Hardware-In-the-Loop Simulation of an Aircraft Brake System

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Outline

• Antiskid Background
• Motivation
• HIL: Hardware; Software
• Antiskid Control
• HIL Tests
• Concluding Remarks
Cessna makes jets, too.
Why antiskid?

- Better performance
- Even tire wear
- Directional stability
- Safety
Antiskid Brake System
Experimental Flight Data

- Wheel speeds
- Acceleration
- Brake pressures

Time (s)
Motivation:

- Product improvement
- Smooth ride
- Engineering curiosity
• Flight test – expensive
• Analytical – slow simulation
• Hybrid – HIL: real-time; cost?
HIL Simulation

- Already had:
  - MATLAB
  - Simulink
  - Real-Time Workshop

- PIII leftovers
- Compatible A/D – D/A card
- xPC Target
HIL: Hydraulic components
HIL: Computer interface
HIL Block Diagram
Simulink airplane model

\[ F_D = \mu F_z \]
Wheel-tire equation of motion:

\[ \tau = I \alpha \]
NASA TN D-1376, Figure 78
NASA TN D-1376, Figure 78

50 knots
NASA TN D-1376, Figure 78

50 knots
Some Assumptions and Limitations

- Tire $\mu$, Brake $\mu$
- 3 DoF
- Trailing link gear model
- Ground effect aero
Antiskid Control Background

• Control logic (black box)
  – Input: Wheel speed
  – Output: Control current

• Antiskid valve
  – Input: Commanded pressure; control current
  – Output: Brake pressure
Pressure vs. Control Current

Change control in two ways:

- Electrically
- Hydraulically
HIL Usefulness

- Cost-effective
- Time-saver
- Multi-purpose