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

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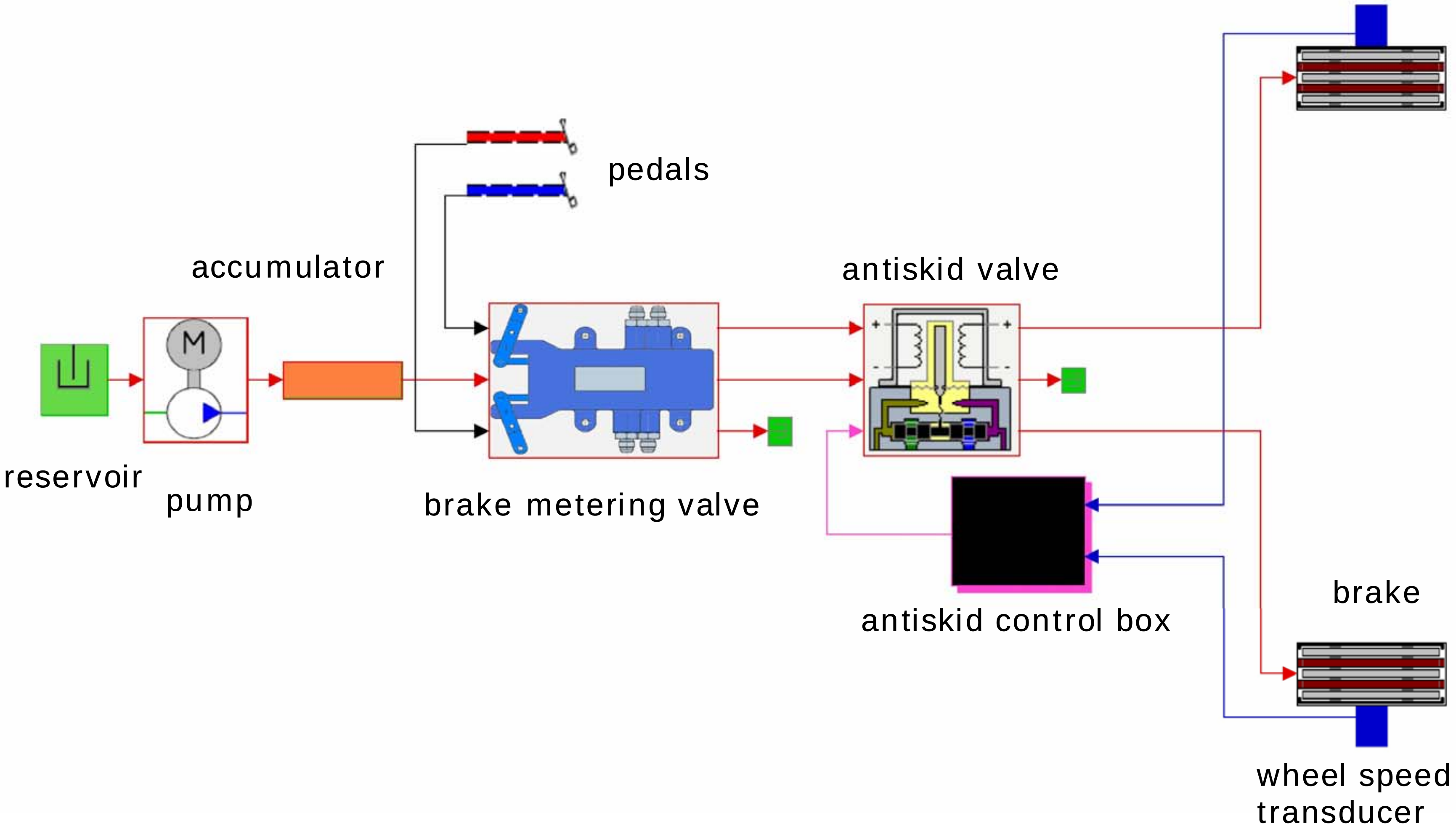
Outline

- Antiskid Background
- Motivation
- HIL: Hardware; Software
- Antiskid Control
- HIL Tests
- Concluding Remarks


Cessna
Cessna makes jets, too.

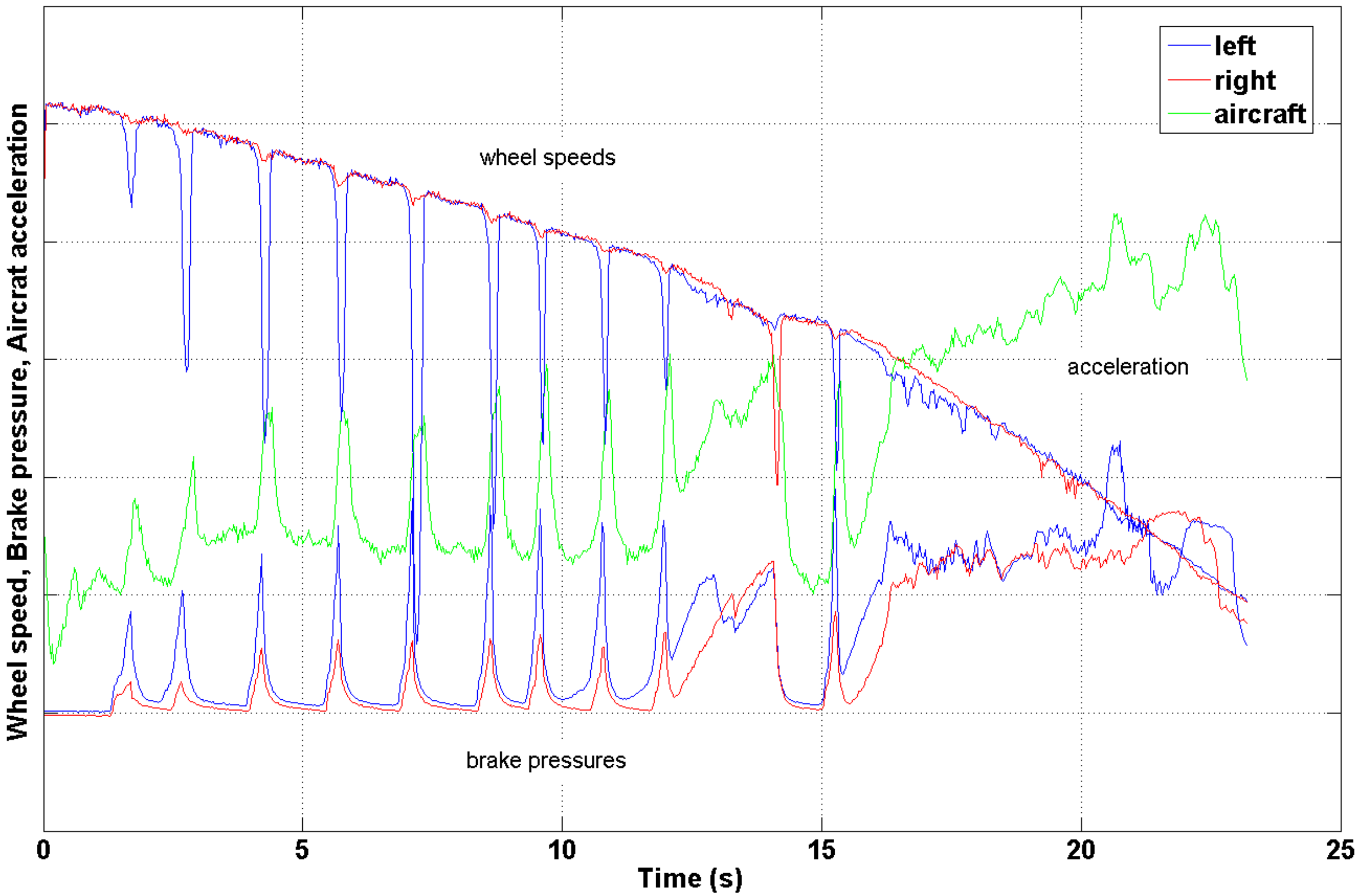
Why antiskid?

