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Flight Testing a Model Free Control Law

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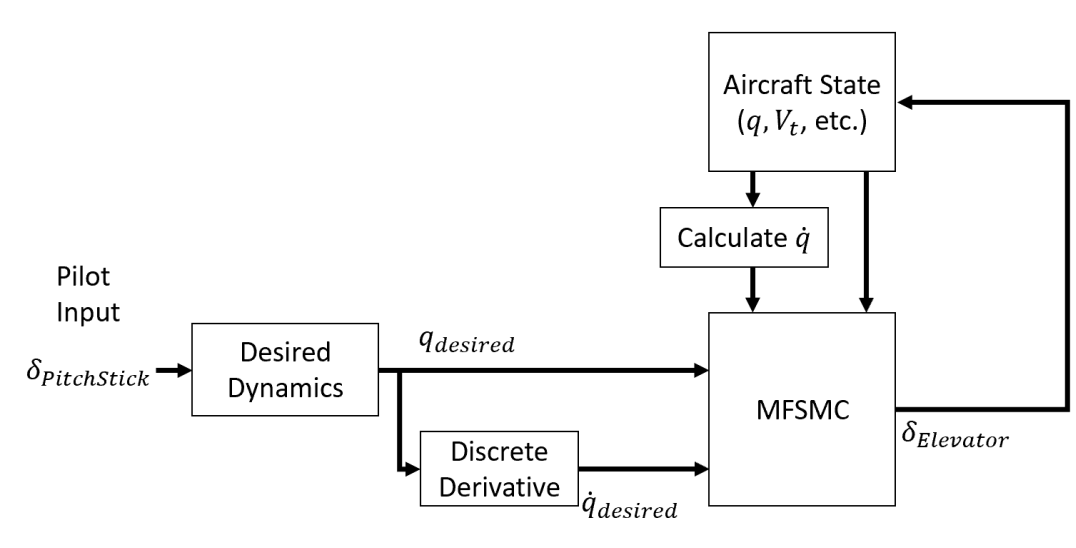
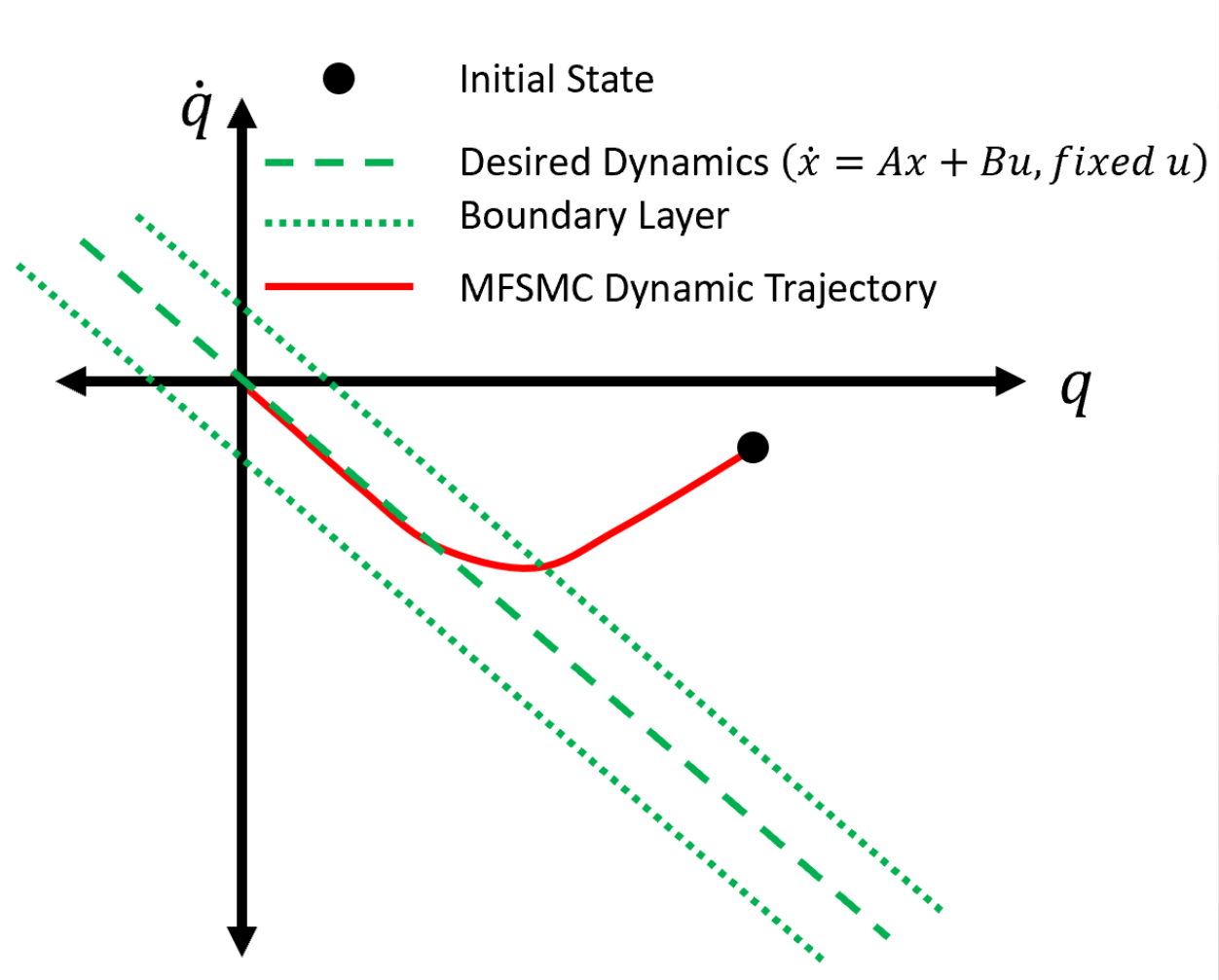
USAF Test Pilot School Test Management Projects

