTROL ACTIVITY

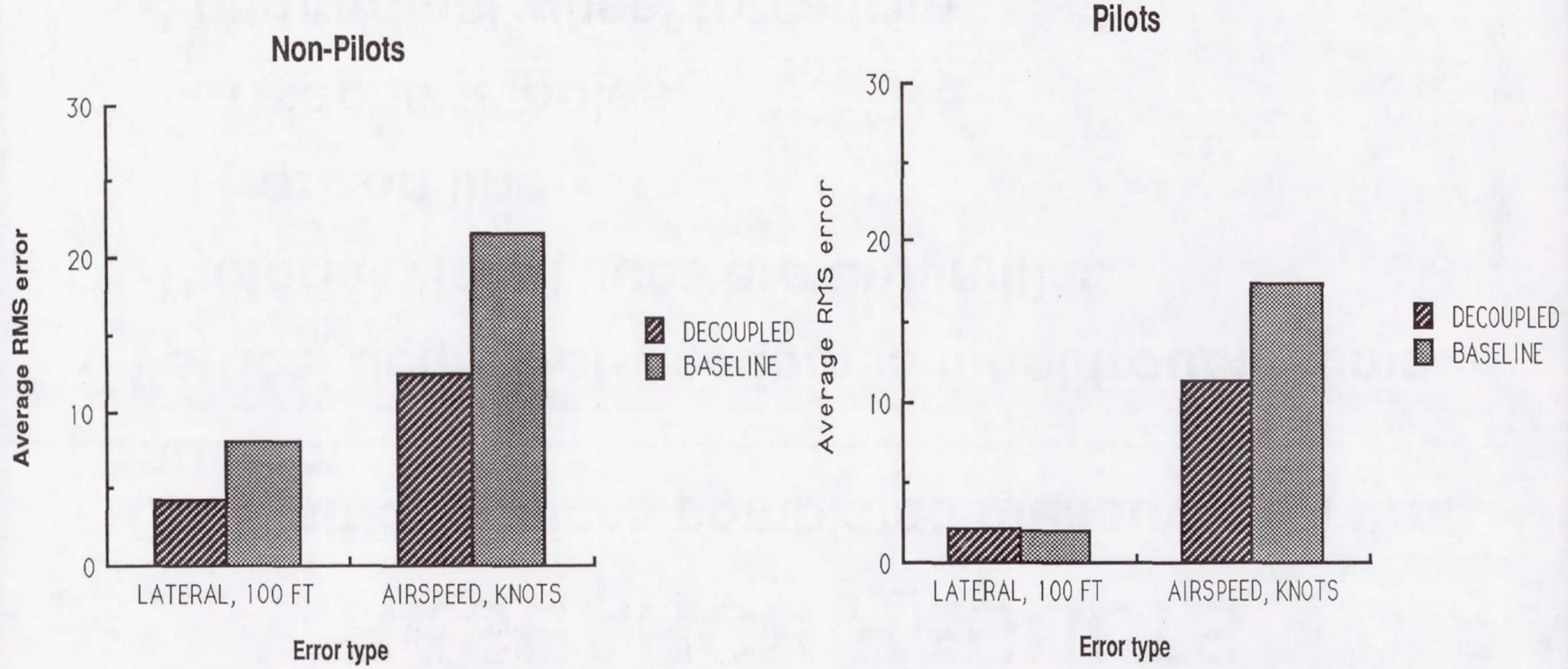
(With Pictorial HITS Display)





IN-FLIGHT PERFORMANCE

(With Pictorial HITS Display)



RESEARCH RESULTS

- One-half of novices completed maneuver on first attempt
- Vertical degree-of-freedom is most troublesome
  - -Pictorial visual cues are unfamiliar
    - Horizon line
    - Telephone poles
  - -Longitudinal wheel force trim
  - -Landing maneuver
    - Narrow field of view on simulator

CONCLUSION

- Decoupled controls and pictorial display necessary for novice

FOLLOW-ON ACTIVITIES

- Command arrows
  - Rotation
  - Tracking
  - Flare
- Automatic pitch control force trim
- Additional pictorial altitude cues
- Flight Evaluation