- Better performance
- Even tire wear
- Directional stability
- Safety



Antiskid Brake System

Experimental Flight Data



Motivation:

- Product improvement
- Smooth ride
- Engineering curiosity

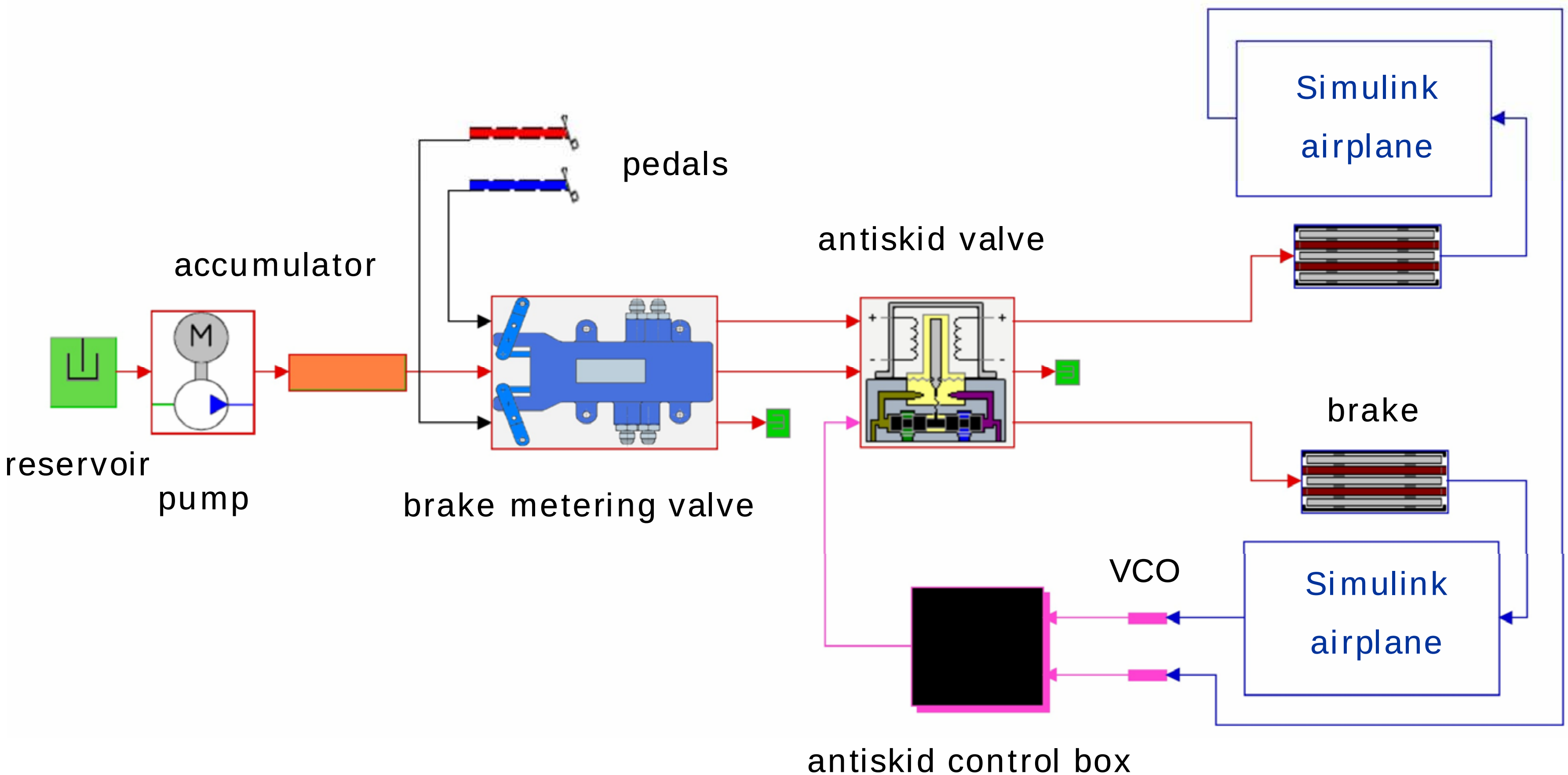
- Flight test – expensive
- Analytical – slow simulation
- Hybrid – HIL: real-time; cost?