- Test Management Project
  - Cradle-to-grave test project
  - Flight Test Research Opportunities
  - Limited by Educational Objectives

Model Free Sliding Mode Control

- Model Reference Control law
- Does not utilize a model of the underlying aircraft
- Measures response and adjusts output





Designed by Dr. Agamemnon Crassidis and his students at the Rochester Institute of Technology

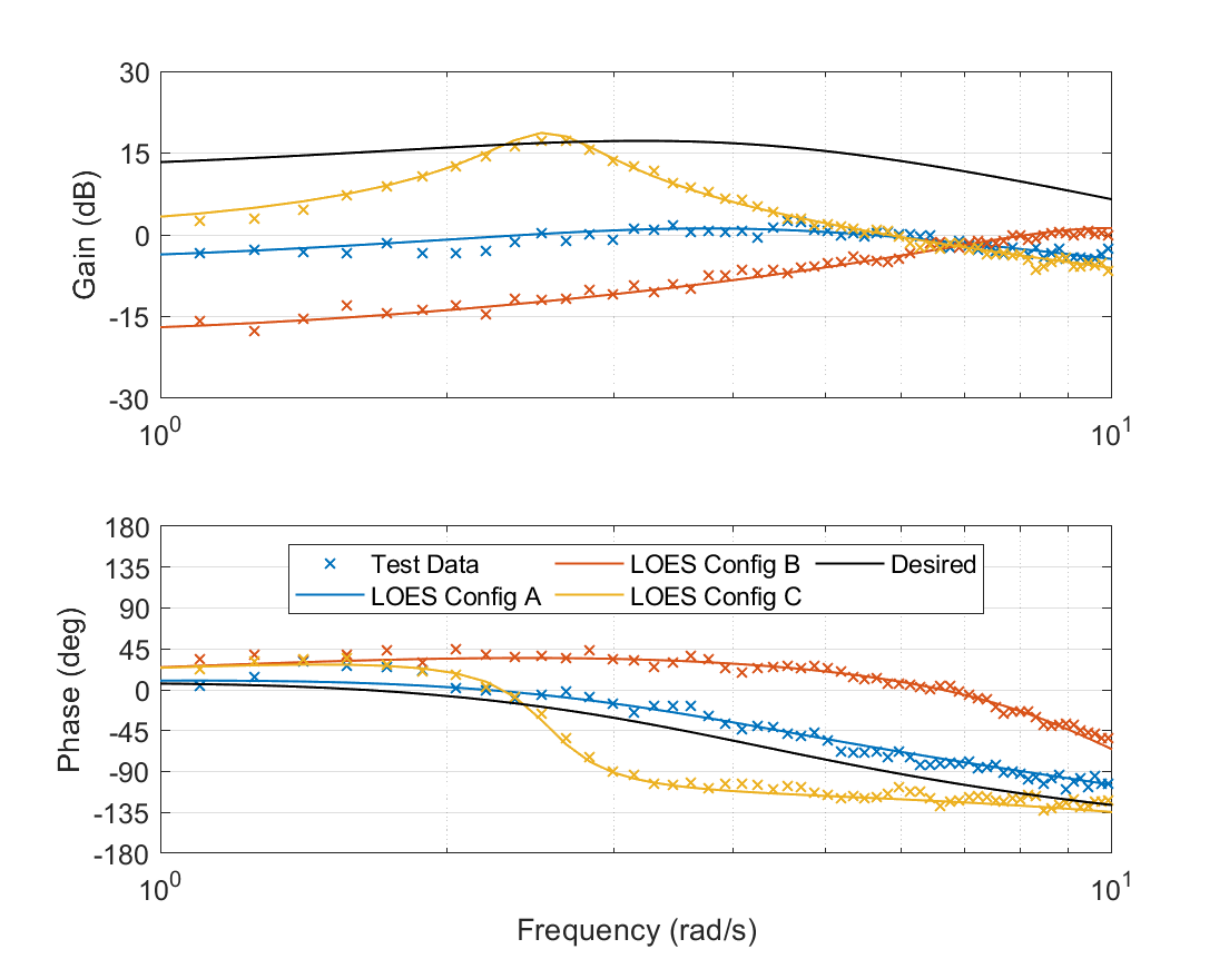
Test Approach

- Test the ability of the controller to match a model
- Model (Black Line)

$$\frac{q}{\delta_s} = K\frac{\omega_n^2\left(T_{\theta_2}s+1\right)}{s^2+2\zeta\omega_n s+\omega_n^2}\frac{5}{s+5}$$

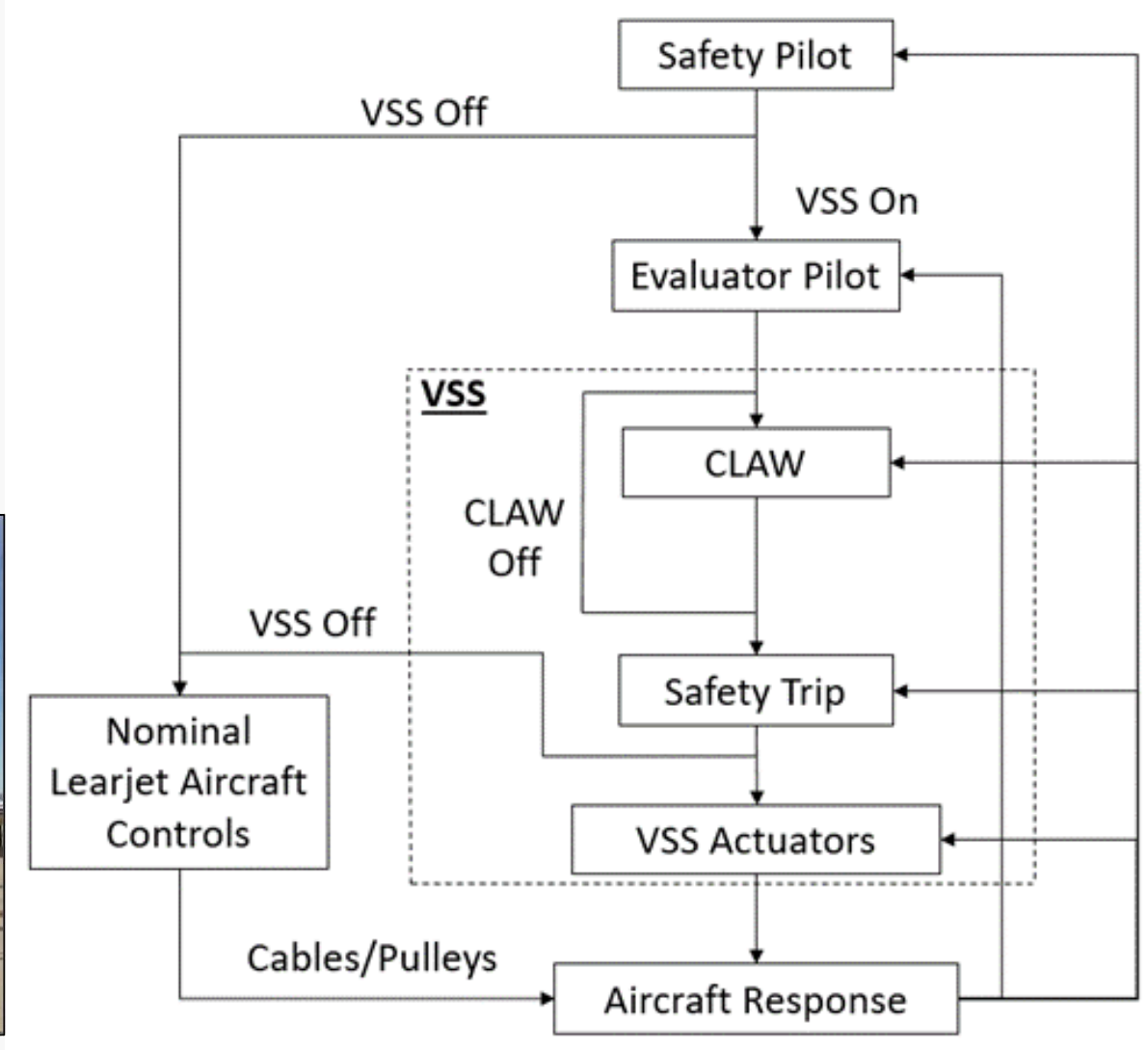
$$T_{\theta_2} = 0.8, \omega_n = 4\frac{rad}{s}, \zeta = 0.7$$