HIL Simulation

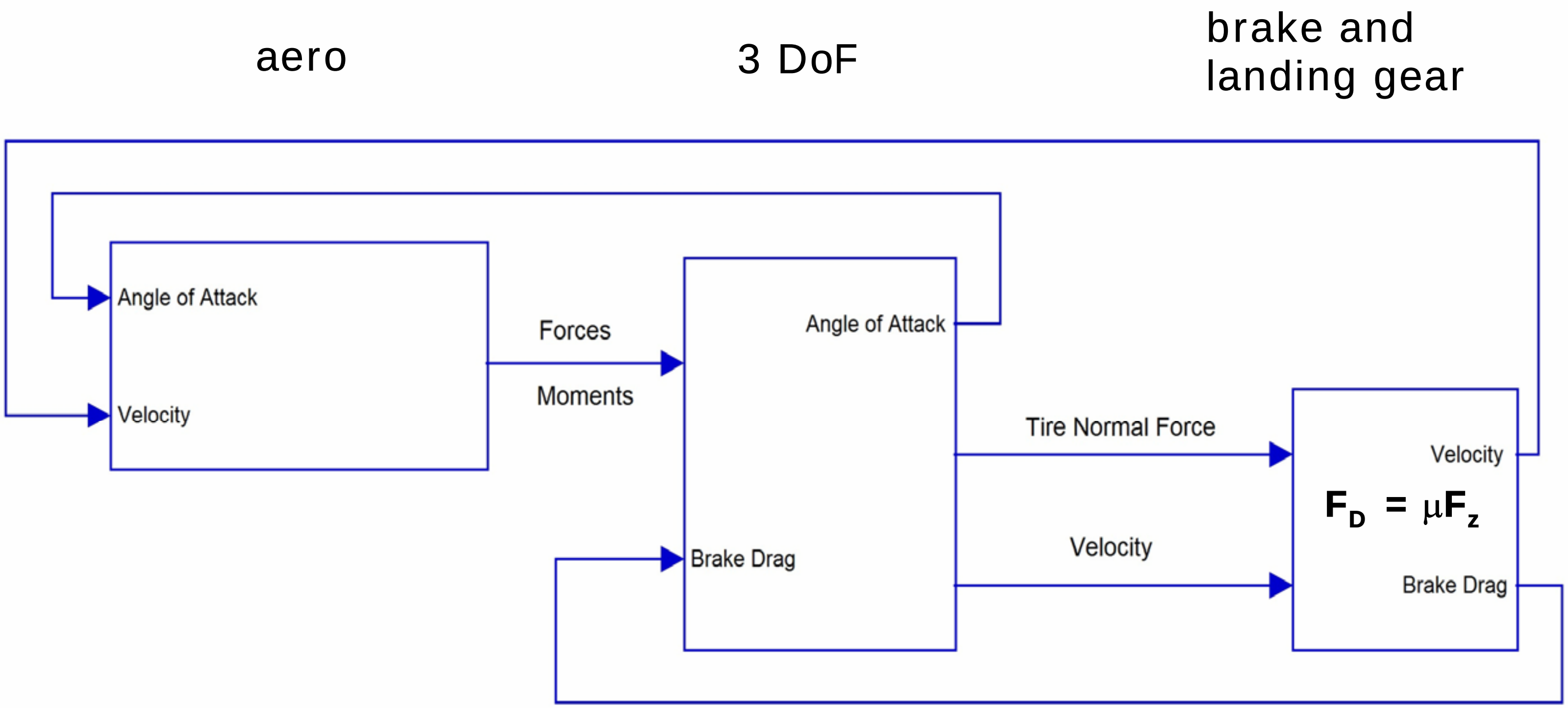
- Already had:
  - MATLAB
  - Simulink
  - Real-Time Workshop
- PIII leftovers
- Compatible A/D – D/A card
- xPC Target