- Low pass added due to noise
- Frequency Sweeps
- Tracking Tasks
- Safety



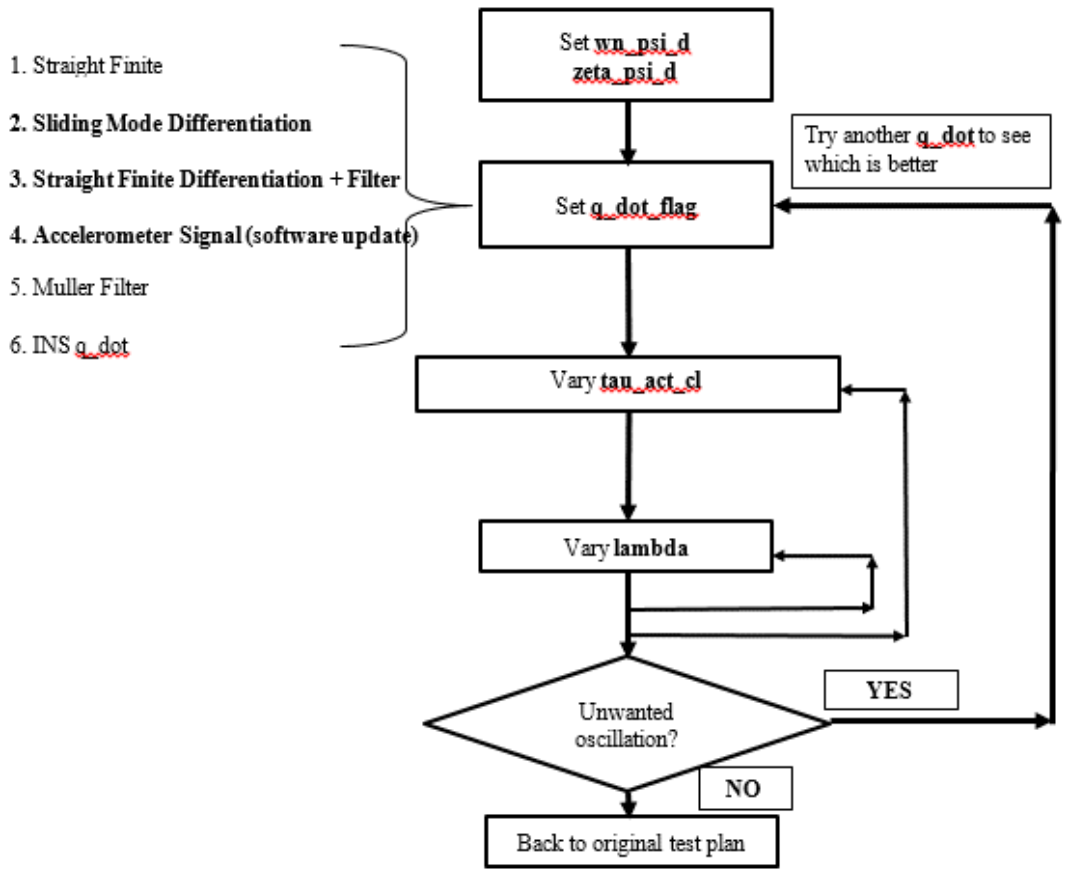
Test Aircraft

- Calspan Variable Stability System (VSS) Learjet 25
- Unique asset to safely test experimental flight controls