HIL: Hydraulic components

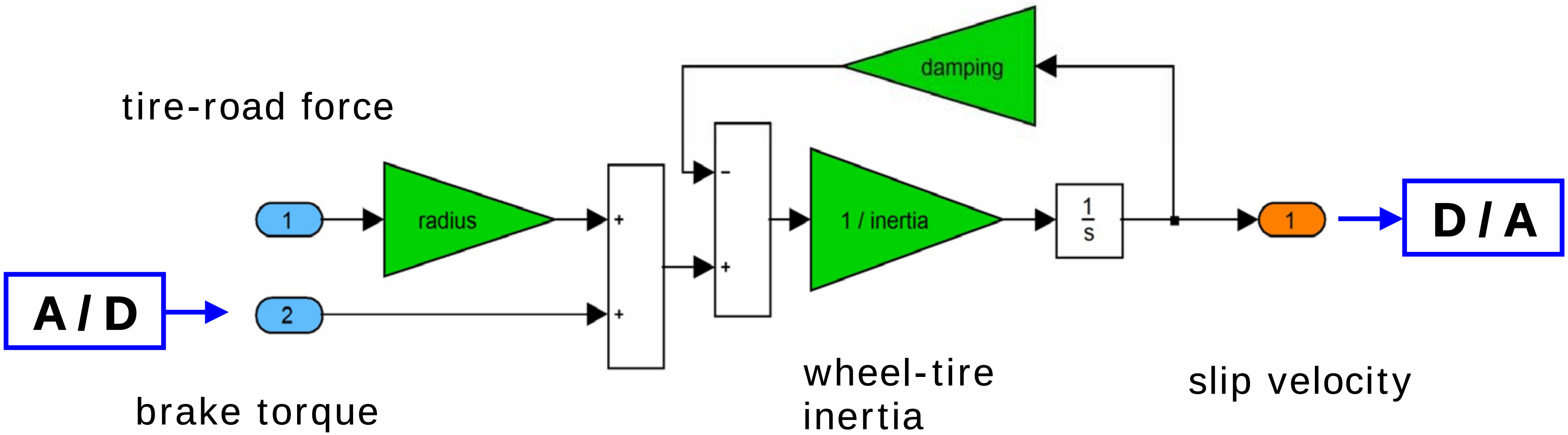
HIL: Computer interface



HIL Block Diagram



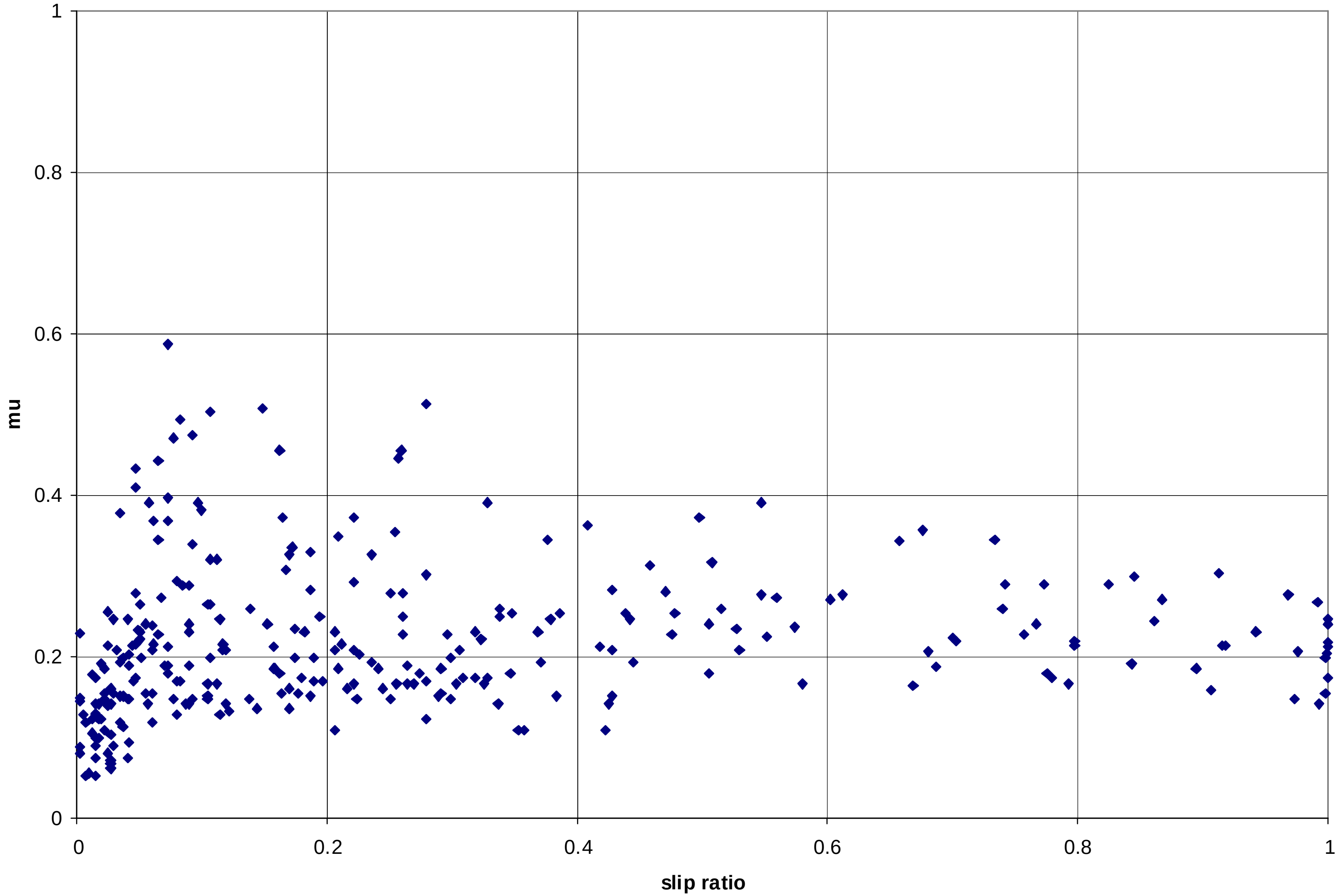
Simulink airplane model



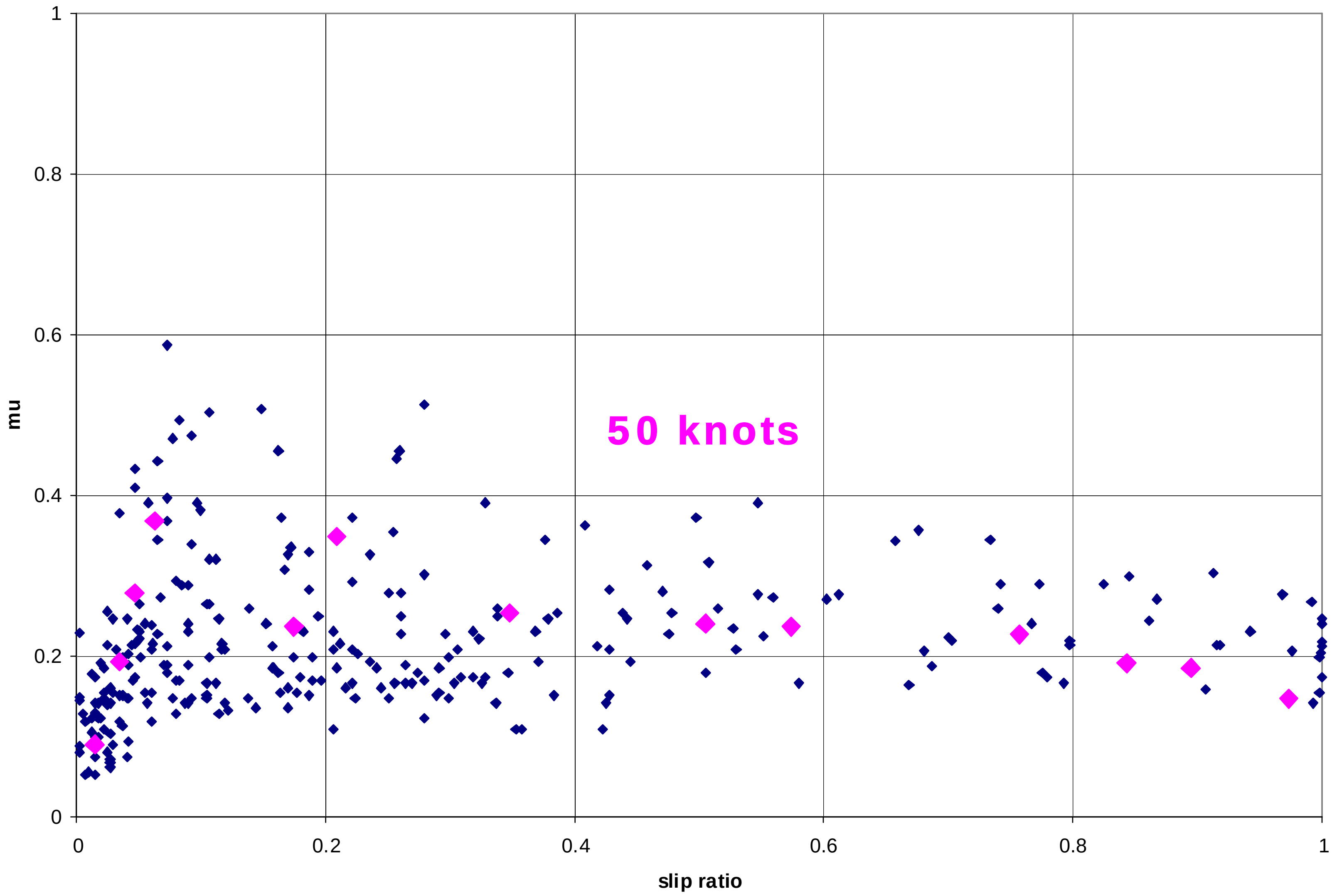
Wheel-tire equation of motion:

$$\tau = I\alpha$$

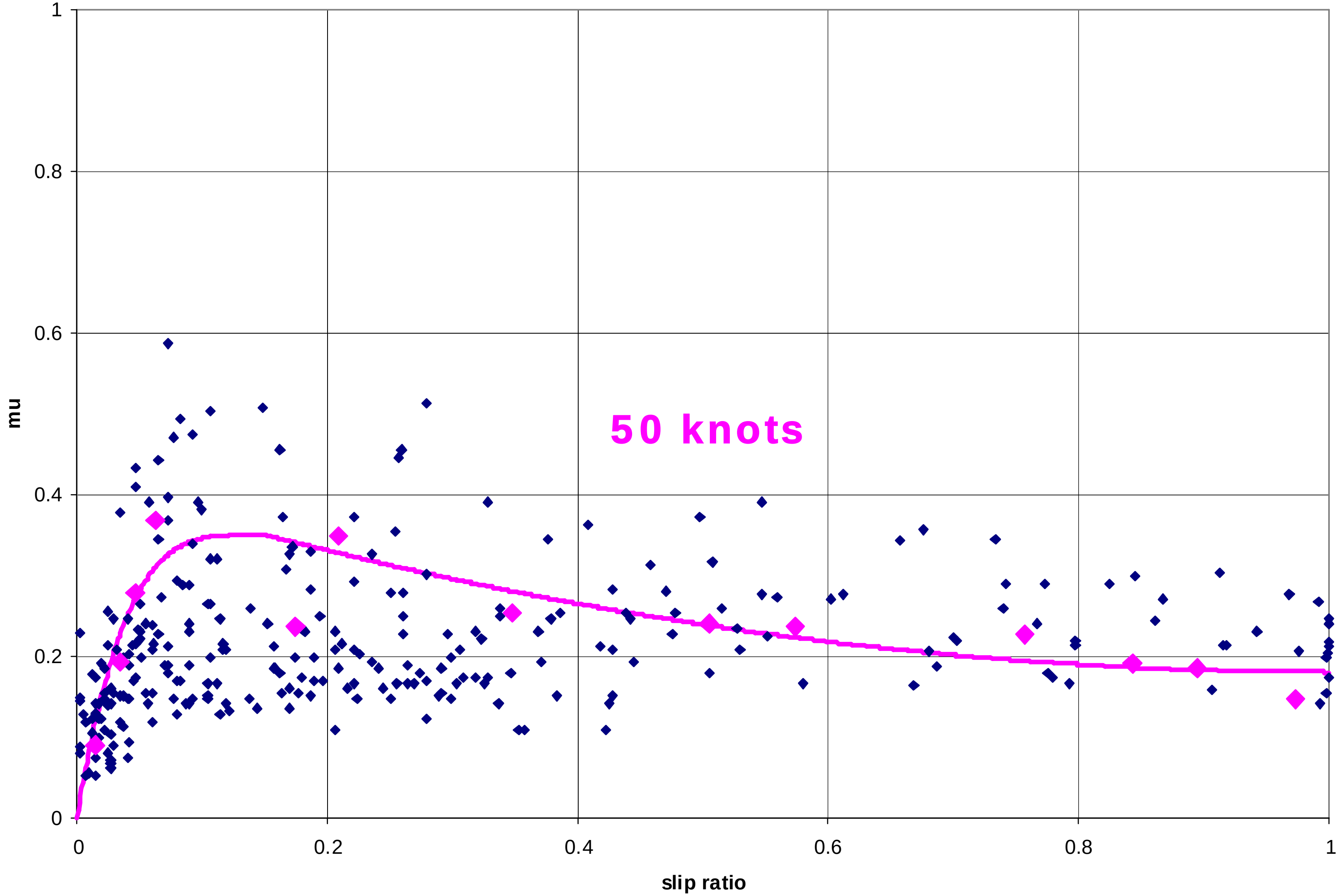
NASA TN D-1376, Figure 78



NASA TN D-1376, Figure 78



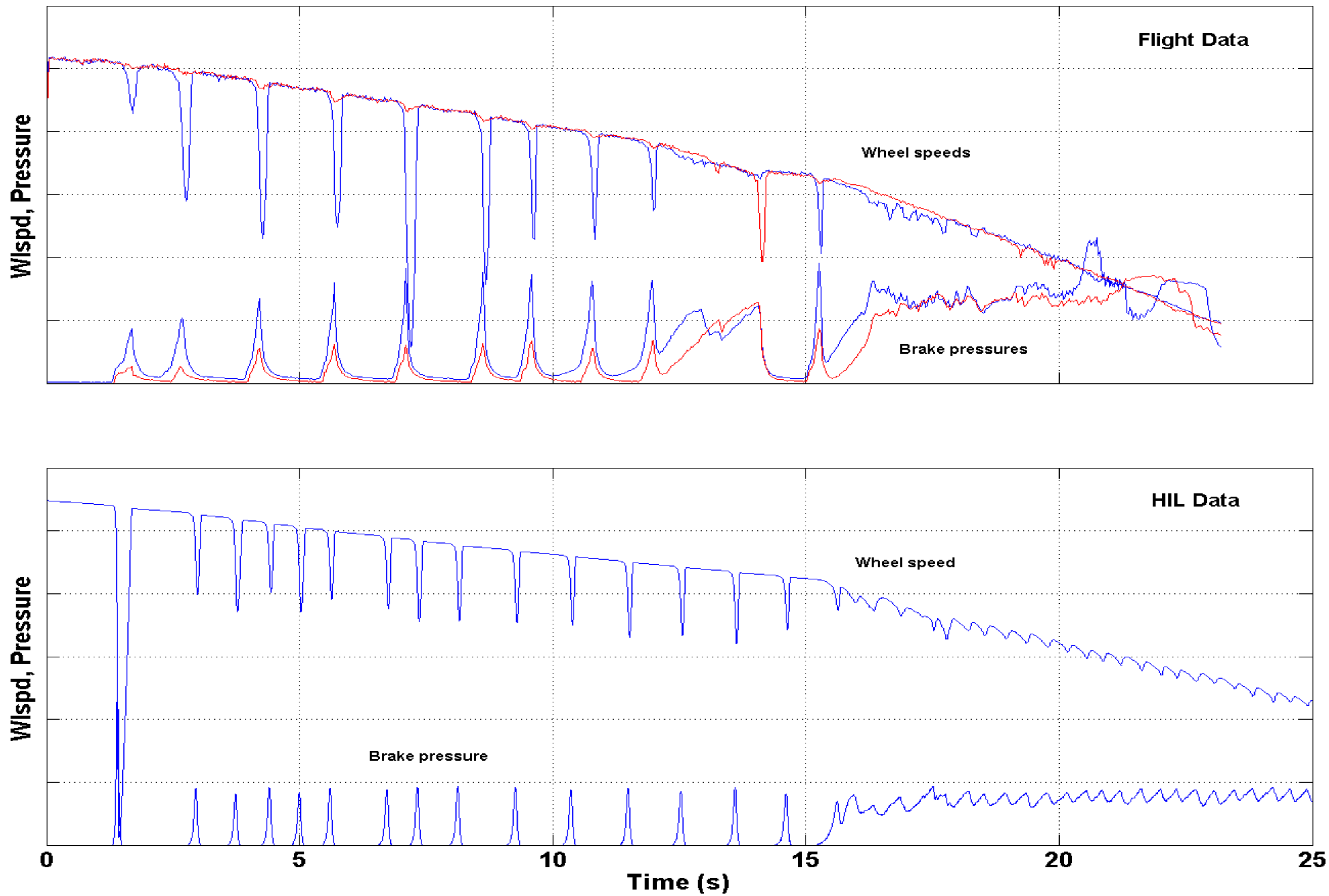
NASA TN D-1376, Figure 78



Some Assumptions and Limitations

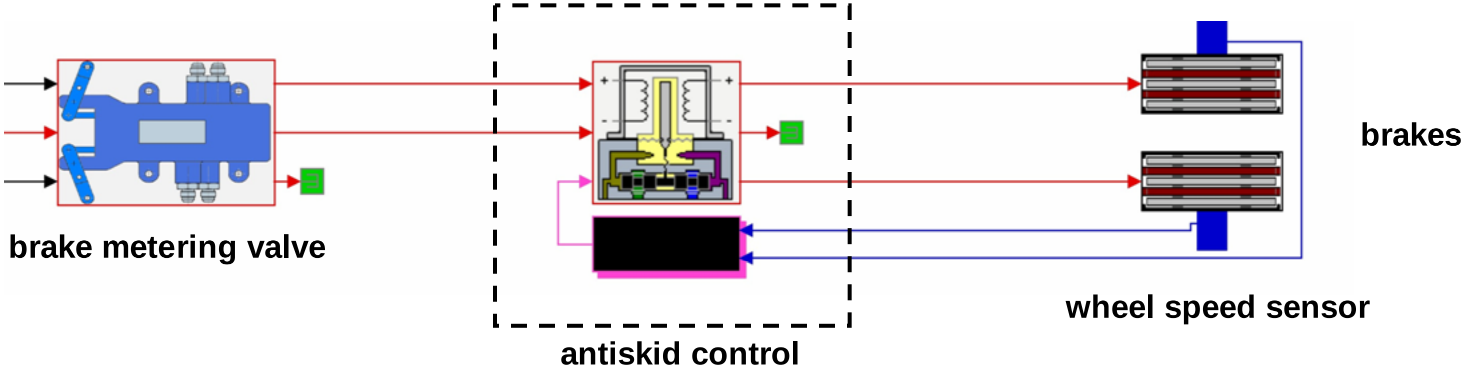
- Tire μ, Brake μ
- 3 DoF
- Trailing link gear model