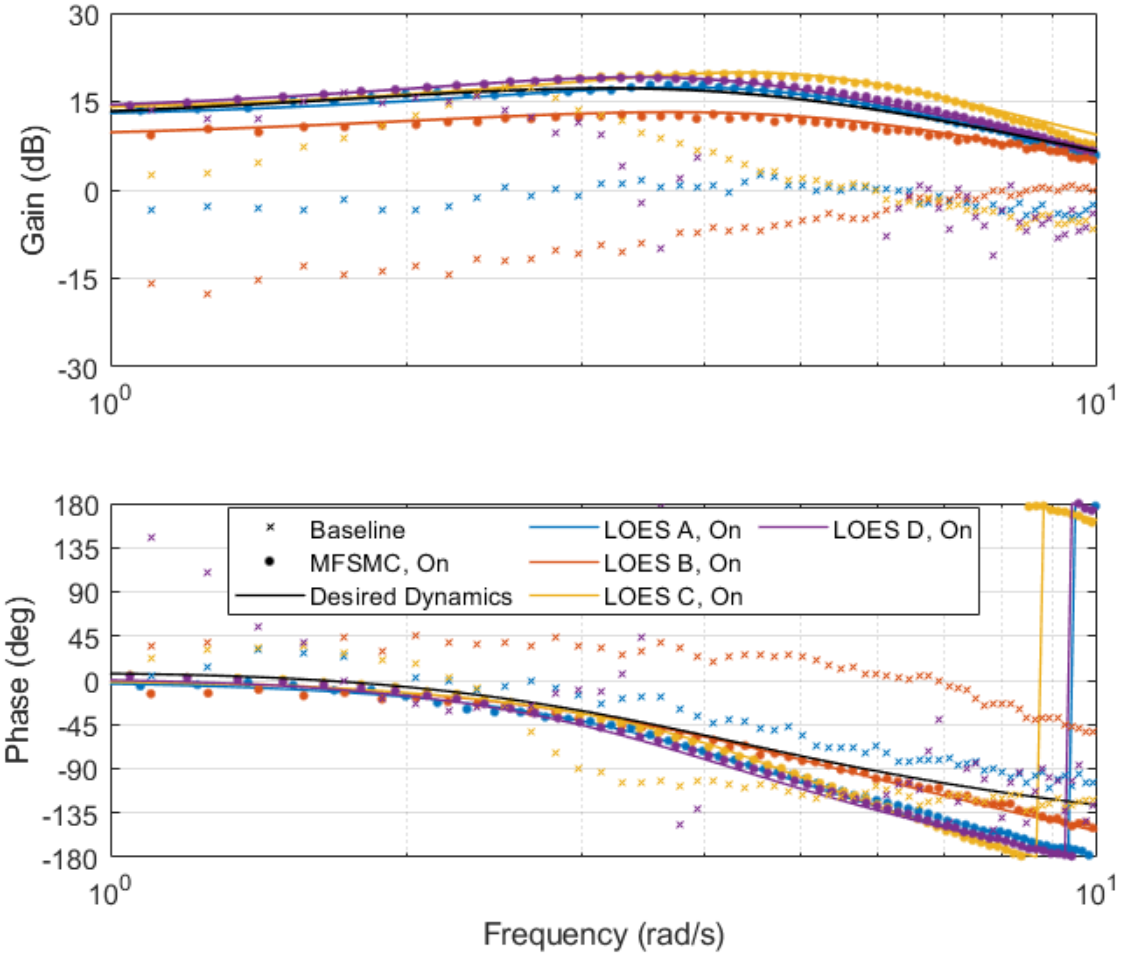
In-Flight Control Law Tuning

- First engagements resulted in an unstable system
- In-flight tuning guide
- Configuration control