- Ground effect aero

Original Control

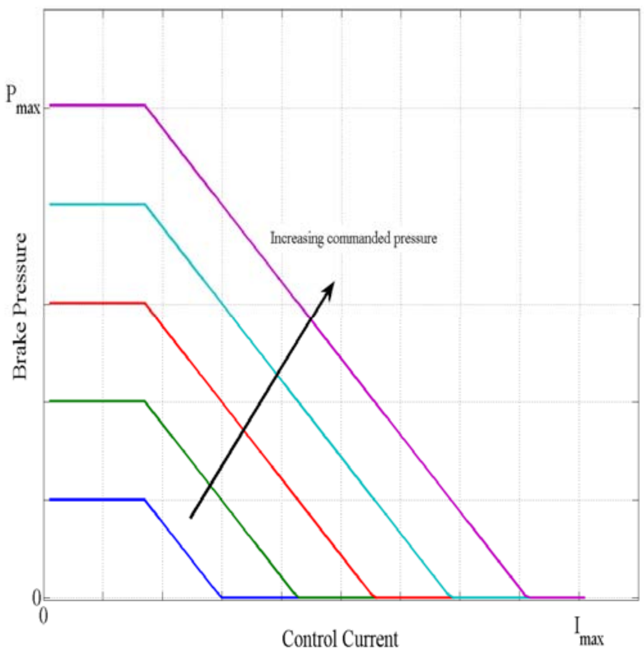


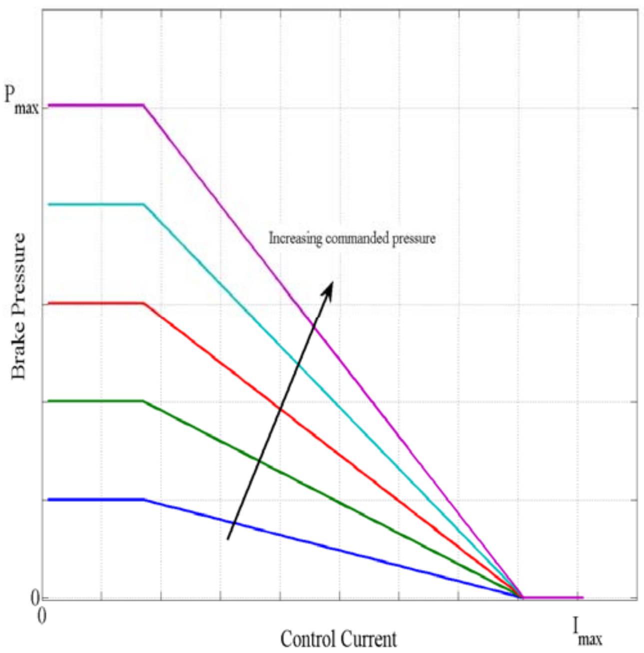
Antiskid Control Background

- Control logic (black box)
  - Input: Wheel speed
  - Output: Control current
- Antiskid valve
  - Input: Commanded pressure; control current
  - Output: Brake pressure