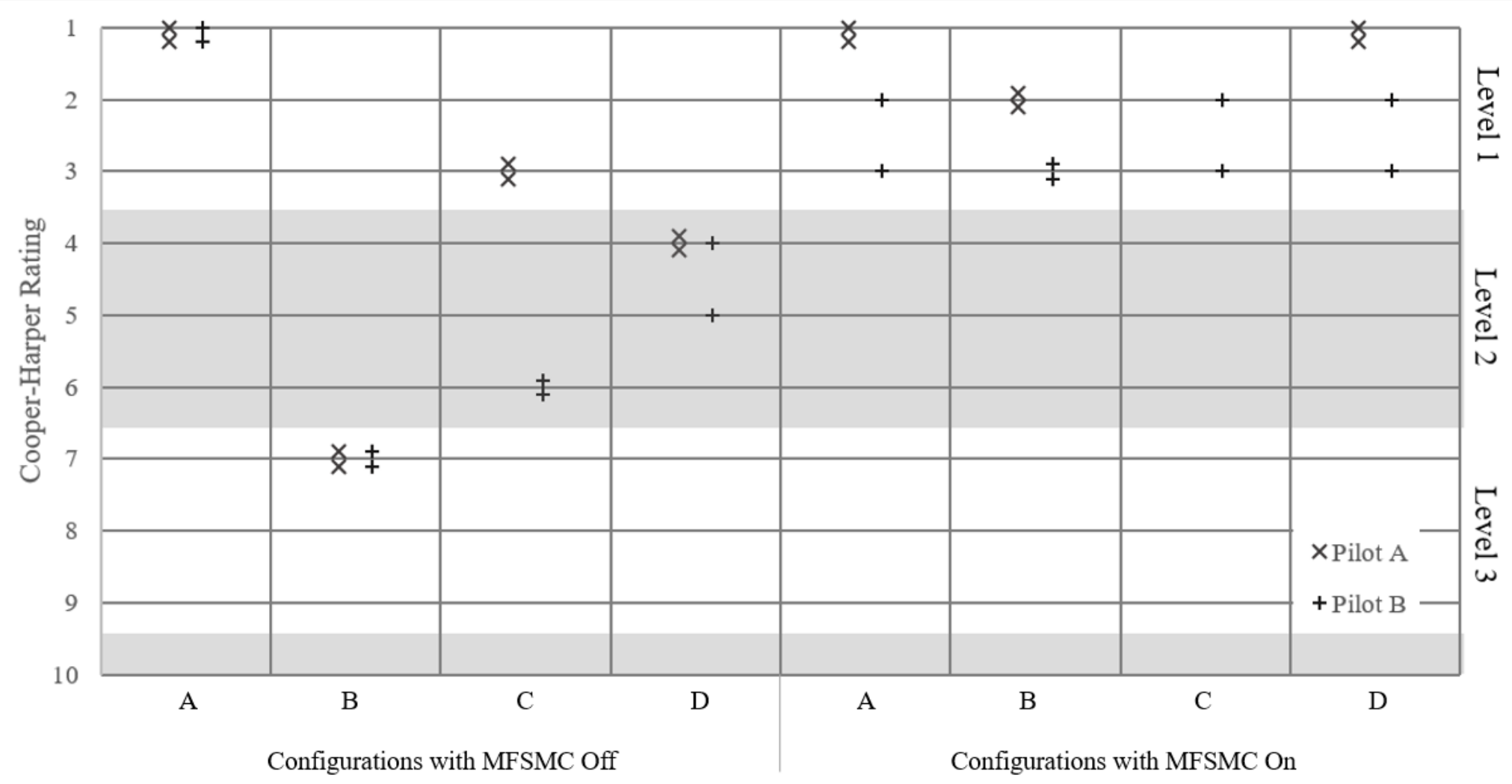


Flying Qualities

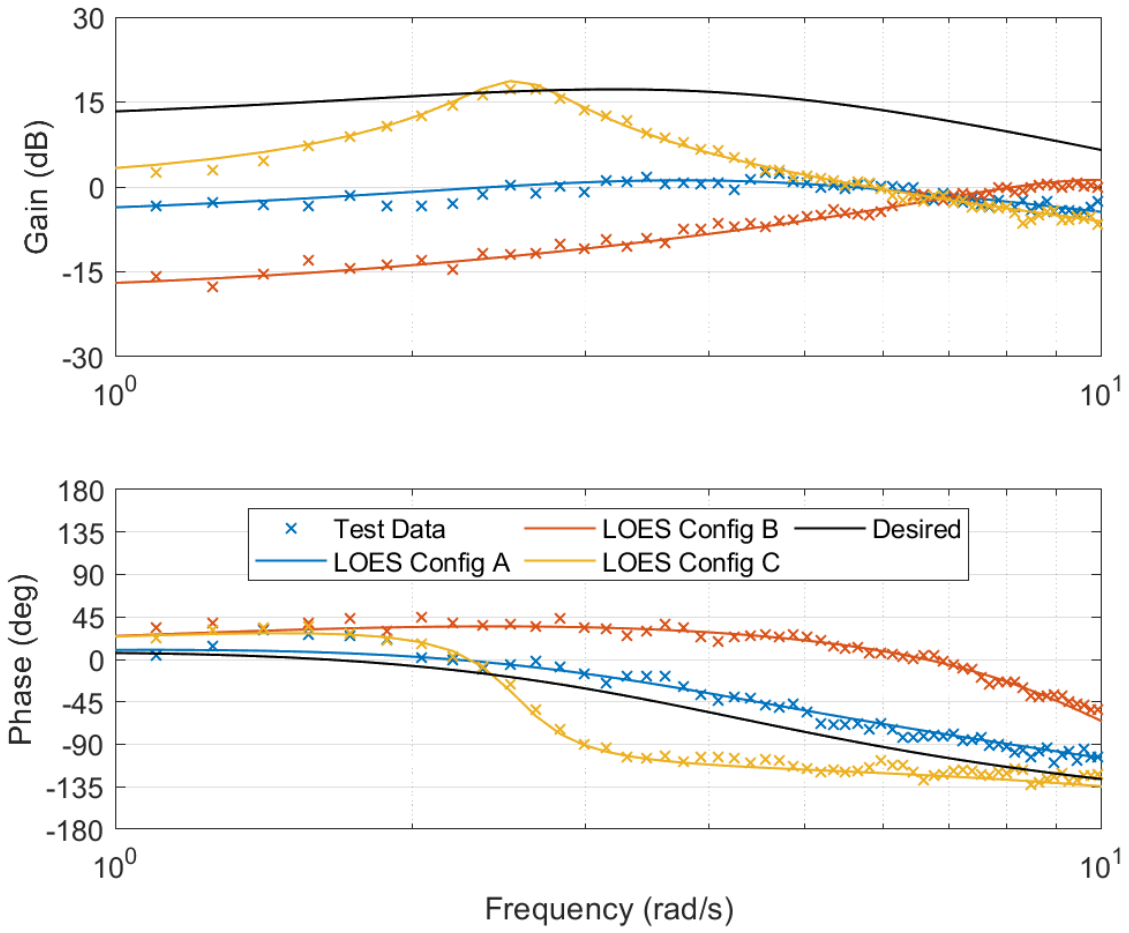
- X are control law off results
- Black line is the desired dynamics
- Controller matched either gain or phase well
- Equivalent Time Delay

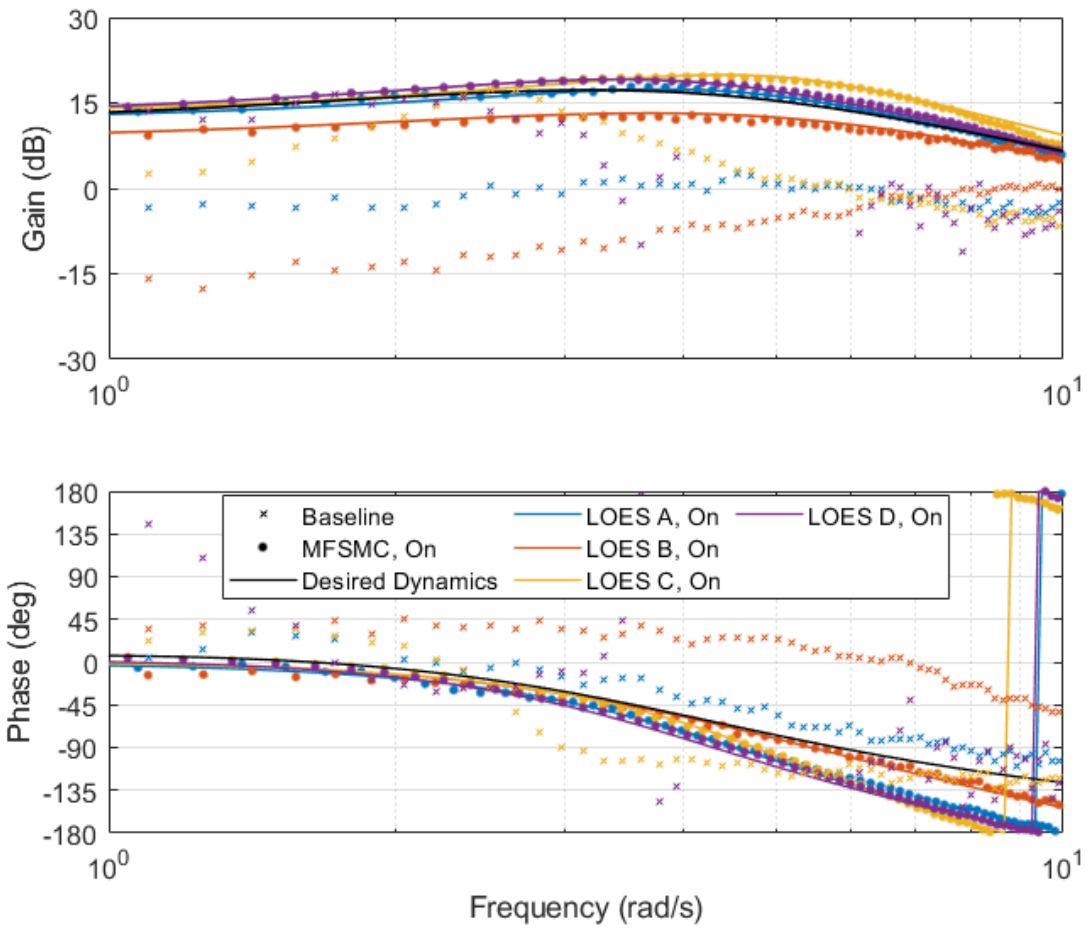


Distant Tracking Cooper-Harper Ratings

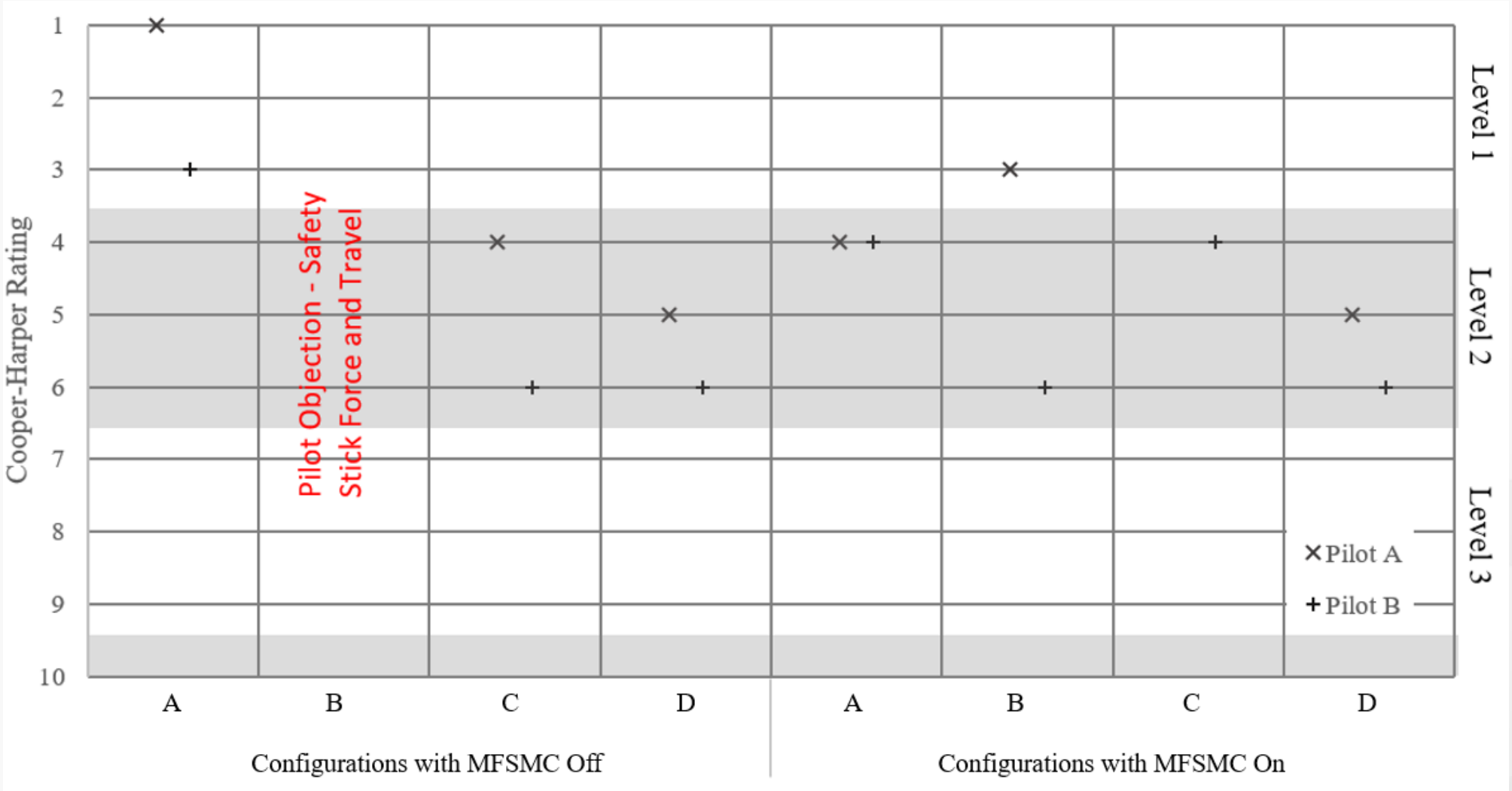


Flying qualities Summary





Close Tracking Cooper-Harper Ratings



Summary

- Unstable to stable in two flights, characterized in two weeks
- Model reference controllers can be non-intuitive
- Controller replicated certain model parameters well, but the model was not the best for close tracking