Pressure vs. Control Current

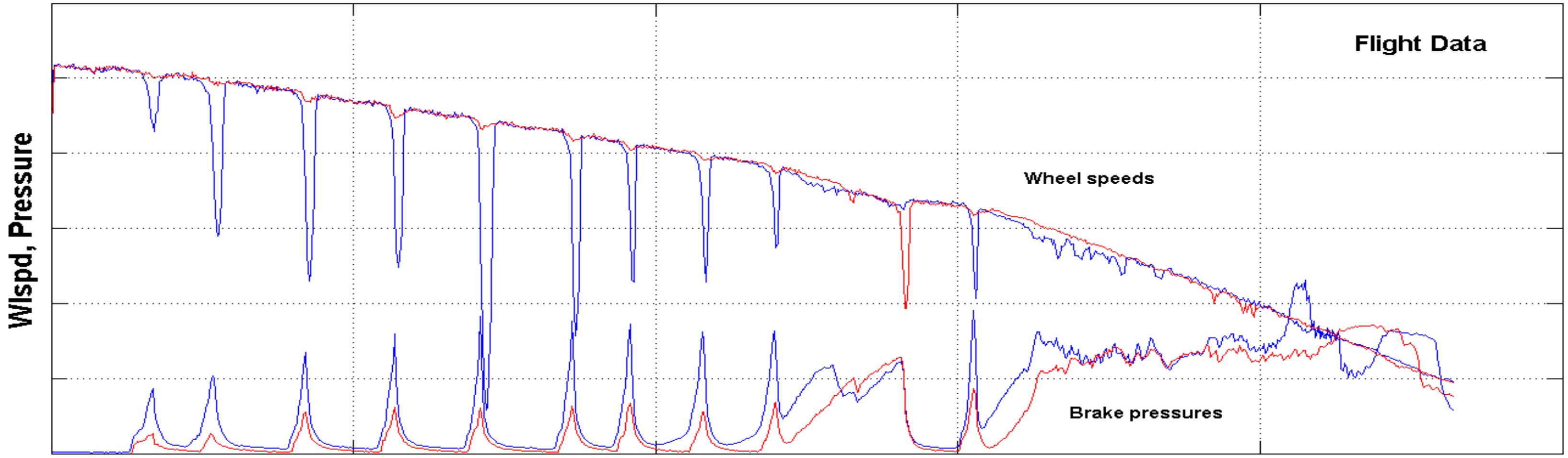


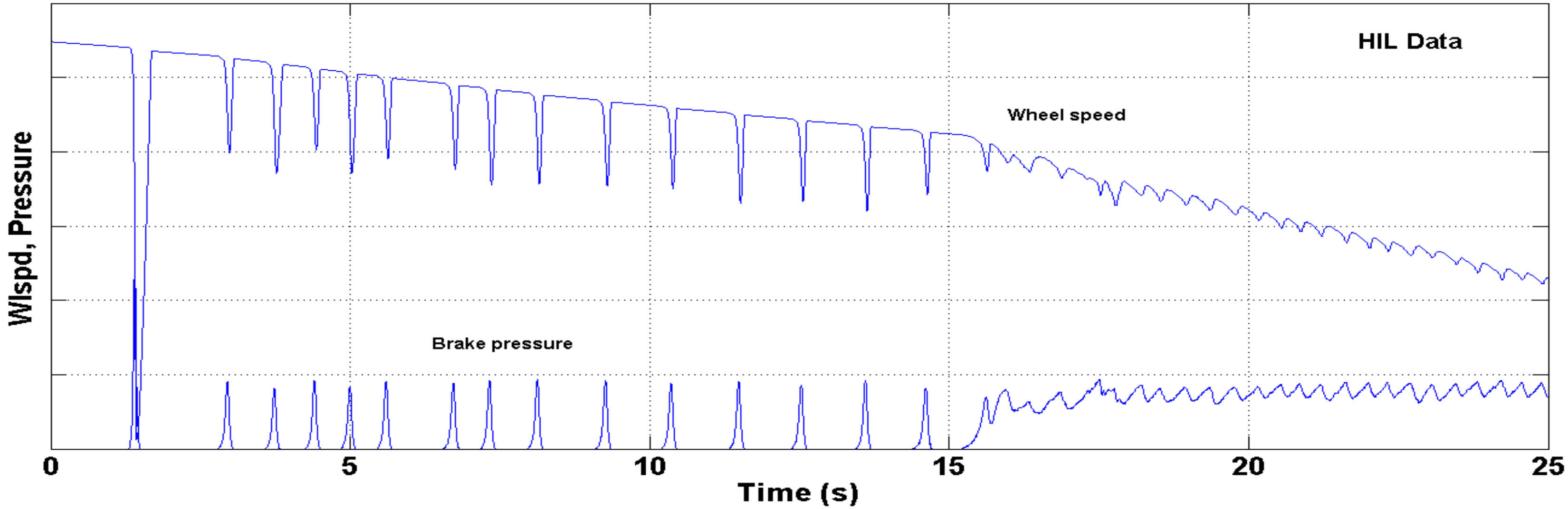


Change control in two ways:

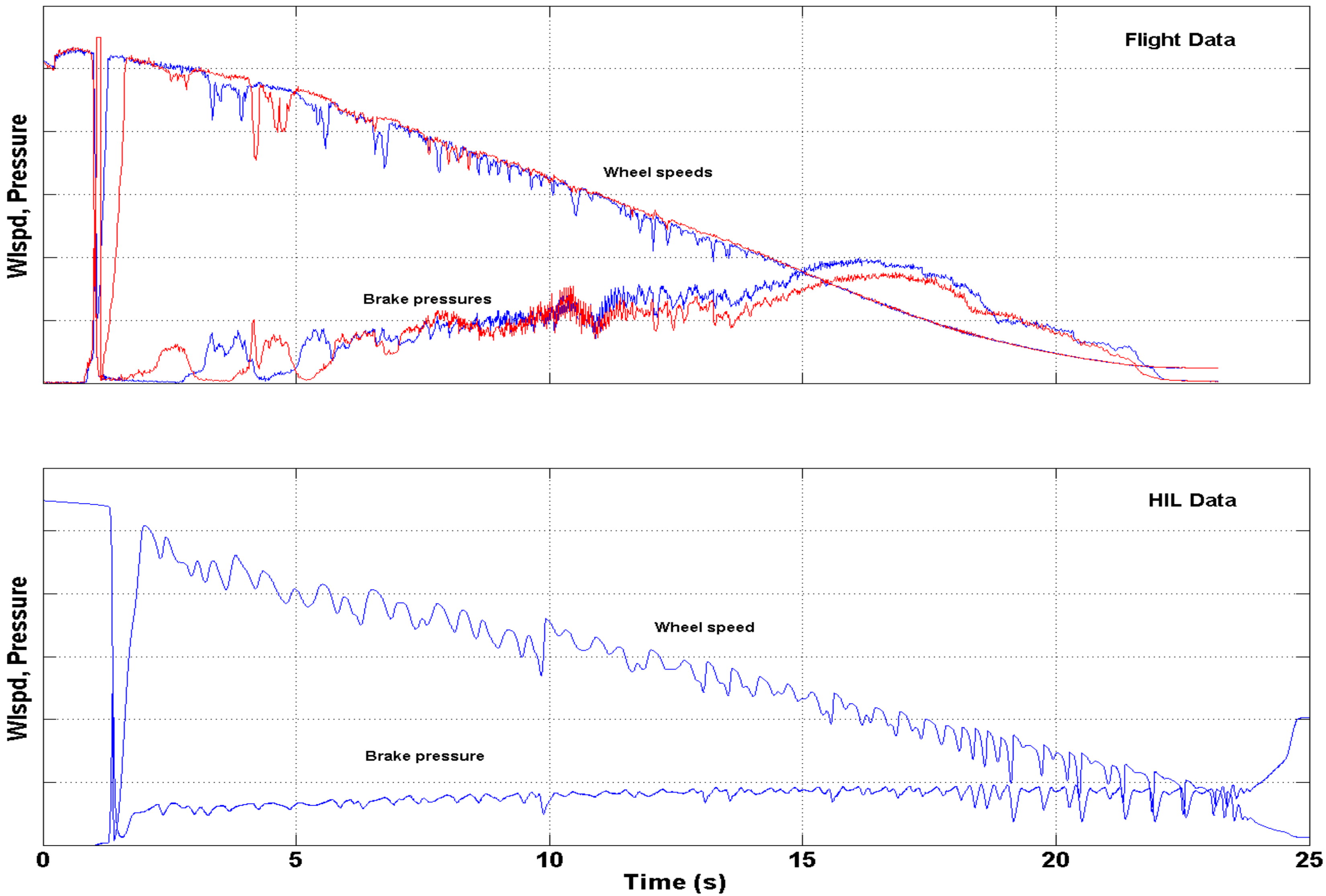
- **Electrically**
- **Hydraulically**

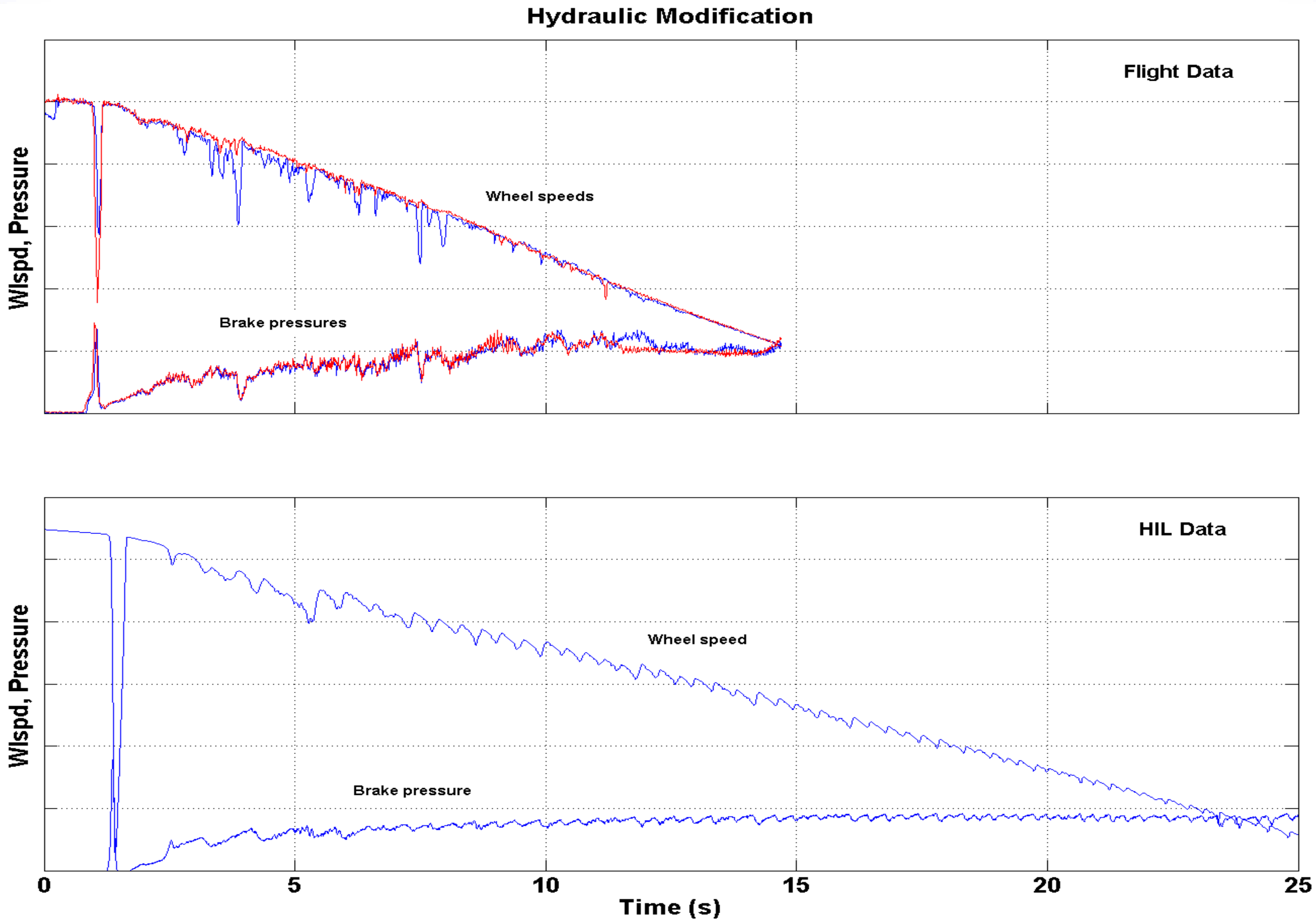
Original Control





Electrical Modification




Hydraulic Modification
Flight Data
Wheel speeds
Brake pressures
Wlspd, Pressure
HIL Data
Wheel speed
Brake pressure
Wlspd, Pressure
0
5
10
15
20
25
Time (s)

HIL Usefulness

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